Barkers Haugh STW

new inlet works
concept, planning, design and procurement strategy

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Barkers Haugh STW serves the City of Durham and is located adjacent to the River Wear immediately downstream of the city centre. The population equivalent is about 34,000 and the design allows for an increase to 46,000 over the next 20 years. Combined flows arriving at the works include a twin inverted siphon under the river. Dry weather flows are 100l/s with Formula A storm flows of up to 600l/s. First flush effects during high flows result in high grit and screenings loads arriving at the works. The original works dated back to 1962 and included screens, screenings handling equipment and a set of low-lift dry well-mounted centrifugal pumps within an 8m deep constricted underground basement. This case study describes the planning, design and procurement strategy adopted for a replacement inlet works at Barkers Haugh STW.

View of elevated works - Courtesy of Mott MacDonald

Original treatment process

After screening, 3 (No.) centrifugal pumps originally lifted flows to above ground constant velocity grit channels from where flow gravitated to the remaining treatment process. Storm flows were pumped by three further centrifugal pumps to storm tanks.

Reason for the scheme

Some of the mechanical plant was over 23 years old and the installation was found to be undersized for future flows, overwhelmed by rag and grit loads and prone to frequent breakdown and damage. The plant had become very labour intensive to operate and maintain, requiring frequent ongoing manual intervention and repair of equipment. Access to the below ground plant was difficult and conditions unhygienic. Severe knock-on effects were being experienced in downstream processes. Rags accumulated in the grit channels and storm tanks could not be automatically cleaned out. Rags in the primary sludge caused pump blockages and rendered the existing sludge thickening plant inoperable, resulting in increased sludge tanker traffic for sludge disposal and a requirement for further treatment at the sludge reception site. In all, additional operating costs and operational carbon footprint was being incurred.

Client's brief and solution

NWL engaged Mott MacDonald to carry out a feasibility study having discounted in-situ replacements due to problems associated with fitting modern equipment within original structures. The optimum solution (taking account of whole-life and embodied

carbon footprint) was found to be a new Archimedes screw pumping station to lift flows from the incoming 6.5m deep sewer to a height of 3.5m above ground level from where the hydraulic profile would allow gravitational flow to re-join the subsequent treatment process. Relocation of mechanical plant to ground level or above would also significantly improve access for inspection, maintenance and operation.

The new elevated works includes: escalator screens; screenings handling plant; flow control, measurement and storm flow separation; and grit removal.

Site footprint and reuse

The footprint for the new works was constrained by availability of land at the site. Two redundant sludge digestion tanks had stood unused for over 20 years, and demolition of the tanks would remove redundant assets from the site, create space, albeit tight, for the new inlet works, and bring otherwise sterilised brownfield land back into beneficial use. Despite the constricted site area, a layout was devised to provide as much vehicle access as possible for future operation and maintenance, with a wide central hard-standing area.

A redundant heater house room was also stripped of redundant equipment, refurbished and brought back into use to house a control panel for the new inlet works.

Concept and design

Variable made ground and soft alluvial flood plain deposits presented an unacceptable risk of differential settlement which would compromise the water-tightness and performance of the new works. It was therefore decided to use piled foundations. To avoid the need for widespread excavation and to keep construction of concrete structures to a minimum, it was decided to extend the foundation piles above ground level, at relatively little extra cost, to support the bare minimum of super-structure at a level to suit the new hydraulic profile.

The lean design resulted in 'doing less': no excavation for foundations and blinding for structures; significantly less steel-fixing, in situ formwork and concrete works; and no backfilling. The following added-value was achieved:

- Reduced design and construction effort, programme and costs (savings in avoided construction alone were estimated at some £200,000 excluding the contractor's time-related costs).
- Reduced construction associated site works-related health and safety risks.
- Reduced use of raw materials (timber formwork, steel rebar, concrete), hence reducing embodied carbon footprint (estimated saving of 90 tonnes of CO_{2e}).
- Removal of risk to the project from unforeseen ground conditions: the majority of the new construction would be at or above ground level, so within the control of the main contractor.

The new inlet works was designed to be constructed off-line of the existing works and a commissioning plan was developed to minimise operational impact during construction and tie-ins, with minimum down-time of power supplies and interruption to flows.

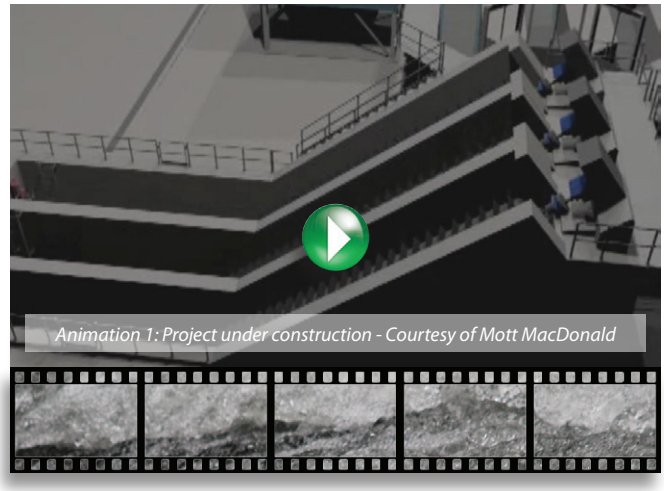
Procurement strategy and risk reduction

Having quantified the benefits to be gained from the project, one of the employer's objectives was to implement a solution as early as practicable. With this in mind procurement for site works was split into three, whilst detailed design was still ongoing. Firstly an enabling works contract to prepare the site (investigation of uncharted services; diversion of a gas supply, BT and power supply cables; removal of asbestos; demolition of the redundant digester

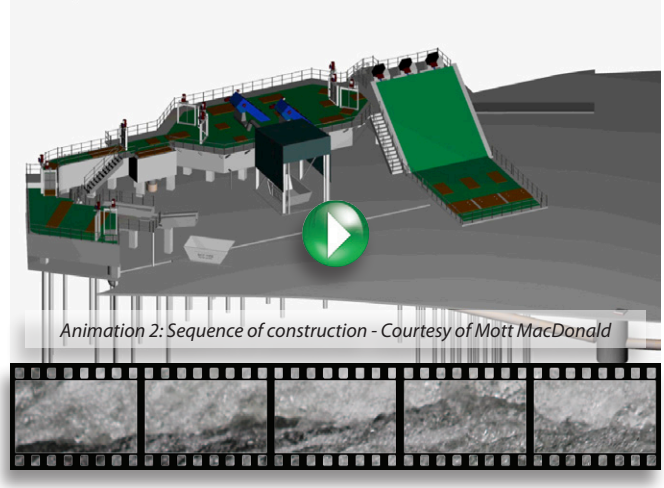
Cables direct to destination - Courtesy of Mott MacDonald

View of elevated channels - Courtesy of Mott MacDonald

Elevated works - Courtesy of Mott MacDonald



Animation 1: Project under construction - Courtesy of Mott MacDonald



Animation 2: Sequence of construction - Courtesy of Mott MacDonald

tanks; strip out of redundant heater room; installation of a working platform for the follow-on piling contract). Secondly an advance piling contract (installation of foundations for the new structures). Finally the main contract (construction of new inlet works).

This phased approach facilitated an early start to delivery of the project, with early gains such as improvements to an existing UWWTD raw water sample chamber, and the reduction of risks to the eventual main contract. Long-lead and project risk items such as third party issues, service and utility diversions, plant and equipment selection, and ground conditions were addressed, and below-ground work for the main contract was reduced to a minimum. The approach helped reduce the risk to programme and increase cost certainty to the project.

The main construction contract was let under an NEC3 ECC Option A Lump Sum contract, with tenderers requested to propose their own sectional completion date for turning of flows and beneficial use of the works.

Planning application

Meetings with the local planning authority were held as early as possible in the design process, to help establish the planning criteria and constraints which would be applied to the project.

Design with buildability in mind

The need to keep the existing treatment process running with minimal disruption whilst building the new works was addressed by adopting an off-line solution and including a commissioning sequence in the tender documents which minimised impact on the works flows and power supplies during construction.

Design for safety, ease of operation and maintenance

Screw pumps were selected because they would efficiently raise the solids content of the flow from the inlet sewer to the new inlet works. The new inlet would improve operational working conditions, health, safety and welfare of the client's operators by locating plant and equipment at or above ground level, in an easily accessible configuration.

The layout for the new works placed the inlet structures around three sides of the available site area, maximising the central space available for a new concrete hard-standing and access to the mechanical plant on what otherwise had been a tight site area.

The reduced construction work resulting from the design would favour improved health and safety during the construction phase, through less exposure to the construction activities: for example, reduced hand injuries typically associated with rebar steel-fixing.

BIM

A 3D Revit model of the new inlet works was created and a video clip animation was made to show the client and contractor's operatives a view of the project being built *(see Animation 1 Above left)*. The clip was used as part of the contractor's induction process to site. NWL agreed to a pilot study trial of 4D BIM being carried out.

Navisworks software was used to review of the contractor's construction programme, the sequence of construction and planned progress at any given point in time *(see Animation 2 - Left)*.

It was concluded that benefits which could be obtained from using 4D BIM included review of: completeness and logic of the programme; buildability; installation sequences, potential for clashes and congestion in working areas or between trades; health and safety by the CDM Coordinator; and for visualisation and 'look ahead' planning for impending construction activities. It could also be used for illustrating method statements and temporary works proposals, showing subcontractors how their part of the works will be incorporated, and for monthly progress reporting and updates.

Sustainability in design: reduction, reuse and added value

Completion of construction was achieved in March 2014 *(refer to separate article published in UK Water Projects 2014 print edition)*.

The project has brought about improved performance and improvements in health, safety, welfare and working conditions of the client's operating staff.

The design has brought back into beneficial use previously sterilised brownfield land and a redundant room, and has removed redundant assets and potential liabilities. Reusable and re-serviceable redundant plant and equipment has been salvaged and moved to the client's stores for possible use on other sites or for spares.

The project has resulted in improved sludge quality and will enable the sludge thickening plant to be brought back into use, reducing the quantity of sludge being exported from the site so significantly reducing sludge tanker visits, associated road traffic and disturbance on local communities, overall operational carbon footprint and sludge treatment costs.

The new screw pump channels and inlet works are fitted with GRP odour covers, and extracted air is ducted to an existing odour treatment system, which was refurbished and separately refurbished and upgraded in parallel with the new inlet works as a specialist contract.

Excavated soils were tested and re-used in landscaping on site, and crushed concrete from the demolished sludge digestion tanks was used to form the working platform for the piling rig in the advance piling contract. The working platform was subsequently retained for use under the main contract as a firm means of access for construction plant. Finally, the material was incorporated into the sub-base for the permanent concrete hard-standings, providing access to the new inlet works for the client's operational vehicles.

The design achieved the following added-value sustainable and environmental benefits:

- A new, modern inlet works with significantly improved access and working conditions for the operators.
- Reinstatement of intended performance of the downstream processes.
- Reduced operational costs and carbon footprint
- The inlet works will cater for future residential growth in the catchment, promoting local jobs and the local economy.
- A compact footprint which fitted and re-used the tight available site area, whilst optimising access to the channels, plant and equipment for operation and maintenance.
- Minimal generation and off-site disposal of construction waste by reusing existing materials on site and by reducing temporary construction material requirements (eg formwork).
- The lean design minimised the need to import and use new raw materials (eg concrete, reinforcement, timber formwork, fill materials) by 'constructing less'.
- Consequential reduction in embodied carbon footprint for the project (reduced material quantities and road haulage requirements).
- Consequential reduced construction traffic and impact on the local community.
- Reduced risk of health and safety incidents during construction, through reduced on-site construction.
- Reuse of existing assets: the redundant heater room (as an MCC room), and a redundant gas pipe culvert (incorporated into the new layout for routing power and control cables directly to the new works, minimising the need to excavate and install new buried cable ducts).
- Using the underside of the elevated inlet works to carry power cables to exactly where they were required, resulting in a very neat and efficient routing of cables, and again eliminating the need to excavate for new cable ducts below ground.
- Adopting a driven pile design which used hollow steel tubes recycled from the oil industry and which produced no waste arisings for disposal.
- The use of screw pumps to raise the incoming flows, which are efficient over a wide range of flows.

The Editor & Publishers thank Matt Agar, Project Manager with Northumbrian Water, and Heraldo Biasi, Technical Manager with Mott MacDonald, for providing the above article for publication.

The procurement and construction of the Barkers Haugh STW inlet works is described in another case study in UK Water Projects 2014 and on www.WaterProjectsOnline.