Proactive Emergency: Replacing Daytona Beach's Most Critical Water Pipe

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With a trend that has moved utilities towards single, regional water treatment facilities, along with recent single-point failures occurring in water supply systems, a utility must take a closer look at individual pipe criticality for loss of service. Criticality assessment often focuses on the distribution system; however, the greatest potential single point of failure is often before water leaves the water treatment plant (WTP).

With aging infrastructure that has typically undergone numerous modifications (deviating from the original design intent), utilities may find themselves with single-feed pipes, a lack of valves, and other operational limitations.

The City of Daytona Beach (city) identified a critical 45-year-old finished water discharge header pipe, which manifolds the high-service pumps (HSPs), as shown in Figure 1, that provide all water to the city via its sole WTP.

This study provides a first-hand example of a pending single point of failure and the emergency methods that were employed to replace it, while maintaining water supply to the city. It provides a summary of the investigational findings, fast-track design, procurement, and construction process, along with results of the replacement of the discharge header for the WTP.

Background

The city supplies water to a population of approximately 70,000. The Brennan WTP was constructed in 1972, discharging finished water through a 36-in. pipe. At the time of construction, the Brennan WTP was the second such plant within the city; however, after its Marion Street WTP was decommissioned, the Brennan WTP became the sole source of water for the city, thus making the single 36-in. discharge header one of the most critical pipes in the system.

This existing discharge header pipe is a 36-in. ductile iron pipe (DIP), which originally discharged to the east. In a later phase of modifications to the WTP, the pipe was extended to the west, which is a 30-in. pipe that reduces to 24 in. once outside the building (Figure 2). There are seven HSPs that can supply water to the city through the discharge header.

This pump station is the only source of water to the entire city, with no offsite storage tanks, though a project is currently in design to add offsite storage.

Located in a humid tunnel (Figure 1), the exterior of the 36-in. pipe became heavily corroded over its 45-year life span (Figure 3), posing a greater failure risk. Upon an operator inspection of the high-service pump station (HSPS) discharge header, the city decided to further evaluate the pipe, which ultimately led to identifying reliability improvements to the HSPS discharge header. Because it's critical to maintain operation of the pump station (and the pipe) to provide supply to the city, the project was viewed as critical and placed on a rapid schedule.

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Investigation

Carollo worked closely with the city during the investigation, and the initial intent was to consider methods for rehabilitation of the pipe. The team was faced with the challenge of assessing a 45-year-old DIP that could not be isolated from service and was located just under the pump room with access limitations.

The city decided to complete an investigation that focused on both the pipe interior and exterior. Although there were no indications or history of interior corrosion issues, the city felt that this was a necessary move to fully understand the conditions. In order to address this, Carollo completed an investigation of the pipe using ultrasonic thickness equipment (Figure 4) to estimate the wall thickness. Ultrasonic readings were taken approximately every 18 in. along the pipe, including fittings. At each segment, eight readings were taken around the pipe circumference at 45-degree angles (Figure 5). Furthermore, the exterior condition was analyzed, with a focus on valves, connections, gaskets, and bolts.

As noted, the initial intent was to determine the pipe's condition and the

Figure 1. Discharge header pipe tunnel.

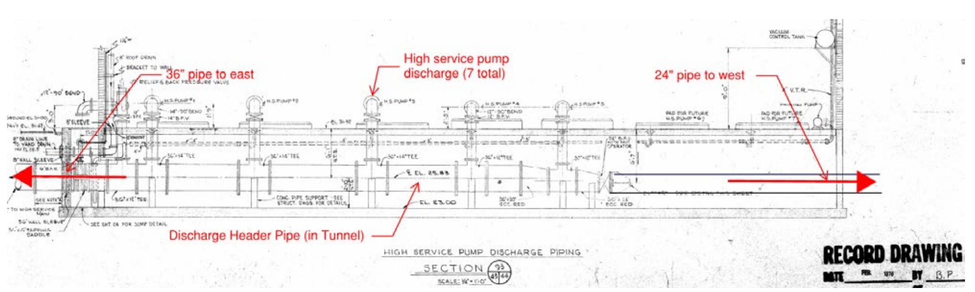

Figure 2. Discharge header pipe record drawing.

ability to rehabilitate the pipe (primarily by blasting and recoating the exterior); however, following investigation, there was significant concern over safety risks and potential failure during rehabilitation.

The following results were noted from the investigation:

- The 45-year-old DIP had excellent wall thickness results.
- There were no leaks.
- The exterior was highly corroded, believed to be due mainly to the initial design and environment, which created a humidity trap and sweating pipe.
- Flange bolts where heavily corroded and significantly deteriorated.
- "Line taps" that included corroded galvanized pipe posed a risk of failure.
- Air release valves were installed on steel saddles, with couplings that were highly corroded.
- Only one valve was installed in-line and was inoperable.

Upon completion of the investigation, a meeting was held with the city to present the results. Although the pipe material itself was not of significant concern, numerous other factors were of great concern. Rehabilitation of the pipe would require a minimum replacement of all flange bolts and tapping saddles, in addition to blasting and recoating; however, the ability to safely access the pipe and complete the work without causing a failure was the primary issue at hand. Additionally, given the lack of proper valves to isolate sections of the header, even the rehabilitated main would not provide an optimal solution.

The team considered potential ways to isolate sections of the pipe, but safe accessibility remained a major issue that could not be resolved. Thus, it was determined that replacement of the header pipe would be the safer, lower-risk, and best long-term solution.

Figure 3. Corroded flange and bolts from a high-service pipe into a header.

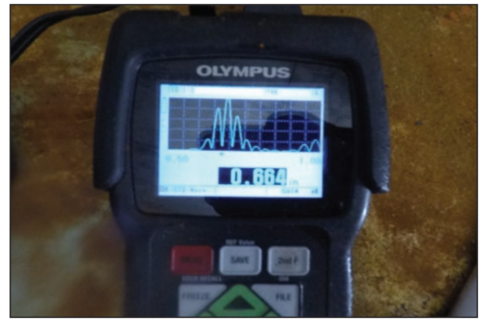

Figure 4. Ultrasonic thickness meter.

		Ultrasonic Readings Along Pipe										
		Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	Reading 6	Reading 7	Reading 8	Reading 9	Average of Readings at Angle	Average of Total Readings Per Fitting
Pipe Identification	Angle											
Spool Piece Next to East Wall	0°	0.919	0.927	0.831							0.892	0.904
	45°	0.975	0.830	0.782	0.996						0.896	
	90°	0.943	0.762	0.690	0.629	0.886					0.782	
	135°	0.965	0.916	0.986							0.956	
	180°	0.930	0.950	0.953							0.944	
	225°	0.914	1.014	0.877	0.830	0.772					0.881	
	270°	1.017	0.980	0.968	1.017						0.996	
	315°	0.953	0.883	0.736	0.972						0.886	
Tee #1 (36" x 12")	0°	1.508	1.530	1.585	1.535						1.540	1.617
	45°	1.646	1.693	1.665							1.668	
	90°	1.968	1.972	1.170							1.703	
	135°	1.930	1.889	1.950							1.923	
	180°	1.737	1.597								1.667	
	225°	1.489	1.409	1.417	1.467						1.446	
	270°	1.489	1.423	1.517	1.371	1.386					1.437	
	315°	1.568	1.555	1.534	1.541						1.550	
Tee #1 (12" Vertical Pipe)		0.536	0.525	0.511	0.515	0.514					0.520	0.520
Tee #2 (36" x 14") (HSP #1)	0°	1.415	1.370	1.450	1.460						1.424	1.643
	45°	1.488	1.590	1.620							1.566	
	90°	1.664	1.603	1.477							1.581	
	135°	1.525	1.577								1.551	
	180°	1.870	1.711								1.791	
	225°	1.989	1.670								1.830	
	270°	1.772	1.710	1.734							1.739	
	315°	1.720	1.637	1.621							1.659	

Figure 5. Sampling of ultrasonic data collected for the pipe.

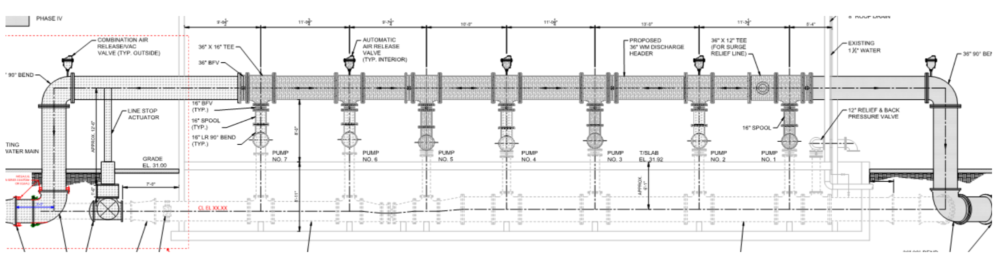

Figure 6. Replacement header draft layout.

Design

Based on the outcome of the investigation, the city made a proactive decision to move as quickly as possible to replace the existing header pipe. This move put the project on a fast-track schedule, with the project direction quickly focusing on the ability to design, procure, and construct a replacement with urgency.

Within a few weeks of the investigation meeting, the design process began. Given the nature of the project schedule, the design process was atypical. At this time, there were still many unknowns, and a scope was established to design the replacement header on an aggressive schedule, with numerous workshops scheduled with the city. In just over two months, design plans were developed. During the emergency design process, numerous site meetings occurred—to make design decisions and to continue data collection.

The initial design effort considered practical site limitations, the potential pipe location, and layout. Several key items that needed to be addressed included:

- What portions of the header should be replaced?
- How is the HSPS operation maintained while replacing the header?
- Where should the replacement header be located? (The "elephant in the room")

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These items were quickly addressed, based on the previous investigation and building limitations. The pipe analysis previously conducted generally produced good results for the pipe wall, but the tunnel design acts as a "humidity trap," creating an environment for high corrosion potential on the pipe. With the bolts and tapping saddles showing the greatest corrosion, along with a lack of operational valves in the header, it was determined to replace the entire "exposed" header that existed within the tunnel. The exterior buried pipe was anticipated to be in better condition due to the more-favorable environment and lack of oxygen exposure.

Based on the investigation effort, it was determined very early in the process that the best (and viewed as the only) option to replace the existing header, while maintaining water supply, was to construct a new header pipe "overhead" of the existing HSPS. This allowed for separate construction of a new pipe and sequenced tie-in to the existing pipe outside of the building and underground. An option was considered to replace the pipe in the existing tunnel, but this required building a temporary partial header. This additional work, along with the challenging accessibility, was anticipated to increase cost and risk to the project.

With the overhead header location, consideration was given to shifting the header alignment "north to south" within the building, but moving the pipe south limited the discharge piping flexibility and crane access to pumps. The best location was determined to be directly over the existing tunnel. The greatest challenge to this was the structural support of the new pipe, while temporarily keeping the existing pipe below grade in service. This is further addressed in the discussion on structural engineering.

Based on the initial agreed-upon layout (Figure 6), key items were established to be addressed in the design. The items have been grouped based on subject.

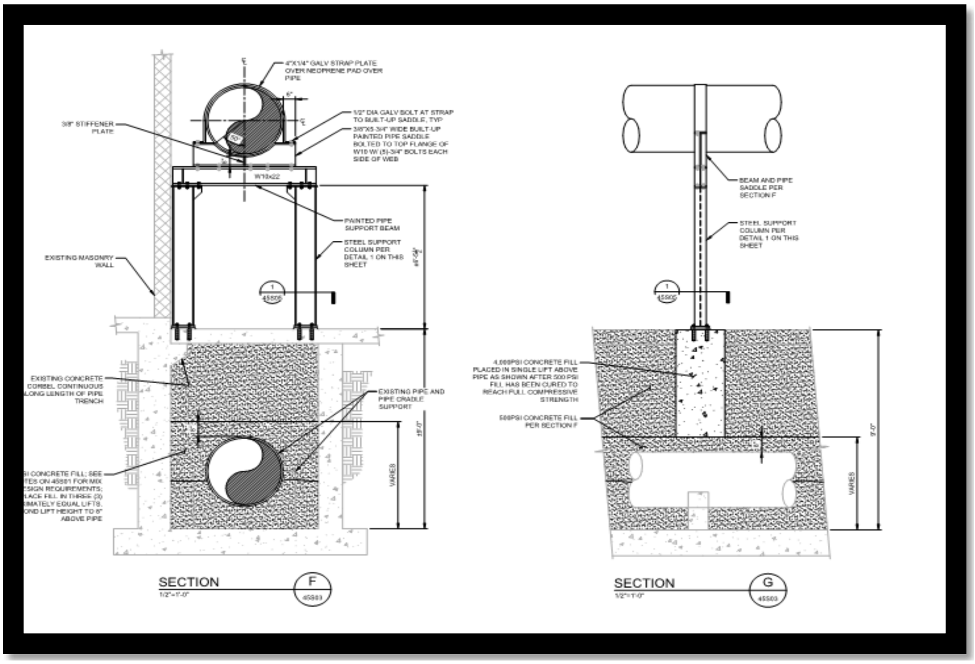

Figure 7. Structural encasement and new header pipe supports.

Pump No.	Pump Manufacturer	Pump Type	HP	Generator Type	Impeller Diameter (in.)	Operating RPM	Nameplate Capacity (gpm)	Nameplate Dynamic Head (ft.)	Operational Flow (gpm)	Operational Dynamic Head (ft.)	Velocity at Operational Flows (fps)				Added Head at Op. Flows (ft.)		
											12-inch	14-inch	16-inch	20-inch	12-inch	14-inch	16-inch
1	Pentair	Aurora 411	300	Detroit	15.1875	1775	5500	173	5500	173.025	14.6	10.7	8.2	5.2	19.6	11.4	7.1
2	Goulds	3215	300	Detroit	18	1180	7800	116.2	N/A; pump curves don't intersect at	173.025	20.7	15.2	11.6	7.4	37.8	21.2	12.7
3	Pentair	Aurora 410	400	CAT	18	1775	7500	170	5250	173.025	13.9	10.3	7.8	5.0	18.0	10.5	6.6
4	Goulds	3408	250	Detroit	13.2	1780	4200	160	3610	173.025	9.6	7.1	5.4	3.4	9.4	5.8	4.0
5	Deming	5064	250	Detroit	14.5	1750	3600	175	4180	173.025	11.1	8.2	6.2	4.0	12.0	7.2	4.8
6	Goulds	3405	400	CAT	13.2	1770	4200	140	2930	173.025	7.8	5.7	4.4	2.8	6.7	4.4	3.2
7	Pentair	Aurora 410	400	Detroit	18	1775	4500	256	5250	173.025	13.9	10.3	7.8	5.0	18.0	10.5	6.6

Figure 8. High-service pump station evaluation summary.

Structural

Structural modifications were required to complete the new overhead 36-in. header design. The key items included:

- Pipe supports of the new overhead header.
- Modifications to the existing stairway to make room for the header, including a new second-floor exit door and exterior stairwell.

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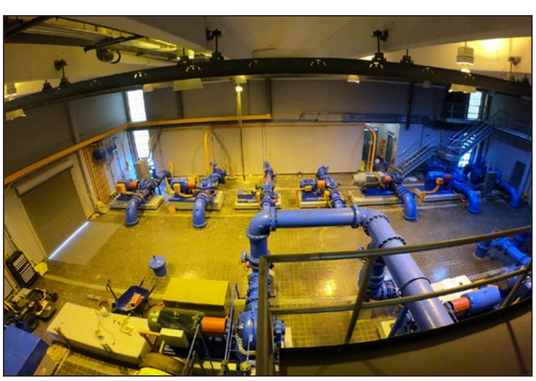

Figure 9. High-service pump station pump room prior to construction.

Figure 10. Phase 1 – Investigation.

Figure 11. Phase 1 – Concrete fills the existing tunnel.

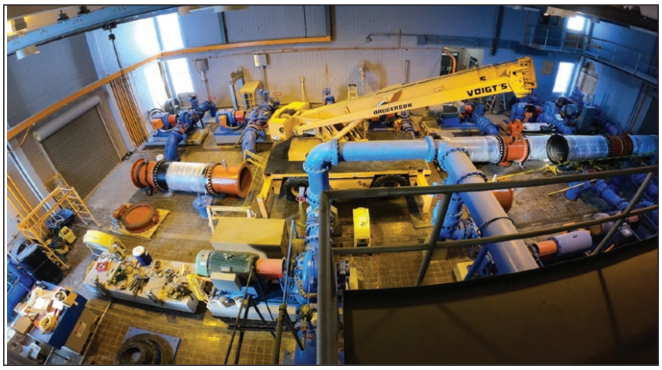

Figure 12. Phase 2 – Beginning of header pipe construction.

Figure 13. Phase 2 – Header pipe construction.

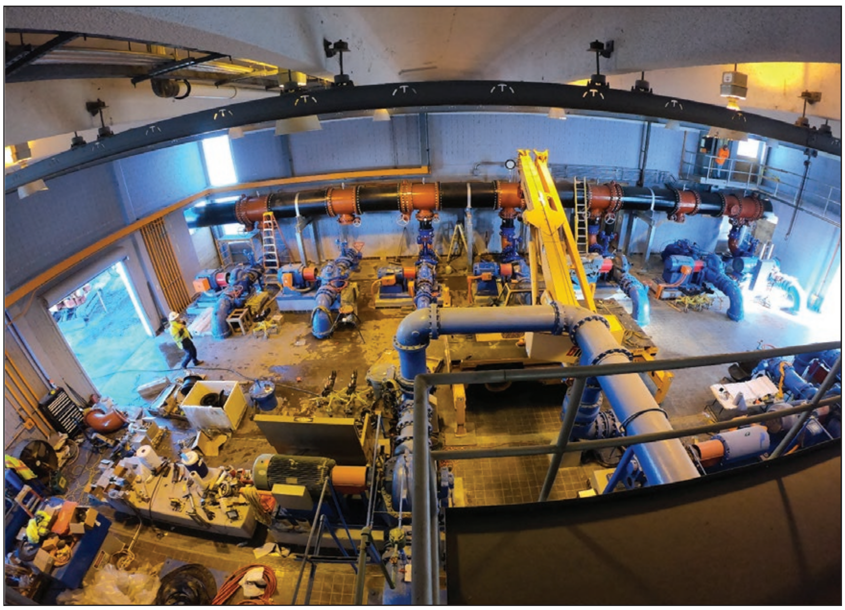

Figure 14. Phase 3 – Tie-in of pumps to header.

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- Modification to the building for the new header to penetrate through the walls on the east and west end.
- Protection of the existing header pipe, which is located underneath the new proposed header pipe.

Based on the key items discussed, the most critical one was protecting the existing pipe. To provide support for the new header pipe, the column supports could not rest directly on the tunnel ceiling without providing more support below. Cutting out and accessing the tunnel was considered a risk to damaging the existing pipe; therefore, the tunnel was filled with concrete to protect the pipe, while also providing a base to build the new supports (Figure 7). Essentially, the existing header was "buried alive" while in service.

Mechanical/Pipe

The new header pipe was the project goal. It needed to successfully replace the existing pipe without interrupting service, while providing a long-term reliable solution. The key items addressed included:

- Selection of pipe material and coatings - Flanged DIP was considered as the best available option, provided that it's properly coated. Flanged cast fittings are commonly available. Cement mortar lining was considered, but ultimately, epoxy coatings that were NSF-61-approved were selected.
- Valves were added to allow for future isolation, flexibility, and redundancy in pumping.
- Hydraulics - Both the main header and individual pump piping size were addressed utilizing a hydraulic model and pump data.
- Pipe supports and restraint.
- Tie-in methodology to the existing exterior piping.
- Sequence of construction.

As further noted, sequencing was viewed as the most critical component to the project for maintenance of operation and supply to the city. The header layout must address safe clearance and walk space underneath, along with practical and safe operation of valves.

Electrical

To install the new header pipe, there were electrical, instrumentation, and control (EI&C) modifications that were anticipated (both interior and exterior) to the HSPS building.

- Interior EI&C piping - This piping is relatively minor, providing connection to existing sensors and local equipment.
- Interior electrical - Pump nos. 3, 6, and 7 were fed via electrical supply from the second-floor control room. This required relocation, with a recommendation that they be installed "flush" to the existing north wall and under the concrete surface to the motors.
- Exterior electrical - There were known electrical supply lines to the site equipment on both sides of the building where construction was to be done. The full impact would not be known until the site underground had been exposed. For this reason, the bid price included a contingency for the contractor to address electrical relocation work underground.

Site/Civil and Ancillary Items

As changes to the building exterior and interior were anticipated during construction of the new header pipe, several key items related to the existing site conditions and the architecture and utilities also needed to be addressed:

- Floor repair - Replacement of tile or alternative repair methods.
- Roof stormwater drain lines - Part of the roof drain goes through the existing tunnel and required modification.
- Water supply lines from the header tunnel supply onsite facilities, including

process water that could not be removed from service.
- Replacement of existing fiberglass windows and removal of minor piping that was unused.
- Asphalt repair - Replacement of the existing driveway, with possible addition around the pipe to maintain facility access.
- Installation of curbs and bollards - Protection must be provided to the new pipe located near or in the existing driveways.

Sequencing of Construction/Phasing

As noted previously, the construction sequencing was viewed as the key to successful project completion. During the design, several "operational limitations" were established based on communication with the facility's operations team. This included review of hydraulic model data, individual pump performance, variable frequency drives, generator connectivity, and size of the piping (Figure 8).

With this analysis, the number and combination of pumps required for operation were established based on seasonal expectations, along with a reliability analysis based on pump history and generator connectivity. This led to a transition approach for the pumps to maintain operation, which would be integrated into the phasing approach to the project.

This, along with a requirement that system pressure be maintained at all times, led to the development of a detailed and phased construction approach to maintain operation of the facility. A five-phase approach was developed as outlined. Each phase was further detailed in the plans, with both written and plan sheets to describe each phase of the header pipe replacement.

Preparation
- Excavate the current header pipe underground on either side of the HSPS building and confirm the existing pipe diameters and locations of connections and existing pipe restraint.
- Relocate or remove miscellaneous piping, conduits, drainage, and other equipment along the path of construction.
- Remove the existing stairwell, knock out the west and east walls for new header pipe construction, and fill the existing tunnel.

New Header Construction
- Install the new discharge header and its associated fittings overhead in the pump room.
- Test and disinfect the header prior to the transition of three of the existing HSPs to the new header. Include prefabrication of new discharge piping from each pump (not yet installed). The header was to be fully prepared and ready for operation prior to the tie-in.

West Tie-In
- On the west underground pipe, complete installation of a line stop (overnight); drain and isolate the 24-in. main.
- Install a restrained 24-in. cap west of the line stop.
- Cut the 24-in. pipe at the location of elbow installation.
- Remove the line stop assembly so that the new discharge pipe can be installed above and then connect to the existing 24-in. main.
- Slowly refill the line, pressure-test and disinfect, and place the new header, the 24-in. west pipe, and the three pumps into operation on the new header pipe.

At this time, both header pipes were in operation.

East Tie-in
- Once the new discharge header is in operation and stable, prefabricate the pump discharge piping for remaining pumps.
- Isolate the 36-in. east pipe and shut down the old header pipe and its pumps.
- Transition the remaining pumps to the new header pipe, drain the 36-in. main, and install the piping connecting the new header pipe to the existing 36-in. main.
- Once installed, activate the remaining pumps, and place the 36-in. east pipe into operation.

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Figure 15. Phase 3 – Line stop at west discharge point.

Figure 16. Phase 4 – Eastern tie-in.

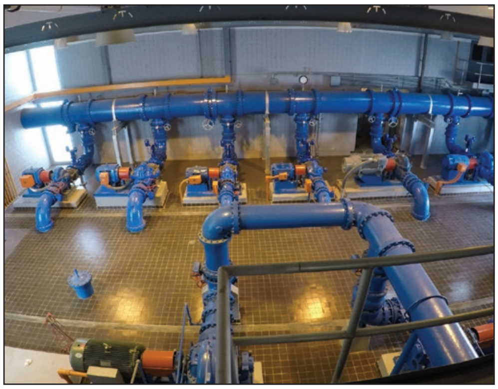

Figure 17. Phase 5 – Completion of the project.

Figure 18. Phase 5 – Completion of the project (full view).

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At this point, the new header pipe was fully operational, and substantial completion of the project was achieved, as defined in the contract.

Final Cleanup

- Install a new stairwell and rebuild the wall and flooring.
- Install curbing, complete paving and painting, and provide overall project cleanup.

Procurement

For the entire design and construction of this project, time was of the essence. Both the city and Carollo reached out to contractors early in the design phase. Communication was frequent to gain interest, check budgetary estimates, and obtain design feedback.

Critical-Path Items

During the design phase, the team was looking ahead, with the ultimate goal of a quick construction timeline. A hypothetical schedule was developed throughout construction to determine the critical-path items. Equipment lead time was of initial concern, and the team reached out to vendors for key equipment. Based on this investigation, new pump discharge check valves were determined to have the longest lead time, and were considered critical-path equipment. To help maintain the construction schedule, these valves were directly purchased by the city prior to bidding.

Best-Value Request for Proposals

A common item of discussion was the need to have a contractor with the right skill set, experience, and ability to get the job done quickly. For this reason, the team considered options for procurement. The city had declared this project an emergency, and successful completion on a fast-track schedule was the highest priority. For these reasons, the city elected to utilize a best-value request for proposal (RFP) procurement process to replace the pipe, which generally includes a focus on qualifications, approach, schedule, and price.

Contractors were scored based on each of the following individual components, with scores weighted as follows:

- Qualifications/Experience - 10 percent
- Approach - 15 percent
- Schedule - 40 percent
- Price - 35 percent

These percentages were developed based on input from city staff. It was clear that the schedule was the most important item to the city, and therefore, it was weighted as such. The best-value RFP process essentially combines an RFP evaluation with a hard-bid component. Committee members reviewed and scored each submittal on its qualifications, approach, and schedule.

After the committee members met and scores were collected, the separately sealed bid prices were then opened, where the scores were totaled. Garney Construction received the highest overall score and was selected to complete the work.

Construction

Garney was awarded the project in July 2019, and the goal remained to have the new discharge header pipe in service prior to Daytona Speedweeks in February 2020. The proposed schedule met this date, but was aggressive, and would require a team effort from all parties involved.

Within days of notice-to-proceed, the construction team had deployed equipment to the site to complete the necessary underground investigation to confirm connection points to existing piping prior to ordering materials. This followed quickly with a number of shop drawing submittals, requiring rapid turnaround by the team in order to procure the majority of equipment.

The construction schedule was developed primarily based on equipment arrival times. Equipment suppliers and vendors were in close communication during this process to ensure timely delivery. This included numerous phone calls, emails, and even a few site visits by equipment representatives to understand the critical nature of the project (Figure 9).

Construction was completed following the five-phase approach, with minor adjustments by the construction team based on early field investigation.

Phase 1

Phase 1 began early in the project to prepare for the new header pipe (Figure 10). While this phase was the longest, the least amount of operational changes was required. The filling of the tunnel with concrete was the most important item in this phase to prepare for the new header pipe (Figure 11). To protect the existing header pipe, while minimizing settlement potential, a "lightweight" concrete mixture was used to fill the tunnel. It was well-planned, thoroughly discussed, and a success. With the header pipe encased, the tunnel was prepared for overhead construction of the new header pipe.

Phase 2

Phase 2 kicked off with the major equipment arrival (Figure 12), and the bulk of construction starting as the holiday season approached, adding yet another challenge to personnel. For this phase, the just-in-time delivery of key components (piping, valves,

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etc.) was critical. As planned, early orders and close coordination with vendors kept the project on schedule. Biweekly project meetings occurred with the entire team, while communications with operational staff occurred daily.

The greatest challenge in this phase was fabricating and installing the new piping overhead the existing HSPs, which were in active operation. The construction team proposed a construction method to fabricate the new header pipe, while minimizing risk to the operational pumps below (Figure 13). Special rigging equipment was implemented, including a 15-ton Broderson IB 200 carry deck crane, which was carefully placed in the middle of the HSPS room. As shown in the construction phasing photos, this was the key to safe installation of the pipe segments, while also maintaining operation.

Phase 3

Phase 3 was viewed as the most critical in the project, where installation of a line stop in the active discharge header pipe was required (Figures 14 and 15). If this were to fail, the entire city would be without water. For this reason, all hands were on deck. The city had a well-organized contingency plan in place. Additionally, the work occurred overnight, when water demands were at their lowest, for purposes of lowering velocities and pressures and minimizing the potential need of interconnects.

The construction team had fully and safely prepared piping underground access, checked all piping restraints, and poured pipe supports and thrust rods in place. The line stop event was successfully completed, which allowed for the new header pipe to be connected into the existing west discharge main in the coming days. With the line stop and transition of pumps, both the old and new headers remained in service at the same time.

Phase 4

Phase 4 followed, completing a similar tie-in on the east piping (Figure 16), but with the new header in service the old header could be isolated, so a line stop was not required. This connection was a "measure twice, cut once" approach due to the alignment and rotation of the underground elbow. For this reason, extra piping and adapters were ordered; however, with proper planning, the piping dropped in as planned and the additional components were not required. Upon completion of Phase 4, substantial completion was achieved on schedule.

Phase 5

Phase 5 included multiple wrap-up items, including painting, paving, and safety features (Figures 17, 18, and 19). This included some unforeseen challenges, including floor repair that required removal of brittle base/grout material that was installed during original construction, but given that there was now "pressure in the new pipe," the pressure was off at this point.

While there were certainly challenges to the schedule throughout the project, the construction team made efforts to communicate and adjust to keep the project goals in mind. Open communication was the key to success.

Figure 19. Phase 5 - Completion of the project (side view).

Conclusion

The overall duration of this project—from design through construction—was right at one year (March 2019 to March 2020). Considering all the major components that had to occur (design, permitting, contractor procurement, equipment lead times, and phased construction), the stars aligned to meet this schedule, and the effort did indeed take a team of personally dedicated "stars." From city leadership to the construction crew, each person involved in the project provided the commitment needed to successfully complete it on time and on budget. The project also displayed teamwork in action to quickly respond and maintain a safe water supply to the community.

This project provides a great example of how a proactive decision by a utility can help to improve the reliability of its aging infrastructure. So, as utility systems in Florida continue to age and facilities may be combined and/or modified, being aware of pipes and facilities may become more critical than originally planned.