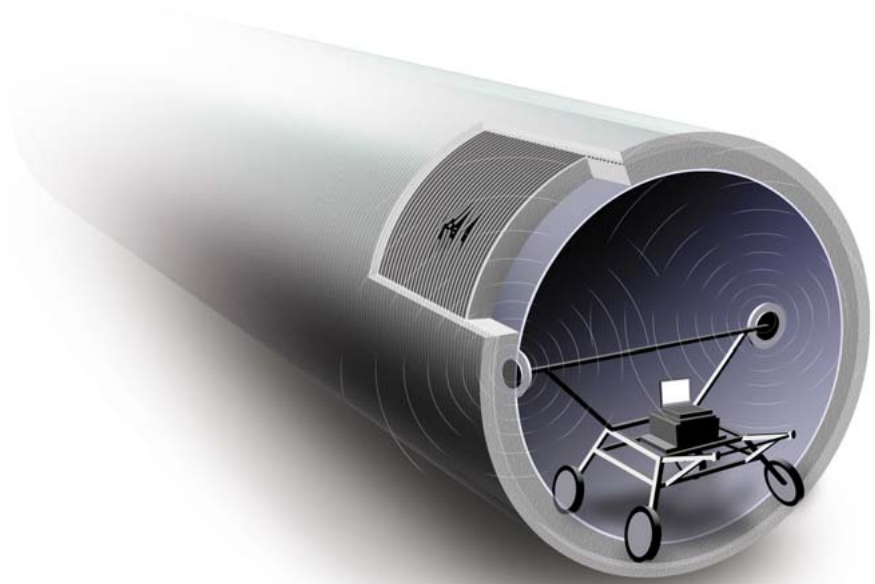
PRE-STRESSED CONCRETE CYLINDER PIPE

PCCP CASE STUDY



Overview of PCCP

Pre-stressed concrete cylinder pipe (PCCP) has been manufactured and installed in the U.S. since 1942. The pre-stressed wire is placed on the outer layer of concrete and covered by either a cement rich mortar or a vertical cast concrete coating. Embedded cylinder PCCP was introduced in 1952. By 1970, PCCP had established an enviable performance record. Few failures occurred and these were attributed to installation damage or the use of oil treated wire that had since been discontinued. However, beginning in the early 1970's the number of failures began to increase. At present over 500 failures are known to have taken place. The majority of these failures have occurred in pipe manufactured by Interpace Corporation, using Class IV reinforcing wire. The company has since gone out of business. Considering that over 28,000 miles of PCCP has been installed across the country, this is not a statistically high failure rate. However, when bursts of PCCP occur, they are usually catastrophic, as was the case for the MCUA, because of the large diameter and capacity used.

PCCP INSTALLATION HISTORY

- In use since 1942
- More than 28,000 miles in service
- Accounts for a major portion of large diameter sanitary sewer force mains and water transmission mains in service, also used for gravity sanitary sewers
- Interpace Corporation advertised a 100-year service life for PCCP

PCCP FAILURE HISTORY

- More than 500 failures since 1955
- Relatively few failures per mile of installed pipe
- Catastrophic nature of ruptures and large diameters involved are a major concern
- Majority of the failures are in PCCP manufactured with faulty Interpace “Class IV” wire

MIDDLESEX COUNTY UTILITIES AUTHORITY

FORCE MAIN RUPTURE

MARCH 2, 2003

Coincidental conditions with the location of the break

- Possibility of induced currents from overhead power lines
- Proximity to lightning strike and JCP&L static line break (approx. 1,140 feet)
- Electrical power disruption at the Sayreville pump station
- Aggressive soils (high chlorides, low pH)

Most probable cause of break

We have concluded that the Pipeline failure of March 2, 2003 was due to a combination of interrelated factors:

- Electrical power disruption at the Sayreville Pump Station from a nearby lightning strike
- Low-level hydraulic transient (44.6 psi) caused by pump shutdowns from electrical disruptions
- Deteriorated mortar coating of failed pipe section
- Wire corrosion and hydrogen embrittlement
- Loss of pre-stressed wire strength
- Reduced internal pressure capacity (44.2 psi)

Summary of the Break

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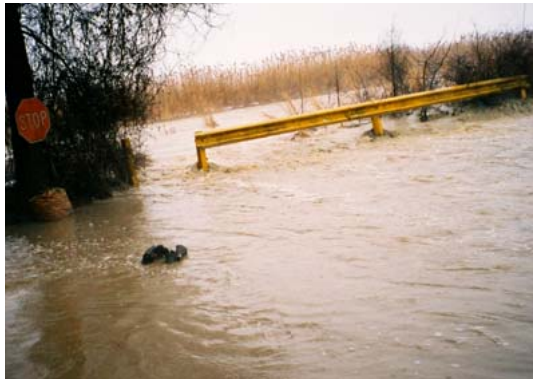
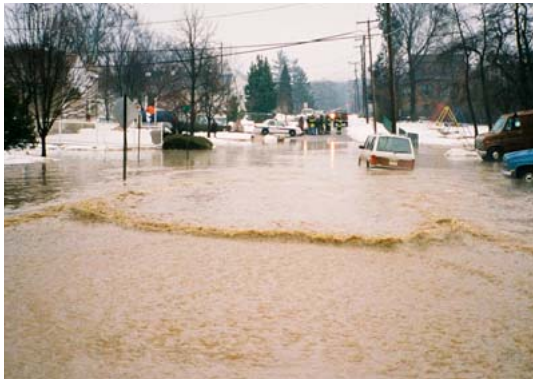
SUNDAY

- Rupture occurs at 9:37 a.m.
- Sewage flows onto Boehmhurst and 6th Avenues.
- Site secured by Sayreville Police and Office of Emergency Service (OEM).
- MCUA and Borough of Sayreville respond with the County Board of Health and NJDEP by implementing remedial measures to assure the safety of residents and roadway. A berm is created by the Borough to divert water away from the residential areas.
- MCUA hires dewatering company to assist with sewage pumping at break site.
- Sayreville Fire Dept. washes down streets, driveways, and residents' homes affected by the sewage overflow.
- OEM informs residents of the Force Main Rupture.
- MCUA switches sewage flow to a backup line to stop the flow from the damaged pipe and to limit the amount of untreated sewage entering the Raritan River.
- Sewage plant loses an average of 4.5 million gallons/hour of sewage within the first 24 hours.





3

MONDAY

- 24-hour pumping begins at break site, using tanker trucks to transport 100,000 gallons/hour of sewage to the MCUA Central Treatment Plant in Sayreville, NJ.
- MCUA and County Health Dept. hand-delivered a letter to the residents impacted.
- MCUA spread lime pellets on lawns and a small public park affected by the overflow; neighbors are contacted and told who to contact with problems.
- MCUA contains sewage leak at break site; NJDEP orders shellfish beds in Raritan Bay closed until testing can be completed.
- Sewage bypass estimated at 3 million gallons/hr.
- Backup system working at full capacity due to melting snow and rainfall. Treats average of 100-110 million gallons/hour.
- Contracted Construction Company mobilized at the break site to assess ruptured pipe for repair.

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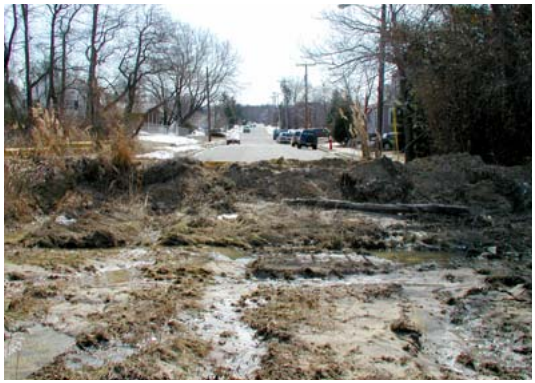
TUESDAY

- Sewage between shutoff valves and break point continue to be trucked to treatment plant.
- MCUA and NJDEP call on residents and businesses within the service area to conserve water in order to reduce the strain on sewerage system.
- Engineering firm hired to sample various sites along the Raritan River to monitor impacts.
- Backup system continuing but still bypassed an average of 1.9 to 3.3 million gallons/hour.



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WEDNESDAY

- MCUA Representatives met with NJDEP, County Board of Health and Borough Officials.
- Dewatering, truck transport and work by MCUA engineers continue in effort to reach pipeline break.
- Bypassing ceased briefly during the 6:00 a.m. hour.
- PCCP repair section delivered to site

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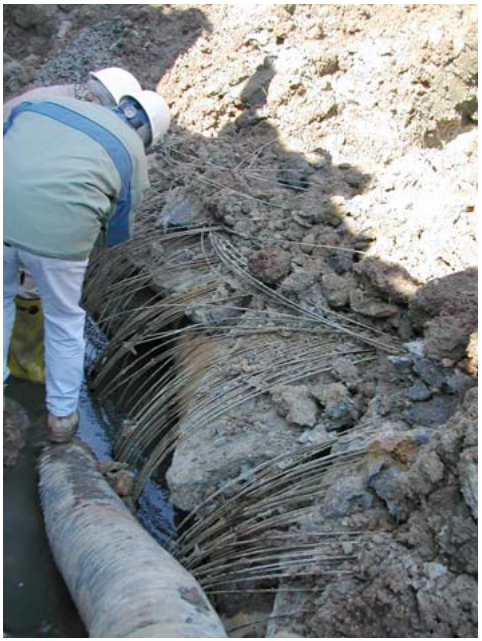
THURSDAY

- Direct access to damage in pipe section is achieved, allowing repair planning to begin.
- Meeting with construction contractor to assess repair schedules depending on different damage scenarios.
- Contractor places steel sheeting around affected area of pipe.
- Raritan River and pump station sampling continue.
- Work continues on a 24-hour basis.
- Bypass sewage estimated at 335 million gallons.
- Average hourly bypass sewage rate varies between 2.7 to 5.7 million gallons/hr.

7

FRIDAY

- Engineering firm hired to conduct soil samples of affected neighborhood.
- Work continues on a 24 hour basis.
- Bypass sewage estimate at 400 million gallons.
- Average hourly bypass sewage rate varies between 0.8 to 2.0 million gallons/hr.



SATURDAY

- Damaged pipe is removed and inspection process begins at break site.
- Sayreville pump station sampling continues throughout weekend.
- Bypass sewage at the Sayreville Pumping Station estimated at 440 million gallons.
- Average hourly bypass sewage rate varies between 1.6 to 3.0 million gallons/hr.

9

SUNDAY

- Break at pipeline isolated to one section. Approval given to go forward with repair, replacement pipe section brought in and welding begins.
- Bypass sewage at the Sayreville Pumping Station estimated at 495 million gallons.
- Average hourly bypass sewage rate varies between 1.3 to 3.0 million gallons/hr.

10

MONDAY

- Repair completed at break site.
- 102-inch pipe filling commences and backfilling of excavation begins.
- Sayreville 8" sewer line section replaced.
- Representatives of the MCUA attended the Sayreville Council Meeting and answered questions from residents and the governing body.
- Bypass sewage at the Sayreville Pumping Station estimated at 541 million gallons.
- Average hourly bypass sewage rate varies between 1.6 to 3.0 million gallons/hr.

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TUESDAY

- At 2:18 p.m. the 102-inch Force Main was placed back into full service eliminating the bypass. All sewage is treated at the Sayreville MCUA Wastewater Treatment Plant.
- Backfilling and grading of site continues.
- From the beginning of the break to today, the total amount of bypass sewage at the Sayreville Pumping Station was estimated at 570 million gallons.

MARCH 2003

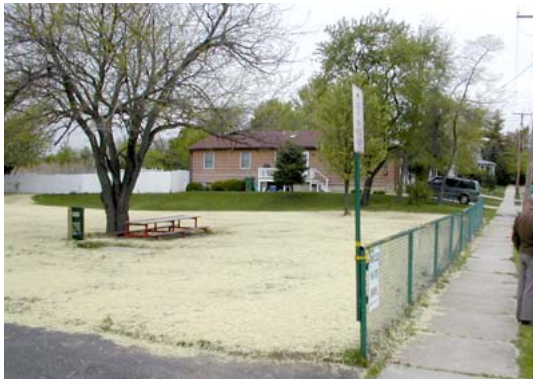
12–13

WEDNESDAY

- Backfilling, excavation, and removal of sheeting continue.

THURSDAY

- Backfilling completed. Site graded with seeding to be performed during the spring months.
- Utilization of both the 72″ pipeline and the repaired 102″ pipeline is required to contain sewage and only treated sewage from the wastewater treatment plant is discharged to the Raritan River/Bay.

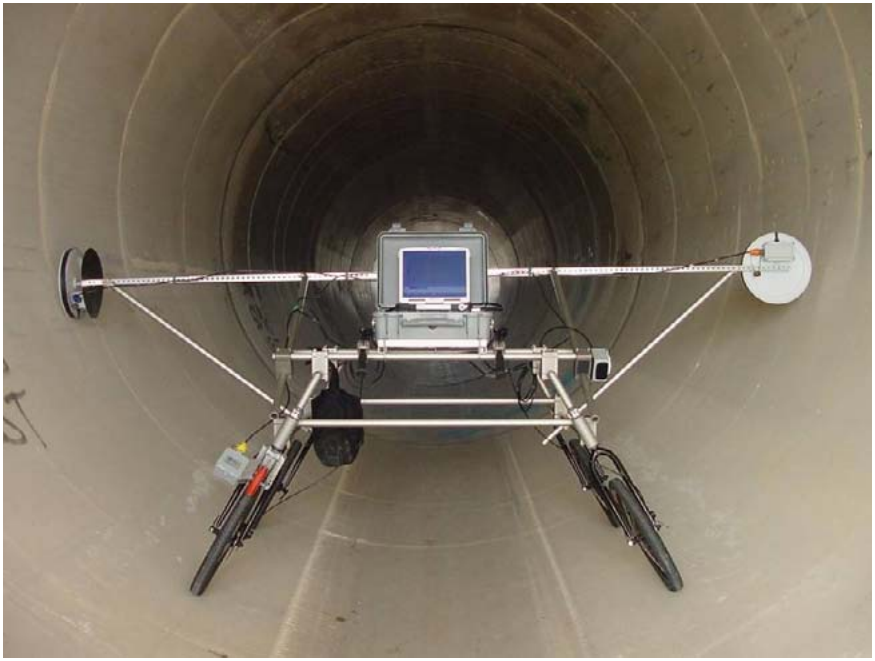


STATE-OF-THE-ART TOOLS

TO ANALYZE BREAK AND MONITOR SYSTEM

- P-Wave™ Electromagnetic Inspection carried out in conjunction with visual inspection during a 2-day period in July 2003.
- Permanent acoustic monitoring system installed and commissioned, December 2003.
- Online Management System, fuses information from P-Wave and acoustic monitoring systems and is accessed via a secure web interface.
- Provides MCUA with near real time continuous data on force main's existing damaged pipe sections, while providing location and frequency of ongoing wire break activity.

P-Wave™, an electromagnetic pipeline inspection technique that provides baseline information on the axial location and number of wire breaks on individual prestressed pipe sections.



P-Wave Survey

- P-Wave results provided “baseline” of current condition of individual pipe lengths.
- 18,000 ft. of pipe surveyed in 2-day period.
- Indicative report issued within 10 days.
- Final report incorporated updated stationing information from visual inspection team.
- Electromagnetic information provided critical first “layer” of information for the ongoing management system employed on the line.

Permanent Acoustic Monitoring System

- 19 Surface mounted acoustic sensors.
- All wireless communicating with central DAS.
- Central DAS monitors passively and continuously 24/7.
- Detected numerous wire breaks since commissioning.
- Provides near real time rate of failure information on individual pipe sections for online management system.

MCUA's Response

- Carry out internal visual and electromagnetic inspections to determine baseline conditions of line.
- Take wire, concrete mortar and soil samples.
- Implement permanent acoustic monitoring system.

PCCP Issues are manageable. Armed with baseline and rate of deterioration information, Engineers and Owners can determine remaining useful life, and avoid future catastrophic failures.

Precautionary measures if you have PCCP:

- Organize pertinent information (e.g., as-built drawings and approved shop drawings, pipe laying schedules, history of pipe failures, normal operating pressures and surge pressure analyses, soils/groundwater data along pipe alignment)
- Assess dependency on pre-stressed wire to withstand the actual pressure conditions
- Inspect the pipe to establish its structural integrity
- Verify operation and maintenance procedures are properly in place to ensure that surge protection devices will properly function to protect your pipeline
- Verify soil profile over pipeline

RESOURCES

- **Jacobs-BBL**
  120 Centennial Avenue
  Piscataway, NJ 08854
  732.457.0700
  www.bbl-inc.com

- **Openaka Corporation, Inc.**
  565 Openaki Road
  Denville, NJ 07834
  973.328.1540
  www.openaka.com

- **Pure Technologies Ltd.**
  10015 Old Columbia Road, Suite B
  Columbia, MD 21046
  410.309.7050
  www.soundprint.com

- **Middlesex County Utilities Authority**
  2571 Main Street
  P.O. Box 159
  Sayreville, NJ 08872
  732.721.3800
  www.mcua.com