

Liverpool WwTW Outfall Extension

designing and installing the next generation of submarine outfall pipelines in the North West

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December 2013 saw the successful completion of a 285m new large diameter polyethylene outfall extension pipe necessary to improve dispersion of the final effluent from the treatment works and ensure compliance with the Habitats Directive. This was the first installation of a polyethylene outfall of its diameter within the UK. The installation required meticulous planning by a team of marine experts working for United Utilities as part of the wider £200m scheme continuing the company's vital work to improve the quality of the water in the River Mersey. The outfall project was part of a £3.6bn investment programme by United Utilities across the North West to improve water quality and the environment by 2015.



Pipe delivery arriving in Liverpool - Courtesy of United Utilities

Background

In the 1980s, the Mersey was considered one of the most polluted rivers in the UK. Liverpool Wastewater Treatment Works was constructed in 1991 as part of the Mersey clean up and is located at Sandon Dock. The works was further upgraded to its current form in 2000 using cutting edge technology and met all the required standards. The Mersey now sustains a wide range of fish including salmon, trout, lamprey and dace. The treatment works is now being upgraded and extended to satisfy the standards set by the regulators.

The existing outfall from the treatment works is located adjacent to the river wall and has limited dispersion and dilution resulting in a visual plume. Water quality dispersion modelling undertaken

in conjunction with the Environment Agency identified a new discharge location for the outfall 285m from the river wall. This location was in the deeper main channel of the Mersey where the tidal currents would provide the necessary dispersion. Construction of an outfall extension was submitted as part of the Price Review (PR09) for implementation during AMP5.

Wastewater treatment

Liverpool WwTW is situated in Sandon Dock and receives flows from the Liverpool catchment to the south and Sefton catchments to the north via an extensive network of tunnels, overflow chambers and outfalls called the Mersey Estuary Pollution Alleviation Scheme (MEPAS). Full treatment flows of up to 11,000 l/s are lifted via pumps to the inlet works where they are screened, settled and biologically

MARINE OUTFALLS INCLUDING,
INLETS AND OUTLETS FOR POWER GENERATION
& DELSALINATION PLANTS.

HYDRO ELECTRIC, WINDFARM CABLE
CONDUITS AND LAND FALLS.

OTHER OCEAN BASED FLOATING
STRUCTURES SUCH AS SECURITY
FENCES, AQUACULTURE
FISH CAGES



LEADING MARINE PIPE SYSTEMS PRODUCER

PipeLife Norge AS is the Norwegian subsidiary of the Vienna based PipeLife Group. Its production facility in Stathelle, Southern Norway specialises in manufacturing larger diameter, solid wall, PE pipes in diameters up to 2500 mm OD in lengths of up to 600m long.

The pipe is continuously extruded into the sea in a sheltered fjord. The pipe ends are sealed off with flange connections and blank plates, or with PE end plugs. It is then towed to site using ocean going tug boats.

Our Stathelle manufacturing plant is project orientated. Its primary focus is to produce world class marine pipeline solutions, providing a full technical support service to our customers and their clients

The primary advantages to this pipe system and its method of delivery to site are:

- Reduced installation time giving significant cost savings
- Minimal site welding required
- No storage costs
- Pipe sections are supplied with factory fitted flange connections and blind flanges so reducing the installation costs

Please contact us during the early stages of your project and we will be happy to support you commercially and technically

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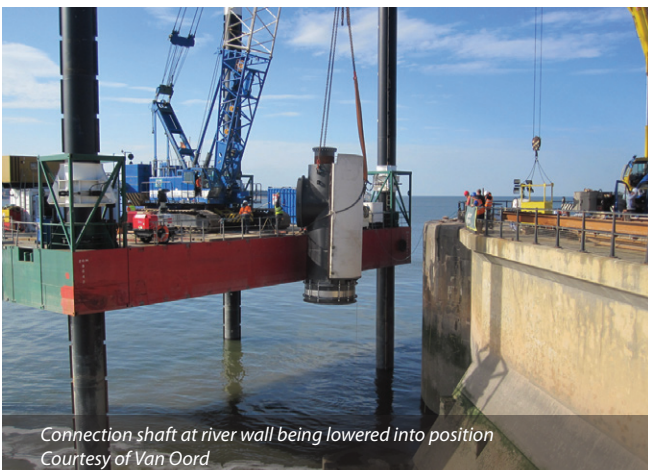
Pipe delivery leaving Norway - Courtesy of Pipelife Norge AS



Concrete collar installation - Courtesy of United Utilities



2.1m diameter Nova Siria Multi Grip coupler
Courtesy of United Utilities



Connection shaft at river wall being lowered into position
Courtesy of Van Oord

treated before siphoning under the Half Tide Dock for discharge at the river wall. During storm events, once the capacity of the treatment works is reached, flows spill directly from the network using real time control at the various outfalls within MEPAS.

Existing outfall

The existing outfall for Liverpool Wastewater Treatment Works receives flows from the siphon beneath the Half Tide Dock at a cascade chamber. This chamber was constructed at the same time as the treatment works by filling an existing disused lock structure. Flows cascade from high level within the chamber and discharge through a series of submerged openings just above the river bed level.

The dispersion of the effluent from this existing structure is limited and a visual plume is formed on the surface which often stays in proximity to the river wall. Adjacent to the cascade a large diameter pipe stub with blanked flange was installed to accommodate a future extension of the outfall if required.

Solution

Water quality dispersion modelling undertaken in conjunction with the Environment Agency identified a new discharge location for the outfall 285m offshore from the river wall. This location was in the deeper main channel of the Mersey where the tidal currents would provide the necessary dispersion. However this location was in close proximity to the navigation channel of the river requiring consultation with the Port of Liverpool. Constraints were imposed on the protrusion into the navigational channel and the profile of any structures protruding above the river bed.

Hydraulic analysis was undertaken of the new outfall over a range of discharge flows and tidal conditions. The outfall had to be capable of discharging the treated flows from the outfall for 95% of the time, with only the existing cascade being used for peak flows in extreme storm and tidal conditions. To satisfy these requirements for the outfall a minimum internal diameter of 2m was required. The diffuser section would incorporate three diffuser risers each with single funnelled ports perpendicular to the main tidal flow direction. Using multiple diffuser ports within this tidal regime was not considered significantly beneficial.

Marine multi-beam hydrographic surveys were undertaken of the river bed in conjunction with tidal current profiling. The outfall would utilise marine design and construction techniques and be buried in an excavated trench along its length with connection externally to the river wall cascade. The outfall pipe would be stabilised using a combination of continuous concrete weight collars as well as rock armour backfill to the trench to provide additional stability from the high tidal current in the River Mersey.

Site investigation

An initial investigation for a proposed outfall pipeline in the vicinity of the proposed alignment was undertaken in 1987. This comprised five deep rotary cores to allow the outfall to be constructed using tunnelling methods.

A non-intrusive over water survey was carried out by Aspect Surveys Ltd in 2010 comprising multibeam bathymetry, side-scan sonar, magnetometer survey and sub bottom profiling and Acoustic Doppler Current Profiling (ADCP). A diver survey was completed to inspect and classify targets within the vicinity of the outfall identified with a magnetometer signature and ensure these were not unexploded ordnance (UXOs).

A final phase of site investigation was undertaken comprising 5 (No.) boreholes below river bed level utilising cable percussive and rotary coring techniques. These were undertaken to determine the presence and thickness of recent sediment and drift deposits and the depth and strength of the underlying rock.

The investigations essentially proved the anticipated geology encountering a surface layer of Glacial Deposits overlying Sherwood Sandstone. Locally Alluvial Deposits described as very soft dark grey clay were encountered.

Constraints

The proposed outfall pipeline and connection to the existing cascade would be undertaken in close proximity to the existing historical river wall structure. A number of reinforcing mini piles were installed in the river wall prior to the outfall works commencing. The condition of the river wall was surveyed throughout the construction period to ensure no settlement or disturbance occurred.

The marine works would require vessels and marine plant to be working in close proximity to the navigation channel of the River Mersey. In addition, the works were undertaken with consent from the Marine Management Organisation.

Design progression

Following completion of the outline design by United Utilities Engineering, Van Oord Dredging and Marine Contractors UK Ltd successfully bid and were appointed as Principal Contractor by United Utilities to undertake the marine works in 2013.

CH2M Hill was subsequently appointed by Van Oord UK to provide detailed design services. Their solution was based on a single long string of PE 100 pipe at 2,100mm outside diameter with flange connections to reduce installation times and minimised underwater jointing and the need for diving work in the River Mersey. This would be the first use of solid wall PE of this diameter in the UK.

The parties worked in close cooperation to produce a final design which provided a high standard of stability and protection to the pipeline through the use of continuous concrete weight collars

supplemented by rock armour backfill along the main pipeline. This combination of measures ensured the pipeline would meet the required wave and tidal current conditions in the river without the need for buoyancy aids during installation.

The use of continuous collars also meant that the PE pipe was fully protected externally from damage during construction and backfilling. Excavated seabed material could be reused above the rock armour to minimise the disposal off site. To protect the integrity of the historical river wall it was necessary to design a bespoke steel connection shaft arrangement to the existing cascade flange. This connection provided a unique solution for connecting new to old.

Marine works

A total length of 265m of polyethylene pipe (2,100mm OD SDR 21) was manufactured by Pipelife Norge AS at their production facility in Stathelle, Norway. Due to the natural buoyancy of the air-filled pipes, it was possible to tow the pipe across the sea without additional support.

Pipe end caps were securely installed to ensure the pipes remained filled with air throughout. The tug Thor Goliath commenced its tow from Norway on 23 April and arrived 7 days later at the Port of Liverpool where the pipe was transported through the lock and half dock for storage alongside the quay of Canada Dock. The diffuser pipework was fabricated in coated steel, due to its complex shape and tapers, and this was pre-assembled within the dock.

The excavation of the marine trench was undertaken by backhoe dredger with the first use of a specialist rock ripping tool of this scale within the UK. This tool minimised noise and vibration in close proximity to the historical river wall and within an environmentally sensitive location. This tool, combined with the GPS system with 3D dig software on the dredger backhoe, allowed for optimisation of the dredged material within the required tolerances.



Outfall pipeline flooding commences - Courtesy of United Utilities

Concrete collars

The concrete collars (each weighing 4.8 tonnes) were fabricated off site by Cornish Concrete Products and delivered to the port for storage. The pipe preparation works prior to installation required the concrete collars to be 'threaded' onto each pipe string within the port. The pipe remained full of air and sealed at both ends throughout, to assist with the installation and positioning of the collars onto the pipe.

Once all 158 (No.) collars were fitted on to the pipe strings, a 2.1m diameter Nova Siria Multi Grip end restraint coupling was installed to allow for the pipe string to be jointed to the connection footing prior to installation. The steel diffuser section would be installed separately at the offshore end using a jack-up barge.

Installation

The dredger Dinopotes was positioned at the river wall end of the excavated trench to receive the pipe and position the connection footing accurately within the trench. The offshore end of the pipe was connected to a small winch on the jack-up platform. The pipe was installed in a controlled manner using the 'float and flood' technique. Seawater was pumped into the pipe via a bulkhead at the river wall end as the pipe was lowered into the trench using the Dinopotes.

By controlling the fill rate, a smooth S-shaped bend is formed in the pipe as it floods and slowly sinks. The process is aided by a number of smaller tugs and multi-cat vessels which assist in the final alignment. Final positioning of the pipe was undertaken on the following high water prior to a detailed multibeam survey of the pipe to confirm its position in the trench.

With the pipe now located and sheltered within the trench, the Dinopotes commenced the placement of the filter and rock armour protection within the trench. The jack-up platform was fitted

out with a dive team from Northern Divers who undertook the installation of the diffuser section.

The diffuser section

The diffuser consisted on 3 single port risers, concrete diffuser domes and rock armour scour blanket.

Following the completion of the diffuser construction, the connection pipework between the new outfall and the existing flange was lowered into position. This pipework incorporated an access flange for future inspections and an air vent pipe extended up the river wall. The connection pipework was protected from damage using precast concrete slabs.

The final connection to the existing outfall was undertaken by removal of the blanking flanges in the stage 2 shaft in December 2013.

Conclusions

The successful completion of this outfall project bears testament to the collaborative working ethos of the project team and suppliers. The outfall combined with other investment undertaken by United Utilities, will continue to provide environmental and water quality benefits to the River Mersey.

The final connection to the existing treatment works outlet was undertaken in December 2013, 15 months ahead of the Regulatory Date whilst achieving cost efficiencies totalling over 10%.

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Diffuser section ready for lifting and installation - Courtesy of Van Oord