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The Northern California Pipe User's Group
29th Annual Sharing Technologies Seminar

A VIRTUAL EVENT
February 18, 2021

INCREASING WATER SUPPLY RELIABILITY TO SILICON VALLEY BY OWNER AND CONTRACTOR WORKING TOGETHER

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ABSTRACT

The failure of the Santa Clara Conduit in August 2015 was the call to action for Santa Clara Valley Water District (Valley Water) for more detailed condition assessments along their prestressed concrete cylinder pipe(PCCP) pipelines. A condition assessment in November 2017 by an On-call Engineering and Analysis Services for Large Diameter Pipelines contractor on the Almaden Valley pipeline indicated a significant section of this critical water transmission main had an unacceptably high risk of failure spread across congested areas of Silicon Valley. Valley Water convened a collaborative emergency technical workshop to inform and to educate all stakeholders on the nature of pipeline distress and renewal alternatives. The workshop included information on several renewal options including pipe replacement, steel slip lining, and carbon fiber reinforced polymer (CFRP) renewal. This workshop provided a quick and efficient forum to daylight relevant pipeline renewal issues and optional resolutions allowing Valley Water an ability to act quickly and engage in emergency repairs. The decision of Valley Water to convene a Stakeholders workshop, contract for emergency on-call engineering services, and select CFRP as the renewal system resulted in a swift and decisive process, reduced the risk of pipeline failure and time the pipeline was out of service, and increased the reliability of the water delivery system to Silicon Valley.

BACKGROUND

On December 5, 2017, the Santa Clara Valley Water District (Valley Water) acting CEO declared that the condition of the Almaden Valley Pipeline (AVP) constituted an emergency condition pursuant to California Public Contract Code §22050, and that Valley Water staff may repair such pipeline, take any directly related and immediate action required by that emergency, and procure the necessary equipment, services, and supplies for those purposes, without giving notice for bids to let contracts. This declaration was continued by the Board at all regularly scheduled board meetings held since the emergency was declared. The emergency condition continued to exist as the Almaden Valley Pipeline was returned to service and the integrity of the pipeline was monitored. This emergency declaration led to a collaborative rehabilitation process involving the owner, consultant and contractor, saving time and getting valuable water resources back online in less 60 days.

The AVP consists of approximately 12 miles of 72-inch to 78-inch diameter Prestressed Concrete Cylinder Pipe (PCCP) and welded steel pipe (WSP). The pipeline was constructed in two major segments: AVP Unit

1 was constructed in the 1960's, and AVP Unit 2 was constructed in the 1980's. The AVP carries water from Calero Reservoir in south San Jose to the Santa Teresa Water Treatment Plant and then to the Vasona Pumping Plant, where the water is pumped into pipes that feed the Rinconada Water Treatment Plant and is a critical asset in Valley Water's distribution system.

Valley Water was an early adopter of pipeline condition assessment and resiliency. Additionally, Valley Water has always understood the importance of reaction time in the event of an unforeseen failure. One specific pipe failure led to the adoption of comprehensive condition assessment measures and emergency procurement for pipe rehabilitation. At approximately 6:30 a.m. on August 1, 2015, Valley Water witnessed drastic pressure loss along the Santa Clara Conduit. Subsequent investigation determined that a one segment of pipe on the Santa Clara Conduit Section 2 had ruptured. The rupture occurred following a power outage at the Pacheco Pumping Station and subsequent valve closures to change the source of water from San Luis Reservoir to Anderson Basin. About 20 million gallons of water was lost as a result of this pipeline rupture prior to the shutdown of the line. In the wake of the Santa Clara Conduit failure, Valley Water was charged with revising pipeline operation strategies in an effort to proactively identify destressed pipe segments before they reached catastrophic failure.

Two years later, as part of the 10-Year Pipeline Inspection and Rehabilitation Program, which included visual, sounding and electromagnetic inspections, the AVP inspection work was initiated on October 27, 2017. Since the AVP was shutdown, the Santa Teresa Water Treatment Plant (STWTP) was also taken offline. Standard Valley Water practice is to follow a Pipeline Management Program which was put in place to prioritize and schedule regular inspection and rehabilitation as needed. Following three weeks of dewatering, inspection activities were performed on November 21-22, 2017 with Valley Water inspectors performing visual inspection and Pure Technologies (now Xylem) performing an electromagnetic inspection. Preliminary investigation results for Unit 2 indicated a large number (154 of 757) of distressed PCCP sections between the Santa Teresa Force Main and Calero Reservoir. PCCP is a segmental pipe, with each segment connected through bell and spigot coupling and each is typically 20 to 24 feet in length. Valley Water, recognizing the inability to return the AVP to safe and reliable service with such a high number of distressed pipe sections, decided to facilitate repairs while the line was out of service and dewatered. Additionally, an investigation and analysis was conducted to understand why such degradation of the pipe has occurred. Failure to return the pipeline to safe and reliable service would pose a significant risk to the Valley Water's ability to provide sufficient water to meet minimum water supply demands as Walley Water's contractual obligations for water delivery increase from winter to spring.

Valley Water's pipeline integrity team briefed executive leadership of the AVP condition and on December 5, 2017, the acting CEO proclaimed an emergency. An emergency was declared due to the critical nature of the pipeline and the water it provided to Valley Water's customers. Additionally, due to contractual obligations, the pipeline had to be operational by March 21, 2018. While the Santa Teresa Water Treatment Plant would have to remain offline for a greater-than-anticipated duration to allow the necessary pipeline repairs to be completed, if the Valley Water lost the ability to receive imported water from the State Water Project (via the South Bay Aqueduct), there would be an immediate and substantial curtailment of water services in the County. The emergency proclamation relaxed legal procurement guidelines thus paving a path for a more timely response. Valley Water was able to establish emergency contracts with the general contractor, the emergency forensic structural consultant and the emergency structural rehabilitation contractor. Valley Water staff engaged emergency contracts with Conquest, the general contractor and Simpson, Gumpertz & Heger (SGH), the emergency forensic structural consultant. Conquest excavated one section of critical pipe and SGH performed an inspection of the wire breaks to confirm the initial electromagnetic report. Once the electromagnetic reporting was verified the segments of distressed pipe were prioritized based on their proximity to imminent failure utilizing risk curves, provided by SGH, which mapped internal pressure and number of wire breaks. Of the 154 distressed 78" PCCP segments, 80 - were identified as critical.

Once the scope of pipe rehabilitation was defined, an options analysis had to be quickly convened to ascertain the method of repair. Criteria for rehabilitation options were speed of repair, track record and cost. The need to rapidly perform the options analysis led to a unique aspect of the project development – the AVP Emergency Repair Options Workshop – hosted by Valley Water with participation from a group of

pipeline industry subject-matter-experts. The workshop was a collaborative technical session in late December 2017 designed to educate all stakeholders and to discuss and weigh various repair options. The Workshop attendees included engineers, technology providers, condition assessment experts and repair contractors, along with Valley Water personnel. The daylong event included discussion of all repair options, along with pros and cons, and input on the most critical pipe segments to repair.

After careful evaluation of the available rehabilitation options, Class IV structural internal CFRP rehabilitation was selected and Walley Water awarded an emergency public works contract to Structural Preservation Systems, LLC, a Structural Group company, to perform the repair of the pipeline with the V-Wrap™ Carbon Fiber-Reinforced Polymer (CFRP) System, manufactured by Structural Technologies, LLC, a Structural Group company. Carbon fiber rehabilitation was selected due to the extensive history of successful use in municipal pipelines and the construction benefits. Rehabilitation is performed using existing access with a minimal footprint above ground, and with no impact on the hydraulic performance of the pipeline. Additionally, CFRP installation can be performed rapidly and supported by AWWA C-305 for a 50+ year design life using Load Resistance Factor Design (LRFD).

REPAIR IMPLEMENTATION

The internal repair of the 80 pipeline segments was an extensive undertaking, given the repair needed to be complete so the pipeline could be reinstated within the allotted timeframe of March 2018. Structural Preservation Systems, LLC (the Contractor) began mobilization of a crew of approximately 60 personnel in early January and completed the project within 10 weeks, ahead of the allotted schedule. Installation of the CFRP system for the 78-inch AVP repair consisted of surface preparation materials saturation, application of the materials, and curing of the system. Surface preparation of the pipe interior included removing sufficient length of inner concrete core near the pipe joints to allow bonding directly to the steel cylinder and joint rings, preparation of the inner concrete surface to minimum ICRI CSP3 profile, and preparation of the exposed steel surfaces to SSPC SP10 near white metals finish over a specified length. CFRP systems are comprised of fabric (glass and carbon) along with a 100% solids epoxy system. The carbon and glass fiber are dry rolls of fabric which are saturated with the epoxy in the field. The fabric is saturated using a machine located topside and the saturated material is transported into the pipe for lay-up on the interior of the pipe.

The first step after surface preparation was the application of a primer coat of epoxy used to fill in imperfections on the pipe surface. A thickened layer of epoxy is also applied, immediately followed by the lay-up of the first layer of CFRP. V-Wrap unidirectional carbon fiber fabric was installed in both longitudinal and circumferential layers to meet design requirements as presented in the approved project drawings. One of the most important aspects of the performance of the CFRP liner is the water tightness of the system. Water infiltration behind the CFRP system can lead to failure of the liner, and the most critical area to address this is at the point of system termination. Typical design for end details of PCCP includes removal of the concrete at the joints down to the steel cylinder and joint rings. Glass fiber is then applied onto the steel and tied into the CFRP liner. (Glass fiber is used to create a dielectric barrier between the steel and carbon fiber.) The end detail is finished with layers of CFRP, per the design. After installation of the designed number of layers on the 78-inch repair segments, the topcoat of epoxy was installed. The topcoat of epoxy adds to the long-term durability of the CFRP system.

Throughout the CFRP installation process a comprehensive set of quality control procedures were followed which include testing of bond strength (ASTM D4541), monitoring and recording of the environmental conditions within the pipeline, monitoring and recording the material preparation process and tensile testing of sample panels of CFRP (ASTM D3039) to confirm design values. Following installation of the CFRP liner, end details and topcoat the system were cured prior to Valley Water putting the 78-inch line back in service. Curing of the CFRP system is a function of time and temperature, where CFRP can achieve full cure more quickly at elevated temperatures. The CFRP system installed for Valley Water achieved cure within the allotted time and the pipeline was placed back in service, successfully concluding the repair project.

Through quick engagement of Valley Water with industry experts Pure Technologies, SGH and Structural Technologies, the 78-inch AVP line was evaluated and a repair plan determined and implemented within the critical time frame. The use of CFRP proved to be valuable and helped avoid costly extended downtime to the pipeline. Repairing this critical infrastructure to full operation in a rapid manner avoided any further obstacles, such as water conservation mandates and customer impacts were avoided.