HUTT VALLEY OUTFALL PIPE REPAIR

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ABSTRACT

A key feature of the Hutt Valley wastewater system is an 18.3 kilometre land based outfall pipeline. A pump control malfunction in March 2009 resulted in five joint failures and the start of a major repair and investigation lasting four months. The traditional response involved open excavation and casting reinforced concrete blocks around the leaking joints.

Difficult access to some of the sites led to a proprietary internal joint sealing system from Germany being used. The internal seal technique has significantly improved the speed and reduced the disruption to public compared to the previous repair approach. In addition this provides a cheaper repair and a better technical solution that maintains flexibility of the joint.

During the repair works, condition inspections were undertaken of the pipes and joints, and an innovative system was developed to pressure test the existing rubber ring pipeline joints. Following the initial recommissioning, a second major failure was discovered caused by tree roots that had affected some pipes. That failure required a structural slip lining repair to be made.

This paper describes the investigations undertaken during that period, the challenges of planning and completing a repair and the innovative repair methods that were developed.

KEYWORDS

Trenchless technology, joint repair, prestressed concrete pipe, outfall

1 INTRODUCTION

A key feature of the Hutt Valley wastewater system is an 18.3 kilometre land based outfall pipeline originally known as the Main Outfall Sewer. This prestressed concrete rising main was commissioned in 1962 and has had a history of joint failures since commissioning.

The quality of the effluent has been progressively improved since the Main Outfall Sewer has been in operation. Initially preliminary grit removal and macerating screens treatment was provided. A milliscreening facility replacing these was commissioned in 1984. A full biological treatment plant with ultra-violet disinfection was commissioned in 2002 and the pipeline has since been referred to as the Main Outfall Pipeline to reflect the change from essentially raw sewage.

The pipeline was originally commissioned to operate at a maximum 35m pressure head, with vacuum assisted syphonic action during low flows. Following difficulties with air leaks that occurred during the first 10 years of operation, the vacuum pump was decommissioned and a weir installed at the outer end to keep the pipe full during operation.

The route of the pipeline is through the industrial area of Seaview for 2km, then under the narrow, winding road that serves the Eastern Bay communities of Eastbourne for 8km, then along a gravel track originally constructed for the pipeline construction that follows the eastern side of Wellington Harbour for 8km to a short outfall south of Pencarrow Head. Access and working conditions are often difficult, with a high groundwater table and challenging traffic management in the urban sections.

MWH New Zealand Ltd has been assisting in the management of the trunk wastewater activity under a Professional Services Contract with the Hutt City Council since 2003.

Figure 1: Pipe Route

2 DESCRIPTION OF THE PIPELINE

2.1 ROCLA PIPE CONSTRUCTION

The pipeline consists of about 4000 prestressed concrete rubber ring jointed pipes including mitre blocks and other specials used at manhole sections and around some of the curves. The 63mm thick concrete cores were formed by a process known as the "Rocla" roller suspension method and were longitudinally pretensioned using cold drawn steel wires. Circumferential prestress was applied by wrapping the cores with a high tensile wire on a varying pitch, based on the pressure rating for that section of pipeline. The prestress wires were protected with shotcrete that had a specified minimum thickness of 20mm. Details of the pipe section are shown below.

Figure 2: Pipe dimensions

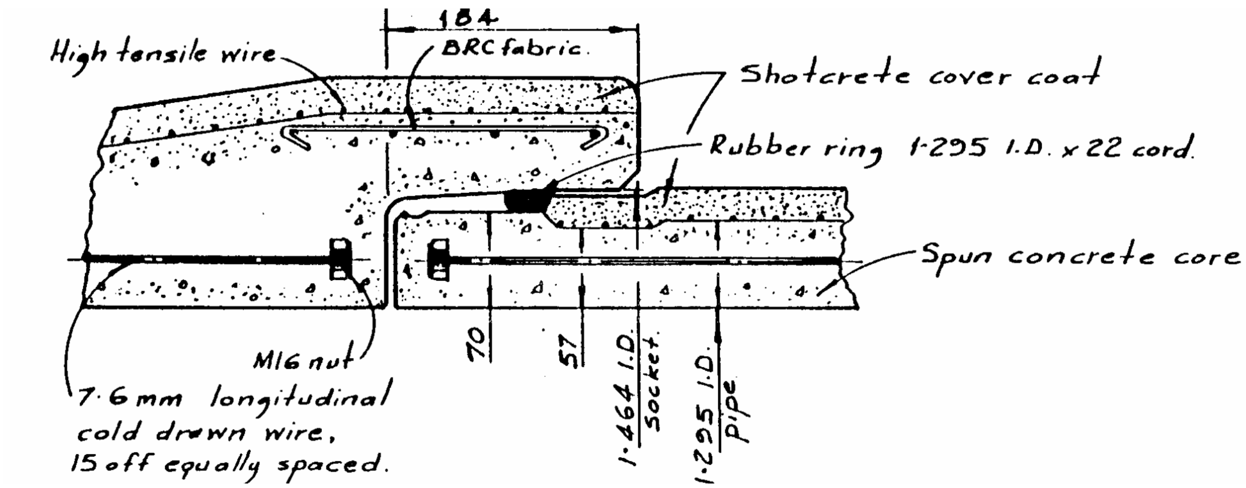

Figure 3: Pipe joint details

The pipeline was laid in a trench with two short tunnel sections at the southern end. Much of the pipeline route is below normal groundwater level.

2.2 HISTORIC PROBLEMS WITH THE PIPELINE

2.2.1 INTERNAL CORROSION

Concrete corrosion developed in the pipe soffit in the first 10 years of operation over a length of about 5km which operated in partly full condition. The corrosion was caused by release of hydrogen sulphide from the sewage, which then formed sulphuric acid on the surface of the concrete. To overcome this problem a flap-gate valve was installed to keep the line full under most conditions. This was then replaced in 1985 with a vortex chamber near the outfall which in effect provides a weir and energy dissipating structure and has proven successful at limiting further concrete corrosion.

A number of repairs were carried out on the worst parts of the soffit corrosion between 1971 and 1984.

2.2.2 CORROSION OF PRESTRESSING STEEL

Catastrophic failures occurred in two pipes in one of two short tunnels in the southern end of the pipeline in 1978. These failures were mainly due to severe corrosion of the prestressing wire, although internal corrosion was also a factor and accidental over-pressurisation may have occurred. The corrosion of the prestressing wires was caused by contact of saline groundwater dripping onto the pipes in the tunnel. In 1995 the annular space of these tunnels was filled with concrete to remove the risk of further wall failure in the tunnels.

This failure raised the concern over possible, albeit slower, corrosion of the prestressing wire due to groundwater conditions. Condition survey work in 1989 and 2003 has found areas of prestressing wire corrosion in five of 44 inspected pipes, however only one of these was significant. One of the pipes inspected also had extensive delamination of the protective shotcrete that was a separate concern.

Photograph 1: View of exposed and corroded prestressing wire

2.2.3 PIPE JOINTS

Prior to 2009 there had been 36 joint failures in the 47 years of operation of the pipe. The frequency had varied, with an obvious reduction in failures from 1982 due to new pumps and a new computer control system in 1981, however since 2001 there had been a slight increase in frequency. There are several contributing factors to these joint failures, including pipe settlement, unsatisfactory installation tolerances, internal pressure fluctuations, ingress of tree roots and loss of integrity of the rubber rung due to stress relaxation and general degradation with age.

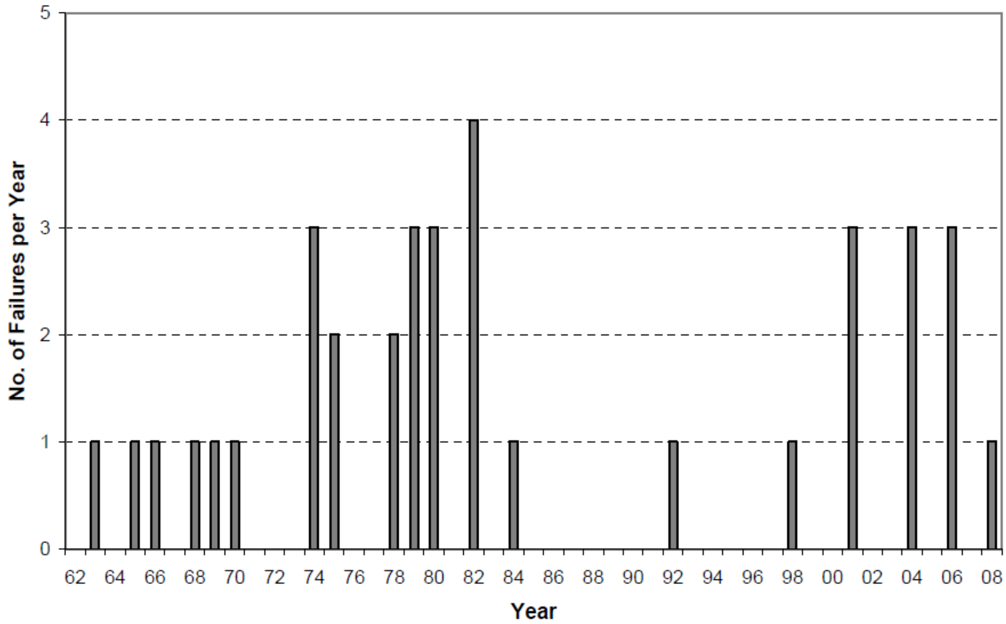

Figure 4: Pipe joint failure histogram from 1962 commissioning to April 2008

3 CONDITION INSPECTIONS AND MANAGEMENT OF THE PIPELINE

3.1 2004 CONDITION INSPECTION

Condition inspection of rising mains is inherently difficult as there is seldom any redundancy to allow the pipelines to be taken off-line. In the case of the Main Outfall Pipeline treated effluent has to be diverted from the Seaview wastewater treatment plant into the lower reaches of the Waiwhetu Stream from where it flows into Wellington harbour. Following commissioning the effects were much less noticeable however were still considered undesirable. Resource consents were obtained for an internal condition inspection of the pipeline in 2004. The previous inspection had been in 1991 and the key finding in 2004 was that most of the pipeline was in good condition and no further deterioration had occurred. The remaining life of the pipeline was assessed as being unlikely to be less than 15 years based on about two joint failures per year being reasonably acceptable to the community.

Photograph 2: Internal condition inspection 2004

3.2 REQUEST FOR QUALIFICATION

During the 2004 condition inspection the Hutt City Council issued a Request for Proposal for Structural Rehabilitation of the Main Outfall Pipeline. This was undertaken as part of the management planning for the pipeline, in order to identify contractors and techniques which could be used to undertake the specialised works to renew or rehabilitate this large diameter pipeline when those works are required.

4 MARCH 2009 INCIDENT (FAILED JOINTS)

4.1 INITIAL RESPONSE

On the morning of 26 March an equipment failure at the Main Pump Station at the Seaview treatment plant lead to over-speeding of the duty pump. Although the back up over-pressure protective switch automatically activated and stopped the pumps the pressure pulse resulted in five leaks being evident as flowing through the road surface. The decision was made to shut down the main pumps and divert treated effluent to the Waiwhetu Stream while repairs were affected.

Two of the leaks were to the side of the gravel access track to Pencarrow and the other three leaks were in the carriageway of the narrow two lane road to Eastbourne. An experienced local contractor was engaged to excavate the pipeline at the leak locations and carry out repairs. Initial excavations were undertaken at four of the sites however there was insufficient room at the fifth site to excavate and maintain one lane of traffic.

Photograph 3: General view of the leak site and close up of scoured pipe and dislodged rubber ring

4.1.1 CONCRETE BANDAGE REPAIR

The standard repair methodology developed over the years of operation was the construction of a reinforced concrete bandage to encase the joint. This was generally undertaken with the pipeline off-line and depressurised, however some successful repairs had been undertaken in recent years with the pipe on-line and the source of the leak diverted to minimize pressure.

One disadvantage with this method of repair is that concrete bandages convert the previously flexible joint to a rigid joint. One repair from 1974 had cracked at the pipe barrel in 2006, requiring the original bandage to be broken out and replaced. Nevertheless, this methodology was a tried and proven technique for repairing a joint failure to enable the pipeline to continue operation.

Photograph 4: Concrete bandage being poured at the first joint leak repair

4.2 CCTV INSPECTION

The pipeline was drained completely and over the period 3 to 7 April 2009 a CCTV inspection of most of the pipeline was undertaken. This investigation identified several joints where ground water was leaking into the pipe, indicating a joint seal failure.

4.3 INTERNAL SEALS

In response to the 2004 Request for Proposal several tenderers had suggested the option of internal seals as a solution to joint failures. While internal seals do not provide structural rehabilitation they are suitable for the joint failure problem that had been experienced and provide a significant technical advantage in retaining joint flexibility as well as speed of installation and obviating the need for excavation.

Contact was made with these contractors to investigate the urgent provision of internal seals. Two prices were received from Australian based contractors and Kembla WaterTech Pty Ltd were commissioned to supply and install 13 AMEX-10 seals. As part of this work a technician from AMEX GmbH flew from Germany to supervise the installation and assist in the training of local contractors E Carson & Sons who were assisting in the repair works.

Two concrete bandages had been installed before the decision was made to install internal seals. The remaining three sites and the additional suspected joint seals identified from CCTV were repaired using internal seals. As the seals had not been used before on the pipeline the excavation at one of the sites was kept open to visually confirm that the seal was effective.

Installation of the seals commenced on 28 April 2009 and six seals were installed in three days. Additional CCTV work on remaining sections and re-assessment of the original CCTV lead to an additional five seals being installed as a precautionary measure in May.

4.4 PUMP STATION IMPROVEMENTS AND RECOMMISSIONING

While the repair works were underway a review of the cause of failure was undertaken. Although the over-pressure cut-out operated as prescribed, the fact that five joints failed drove the need to have an even more conservative approach to the back-up systems. The control logic for the pumps was reviewed and this resulted in several improvements being made while the physical repairs were made.

Gravity refilling of the pipeline commenced on 13 May and the pumps were slowly ramped up to have the pipeline operational on 14 May 2009.

5 MAY 2009 FAILURE (CRACKED PIPES)

The pipeline had operated satisfactorily until 22 May 2009 when a leak was reported in Eastbourne. The pumps were shut down later that afternoon and the pipeline was once again drained.

5.1 CRACKED PIPES

An internal inspection at the leak area revealed horizontal longitudinal cracks in three adjacent pipelines. A rubber ring from one of the pipes had dislodged and it appeared that the leak was coming through the joint, rather than the cracks. The pipeline was excavated to confirm whether the damage extended through the pipe wall. Once again the shotcrete cover near the joint leak was scoured away and in this location one of the prestressing wires had even been scoured through, suggesting that the leak had been present for a long time.

Photograph 5: Detail of joint leak and root intrusion and general view of area

Measurement of the pipes showed that the central damaged had deformed 20mm to be oval. The pattern of longitudinal cracking, combined with the presence of roots from the Norfolk Pine suggested that horizontal compression from the tree had caused the cracking.

5.2 INTERNAL INSPECTION

Review of the CCTV taken 6 weeks previously showed no sign of either the cracking or groundwater intrusion. The pipeline tends to be covered in a layer of slime and the extent of the cracking was not fully evident until that section had been water-blasted.

While the repair methodology was being developed a further internal inspection was undertaken. While the CCTV quality was much improved from previous years it was considered that an experienced human eye would be more accurate. The original survey had been undertaken using CCTV primarily to minimize the hazards associated with man entry to the confined space. E Carson & Sons were commissioned to undertake a manual inspection of the pipeline to look for any further evidence of pipe damage or leaks. This inspection took several days and 40 possible joint faults were identified. Soft areas of concrete were also identified at the two original concrete lined steel "closing sections" and these were investigated and repaired. One additional cracked pipe was identified, and this was also repaired.

Photograph 6: Internal inspection team members

5.3 SLIP LINE REPAIR

The Norfolk Pine that had caused the damage to the pipe was noted in the District Plan as a Protected Tree. Several repair methodologies were considered, and it was decided to cut open the section of pipe that had been excavated for inspection and slip line with steel sections. A 900mm inspection manhole was fabricated onto one of the steel sections, to allow easier access of equipment in future.

The steel sections were pulled into position on polyethylene runners and were pulled into position using a pulling post. Once they had been positioned they were grouted into place and the final manhole section was concrete encased. Stepped AMEX seals were used to seal the ends of the steel slip line section.

Photograph 7: Lowering the final steel section in for slip-lining

The pipeline was recommissioned and was operational on 22 July.

6 JOINT TESTING

Excavation of the leaks had shown evidence of anaerobic soil at all of the sites and scouring of the protective shotcrete at most of the leaks, as seen in Photograph 4. This suggests that the leaks that were evident following the pressure pulse may have been leaking at a slower rate for an extended period prior to the event. While the pipeline was out of service the opportunity was taken to undertake some testing to confirm the integrity of other suspect joints.

One of the features of the AMEX-10 and similar internal seals is the option of a pressure test valve. Some informal trials were undertaken in May manually installing a seal at a joint for the purpose of pressure testing, however this was a relatively slow process.

Pressure testing rigs had been used during the original construction of the pipeline when each joint had been individually tested. In order to make the process efficient a rig was constructed based around the AMEX seal. This rig had to be manufactured to be dismantled and reassembled through the rectangular manhole openings in the pipeline. The manholes have a clear opening of 300 x 400mm only, and are located 300 metres apart on average.

The forty possible leaks were tested first, and most of these were found to hold the prescribed test pressure. A further 100 joints were then tested as a survey of the general pipeline condition. One of these joints was found to not hold pressure.

Photograph 8: Trialling of the joint testing rig at repair site

Eight AMEX-10 seals were installed on pipe joints that were identified as leaking or otherwise faulty from the internal inspection and pressure testing.

7 RESOURCE MANAGEMENT ACT ISSUES

7.1 EMERGENCY PROVISIONS

Due to capacity limitations with the Main Outfall Pipeline, Hutt City Council holds a resource consent to discharge treated effluent to the Waiwhetu Stream during wet weather, however the discharge of treated effluent during this repair work was obviously outside that consent. As had been done during previous repairs, Hutt City Council kept Wellington Regional Council officers informed of the repair actions and progress. The discharges were considered by Hutt City Council to be covered under the emergency provisions under the Resource Management Act 1991.

Unfortunately, in July 2009 Wellington Regional Council issued Abatement Notices to the Hutt City Council for the ongoing discharges. The repair works were at a stage where it was possible to comply with these notices, and no further action was taken.

7.2 CONSULTATION

Consultation with and preparation of factual information to the various agencies who are directly affected or have an interest in the events of this type was an important part of the service provided by MWH to Hutt City Council. Parties involved in the consultation process included Greater Wellington Regional Council, Regional Public Health and the Eastbourne Community Board.

7.3 ENVIRONMENTAL MONITORING

7.3.1 WAIWHETU STREAM

Daily samples were taken of suspended solids, biochemical oxygen demand (BOD) and indicator faecal coliform and enterococci bacteria from each discharge and upstream in the Waiwhetu Stream. The treatment plant discharge had no noticeable adverse effect on microbiological quality of the Waiwhetu Stream, as seen by the increases from upstream to the downstream samples. These results are summarised in Figure 4.

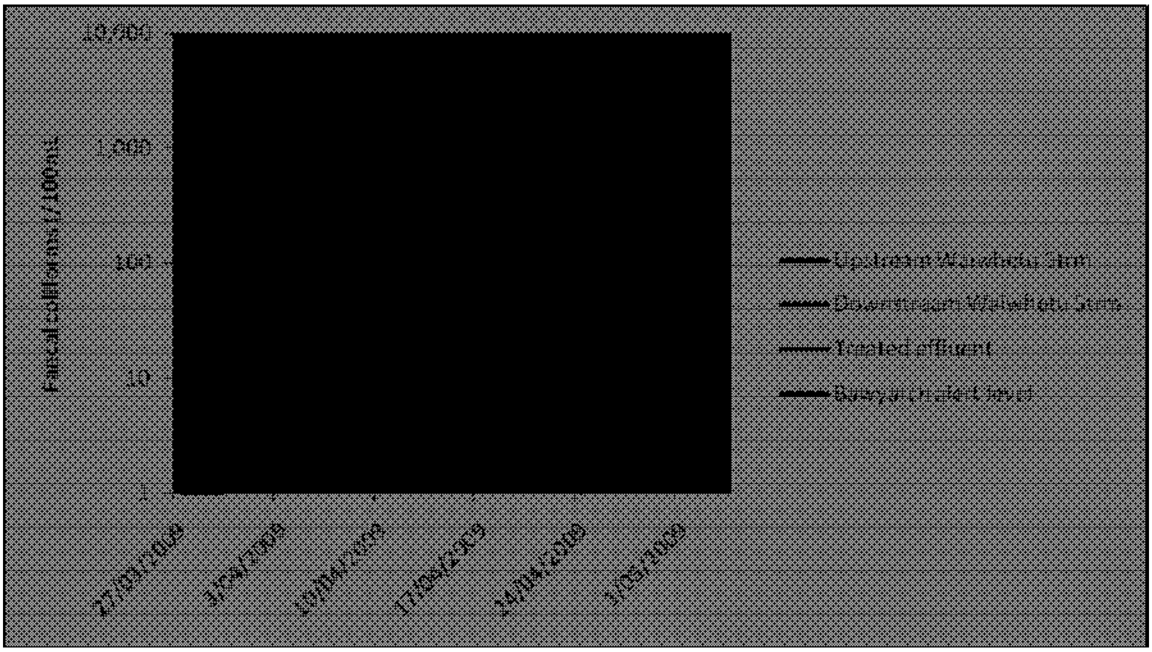

Figure 5: Bacterial indicator monitoring results from Waiwhetu Stream

Several samples were taken for Ammonia Nitrogen that showed a noticeable effect in the Waiwhetu Stream with the treated effluent average 23 g/m^3 and the Waiwhetu Stream 8.7 and 4.2 g/m^3 for upstream and downstream, respectively. The Waiwhetu Stream is subject to tidal effects and the distances from discharge to sampling point will not represent full mixing.

Monitoring was also undertaken locally around scour points during dewatering of the pipeline and this showed limited effect with the lower volume of discharge and higher mixing.

7.3.2 BAYWATCH SAMPLING POINTS

In order to provide the data to verify that the treated effluent was not having any health effect on the bathing water beaches additional "BayWatch" samples were undertaken on a regular basis. These points are monitored weekly during the bathing water season which officially ends on 31 March in Wellington.

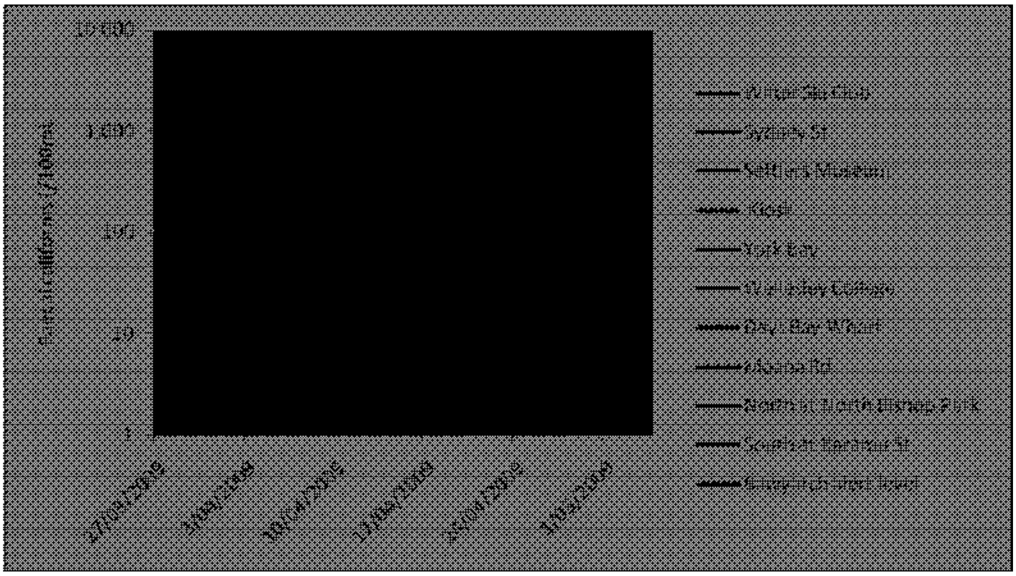

Figure 6: Bacterial indicator monitoring results from Baywatch monitoring points

These samples showed very few exceedances of the “alert level” for bathing water quality. The few exceedances were related to rainfall events or other factors.

7.4 PUBLICITY

Previous repairs had resulted in varying levels of interest from the media and the community. In some cases, the initial media articles have headlined “Sewage pours into harbour” or similar emotive terminology.

While the repair work was progressing press releases with factual information on the minimal health effect the discharge of treated disinfected effluent were having on the receiving waters were regularly made to keep the public informed of progress. This was necessary to rebut some of the less informed statements which were appearing in the media.

8 SUBSEQUENT JOINT REPAIRS

In the year since the major repair works were completed there have been two minor joint failures, on 10 August 2009 and 7 September 2009.

The first of these was repaired very efficiently, with the pipeline out of service for less than 36 hours. AMEX seals were placed on the suspected leaking joint and also each joint either side, to ensure that the correct joint had been repaired.

The second repair was on the southern section of the pipeline where historic corrosion of the pipe soffit had occurred. In order to ensure the AMEX bandage would seal fully the corrosion had to be locally repaired using a cemetitious epoxy mortar. The product used took several days to cure in the ambient conditions, however the pipeline was returned to service on 14 September.

No further joint repairs have been required at the time of writing this paper. This suggests that the joints which had been leaking to the extent that they were not visible at the surface may have largely been discovered through the extensive repair and investigation works undertaken.

Photograph 9: Repair of pipe soffit prior to placing internal AMEX seal

9 CONCLUSIONS

The repair works of 2009 presented a complex challenge to manage and undertake. The challenges resulted in the adoption of technology not previously available in New Zealand. This has proved eminently successful in dealing with the joint failures which has been the predominant mode of failure in this pipeline. Subsequent minor joint failures have been repaired much more quickly and more cheaply than the previously used concrete bandage method. The trenchless technology approach has also allowed the repairs to be undertaken without the disruption to traffic and public inconvenience of excavation for external repair.

Experience in managing structural repairs was also gained during the work. The use of steel sections of pipeline had been successfully undertaken previously but the use of the internal seals as a jointing technique was innovative and has increased the speed of repair.

The limited number of failures since the major repair exercise confirms that the repair work undertaken has been successful and suggests that previous life expectancies can at least be maintained.

ACKNOWLEDGEMENTS

The repair work was very much a team effort, and special thanks go to:

- E Carson & Sons, the drainlayers and specialist pipe repair contractors
- John Wood, independent consulting engineer who provided technical advice and support
- Hutt City Council, the client
- Hutt Valley Water Services, the network operators
- MWH colleagues.

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