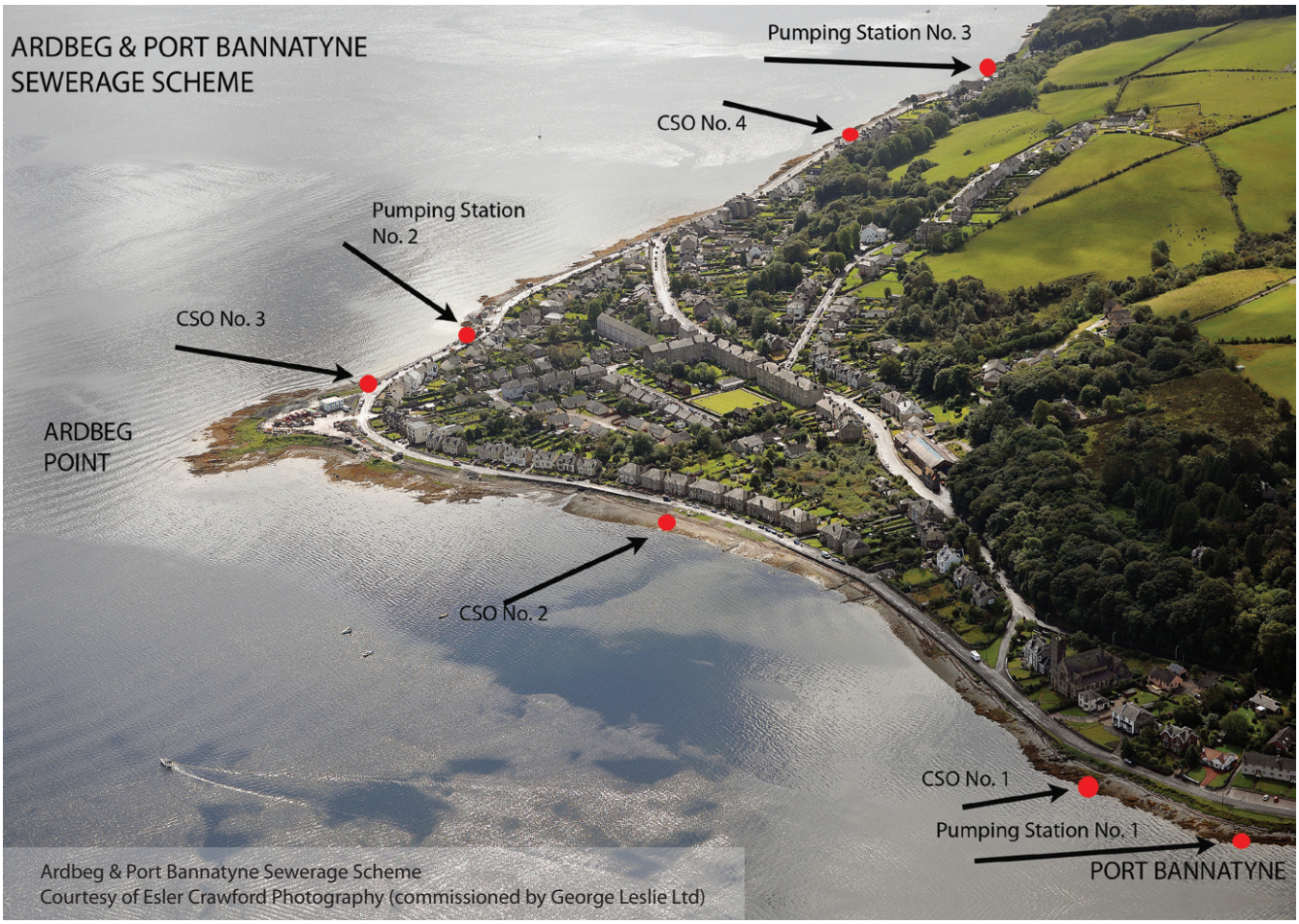
Ardbeg & Port Bannatyne Sewerage Scheme

a £6m Scottish Water project to remove untreated sewage sea outfalls on the Isle of Bute

by David Ross

Situated on the Firth of Clyde some 50km from Glasgow, Bute is the most accessible of the islands off the west coast of Scotland. Renowned for its beaches and scenic coastal landscape, it remains a popular holiday and day-trip tourist destination. Compliance with the 1991 Urban Wastewater Treatment Directive required intercepting and capturing the flows from thirteen untreated and unscreened pipeline sea outfalls and transferring the collected flows around the coastal road to connect into the upgraded sewerage system in the island's principal town of Rothesay. In October 2010 tenders were issued for a Design & Build contract to upgrade and improve the sewerage system in the Ardbeg and Port Bannatyne areas on the Isle of Bute. Following a competitive tender, Scottish Water awarded George Leslie Ltd the NEC Option C contract to develop a detailed design from the outline scheme and thereafter to construct and commission the project.



Ardbeg & Port Bannatyne Sewerage Scheme
Courtesy of Esler Crawford Photography (commissioned by George Leslie Ltd)

Design development

The contractor appointed Atkins as principal designer and upon contract award, the project team reviewed the outline design, the main elements of which at that time comprised:

- 5 (No.) sewage pumping stations.
- 5 (No.) combined sewer overflows (CSOs) with associated long sea outfalls.
- 2.4km of gravity sewers.
- 340m of on line storage.
- 3.4km of rising mains.

The key objectives of the review were to develop the design-phase programme of further investigation, modelling and detailed design to rationalise the scheme to deliver efficiencies in both capital and operating costs, at the same time as meeting the aspirations of stakeholders in the local community to minimise the inconvenience during construction as well as the visual impact of the completed works. Throughout the design development, the design & construction team worked to deliver the optimum solution which achieved regulatory compliance, efficiencies and buildability.

Innovation in the design was introduced in a number of areas including:

- Large-diameter structured HDPE pipelines were developed for sewers and on line storage and with their lower friction coefficients than the original concrete pipes, this enabled

shallower gradients resulting in reduced depths of rock excavation.
- Complex precast concrete solutions were developed to support the pumping stations located on the foreshore.
- Prefabricated HDPE CSO chambers were also incorporated complete with pre-fitted screens at the high level overflows.

All of these combined to shorten the construction programme, reduce vehicle movements with lesser volumes of excavation and imported fill, minimise operational Health & Safety risks with lighter-weight handling and shallower excavations, and reduce the overall carbon footprint of the project.

These factors contributed to maintaining a good relationship with local stakeholders, with the visible efforts being made to minimise the unavoidably intrusive nature of the construction activities within the community.

Final design

The final design resulted in the main construction elements comprising:

- 3 (No.) segmental-ring pumping stations, two of which were constructed on reclaimed land on the foreshore below the seawall, complete with extended marine sea defences.
- 4 (No.) CSO chambers, with outfalls extending below mean low water spring (MLWS) level.
- Enlarged-diameter manholes to provide further on line, storm attenuation.
- 1.9km of HDPE gravity sewer up to 1,500mm diameter for attenuation, and incorporating dry-weather flow channels.
- 2.0km of HPPE pumped rising main.

Pumping stations & CSO chambers construction

Pumping Station 1 (PS1) is located in an existing car park area close to the sea front and collects the existing gravity sewers from the outlying areas.

Excavation within rock was undertaken within a sheet-piled cofferdam with hydraulic braced shoring for this 8m deep wet well. Precast concrete ring segments were then built up and an in-situ concrete surround cast around the structure to counter flotation, with groundwater controlled throughout by continuous sump pumping.

Both cost savings and environmental enhancement were achieved by on-site processing of the excavated rock for reuse as a natural backfill to the structure. This also reduced the number of vehicle movements in and around the area.

The valve chamber was constructed at a higher level within the excavation as the backfilling progressed, with coring undertaken in the two structures to fit the inter-connecting pipework. On completion, the area was landscaped using grasscrete hardstanding to blend in with the natural environment.

Pumping stations 2 & 3

The locations for PS2 and PS3 were again chosen as the most practical to intercept the existing sewers and both are located on the outside of the sea wall. Construction was undertaken on reclaimed land on the fore-shore, achieved through the construction of 'L-shaped', precast retaining walls, placed against the sea wall.

Due to the tidal effects on these two areas, caisson construction methodology was adopted. A concrete collar was cast at shore level to jack the caisson rings down, with excavation within the collar to allow the first ring to be positioned.

Pumping Station No. 2 - Courtesy of Esler Crawford Photography (commissioned by George Leslie Ltd)

Pumping Station No. 3 - Courtesy of Esler Crawford Photography (commissioned by George Leslie Ltd)

Pumping Station No. 2 - in the rocky foreshore Courtesy of George Leslie Ltd

Pumping Station No. 3 Courtesy of George Leslie Ltd

The subsequent excavation in rock was undertaken by mechanical excavator with hydraulic breaker to achieve the formation depth of approximately 7m for each of the 4m and 5.5m diameter segmental-ring, wet-well shafts.

Groundwater was again controlled by 24-hour sump pumping with construction work restricted to periods of low and neap tides. A concrete plug was poured at the bottom of the shafts with the annulus between the segments and the excavated rock face grouted to create a water-tight seal for the structures.

Thereafter, the precast concrete retaining wall units were positioned in a trench cut into the bed rock, using a 120t mobile crane sited on the promenade, with the units securely anchored into the bed rock and the joints sealed.

The valve chamber structure and inter-connecting pipework were then constructed in the same fashion as for PS1, and protection to the structure from the tidal/wave action was then achieved around the structure by placing rock armour, which was processed for reuse from the arisings from the caisson excavation.

The pumping stations operate using a set of duty/stand-by submersible pumps ranging from 2.4kW fixed speed to 5.9kW variable, discharging through actuated valves within the valve chambers. Control is through a local MCC unit from level sensors within the wet well. Operation, levels and flow data are monitored by telemetry back to the local control centre. Bespoke GRP kiosks were manufactured with both design and colour adopted to complement the existing, distinctive street furniture on the island.

The innovative development by the project team of prefabricated, HDPE CSO chambers to facilitate the screening of discharging storm flows from the network, reduced construction time and minimised both construction and associated health and safety risk. Within 4m deep, shored excavations, the prefabricated units were lifted into position, the inlet and outlet pipework connected and the excavations backfilled with concrete to prevent flotation.

HPPE pipe ranging from 160mm to 450mm in diameter laid in trenches provided the overflow sea outfalls. Discharging below MLWS, each was fitted with concrete collars to prevent flotation, with Tide-Flex valves at the discharge to prevent sea water ingress at high tide.

Collection & transfer pipeline construction

In total, 1.9km of new sewer pipes made up the gravity collection system to collect the flows from the 13 (No.) raw sewage outfalls that had to be removed. Laid predominantly through the narrow streets within the two villages, construction was programmed and phased to maintain existing flows and to ensure that the new flows were routed into the new pumping stations as they were brought on line.

To accommodate the storage volumes determined through the hydraulic modelling of the network, pipe sizes range from 225mm to 1,500mm diameter laid at depths varying from 1.2m to 6m. Care and consideration were required to maintain progress whilst at the same time minimising the impact on the local communities from the inevitable road restrictions that were required.

Standard uPVC pipes were used for diameters up to 450mm, however for the larger diameter pipes, a polyethelene pipe was used, jointed with proprietary couplings or extrusion- welded from the inside. To accommodate low flows and maintain the minimum flow velocity, dry weather flow channels were incorporated within the larger diameter pipes.

Recycling opportunities were maximised, with rock arisings from the excavations processed for reuse as backfill.

2km of pumped rising mains transfer the flows from the pumping stations and connect to the existing sewerage network in Rothesay, for subsequent transfer to the nearby treatment works. These HPPE pipes range in size from 160mm-250mm and are laid at nominal depths of 900mm.

Flow meters, sited inside small chambers on the pumped rising mains, were installed close to each of the pumping stations to monitor flows.

Summary

The contributory factors in delivering a successful project to meet regulatory compliance included:

- Innovative design which increased buildability, reduced on-site duration, and minimised both construction risk and visual intrusion.
- Careful planning & programming and the use of construction techniques which reduced construction duration and minimised unavoidable disruption to local businesses and residents.
- Engagement of the local stakeholder business and resident community in appreciating their concerns, accommodating their aspirations and exceeding their expectations.

The cooperative and proactive approach adopted by all members of the project team – client, contractor and designer – also played a large part in ensuring a successful outcome.

The Editor & Publishers would like to thank David Ross, a Director of George Leslie Ltd, for providing the above article for publication The author would like to acknowledge the contribution from Nasir Uddin, Senior Engineer at Atkins, in the preparation of this article.

Precast walls at pumping stations on foreshore
Courtesy of George Leslie Ltd

Coastal road working
Courtesy of George Leslie Ltd