



Water Transmission Main Replacement Threads the Needle of Materials, Design, and Constructability Constraints

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The Florida Keys Aqueduct Authority (FKAA) is undertaking a long-term program to replace its water transmission main for the entire 130-mile chain of islands to strengthen the system's resilience and reliability. Existing ductile iron pipe is being replaced with cathodically protected steel pipe to resist early corrosion from aggressive soils and subterranean tidal flows. Efforts began in Islamorada, a village in Monroe County, with a five-mile transmission main replacement project on Upper Matecumbe Key.

The project faced numerous unique challenges:

- ◆ Procuring materials in a COVID-19 economy
- ◆ Designing the pipeline alignment in limited space
- ◆ Minimizing construction impacts

The lessons learned during this project are helping FKAA optimize its approach for future water transmission main replacement projects.

Early Procurement Strategy Minimizes Material Cost and Availability Risks

The project began in 2021 under COVID-19 pandemic conditions that were significantly impacting supply chains. Shortages in raw materials and parts made it difficult to obtain them, lock in prices during bidding, and develop accurate cost estimates. Valves, which normally take longer to obtain than other items, were particularly difficult to procure using the contractor's normal process of submitting and purchasing. Lead times were extending from a couple of months to over a year and material prices were escalating rapidly.

In addition, vendors could not provide locked-in prices during bidding and quotes were sometimes only good for a few days. For example, the cost of hot-rolled steel coil, the raw material for

steel pipe, tripled during the project's preliminary design phase. Since cost estimates were difficult to complete with any accuracy, it was nearly impossible for FKAA to budget for projects.

To expedite the project and avoid material delays, the FKAA team implemented an early owner-direct purchase program for the straight steel pipe sections and butterfly valves. During this process, the required pipe size and wall thickness were confirmed so steel coil could be procured early to lock in the material cost. The steel pipe manufacturer was able to plan in the manufacturing of the pipe ahead of the scheduled construction and store the pipe onsite until it was needed for installation. Early coordination with FKAA on the connections allowed the project team to quantify the valves required so valve procurement could begin prior to final design and selection of a contractor. A supplier was chosen in September 2022, with estimated delivery of the first crucial 36-inch valve in July 2023 and the remainder of the valves in November 2023.

Unforeseen supplier challenges threatened additional delays to the construction schedule: one of the supplier's foundries closed during the bidding process and another suffered a major fire. To enable the contractor to continue with construction, a spacer piece was temporarily installed between pipe segments until the valves arrived and could be installed. Since steel pipe is welded, there was no material flexibility to fill the required gap to slide the valve in later. The solution was to cut the steel pipe, tighten the valve into place, and fill the small gap using an exterior butt strap. This was possible because an access manway was added once the possible delay was identified.

Frequent communication and coordination with the valve supplier proved critical to keeping the construction schedule on track. As the project progressed, the project team requested cost and schedule updates on a regular basis. Obtaining up-to-date information about valve delivery times and potential delays enabled the project team to proactively work with the supplier and build a

team-like relationship. This enabled the supplier to better track the production performance and the project team could inform the supplier about specific valve sizes needed to help prioritize production.

"The valve manufacturer possessed unique project management capabilities. Direct communication from the factory to FKAA and the project management team enabled prioritization of valve deliveries in the order they were needed for installation, which allowed the project to continue moving forward," said Robert Whritenour, owner of Fluid Control Specialties Inc.

Pipeline Alignment Designed to Optimize Constructability

Determining the transmission main's optimal route through Islamorada was critical to navigating the unique challenges of the Keys for underground utility installation. Groundwater tables fluctuate, even surpassing road elevations during high tide events; the coral rock geology is hard and highly porous. Linear in nature, the Keys are served by U.S. Highway 1 (U.S. 1), the main north-south roadway and only evacuation route. The pipe alignment had to be constructable, with minimal impacts on traffic flow.

Three alternative alignments were evaluated: Old Highway; U.S. 1, northbound shoulder; and U.S. 1, southbound shoulder. Old Highway was ranked least desirable due to congestion of an existing sanitary sewer, its more-residential setting, distance from the existing transmission main, and lower elevations. The northbound shoulder was ranked second, mainly due to an existing electrical duct bank that meandered along the shoulder and existing stormwater structures that would have caused numerous vertical or horizontal deflections. Ultimately, the transmission main was routed under the southbound lanes of U.S.1 to avoid areas congested with existing utilities and allow for shorter connections to existing distribution systems.

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Selecting U.S. 1 as the pipeline corridor enabled the project team to take advantage of higher road elevations, with a U.S. 1 right of way (ROW) resembling an elevated berm through the middle of Islamorada. The U.S. 1 roadway in the project area is commonly one to two feet higher than the rest of the ROW, allowing the pipe trench to remain dry with very little, if any, dewatering for a majority of the project length. Typically, a top-of-pipe elevation above four feet during usual tides provided a bottom trench 0.5 to 1 foot above groundwater levels. The dry pipe trench allowed the contractor to perform exterior welding, enabling production rates (up to 250 feet per day) two times the original project estimate compared to installation with interior welding. The exterior welding and dry trench also increased overall project safety.

The route also included horizontal directional drilled (HDD) subaqueous crossings of the Tea Table Key Relief Channel and the Whale Harbor Channel to tie together the new steel pipe segments. Installing the pipeline beneath the channels will help increase resiliency of the system and reduce risk from high winds and storm surge associated with bridge crossings. The FCAA is looking to provide redundancy at bridge crossings by installing all new transmission main channel crossings via HDD and then rehabbing the existing bridge crossings.

Construction Approach Minimizes Impact and Maximizes Efficiency

Since U.S. 1 is the only roadway and evacuation route for the Keys, maintenance of traffic during construction was critical. A lane shift, diverting the northbound traffic onto the shoulder and the southbound traffic into the northbound lane, provided approximately 30 feet of roadway for contractor workspace and the required separation between the open trench activities and vehicular traffic. Avoiding an alternating traffic pattern, the contractor utilized a 24-hour workday during the week to maximize installation efficiency and maintain a continuously moving zone of construction.

While the 24-hour work schedule might sound like a major impact on the surrounding businesses and residents, the drastic reduction of overall workdays in front of a property outweighed the nighttime work effects. Using a train process for pipe installation, construction activities were continuously moving and methodically sequenced at both the front and back of the work zone as installation progressed. Installation and backfill operations occurred during the day and milling and pretrenching activities occurred overnight to prepare for the next day's installation.

“When I drove through the project site, the construction resembled a perfect example of train-type construction for linear utility installation,” said Saud Kahn, specialist for the Florida Department of Transportation District Six Maintenance of Traffic (MOT).

The MOT was set up as a rolling lane closure that allowed for a 1,000- to 2,000-linear-foot (LF) work zone on average and would be moved concurrently with the project team. Paving typically occurred on a weekly basis to allow the approximately 1,000 LF per week to have regular traffic flow each weekend. Sunday night the MOT was reset, and the milling and pretrenching began again to prepare for the pipe laying operations on Monday.

Construction began in April 2023 and the new transmission main was put into service in July 2024, cutting the anticipated construction schedule in half and significantly reducing impacts on businesses and residents. Additional efforts to minimize traffic impacts through the U.S. 1 corridor included the steel pipe supplier's willingness to store materials until they were needed for installation. This eliminated unnecessary trucking of pipe from a staging area through the U.S. 1 ROW. The supplier would ship pipe based on the availability of ROW in the specific construction area, with some areas having plenty of green space for 1,000 feet or more of pipe and other areas limited to a single truck load each day. In addition, these coordinated deliveries helped the contractor keep the multiuse Overseas Heritage Trail open on the impacted side of U.S. 1 for more of the project duration than expected.

The FCAA has leveraged the lessons learned and strong partnerships built on this project by continuing north into Windley Key with the same project team, including the material suppliers, engineering team, construction administration firm, and contractor. The Windley Key project has had its own specific obstacles, but FCAA has been able to mitigate material delay concerns, fast-track the design to construction, and achieve fast and safe installation of another 1.5 miles of transmission main.

The FCAA understands the importance of a project team that is focused on mitigating material risks, familiar with the project area, and committed to providing innovative solutions. As FCAA continues replacing its aging infrastructure, the lessons learned will help guide project teams in keeping these critical projects on schedule while minimizing impacts to residents and businesses.

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