Bentley’s HAMMER® Saves Gwinnett County $45,000+ in Force Main Repairs
Hydraulic Analysis and Modeling Reveal Viable Solution to Pressure Surges at Subdivision Pumping Station

Unsolved Pipe Break Issues
Located approximately 30 miles northeast of Atlanta, Gwinnett County, Georgia, is home to more than 800,000 people in a 437-square-mile area. The Gwinnett County Department of Water Resources provides water, wastewater, and stormwater services at the best possible value to customers. When the department couldn’t find the cause of a recurring force main leak in a small subdivision, it applied Bentley’s HAMMER for transient analysis and modeling and ultimately found a cost-effective solution to the problem that saved the county more than $45,000.

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Randy Rosbury, planning manager at Gwinnett County Department of Water Resources, said: “Hydraulic analyses and field investigations revealed that the force main was not installed as designed, resulting in high surge pressures. Based on modeling what-if scenarios, the county’s engineers proposed the addition of two air relief valves (ARVs) at a total cost of $14,800 – 75 percent less than the previously suggested low-cost solution. This new option provided a viable alternative that was within the county’s budget.”

The county water department owns and maintains more than 230 sewage pumping stations with firm capacities ranging in size from 115,200 gallons per day (gpd) to 30 million gpd. The staff has been performing sewer and water modeling for at least five years. However, it has only been within the past year that the department invested in transient analysis software with the purchase of HAMMER.

One of the first projects examined with HAMMER was the Cascade Falls subdivision sewage pumping station, which had been upgraded in 2007. The 2,168 feet of PVC force main had been lengthened by adding an additional 1,589 feet of ductile iron pipes (DIP), and the pumps were increased in size from a firm capacity of 446,400 gpd to 996,200 gpd. However, the pumping station had experienced multiple breaks in the PVC section of the force main for no apparent reason.

The water department initially considered three solutions. These ranged in cost from about $60,000 to nearly $500,000, none of which were viable for a variety of reasons.

Solution 1: Partial Replacement
The first solution recommended replacing a 1,100-foot segment of the PVC pipe with high-density polyethylene to strengthen the weaker section of the force main. The cost of this solution was approximately $60,000. However, given the current alignment and high pressure surges, partial replacement would only relocate the weakest section. Replacing the entire PVC section with DIP would enable the force main to withstand high transient and pressures.

Solution 2: Full Replacement
Replacement of all of the PVC with DIP would make the force main less susceptible to failure during transients. However, if the force main were replaced, air relief valve installations would be required to minimize the transients. The department estimated that this approach would cost about $265,000, plus design work. This amount of money, not currently in the capital improvements program budget, would have taken months to appropriate and would have delayed the project. In the meantime, the subdivision would have experienced further breaks, repairs, and possible sewer spills.

Solution 3: Relocation and Replacement
The most expensive option, relocation and replacement of the entire force main, was the last solution considered due to the estimated $495,500 cost and the time delay associated with easement acquisition and funding appropriation. Moreover, rerouting would not reduce transient pressures in the system. Because there were inherent problems with each solution, the county needed a fourth solution that would not only reduce transient pressure but also be financially feasible.

Field Investigation and Analysis
Using HAMMER, the water department performed a hydraulic analysis of the force main to determine the primary cause...
After creating a simple model in HAMMER, the department ran transient analyses on a small simple force main using HAMMER’s scenario management tool to perform “what-if” scenarios.

of the main failures, evaluate the proposed remedial repairs, and determine the effects a new alignment would have on the station and the force main.

A careful review of the force main profile indicated three areas that were deeper than standard, presumably to lower high points and negate the need for ARVs. Interviews with field operations staff revealed an ongoing hammer problem that could be felt while standing on top of the force main. Since startup of the new pumps, the station had only pumped 88 percent of the original design, indicating more total dynamic head than anticipated. Interviews also revealed that the force main was installed on rock, confirming the theory that high spots were probably much higher than the as-builts reflected.

Drawdown test results and field observations indicated that the force main may not have been installed as designed. It is important to note that depth-to-rock is variable in Gwinnett County, and the contracting firm may not have excavated to the design depth as a result of its encountering rock. These assumptions would be impossible to confirm without digging up the force main. Since the majority of the pipe is located under the centerline of the street, this would have been costly and disruptive. Therefore, a different field investigation was needed.

What-if Scenario Modeling

A “pot hole” dug at one high spot would confirm the actual installed force main depth, which could be used in the hydraulic analysis. The force main high point requested for pot holing was reported at a depth of 38 inches, confirming that the force main was not installed to the required design depth of 10 feet.

After creating a simple model in HAMMER (Figure 1), the department ran transient analyses on a small simple force main using HAMMER’s scenario management tool to perform “what-if” scenarios. Actual force main alignment was copied for interpretation by people unfamiliar with hydraulic modeling. However, elevations were altered to match the hypothesis that the three high spots were not excavated to the proper depths.

Four “what-if” scenarios simulated possible configurations for the force main:

Scenario 1: Original Configuration

With the model programmed to duplicate the hypothesized installed conditions, the transient analysis indicated a 503.99 psi spike in pressure at the original ARV location, resulting in a maximum hydraulic grade line (HGL) of approximately 2,255 feet. During the 140-second analysis, this pressure spike fluctuates and travels the entire length of the force main several times (Figure 2).

Scenario 2: One Additional ARV

A second scenario was run with an additional ARV installed at the first intermediate high point. Elevations were assumed at a standard depth of 5 feet, indicating that the force main bed was not excavated beyond the rock. If the elevation assumptions were correct, the installation of the second ARV would lower the maximum HGL to approximately 1,415 feet, which translates to a pressure spike of 140.36 psi (Figure 3).
Using HAMMER, the county’s engineers proposed a viable solution that would reduce the transients to an acceptable level

Scenario 3: Two Additional ARVs
The same assumptions were made regarding the installation of the pipe (Figure 4). With two additional ARVs installed on suspected high points, the maximum HGL was reduced to 1,338.9 feet, translating to a pressure transient of 107.42 psi (Figure 5).

Scenario 4: Three additional ARVs
The last scenario determined that the addition of yet another ARV was unnecessary because it did not produce any substantial improvement in the system. Without the analysis in HAMMER, the third ARV would have been installed.

Cost-Effective Solution Selected
The field investigation and analysis revealed that the force main was not installed as designed due to underlying rock, resulting in high surge pressures. More specifically, the following assumptions were confirmed:

- The design force main profile indicated that high points were lowered to eliminate the need for ARVs. Field measurements of the actual depth indicated the force main at the high points were not installed as designed, thus creating unforeseen high points without the benefit of ARVs. The hydraulic model confirmed these findings and the resulting transient pressures.
- Statements from the Collection’s staff regarding “feeling it under the sidewalk” indicated that a hammer condition was present. The hydraulic model confirmed this finding.
- The addition of two ARVs at the intermediate high points greatly reduced the transient pressure experienced to an acceptable level within the hydraulic model. These could be installed by in-house staff at a cost of less than $5,000 per ARV. This also removed the need to relocate the force main or reinstall a new force main in its current location causing a major inconvenience to residents as well as a major expense to the county, which would include repaving of the entire road.
Since none of the proposed alternatives was a viable solution, the county’s engineers proposed a fourth solution identified by conducting the transient analysis project using HAMMER. This solution consisted of adding two ARVs in the water system at a cost of $14,800 to implement:

- Materials cost at $10,000
- Six in-house personnel at $50 man/hr, and two eight-hour days for a total of 96 man/hrs, which means a total installation cost of $4,800

The hydraulic model confirmed that the addition of two ARVs at intermediate high points would reduce the transient pressure to an acceptable level. These could be installed by in-house staff at a cost of less than $15,000. This also eliminated the need to replace all or part of the PVC pipe, or relocate the force main.

Rosbury concluded: “Using HAMMER, the county’s engineers proposed a viable solution that would reduce the transients to an acceptable level, mitigate force main failures, stop residents from feeling the hammer effect, and cause no damage to the road or sidewalks. The expected results were realized, and residents and county personnel were completely satisfied with the results.

The county saved between $45,200 (when compared to Solution 1) and $485,758 (when compared to Solution 3).”

### Solutions Summary and Comparison

<table>
<thead>
<tr>
<th>Description</th>
<th>Solution 1</th>
<th>Solution 2</th>
<th>Solution 3</th>
<th>Solution 4</th>
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</thead>
<tbody>
<tr>
<td>Pipe burst 1100 feet of PVC</td>
<td>Replacement of PVC section of force main in place</td>
<td>Relocation and total replacement of force main</td>
<td>Addition of 2 ARVs</td>
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<tr>
<td>Cost</td>
<td>About $60,000</td>
<td>$270,284</td>
<td>$495,558</td>
<td>$14,800</td>
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<td>Analysis</td>
<td>Will not reduce transients and will likely continue to fail in the next weakest spot.</td>
<td>Will not reduce transients and will continue to sustain high transient activity. Residents will still feel the hammer and sidewalks will continue to sustain damage.</td>
<td>Will not reduce transients and will continue to sustain high transient activity. Residents may not feel the hammer and sidewalks may not continue to sustain damage depending on available routes.</td>
<td>Will reduce the transients to an acceptable level, mitigate force main failures, stop residents from “feeling” the hammer effect, and cause no damage to the road or sidewalks. It is also the cheapest option.</td>
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<td>Decision</td>
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