

Creative Solutions to Minimize Impact of Critical Water Main Replacement in the Keys

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30-inch Wye Placement, Islamorada

Abstract

The Florida Keys Aqueduct Authority (FKAA) serves a population of 83,000 residents, delivering over 21 million gallons of high-quality drinking water daily through a single, 36-inch to 18-inch diameter water transmission main along US1 from Florida City to Key West. However, the aging pipeline faced issues with continuous water supply, requiring FKAA to invest in a new 36-inch steel water transmission main. The project team encountered multiple challenges including rapid inflation, corrosive high-water tables, tough coral rock geology, maintaining service, and the limitation of a narrow, congested US1 corridor that acts as the exclusive north-south transportation route. Through

innovative approaches and creative problem-solving, the project team successfully minimized the impact of critical water main replacement in the Florida Keys.



18-inch Connection to Existing Transmission Main, Windley Key

Project Background

The Florida Keys is a coral cay archipelago where a person rarely, if ever, finds themselves standing at an elevation in the double digits or further than a few hundred feet from the ocean.



HDD Drill Rig Setup at Tavernier Creek on Plantation Key



HDPE (High Density Polyethylene) Pipe Fusing

Spanning approximately 127 miles, the Keys are linear in nature with US1 the single thoroughfare for most of the island chain. The Florida Keys Aqueduct Authority (FKAA) serves a population of 83,000 residents, delivering approximately 21 million gallons of high-quality drinking water daily. FKAA operates three Water Treatment Facilities: J. Robert Dean, Kermit H. Lewin Reverse Osmosis, and Marathon Reverse Osmosis with J. Robert Dean providing most of the output. The J. Robert Dean facility is located in Florida City and treats water primarily from the Biscayne Aquifer but also from the Floridian Aquifer. The treated water is then pumped through a 36-inch-diameter transmission main south along US1 down the area locally known as “the stretch” which is an 18-mile section of generally undeveloped land between the mainland and Key Largo.



Tea Table Tie-in Wye is being Installed, Islamorada

Once in Key Largo, the drinking water continues south and west through a series of booster pump stations and a single, 36-inch-diameter transmission main dissipating down to an 18-inch-diameter pipe in Key West. The age of the transmission main differs; some sections have been recently replaced and others date back to the 1940s. Throughout the project area, the existing 30-inch-diameter, ductile iron pipe, constructed in the late 80s, faced issues with providing continuous water supply due to constant leaks and occasional breaks.

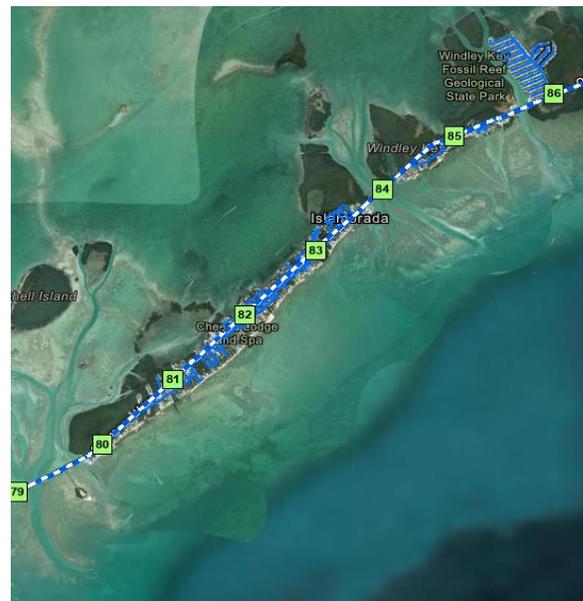


Figure 1. Project Limits

Understanding the pipeline was getting to the end of its useful life, FKAA decided to invest in a new, 36-inch-diameter, steel water transmission main. This paper discusses the specific project area in Islamorada and Windley Key, spanning approximately 6.5 miles between mile marker (MM) 79 and 85.5 (**Figure 1**), as well as the next steps FKAA is undertaking to improve the distribution system.

Project Challenges

In early 2020, FKAA began the project by gathering surveys and geotechnical information and evaluating potential routes and challenges.

Installing underground utilities in the Florida Keys is not for the faint of heart, and early in the preliminary design phase, FCAA knew this project was going to face some tough challenges and require critical thinking to be successful. In June 2021, FCAA advertised a Request for Qualifications (RFQ) for Transmission Main Replacement Professional Engineering Services.



Tea Table HDD (Horizontal Directional Drilling)

Wade Trim qualified and was awarded the Islamorada section from MM79 to MM84 including Tea Table fill key, Tea Table channel crossing, and Upper Matecumbe Key to the terminus at the north end just south of Whale Harbor Bridge. After the construction contract was awarded for the first phase (MM79 to MM92), FCAA experienced a significant break in Windley Key. Therefore, FCAA amended both the design and construction contract to include Windley Key.



Pipe Stringing for Pull Back, Whale Harbor

The project team knew the project would face material challenges due to the general economic backdrop from the last year of the COVID-19 pandemic. Raw material and part shortages were causing long lead times and sometimes unknown hard deadlines. Valves, commonly a long lead time piece during a pipeline project, required an early shop drawing review and approval process to avoid project delays. Raw material prices were rapidly inflating with hot-rolled coil steel tripling during the preliminary design phase from \$500/ton in 2020 to \$1,500/ton during the RFQ (Request for Quotation) process (Figure 2). The rapid inflation was to the point that vendors could not provide locked in prices during a bidding phase and quotes sometimes were only good for a few days. Cost estimates were hard to complete with any accuracy making it nearly impossible for Utility Owners to budget for projects planned in upcoming years.

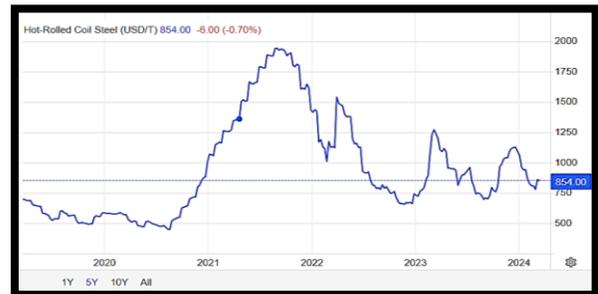


Figure 2. Raw Steel Prices

In addition to challenges of the general market, the project area included a corrosive environment, high groundwater tables, coral rock geology, linear distribution system, and a congested US1 corridor that is an evacuation route and exclusive north-south transportation route. The Florida Keys are subject to constant sun and salt spray. Wind in any direction becomes onshore wind from either the Atlantic Ocean or the Florida Bay. The salt air and salt groundwater cause early corrosion of the most resistive materials, with even 304 stainless steel beginning to rust after a short duration.

Groundwater is generally consistent with the surrounding ocean water both in salinity and water levels. With the Keys being coral islands, the ground is highly porous, allowing groundwater elevations to increase or decrease with the tides or other meteorological events. Typical elevations in the Keys are only 2 to 7 feet NGVD (National Geologic Vertical Datum), with the average elevation in the Upper Keys of 4.8 feet NGVD, allowing many low-lying places to flood from groundwater during king tide or strong consistent onshore winds. The coral rock geology, while being porous, is very hard and nearly impossible to excavate without special equipment.



Cathodic Protection, Islamorada

Typical water distribution systems favor a loop type layout with multiple options for supplying water to service areas even during routine maintenance or emergency situations. The linear nature of the Keys does not lend itself to such a system nor does it provide a reasonable option for a secondary water source at the southern end in Key West. During any unplanned or planned shutdowns of the transmission system, all service areas south of the shutdown rely on back feed from storage tanks or the two smaller RO plants in Key West and Marathon. Similar challenges associated with shutdowns in water flow apply to impacts or shutdowns on the flow of vehicles heading along US1. The US1 ROW is the only north-south corridor for vehicles or utilities, and all are competing for the prized real estate. The proposed pipeline alignment had to navigate existing utilities while also being constructable with minimal impacts on traffic flow.



Transmission Conduit being Installed.

Creative Solutions

To expedite the project and avoid material delivery delays, the FKA team implemented an early owner-direct pre-purchase program for the typical length straight steel

pipe sections and the 316 stainless-steel, high-performance, butterfly valves. During this process, the required pipe size and wall thickness were confirmed so the raw materials for the steel pipe (steel coil) could be procured early to lock in the material cost. Design information for the steel pipe is shown in **Table 1**. 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 the project was ready for construction. Wade Trim staff visited the plant during production and were able to inspect the pipe prior to shipping, allowing for the pipe to be sent down in convoys of two to four trucks (4 x 50-foot sticks per truck) on a regular basis, reducing the required staging area during construction. This also eliminated unnecessary trucking of pipes from a staging area through the congested US1 ROW.

Di	Finished Inside Dia. (in)	36	D1	Deflection Lag Factor	1.0
Pw	Working Pressure (PSI)	250	Hc	Height of fill over top of pipe (feet)	3 ft. to 10 ft. See Note 1
Pt	Surge Allowance (PSI)	100	w	Weight of Soil (lb/ft ³)	120 lb/ft ³
Pw+Pt	QA Test Pressure (PSI)	350		Bedding Angle (Central)	90 Degrees
Pf	Field Test Pressure (PSI)	300	K	Bedding Constant	0.096
Pv	Vacuum Pressure (PSI)	-14.7	R	Mean Radius of Pipe Shell (inch)	Dependent upon Pipe Size, Ty, and Lining Thickness
Dx	Maximum Deflection	2% inside diameter of finished pipe	EI	Pipe Wall Stiffness (lb-in ²)	See Note 2
Wd	Dead Load	wHeBc. See Note 1	Ty	Wall Thickness (inch)	0.375
Ww	Live Load	2 AASHTO H-20 Trucks Passing	Dy or Bc	Outside Diameter (inch) (min)	38.45 (or smaller)
E'	Maximum Soil Modulus	1,000	Fy	Minimum Yield of Steel (psi)	In accordance with these Specifications
			F	Impact Factor	1.5

Table 1. Steel Pipe Parameters



Pipe Stringing for Pull Back, Whale Harbor

Early coordination with FKAA on the connections allowed the project team to quantify the valves required so 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. Due to unforeseen issues at the manufacturers' foundries, the valves were still delayed in getting to the project site to keep up with pipe installation. The solution to keep the contractor working was to install a spacer piece temporarily and then come back later to install the valve. Steel pipe was welded, allowing for zero stretch to clamp the valve in place. The flanged piece on one side had an access manway added that would be cut in half, the flange section removed, and valve bolted and clamped into place. Finally, a butt strap would be welded over the cut section to make up the slight gap (Figure 3).

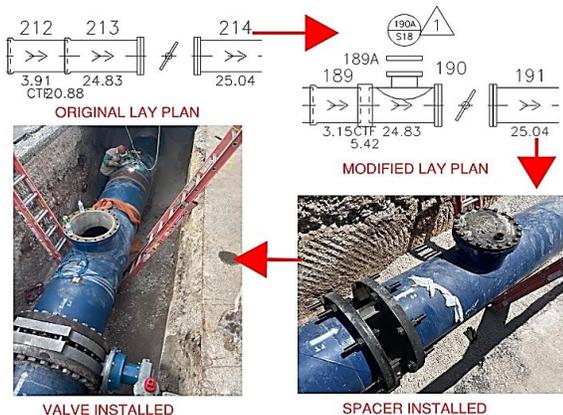


Figure 3. Valve Spacer

This early procurement strategy eliminated risk associated with material cost uncertainties during the bidding process and assured contractors that material availability would not delay the start of construction. Procuring the material and contracting a quality installer was only the first battle, the pipe and valves would still need to be installed in the ground and placed into service.



18-inch Connection to Existing Transmission Main, Windley Key

Installing underground utilities in coastal Florida, particularly the Keys, presents considerable challenges. Groundwater tables fluctuate, even surpassing road elevations during high tide events. Selecting the correct alignment was crucial in mitigating project challenges. Three general alignment options were evaluated as shown in Figure 4: Old Highway, US1 northbound shoulder, and US1 southbound lane. Old Highway was ranked least desirable due to congestion of existing sanitary sewer, more residential setting, distance from the existing transmission main, and lower elevations. US1 northbound shoulder was ranked second mainly due to an existing electrical duct bank that meandered along the shoulder and existing storm water structures that would have caused many vertical and horizontal deflections. Ultimately US1 southbound lane was selected because it allowed for shorter connections between existing main transmission infrastructure, was

virtually conflict free. The only real downside was the MOT related to losing the traffic lane. The major advantage of selecting the US1 roadway for the pipeline corridor was its ability to take advantage of the higher road elevations, with US1 ROW resembling an elevated berm through the middle of Islamorada. US1 in the project area is commonly 1 foot to 2 feet higher than the rest of the ROW allowing the pipe trench to remain dry with very little, if any, dewatering for most of the project length. Typically, a top of pipe elevation above 4.0 feet during usual tides provided a bottom of trench just above the groundwater levels. The dry pipe trench allowed the contractor to perform exterior welding, enabling production at twice the rate of the original project estimate.



Figure 4. Possible Alignments

However, installing the pipe within US1 did not come without its own set of challenges. US1 serves as the main thoroughfare for the Keys so proper maintenance of traffic (MOT) is crucial. 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 trenching activities and vehicular traffic (Figure 5). By not employing an alternating traffic pattern, the contractor is able to work 24 hours a day to shorten the project duration. While the 24-hour work schedule might sound like a major

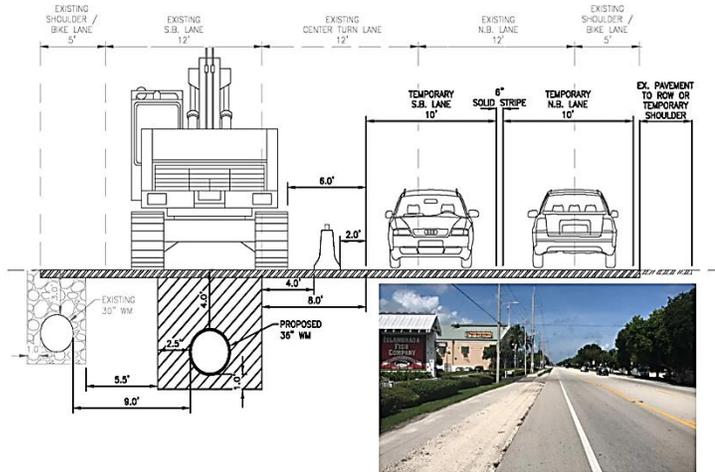


Figure 5. Typical MOT (Maintenance of Traffic) Cross Section

impact on the surrounding businesses and residents, the drastic reduction of workdays in front of property outweighed the nighttime work effects. Major pipe installation including excavation and backfill operations would occur during the day, and then at night the crews are able to mill and pre-trench for the next day's installation. The MOT was setup in sections allowing for a 1,000- to 2,000-foot work zone and would be moved concurrently with the project team on a weekly or bi-weekly basis. Paving typically occurred on a weekly basis to allow for approximately 1,000 LF per week to have regular traffic flow each weekend. Sunday night the MOT would be reset, and the milling and pre-trenching would begin again to prepare for the pipe laying operations on Monday.

Another special aspect of the Keys' geology is the highly porous nature of the coral rock which enables the washing out of fines from trenches if regular backfill is used. To ensure the trenches would not settle in the future, even if with sea level rising, 89 stone was used for the backfill for most of the trench and then capped off with filter fabric under the roadway base material (Figure 5). The 89 stone is too large to navigate out of the trench through the pores and the filter fabric helps prevent the fines from the roadway base from washing down into the backfill.

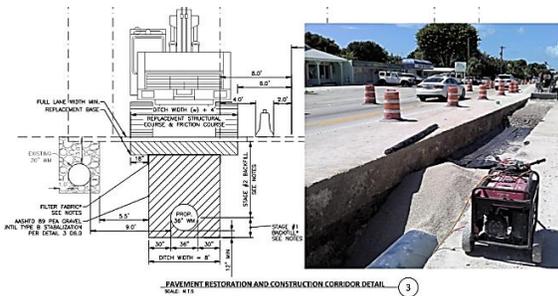


Figure 5. Backfill Detail

Subaqueous Crossings

The project area required subaqueous crossings at Tea Table Relief and Whale Harbor. Each crossing was installed with 42-inch-diameter, high density polyethylene pipe (HDPE) with a pressure rating of 200 psi (DR11). Due to the thickness of the pipe walls, the interior diameter was 34 inches, which was slightly smaller than the welded steel pipe. The crossings, ranging in length from 835 to 1,700 feet, were pulled in one day once the alignment was created using the reaming machine. To receive more competitive pricing, FCAA bid the subaqueous projects as independent projects to be completed as a dry line and left for the open cut contractor to connect to. By installing the HDD crossings as a dryline, the contractor, who specializes in HDD installation of the HDPE pipe, was not required to mobilize in a different crew or equipment to install the open cut steel pipe. To mitigate risk of the HDD crossing connection to the open cut, the contractor was required to flush, pressure test, and perform samples on the new line ensuring an acceptable line for certification once connected. The contractor for the open cut work was required to perform the overall flushing and disinfection and make the final connections. While there were some coordination issues that had to be managed in the field, the entire project team worked cooperatively to integrate these separate projects successfully.



Windley Key

With the project team mobilized on site and the threat of additional transmission main breaks in Windley Key, FCAA seized the opportunity to expand the Islamorada contract



leveraging the existing HDPE Pipe Pull Back being Installed relationships and communication. Michels provided a cost based on permitted 60% design plans and the project team worked to finalize the entire alignment and connections while keeping the project costs the same as in the 60% design drawings. Unlike Islamorada that had consistent straight alignments of US1 and existing utilities, Windley Key turns



Cutting Existing 30-inch for Tie-in Wye, Windley Key

about 45 degrees in the middle and the existing 18-inch and 30-inch transmission mains meander throughout the ROW. Knowing this early, the project team worked together. Michels performed soft digs to locate the existing mains throughout the project limits while starting on the south end of Windley Key. Roughly one quarter of the alignment had to be switched from one side to the opposite side of the existing 30-inch main and another half of the project was able to be shifted further onto the shoulder after Michels supplemental soft



Storm Crossing, Windley Key

The Windley Key 1.5-mile segment was cleared and placed into service in November 2024, just 4 months after Islamorada was placed into service.

Summary and Conclusion

No utility project comes without its own set of challenges, but the solutions developed are what determine its overall success. This project team faced multiple challenges from start to finish. Controlling costs during a volatile economic period and getting material on site in time threatened the project before it even started. During the preliminary design phase, a difficult project corridor and the linear nature of the Keys heightened the possible effects of choosing the wrong alignment. Fortifying the long-term operations of the transmission main required protection from the corrosive environment and the ability to access the piping in the future from hard coral rock. Finally, during the construction phase, impact on the residents and constructability had to be mitigated.

Through innovative approaches and creative problem-solving, the FKA team successfully minimized the impact of critical water main replacement in the Florida Keys. Early owner direct pre-purchase programs mitigated the effects of rapid price inflations and long lead times on materials and parts. Selecting the

digs. Both alignment changes were made with input from the contractor to minimize MOT disruption and costs from additional temporary pavement. The

pavement. The

correct alignment minimized the effects of the corrosive high-water table, difficulties in dewatering, and provided a clear path for the contractor to maximize installation efficiency. Additionally, FKA was able to harvest the lessons learned during Islamorada and apply them to Windley Key by keeping the project team together.

Next Steps

FKA continues to expand the transmission



Tie-in Wye Installed in Existing Water Main

main replacement to the North and South. The Plantation Key Water Transmission Main project is currently under construction and consists of 6.5

additional miles of 36-inch steel or 42-inch HDPE pipe to replace the existing 30-inch ductile iron. In Tavernier Creek two open cut sections require a 2,100-foot subaqueous crossing between gaps. The crossing started in February 2025 with MOT setup. The project was temporarily stopped by FDOT due to the MOT



Installation with Narrow ROW (Right of Way) for lane shift

impacts associated with the drill rig setup. The project team had already identified this as a potential risk and was able to implement a slight shift in the HDD alignment allowing for an additional lane of traffic and the HDD was successfully completed in May 2025. Currently the open cut installation has completed over 11,000 feet progressing from the south end of the project at Snake Creek Draw Bridge (MM 85.5) towards the Tavernier Creek HDD.



Islamorada water Transmission Construction

A smaller, isolated section in the southern end of Marathon on Knights Key was identified as a place of critical concern due to the existing 30-inch pipe alignment outside roadway and concrete retaining wall making future repairs costly and time consuming. The project consists of a roughly 2,300-foot HDD using 30-inch DR9 HDPE and short sections of open cut 30-inch steel on either side for a total project length of 3,100 feet.



All the way at the southern limits of the transmission main, FKAA is currently finalizing the design of a new 3 MG storage tank to improve storage capacity for holiday weekends or even scheduled shutdowns due to the linear nature of the distribution system. FKAA continues to improve the resiliency of the water distribution system to best serve Florida Keys residents.