Moray Coast Wastewater Project

£60m capital investment in the far north of Scotland

by J P Jackson BSc, CEng, MICE

The Moray Firth is one of Scotland's most northerly firths. It is an area of outstanding natural beauty with rare and protected wildlife and one of only two places in Britain where there is a resident population of bottle-nosed dolphins. The Moray Coast Wastewater Project covers sixty miles of coastline from Burghead promontory in the west to Macduff in the east. The fishing industry was traditionally the mainstay of the area, but is now centred further east in the larger ports of Peterhead and Aberdeen. Tourism, food and whisky production now dominate the area which contains the seaside towns of Lossiemouth, the cathedral city of Elgin and the important Spey and Deveron Rivers.

Berrymuir: Macduff WwTW situated in disused quarry *(courtesy Bechtel-Morrison JV)*

Project background

The sewerage infrastructure of coastal communities, which discharge into large water masses, has historically been developed without the provision of treatment facilities or with only minimal treatment such as screening. These communities have relied on the natural processes of the adjacent receiving waters for the disposal of their wastewater. As coastal communities have grown and quantities of effluent increased, this practice has led to unacceptable levels of pollution of coastal habitats and beaches.

This section of the Moray coast is typical of this philosophy. Apart from screening at Elgin and Banff there is no treatment in the area. Raw sewage is currently discharged down a long sea outfall at Lossiemouth and a series of short sea outfalls elsewhere.

The purpose of this project is, therefore, to improve marine and coastal water quality and to have a positive impact on the environment.

Legislation driving this improvement is:

* The EC Urban Waste Water Treatment Directive (271/91/EEC) (UWWTD), which lays down requirements for the treatment and disposal of waste water and waste water sludge which are to be implemented in Scotland through the Urban Waste Water Treatment (Scotland) Regulations, and

* The EC Bathing Waters Directive (BWD), which lays down requirements for water quality within designated bathing, recreational and shoreline waters.

The Moray Coast Wastewater Project was the fourth Design Build Finance and Operate Concession to be awarded by the now defunct North of Scotland Water Authority. Following Highlands (Fort William and Inverness) and Tay, it was the third Concession to be awarded to the *Catchment Consortium of International Water Holdings, United Utilities Ltd and Morrison Construction.*

Tender documents were issued in June 1999 and the tender process, which included a 'Best and Final Offer' stage for the lowest two tenderers was concluded in May 2000 when *Catchment* were nominated 'Preferred Bidder'. Financial negotiations took 13 months and *Catchment* became the *Concessionaire* in June 2001.

Scope
The project contains the following elements:
* 46km of rising mains;
* 8km of gravity sewers;
* 22 pumping stations;
* 3 wastewater treatment works at Lossiemouth, Buckie and Macduff;
* 2 long sea outfalls plus remedial works to the existing long sea outfall at Lossiemouth;
* extension or replacement of 14 short sea outfalls.

The Project comprises three schemes (Lossiemouth, Buckie and Banff/Macduff) which are predominantly self contained except for sludge disposal which is centred at Lossiemouth. In all three schemes, existing wastewater discharges are intercepted and pumped by a series of conveyance sewers, rising mains and pump/storage stations to the three new wastewater treatment works.

Contractual arrangements
Catchment, as the successful *Concessionaire and Development Company,* set up three separate contracts to fulfil its obligations under the Concession.

Engineering, Procurement & Construction :-
Bechtel-Morrison Joint Venture.
Operations & Maintenance:-
Caledonian Water (Moray) Ltd; (a subsidiary of United Utilities).
Sludge Disposal:- *Snowie Ltd.*

Evaluation of the Concession tenders was not only tariff based (cost per m^3 of wastewater treated) but also included deliverability and demonstration of risk transfer.

The EPC subcontract is a fixed price contract between *Catchment* and the *Bechtel-Morrison JV* with neutral cash flow payments based on previously agreed progress milestones. While a small amount of equity is put up by the Concessionaire, the majority of funds to build the scheme comes from the lender, *Abbey National Bank.*

The Concession is for 30 years. During contract negotiations an Advance Contract was in place to enable the design to be undertaken, all consents to be obtained, long lead equipment to be ordered and for the long sea outfalls to be installed during the 2001 weather window.

The wastewater treatment works and ten pumping stations are to be completed in the summer of 2002. Twelve outlying communities, although not required by the EU directive until the end of 2005 will be brought on line by March 2003.

Environment
The environmental constraints of working in such a location have been particularly challenging. The Environmental Statement (12 volumes, over 400,000 words) was prepared in accordance with the Environmental Impact Assessment (Scotland) Regulations 1999. In addition, the Contractor has produced a further 27 Environmental Plans, one for each of his work fronts.

The Planning process was rigorous. The main submission in the summer of 2000 was followed by major re-submissions in October 2000 and October 20001. In addition, the Contractor has been required to make a further 15 re-submissions on changes to the proposals during construction. During the Consultative period over 50 environmental, statutory or local organisations were contacted for opinion.

The selection of sites for the Treatment Works has been particularly innovative. The **Lossiemouth** Treatment Works is in the middle of a commercial wood at Oakenhead and the **Macduff** Treatment Works is located in a disused quarry on the cliffside waterfront at Berrymuir on the outskirts of Macduff.

Location of the 22 pumping stations has also required ingenuity, particularly in the tight ancient harbours at Findochty, Portknockie, Cullen, Banff and Macduff.

Planning conditions have imposed noise and odour requirements which are amongst the most stringent experienced in the water industry.

* odour standards requires a 98% compliance of IOU (odour unit/m^3) on an hourly average at any location beyond the treatment works site boundaries.
* operational noise levels for all treatment works and pumping stations require that background noise levels are not exceeded by more than 5dB(A) at any noise sensitive premises. In addition, operational noise levels from pumping stations must not give rise to noise levels in excess of Noise Rating Curve 25 between 11 pm and 7 am.
* construction noise levels are required to be less than 55dBLAeq 1 hour (free field) as measured at any noise sensitive location.

Design - network & marine modelling
A major challenge for the project team was determining strategy, location and volumes for storm water storage

EC Bathing Waters Directive sets both Guideline and Mandatory maximum faecal coliform levels in the receiving Bathing Waters. SEPA (Scottish Environmental Protection Agency) evaluated that designated and candidate Bathing Waters and Recreational Waters should meet the more stringent Guideline standards. Shoreline and other waters were to meet Mandatory Standards during the Bathing Season.

The engineering team sought to determine the minimum storage volumes the network systems required before bathing water quality was compromised. Marine modelling was employed to quantify the impact of storm and wastewater discharges on water quality at sensitive receiving waters. Verified *HydroWorks* models were used to provide detailed storm water spill discharge hydrographs for a sample of discrete short duration storm events. These results were used as a basis to calibrate simplified spreadsheet based *SIMPOL* models for each of the three schemes. The use of *SIMPOL* models enabled the team to quickly run long duration storm events continuously.

Requirements of the EC bathing waters directive can be satisfied without the need for marine modelling by providing storage volumes sufficient to limit storm water spills to the standard three spills per bathing season criteria. *SIMPOL* models were initially used to ascertain these volumes. Assessments by the engineering team of the practical implications of providing these volumes

Capital Investments: Macduff WwTW *(courtesy Bechtel-Morrison JV)*

determined that most pumping stations would require large volumes of rock excavation and would encounter difficulties with site constraints, particularly in harbour locations.

It was, therefore, decided to attempt to reduce storage volumes by linking the results from the *SIMPOL* model to a Marine Model. The *SIMPOL* models were used to select numerous storm events from 20 years of rainfall data for input into a modified *MIKE21* Marine Model. *MIKE 21* (2 dimensional marine model) and *STORMIMPACT* (a design package developed by *METOC* plc to provide rapid assessment of large coastal network catchments) were employed.

With an upper storage volume limit (ie 3 spill) defined and also a legal minimum mandated by SEPA the *SIMPOL* models in conjunction with the Marine Model were used to iterate the storage volumes until compliance was achieved.

Ultimately this process reduced storage volumes significantly, maintaining compliance whilst enabling constructable storage structures to be proposed.

Design - wastewater treatment works

The three wastewater treatment works are situated in **Oakenhead Wood at Lossiemouth**; beside **March Road Industrial Estate in Buckie;** and in disused **Berrymuir Quarry** on the outskirts of **Macduff.**

In essence these three treatment works are the same design only differing in size. Lossiemouth Works is the largest with a flow to full treatment (FFT) of 419 l/s; Buckie's flow is 152 l/s and Macduff is the smallest with 109 l/s.

Each works has an inlet works structure for receiving flow, which incorporates 6mm screens and a 'bendy channel'. This new design simulates a bend in a river and causes grit to be thrown out where it is captured and removed.

Biological treatment is an Intermittent Cycle Extended Aeration System (ICEAS) Sequential Batch Reactor (SBR). The SBR is divided into two zones, the pre-react zone and main react zone. Flow enters the pre-react zone below bottom water level. At the opposite end of the SBR, in the main react zone, clear water is removed via decant arms running the width of the SBR.

Four SBR basins are provided, which operate in a phased sequence through aeration-settle-decant. This design of aeration and settlement removes the need for large areas of ground to be set aside for traditional settlement tanks and, therefore, cuts down the footprint size of the treatment works. In addition, there is provision for UV treatment at Macduff works.

See Tables on next page.

Sludge treatment

On all three sites, the sludge is thickened and dewatered to 15 - 25% dry solids. From Buckie and Macduff the thickened and dewatered sludge is transported to Lossiemouth site for further drying. There is also capacity for sludges to be dried from works outside the Concession.

The dryer produces granules/pellets with a bulk density between 0.6 and 0.7t/m^3. When operating at capacity the dryer has a minimum evaporative capacity of 2.7 t_e/hr for raw sludge.

Outfalls

The predominantly rocky coastline comprises metamorphic Dalradian rocks east of Buckie, typically metasandstones, metasilt stones, schists and quartz. West of Buckie, Devonian (old red sanndstone rocks) are present. On this rocky coastline in the hostile North Sea environment, the design and installation of the long sea outfalls at Gabert Point, Buckie and Berrymuir, Macduff were challenging.

The Gabert Point outfall is 383m long and 450mm in diameter. Despite the rocky terrain a curved channel was identified to allow the installation by an offshore pull, The outfall consists of a steel pipe, prefabricated in four individual strings of 96m (two strings) and 84m (two strings) and a diffuser of 23m. The steel pipe has a concrete coating with a thickness of 50mm.

The outfall was pulled from an *Abeko Server* self-sailing pontoon. The first pipe string was welded to the diffuser and pulled before three further welds and pulls completed the initial installation. The joints used were Reynolds joints.

The Macduff outfall at Berrymuir was, however, even more challenging. The outfall is 234m long and 350mm in diameter. The topography varies dramatically from the point of the proposed launch site to the foreshore where it drops a further 8m on a 45 degree angle. Any microtunnelling option would have required a very deep shaft. There was also the problem of getting adequate cover beneath the low water mark during the first 100mm, as the profile of the seabed undulates and comprises large outcrops of rock and deep gullies. Despite the potential geological pitfalls and past history of using directional drilling in this area, this was the chosen method.

The marine boreholes revealed a great variation of hardness in the quartzite rock, with compressive strengths ranging from 120Mpa to 393Mpa. After careful consideration a 350T rig with a 450mm diameter tri-cone tungsten carbide bit were used for the successful drill.

Conclusion

At the time of going to press flows have been turned into the Lossiemouth and Macduff works and both works have commenced the commissioning phase. Mechanical completion has been achieved at the Buckie works, The contract was on schedule for completion by mid-December 2002.■

Note: *The author of this article, J P Jackson, is Project Manager for the Bechtel-Morrison Joint Venture.*

Castehill Park Pumping Station, Banff *(courtesy Bechtel-Morrison JV)*