LARGE DIAMETER PIPELINE – INNOVATIVE FAST TRACKED REPAIR

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ABSTRACT

Hampton Roads Sanitation District (HRSD) in Virginia recently suffered construction damage to one of their 42-inch wastewater force mains. This particular main is the primary transmission main for a large service area and cannot practically be removed from service for a long period. HRSD needed a plan to quickly and permanently repair the pipeline despite the challenges in doing so.

The permanent solution required construction activity near a casing on an adjacent section of the pipeline that crossed an interstate. The presence of the casing, and requirement not to disturb it, severely limited the design and construction options for implementing the repair.

In order to implement the repair, the damaged location was bypassed with a line stop, creating a temporary dead end that needed thrust restraint. However, the line does not have restrained joints in the vicinity of the hit location. Geotechnical testing at the site showed poor soil support properties.

A concrete reaction block, over 70,000 lbs. in weight, was designed and used as the primary means of thrust restraint. The size of the block was established based on a review of recent typical pressure data in the line with a factor of safety incorporated due to potential variation in the line pressures. The block incorporated a large concrete mass and space for double line stop taps through the pipe crown.

Helical anchors were embedded in the block and extended down deep into the soil due to the poor soil support revealed by geotechnical testing. The line was successfully repaired without further incident and returned to regular service. Total time from third-party damage to implementation of final repair and return of the line to regular service was approximately 40 days.

This presentation will detail the design and construction of this large-diameter pipeline repair, including the efforts taken to expedite the schedule and work within the design constraints.

KEYWORDS: Pipeline, Repair, Bypass, Wastewater

INTRODUCTION:

On August 2, 2012, a 42-inch prestressed concrete cylinder pipe (PCCP) force main, owned and operated by the Hampton Roads Sanitation District (HRSD), was severely damaged by a contractor installing anchors for a new utility tower. The contractor stopped his installation before completely puncturing the pipe wall. However, HRSD was concerned that the damage had compromised the pipeline to an unacceptable failure risk. After the hit, HRSD immediately involved the services of its consultant to begin looking at emergency design requirements under a task order contract already in place. This allowed for design concept development to begin immediately. This force main, known as the Birdneck Trunk, continuously transmits flow towards the Atlantic Treatment Plant where it is treated and subsequently discharged to the Atlantic Ocean. Hourly average dry weather flow is approximately 8.5 MGD and wet weather flow can be as high as 28 MGD.

Despite the extensive force main manifolds in the HRSD system, no other practical path is available for the flow to reach the Atlantic Treatment Plant. Diversion to other treatment plants is possible, but requires
other extensive measures so that connected pump stations can handle the resulting pressure changes due to the new flow path. Given HRSD’s essential mission to provide continuous service without a wastewater spill, the Birdneck Trunk was required to stay in service during the repair. Therefore, the inherent restrictions imposed by the service area characteristics and HRSD’s given mission required a quick repair in order to return the pipe to regular service.

**METHODOLOGY:**

**IMPACT LOCATION**

The location of the damage was very close to the right-of-way of Interstate 264. That interstate is the primary roadway through the central east-west corridor of the City carrying traffic to and from downtown, oceanfront and major public park areas. The location of the hit was approximately 50 feet north of the north end of the casing, leaving only 3 joints of pipe between the damage location and the end of the casing. Figure 1 shows a portion of the record drawing for this force main marked with the approximate location of the damaged pipe:

![Figure 1 Location of Damage](image)

As illustrated in Figure 1 the pipeline goes through a casing under the interstate. The vertical drop to get under the casing is clearly shown, although somewhat distorted by the different horizontal and vertical scales of the record drawing.

Figure 2 shows the site context for the force main with the approximate location of the hit noted. The figure also shows a nearby pressure reducing station (PRS), which HRSD uses as part of normal operation to provide assistance to the system by boosting upstream flow towards the treatment plant via inline pumps. The PRS was integrated with the temporary piping as part of the bypass system. The location of the utility tower adjacent to the site can be seen in the lower left corner of the picture. This is the location of the construction damage that required the prompt repair.
An external inspection of the line revealed that the hit deformed the pipe enough that it bent the steel cylinder. HRSD staff subsequently took the line out of service so an internal video inspection could be performed to determine the extent of the internal damage and make a final decision as to how much pipe
would need to be replaced. Figure 4 shows the interior view of the damage with buckling of the cylinder clearly visible. From the external and internal evaluation, the team decided that only a single stick of PCCP needed to be removed and replaced. Ductile iron was chosen as the replacement material.

Figure 4: Damaged interior of pipe

Since the casing is in place to protect the roadway, an expedient repair could not remove sections of it. In order to leave the casing undisturbed, the pipe replacement and reconnection, along with the entire line stop and bypass setup, had to be placed inside a total distance of approximately 40 ft.

TEMPORARY FLOW HANDLING:

Since the team chose to replace the damaged pipeline, temporary flow handling was required to bypass the flow around the repair location to another downstream location. The entire flow had to be removed from the damaged portion in order to remove and replace the damaged stick. As noted previously the damage location was only approximately 50 ft. from the end of the casing that goes under the interstate. The team initially considered placing the line stops on the south side of the interstate, since there was more room for the setup there, and routing the temporary piping through the same casing as the permanent pipeline. However, there was not enough investigative time to determine if the casing or the pipe inside could withstand the pulling required or the fully filled temporary pipe. Therefore, the team decided to place the line stop assembly and temporary piping connection within the 50 feet between the damage spot and the interstate and support both with a single reaction block.

Typical line stop setups require a line stop unit at each end of the section to be bypassed with connecting piping in-between the two units. In this case, the nearby PRS had permanent piping suitable for connecting to the temporary piping. The team took advantage of this to use the PRS as if it were the upstream line stop with the added advantage of continuing its normal function of providing pressure assistance. The bypass piping selected for the project was 24-inch high-density polyethylene (HPDE). A closed mainline valve in front of the PRS forces flow to go through the inline pumps inside the station. Temporary piping was connected directly to the pressure reducing station piping, buried under an adjacent parking lot and laid over to just beyond the line stop location downstream of the damaged pipe.
THRUST RESTRAINT DESIGN AND INSTALLATION

Figure 5: Temporary piping connection at PRS

Figure 6: Buried temporary piping across parking lot
The severed end of the concrete force main eliminated the thrust restraint available from the installed pipeline upstream of that location. The line stop created a dead end with potential for high end of line pressures and a vertical flow redirection that would subject the pipe to significant thrust forces. The forces estimated for the thrust restraint were based on typical pressures in the force main and incorporated factors of safety. Average pressures were estimated at 35 psi with an estimated surge to 70 psi. Concrete placement was designed as a combination of reaction block, tie-downs and final encasement pours so that the work could proceed as fast as possible and with the necessary concrete cured in time for the given need. The first pour included the bulk of the reaction block to go underneath the pipe up to its springline. The second pour included the concrete tie-downs over the top of the pipe at each end of the first pour. The third pour was the final encasement up to the flange of the tapping saddles. Overall dimensions were 14 ft. x 13 ft. x 8 ft. Figure 7 shows the reaction block pour around the pipe and the line stop flanges, each 24-inch diameter, are shown laying on top of the pipe.

![Figure 7: Thrust Block Installation](image)

**SUPPORT DESIGN AND INSTALLATION**

Geotechnical samples taken on August 17, 2012 and subsequently lab-tested for support strength revealed that the soil would not be capable of supporting the reaction block necessary. The engineer designed helical anchors to be drilled approximately 28 ft. into the soil and be embedded at their top ends in the reaction block.
Figure 8: Helical anchor installation

The contractor discovered that helical anchor installation at the designed 30-degree angle was not possible for the anchors closest to the end of the casing pipe. The contractor then coordinated with the on-site inspector who notified the design engineer that day. The design engineer determined that a reduction to 25-degrees was acceptable. This prompt coordination from the contractor and communication from field staff to design staff kept the construction on the desired rapid schedule.

Figure 9: Completed line stop and bypass tap assembly

REPAIR COMPLETION

The contractor completed installation of the replacement piping and connections to the sleeved adaptors on September 7, 2012, thirty-six days after the initial damage event to the pipeline. Figure 10 shows one of the completed connections from the ductile iron replacement into the PCCP original pipe.
Site restoration repairs were substantially completed by September 12, 2012, which was 41 days after the damage event. Therefore, full repair of a damaged 42-inch pipe was completed; with unique thrust restraint, support and flow bypass requirements in less than 42 days.

CONCLUSIONS

This example shows how a significant repair effort, when coordinated and mobilized effectively, can efficiently overcome unpredicted construction challenges and produce a permanent repair suitable for permanent use. The conflicting utility installation was subsequently moved to avoid the conflict and potential for further damage to the HRSD pipeline. A working team, comprised of an owner, served by a consultant and contractor who were already very familiar with the owner’s design and operational requirements and preferences, provided an effective force for implementing the repair in a very short amount of time. Early identification of site constraints followed by frequent and prompt feedback of unexpected challenges during installation kept the repair on schedule. Familiarity among the team and expertise with the owner’s system allowed for quick solution development to adapt to the unforeseen conditions. Other emergency repair preparation and implementation efforts can benefit by using this example as a model of an effective expert technical solution implemented, facilitated and supported by team dedicated to cohesive relationships and situational adaptability.