



# natm

## The UK's Leading Specialist Civil Engineering Journal

incorporating Tunnelling, Directional Drilling  
Sewer Renovation and Geotechnics





Photograph Above. Setting up for the tunnel drive. The launch of the TBM is unbelievably fast. From lowering in the shield to burying the first pipe a time of under 40 minutes was recorded by NATM.

# “The EAGLE has LANDED”

## Tunnelling US Style smashes World Record in South Wales

**Scheme Title:** Western Valley Pipeline (Part of the Cardiff Sewerage Scheme)

**Client:** Dwr Cymru Welsh Water

**Engineer:** Hyder

**Main Contractor:** David Lewis Civil Engineering

**Spec. Contractor:** B & W Tunnelling

**Form of Contract:** NEC Option A

**Contract Value:** £3.5 million

**Contract Duration:** 40 weeks

### Introduction

In life it is nice to be good at what you do. It is even better to be very good at what you do. But how would you feel if you were the best at what you do? I mean the very best? Not just better than most, for instance the best in the world?

How could you ever describe it? I don't think you could.

Tunnelling, pipejacking, and microtunnelling has various records, but how can these be judged. Different diameters, different machines, different ground conditions, and of course different and often longer shift patterns.

It is very hard for someone to hold their hand up and say, “hey we are the best.”

All the TBM manufacturers keep tabs on their customer's progress, not least of all the North American's. When they do it, they not only do it in style they also like the world to know of their products achievements.



Nick John, Project Manager, DLCE



Steve Williams, Director, B&W

David Lewis Civil Engineering and B&W Tunnelling recently joined forces and purchased a 1780mm Akkerman Tunnel Boring Machine from the U.S.A. to undertake 2.2km of pipejack work at St. Brides, just south of Cardiff. This is the only machine of this type and size in the U.K.

Now the Akkerman TBM in short is one hell of a machine provided it is put in the



Photograph Above. The first launch of the brand new Akkerman 1500 TBM

appropriate ground conditions. But most TBM manufacturers can or could say that. The appropriate ground conditions for the Akkerman TBM are clays. And can this machine move through it. Add the right back up system and contractor to drive it, the system is without doubt, beyond compare.

In 1994 in St. Louis a record of 147ft was set for a single 12 hour shift with the selfsame system.

**The scheme**

First things first though. The scheme at St. Brides is required to divert existing trunk sewers from the Welsh Valleys into a new wastewater treatment plant currently under construction. The new plant associated sewers and outfall total £180 million of infrastructure investment. The project team undertaking these diversionary works are a partnership drawn from Hyder's water business Dwr Cymru Welsh Water, Hyder Consulting, David Lewis Civil Engineering and the cost consultants Chandler KBS.

The partnership was formed in January to develop the design and assess the construction challenges presented by one of the final contracts to be let for Cardiff WWTW. It will

serve a population of 880,000 and will intercept and replace 4 No. existing crude wastewater discharges into the Severn Estuary from Central and Eastern Cardiff as well as the Rhymney and Western Valleys of Gwent.

**Partnering**

David Lewis Civil Engineering (DLCE) currently has £20 million of capital work schemes in

industry although successful implement is down to the individuals and their ability to work with new disciplines and as a member of a wider team. Whilst our company has an established reputation and excellent track record with Hyder using traditional competitive tendering, partnering has given us a better opportunity to influence design as well as optimise and innovate the best construction techniques."



Photograph Above. The jacking set up in the drive pit



Photograph Above. The Akkerman had already been tried and tested in Gloucester and Oxford

progress with Welsh Water principally being undertaken by a partnering approach. This was developed in part to overcome traditional cost and programme over runs associated with large complex civil engineering projects. Director of DLCE, David Boden Explained: "The principals of partnering are now well understood in the in

**The contract**

The works is split into 2 No. sections of work. TBM tunnelling in St. Brides and conventional backhoe tunnelling over in St. Mellons. These comprised 1.5km of 1.50m in dia. tunnelling using the Akkerman TBM, 716m of tunnelling using the 1.35m in dia. backhoe machine. There is also 3.5km of 1.0-1.2m in dia. open-cut and modifications to the storm water storage tanks on both systems.

**Ground Conditions**

Whilst these new sewers are at a relatively shallow depth anticipation that the works could





Photograph Above. 2 No. excavators serving the tunnelling operation. The TBM mined at such a speed that a specially adapted and much larger skip had to be manufactured by PL Manufacturing. A staggering 187 ft was driven in 1 No. 12 hour shift.

be carried out using conventional excavation techniques was not possible. The site investigation found extensive estuarine silty clays with bands of peat. The clays exhibited "dilateny" a characteristic that they soften or become semi fluid if subjected to disturbance or vibration.

#### Options

The contractors Project Manager Nick John undertook a review of construction options and in view of the ground conditions proposed, tunnelling would be necessary to avoid the need for heavy plant associated with traditional pipe construction as this plant would inevitably cause the clays to heave and damage the proposed pipeline.

B&W Tunnelling has co-operated with David Lewis on numerous previous contracts for client Dwr Cymru Welsh Water and has an established track record in providing cost effective solutions to a variety of engineering challenges. The company's staff looked at a number of TBM Manufacturers.

#### Slurry machines

Most contractors look to full-face slurry machines when tunnelling or microtunnelling is mentioned. This being the case the main thoughts regarding slurry machines is that they are ideal in water bearing sands and gravels, chalk and rock etc. Saying this, few slurry systems really have the capability of tunnelling through clay as well as they do through other ground conditions. Also separation of solids from the slurry is a major issue. It can add high costs to tunnelling projects and to separate clays from the slurry is not as straightforward as the separation of sands and gravels, and the technical "know-how" would have to be brought in to operate the system adding more costs to the project.

An open-faced system appeared the logical answer but at the given diameter and since Lovat ceased the manufacture of their smaller systems, only Akkerman had what they were looking for.

not do was to dwell on the past. They looked to the future and went out and procured 2 No. backhoe machines and several auger boring machines.

This year B&W moved one step further.

Both B&W and DLCE travelled to Minnesota, U.S.A. to discuss their requirements for this project and looked at a 900mm-dia. machine in operation tunnelling through sand. The order was finally agreed after a reciprocal visit by President of the TBM manufacturer, Maynard Akkerman to Wales to meet Hyder's Project Director Jeff Martin.

#### Having faith in something you've not seen?

It is not the easiest thing in the world to say how good a product is, especially to a company

who has never seen it in action. A valid point is that salesmen the world over will say "it's this good" and "it's that good" and "it'll do this" and "it'll save you that". And then once purchased it does the contrary and the service and back up is not there.

Mr. Martin explained: "Whilst we had faith in the expertise at Akkerman, their visit to assess our local conditions was necessary to give additional confidence before placing this order."

Mr. Williams explained: "as with a lot of tunnelling and microtunnelling contractors, we have been in close communication with Akkerman over the last couple of years, and



Photograph Above. Lowering down one of the half moon spacers and preparation of the first pipe to be jacked.

There are already 3 No. Akkerman TBM's in the UK, 2 No. of which are owned by Barhale. These have already made an excellent impression with clients such as Thames Water and Severn Trent Water.

Director for B&W Steve Williams' track record in pipejacking is to be quite frank, 'as good as it gets', and anyone who knows him will tell you, he knows the industry. He has been involved with jacking pipes since the methods conception and only last year when the HAVS debate was 'cruelly' brought to light it was envisaged that the old type of tunnelling specialists days were numbered. This did not deter B&W, and one thing they did

looking at the ground conditions we thought that this was the ideal opportunity to use the system."

From a NATM point of view, meeting Mr. Akkerman himself, you can see in his face what he says regarding the system, is fact. This was backed up with a 'belt and braces' scenario by the TBM's performances in London, Oxford and Gloucester. The Akkerman's UK track record although brief, is outstanding.

### St. Brides

#### The Akkerman TBM

The machine is undertaking a total of 1.5km of tunnelling. This will be split into 6 No. drives running parallel between shaft MH5 to MH2.

The Akkerman TBM wheel machines range from 1.18m to 3.25m dia. and can be equipped or dressed with three types of cutter heads. These encompass the dirt cutter for ground conditions comprising clays, sand and silt; the carbide cutter for soft to medium hard rock; and sand shelves for loose unstable soil.

The wheel machines have powerful hydraulic motors, which rotate an inner drum. The cutter head is connected to the drum. As the drum rotates, the teeth excavate the face and the mined spoil falls into the drum. Scoops within the drum dump the soil onto the conveyor. This can be a conventional belt system or a cased auger dependant on the consistency of the ground conditions. The conveyor transfers the spoil to the skip for removal. Hydraulically operated torque wings control the rolling of the machine.

There is a bit of a problem though. US specification is very much different to UK specification. This was brought to light when Barhale procured the machines and had to undertake modifications at their plant and fabrication depot before the machine got buried in the ground.

Both B&W and DLCE were well aware of this, and Mr. Williams' knowledge in the tunnelling industry brought together two great 'tunnel-engineering minds' in PL Manufacturing and Tunnel Engineering Services UK to modify the US kit for use on UK soil.

A 500kVA generator and hydraulic power pack to drive the TBM motors was also procured for the job.

#### Launching of the TBM

With a slurry system the TBM launch has a much more technical look to it. With it being

With the Akkerman, the operator is within the shield and is in total control of the system. It is not too dissimilar to that of a SM type roadheader, where 'he', the operator can keep a constant vigil on what occurs at the face from day 1 of the launch.

With video evidence to support it, the Akkerman is lowered into the shaft and within 45 minutes the first pipe was buried in the ground. It is astounding.

#### Tunnelling

To serve the TBM, jacking configuration



Photograph Above. A view of the mining operation from the right side of the auger.

both automated and operated from the surface everything from the laser to the slurry separation system has to be in place.

To 'go for broke' with this system can produce its own pitfalls. A badly set up separation system can cause the TBM major downtime. Laser guidance and automation from the surface also has to be 'spot-on'. Failure to do so prior to jacking can be a problem as trying to get the machine back on line and level can be a complex and time consuming exercise, and when constructing a gravity system the correct tolerances on a tunnel drive is imperative.

comprising 2 No. 300T 1.82m long x 200mm bore rams are being utilised on each of the 250m long drives.

"Sods Law" is part and parcel of tunnelling and the use of interjack stations is a 'necessary evil', i.e. if you didn't install them it would be odds-on that they would be needed. Mr. Williams explained that initially B&W opted for the use of 2 No. 8-ram interjack's on each of the drives, although with jacking forces averaging 100T these were never put into operation. Only 1 No. interjack is now being installed on each of the drives.

Rotation of the cutting head is a major feature. When first introduced to the UK it was a known



fact that the head would only rotate in a clockwise direction. With this being the case the machine could have a tendency to roll, especially in harder ground. As with the other machines in the UK, the motor driving the head of the TBM now has the capability of also rotating in an anti clockwise direction, and is therefore able to counteract roll.

The head spins at up to 30 cycles per minute.

The ground conditions are such that to stop the clays sticking to the both the screw of the auger and the cutter teeth the face is sprayed with water after each cycle of mining.

The 14" auger conveyor was introduced early on in the job as opposed to

using the conventional belt driven system. This was due to the clay being far too wet and sticky. This being the case, with the belt system being far shorter in length than the auger, it is still used during the TBM launch to help get the first pipe on each drive buried in the ground.

The machine is driving with cover to the crown of the tunnel being approximately 3.5m. With the tunnelling being undertaken beneath farmland settlement on the drives was negligible.

#### Advance

Both B&W and DLCE were quick to overcome the learning curve on the TBM and its associated back-up system. Within a few weeks the contractor were mining at such a speed that the only downtime incurred was not being able to get shut of the mined spoil quickly enough. A newly designed and larger skip was therefore fabricated by PL Manufacturing and subsequently introduced to the job. Within the matter of days a 6-year record which was held by miners in St. Louis of (44.8m) 147ft in a 12 hour shift was not only bypassed, but unreservedly smashed with B&W recording a staggering 55m. The Akkerman TBM can fill a conventional skip in less than 60 seconds.

A Sennebogen 35T hydraulic crawler crane has been purposely procured and utilised to serve the tunnelling operation with Mr. John adding, "it is a quick machine and is helping the tunnelling on the contract no-end."



Photograph Above. TBM breakthrough

At the time of NATMs second visit to site, B&W only have 2 No. drives on this section to complete.

B&W are tunnelling 5 days a week, but a point worth noting is that due to the nature of the ground conditions and tidal pressures, it can take an extra 1000psi of pressure on commencement, to jack the pipe on a Monday morning. Lubrication has been handled by using two-coats of clay cap (from Tunnelling Accessories) on each 2.5m pipe.

#### Shaftsinking (TBM Drive)

B&W went the way of sinking 7.5m x 4m by 5.5m deep sheet piled shafts with a meaty 1m thick backwall as opposed to segmental structures. These were constructed driving Larssen 20 piles, which were towed in 5m. The shafts were excavated using a 30T Komatsu 210 Excavator and the piles driven with a NCK crawler crane which easily drove them to formation level. Shor

ing of the drive pits was undertaken using steel beams and Water Problems.

The abundance of groundwater was never a major issue although tidal influences do affect the clays. A 3" electric pump on hire from Pump Supplies Ltd situated in the pit bottom has capability handled any water, with the biggest problem with water being the bad weather.

#### Logistics

Both parties were aware of the weather and seasonal climate changes. As it was the weather has been bad in the fact that there has been constant and torrential rain. It was agreed at the beginning of the contract that the tunnelling operation would commence (in summer) at the furthest point away from the main road with the tunnelling operation planned to move closer towards the road in the later months. This was a scenario, which was well planned.

#### Maintenance

"We did the first drive and had a Technician from the US on site. At the end of the first drive it was just a clean up and lubrication of the machine. There was no wear on the picks or shield whatsoever.

Universal Couplings procured from James Dunkerley Steels in Oldham.

#### St. Mellons The Backhoe

A total of 716m of tunnelling was to be undertaken at the other side of the works. This was to be executed in 5 No. drives by a 1.35m dia. backhoe machine.

The drives run parallel between 6 No. shafts incorporating a dog leg after the first drive.

In the past B&W were renowned for their vast experience on hand excavated pipejacks.



Photograph above. Mucking out to enable the TBM launch



Photograph Above. The view of the face through the shield.

The HAVS guidelines which were implemented by the HSE made the specialist rethink their strategy and last year they procured 5 No. Custom-built backhoe units from Tunnel Engineering Services UK of Manchester.

These machines proved to be a revelation.

Although they appear to be relatively straightforward or even simplistic, it is a totally mechanised backhoe system. The system has a hydraulic excavator mounted within the shield, which feeds directly onto a swan-neck conveyor system, which runs through the centre of the shield. It is driven by an electric power pack, which is sited, at the surface with hydraulic pipes feeding all operations within the shield.

The reason B&W decided to put all of this set up on the surface was to give them maximum working space within the shield.

The telescopic arm is mounted from within a roof-mounted bearing, which operates off of a slew-ram within the centre of the shield and provides a 40-inch (1.01m) stroke.

The bucket is attached at the end of the

telescopic arm giving a claw-like grab and possesses 5 no. teeth. These comprise 2 no. side cutters and 3 no. main cutters located within the centre of the bucket.

The whole system is driven by a 100kV generator, which drives the hydraulic power pack.



Photograph Above. In total control. Leading Miner Gareth Davies operates the back up system.

The power pack has a maximum working pressure of 3000psi.

#### Tunnelling

A total of 3 No. drives have been completed with average production being 3-4 No. pipes (2.5m long) per shift. The ground conditions on

this side of the contract are not comparative with the Akkerman drives, and in this area the clays possess both low waterbearing sands, gravels and rock giving the machine operator an inconsistent face to mine.

The tunnelling operation is being driven from a 6m x 4m by 4-5m deep sheet piled shafts. The jacking configuration in the pit bottom comprises 2 No. 300T 4ft stroke rams.

#### Open-Cut

The remainder of the contract comprises a further 3.5km of 1.05-1.2m dia. pipeline carrying both flows for treatment and screened storm water overflows. Generally the project team has opted for Johnston's GRP pipe to benefit from both its lightweight and pressure rating to 3 bar. This will easily resist the positive tidal pressures on the system.

Each pipe is 6m long and the tidal pressures exerted on the side of the drag box can be anything up to 70T.

"We are using a 7m long drag box with its 2m extension totalling 9m from Mabey Hire and to handle that we have 2 No. 45T Komatsu Excavators.

#### Summary

Mr. John summarised the job by saying: "We are all very impressed by the Akkerman's performance and the job is going exceptionally well at the moment and all we need now is another job for the machine."