

# Thirlmere Aqueduct Refurbishment

## 134km aqueduct supplying major city - refurb story continued

by  
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**C**onstruction of the 134 km long Thirlmere Aqueduct, which operates entirely by gravity, began in 1885 with the aqueduct being commissioned in 1894. It is made up of 82km single line tunnel or conduit approx. 2.1m square and 52km of 4 parallel pressure pipelines. In October 2007, the Aqueduct which supplies up to 250 million litres of raw water per day to over one million people in Manchester, was drained for its entire length for the first time in over 50 years, from Thirlmere in the Lake District to its termination at Lostock WTW, just north of Bolton, Lancs, for essential maintenance. This outage followed detailed inspections carried out in 2005 and 2006.



*Aqueduct shows change of construction from unsupported rock to concrete lined tunnel*

*courtesy Planned Maintenance Pennine (PMP) Ltd*

In October 2005 the first 34km of the aqueduct between Thirlmere and Kendal had been taken out of service for 4 weeks to carry out an inspection of 26km of tunnel and conduit. Following on from this, in October 2006 the aqueduct was drained down from Thirlmere to Adlington (6km north of Lostock WTW). This enabled an inspection of a further 50km of tunnel and conduit (see article on page 161 of last year's 'UK Water Projects'), and essential maintenance to be undertaken on the section of aqueduct inspected in 2005.

**This paper describes the work carried out in 2007 as part of the major project to refurbish the aqueduct.**

### **Outage strategy**

Any inspection of the aqueduct and subsequent refurbishment requires the aqueduct to be taken out of service and drained. It was determined that a rolling programme of inspection and refurbishment would deliver the best solution to accommodate the overall programme constraints. In year 1 (2005) the aqueduct was inspected

between Thirlmere and Kendal. In year 2 (2006) the aqueduct was inspected south of Kendal and repairs carried out to the northern section inspected in 2005. In year 3 (2007) priority repairs would be carried out to the southern section and the final 6 kilometres of aqueduct drained and inspected. Years 4 and 5 would see the completion of all repairs.

The AMP 4 programme of WTW outages and large diameter trunk main cleaning projects was built around this programme and the assumption that the aqueduct would be out of service every October for at least 5 years. Consequently, this programme cannot slip as it has the potential to affect other major contracts within the overall AMP4 programme.

### **Contract strategy**

The contract strategy for year two (2006) involved three contractors, one carrying out the inspection south of Kendal, one carrying repairs north of Kendal and also advanced works for an associated project



*Thirlmere Aqueduct: Permanent repair to aqueduct floor*

*photo courtesy of MWH*

south of Kendal. A third contractor was employed to carry out refurbishment work to a number of conduit bridges. This strategy inevitably caused issues with responsibilities and interfaces. Therefore, for the 2007 outage a single contract was let to *Daniel Contractors Ltd.*

## Repairs

The inspections had revealed that the condition of the 103 years old aqueduct was generally very good, however a considerable number of repairs were required to ensure the continuing longevity of the tunnels and conduits. The repairs were broken down by type and importance (criticality). Defects to the base and the base wall joint were of particular concern and these defects have the potential to result in ground loss, leading to undermining of the aqueduct. Hollow base defects were repaired using low pressure (gravity) grouting, whilst the base/wall joint defects were resin injected and repaired using a modified cementitious mortar.

The work in 2007 encompassed over 500 repairs to cracks and fillet joints, leak sealing, installing pressure relief pipes etc and the replacement of over 40 pressure relief valves in the tunnels and conduits. It also included a detailed investigation of a suspect 4.5km length of conduit laid in a peat bog, which also happens to be a SSSI. The results of this investigation have revealed that a 25metre long section of the conduit wall will need to be completely rebuilt in 2008.

The construction work carried out in October 2007 was spread over the full 134 kilometres of the aqueduct with over 100 separate work sites and access points. The main contractor employed a number of specialist sub-contractors, and a labour force of over 150. The construction spend in the four weeks being in excess of £2.7 million. All the work being completed ahead of programme with the aqueduct being handed back to Operations staff two days early.

## Health & Safety

Health and Safety is at the very heart of this project. The work is all carried out within a confined space environment. During the initial survey in 2005 there was no communication with the surveyors, so they were given a time allowance for the particular length being inspected. If this were exceeded then emergency procedures would be activated. Further investigations during 2006 had revealed that the m-com communications system would work exceptionally well even in damp conditions and this system was used for all long distance entries.

Wherever possible, access points - buried man ways - were opened up to provide man entry to the aqueduct at 800m centres. This meant

that 110 volt electrically operated power tools could be used without a significant power loss.

To ensure a safe working environment forced ventilation was employed throughout with standby generators and fans. The capacity of the fans was increased in three identified areas where a precontract gas monitoring survey had indicated there could be a risk of methane due for example to the proximity of a landfill site.

The ventilation also had the benefit of providing mitigation in respect of the presence of Radon. A radiological advisor (IRAS) was brought in to supervise and monitor the works by providing workplace monitors and carrying out an evaluation of the exposure levels of the workforce during and after the contract. Radon had been identified as a risk during the pre-contract survey. The workforce were all given a three hour briefing session before being allowed to work in the aqueduct.

## Emergency repairs

During the inspection of the final 6 km between Adlington and Lostock WTW - a section of aqueduct not previously drained - a base heave was discovered. Ground started to pour in through the heave threatening the stability of the aqueduct. Resources were immediately deployed to carry out emergency repairs. If the contractor had not reacted quickly the unreinforced concrete conduit could have failed leading to a progressive collapse with major consequences.

During the next seven days a permanent solution, requiring a resin injection cut off curtain and the construction of a 12m long reinforced concrete slab, incorporating pressure relief pipework was installed. As a result of this discovery an extended geotechnical study and risk assessment of a 4km length of aqueduct will be carried out in 2008.

## Teamwork

The success of this ongoing project can only be achieved through teamwork and the close working relationship between all the parties involved. It was an essential element that relied on trust, co-operation and the knowledge that the UU, MWH and Daniels were consulted and represented throughout the planning and execution of the work. It was also necessary to ensure that the public were informed and this was achieved via articles in the local newspapers and local television.

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