

EXECUTIVE SUMMARY

On June 5, 2024, the Bearspaw South Feedermain (BSFM) suffered a catastrophic failure. The BSFM is the most important feedermain in The City of Calgary's (The City) potable water transmission network, consisting of 1950 mm and 1500 mm diameter pipe, constructed in 1975. The BSFM is comprised of both Prestressed Concrete Cylinder (PCCP) type pipe, as well as carbon steel pipe; the failure was in a single 4.9 m long section of 1950 mm diameter PCCP. Immediately following the rupture, The City requested Associated Engineering (AE) to undertake a forensic investigation of the failed pipe, considering subsequent information gained during the exposure of additional pipes identified to be in distress following the initial failure. This report outlines the findings obtained through various field, laboratory, and desktop investigations undertaken by AE, The City, and The City's subcontractors.

The cause of the June 5 failure was the breakage of a sufficient number of prestress wires in a pipe segment causing a loss of pressure resisting capability in the pipe. The prestress wires are 16 gauge (approximately 4 mm diameter) wrapped under significant tension around the pipe's outer concrete core at a pitch of approximately 10 mm. The wires are protected with a 20 mm thickness of cement mortar. Upon their exposure after the event, approximately 200 wires (based on wire spacing) were observed to have failed. It is believed a lesser number led to the initial failure, with additional wires breaking during the failure event.

The forensic investigation yielded the following observations relative to the ruptured and distressed portions of pipe:

- Some pipes showed visible mortar cracking and delamination upon excavation, while other pipe had intact mortar.
- Soil testing along the feedermain showed significantly aggressive soils in certain areas, predominantly due to high chloride concentrations.
- Laboratory testing confirmed that some distressed pipes did have chlorides penetrate the mortar, while other pipes showed no evidence of chloride penetration.
- Severe pitting and corrosion of the prestress wires was present, as well as significant quantities of brittle wire failure. Laboratory testing determined that prestress wires were prone to splitting.
- Evidence of Hydrogen Embrittlement and Stress Corrosion Cracking of the prestress wires was found. Both in this case appear to be due to chloride penetration of the mortar and/or microcracking.

Factors believed not to have contributed:

- There is no information indicating that the manufacturing standards applicable in 1975 were not followed. We note that these standards have evolved since this time, and that some of these changes may have extended the life of the pipe if they were in place in 1975.
- Stray current induced corrosion does not appear to be present.
- Pump operations immediately before the event at the Bearspaw Water Treatment Plant and secondary pump stations connected to the BSFM did not create an over or under pressure situation that contributed to the failure.
- A transient pressure event did not occur immediately before the rupture.
- Live loading subsequent to the construction in 1975 is not believed to be a contributing factor.

Based on the information available to date, we believe that the ruptured pipe experienced microcracking or previous mortar damage allowing soil interaction with the prestress wires. The compromised mortar allowed Stress Corrosion Cracking and/or Hydrogen Embrittlement of the prestress wires resulting in brittle wire failures/fractures. The lack of chloride penetration and simultaneous corrosion occurring on some pipes suggests microcracking of the cement mortar coating may have occurred.