Memorandum

To:	Daniel Harrison
From:	Victor Valenzuela, P.E.
Date:	February 17, 2016
Project Name:	Poor Creek Force Main Replacement Project
Project Number:	R14253R-02
Subject:	Poor Creek Force Main Condition Assessment Summary
cc:	Andy Snyder, Jason Garofalo (DAA) Kim Taylor, Ed Stelter (Faulconer) Joseph Modica (MBP)

The purpose of this memorandum is to summarize the findings from Draper Aden Associates' 2010 Condition Assessment of the Poor Creek Force Main, which consists of mainly 24-inch ductile iron pipe (DIP) and a small section of 20-inch DIP. The following sections of this Memorandum detail the procedures for determining the condition of the existing force main, observed testing results, and recommendations:

<u>Condition Assessment Procedures</u>

In December of 2010, Draper Aden Associates (DAA) in conjunction with G.L Howard and Nova Data Testing conducted a condition assessment of the Poor Creek Force Main by measuring pipe wall thicknesses at fourteen (14) locations along the force main alignment. The pipe wall thickness of DIP is a reliable indicator of the pipe's structural integrity as the presence of corrosive gases, such as hydrogen sulfide, gradually eat away at the interior pipe walls reducing the pipe wall thickness and making it more susceptible to failures. Generally, the section of the pipe that is most exposed to corrosive gases is the top of the pipe (i.e., crown). The bottom of the pipe (i.e., invert) is typically submerged with raw sewage and is less likely to have contact with corrosive gases. Hence, it is typical for the top section of pipe to experience the most corrosion and to have the thinnest pipe wall thickness.

At each of the fourteen (14) testing locations, ultrasonic measuring equipment was used to measure the pipe wall thickness. Pipe thickness readings were taken radially around the pipe at various "clock" positions. It should be noted that due to the physical properties of ductile iron pipe, ultrasonic testing on this pipe material is only accurate to within ±5%. In determining the overall condition of the pipeline, DAA used the collected pipe wall thickness data in conjunction with visual observations.

<u>Understanding Ductile Iron Pipe</u>

All DIP is designed with a casting tolerance, which is 0.07 inches for both 20- and 24-inch diameter pipe (Per AWWA C151/A21.51-02). This accounts for the variability in the casting process. In addition, all DIP is designed with a service allowance thickness of 0.08 inches. This additional wall thickness is added to the design thickness of each class of DIP in an effort to offset any corrosion or minor surface imperfections that might compromise the integrity of the pipe and pipe design. The additions of the 0.08-inch service allowance and 0.07-inch casting tolerance ensures that the actual wall thickness will exceed the design thickness, delivering an additional margin of safety and reliability. The following table details the pipe wall thickness tolerance range and minimum design thicknesses for both 20- and 24-inch DIP:

Table 1 - Ductile Iron Pipe Thickness*

Thickness Class	Casting Tolerance	Service Allowance	24-Inch Diameter Pipe			20-Inch Diameter Pipe		
			Thickness Tolerance Range		Minimum Design Thickness	Thickness Tolerance Range		Minimum Design Thickness
	in.	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
50	0.07	0.08	0.38	0.31	0.23	0.36	0.29	0.21
51	0.07	0.08	0.41	0.34	0.26	0.39	0.32	0.24
52	0.07	0.08	0.44	0.37	0.29	0.42	0.35	0.27
53	0.07	0.08	0.47	0.40	0.32	0.45	0.38	0.30
54	0.07	0.08	0.50	0.43	0.35	0.48	0.41	0.33
55	0.07	0.08	0.53	0.46	0.38	0.51	0.44	0.36
56	0.07	0.08	0.56	0.49	0.41	0.54	0.47	0.39

** Per AWWA C151/A21.51.-02, "Table 15, Dimensions and weights for special thickness classes of push-on-joint ductile-iron pipe"*

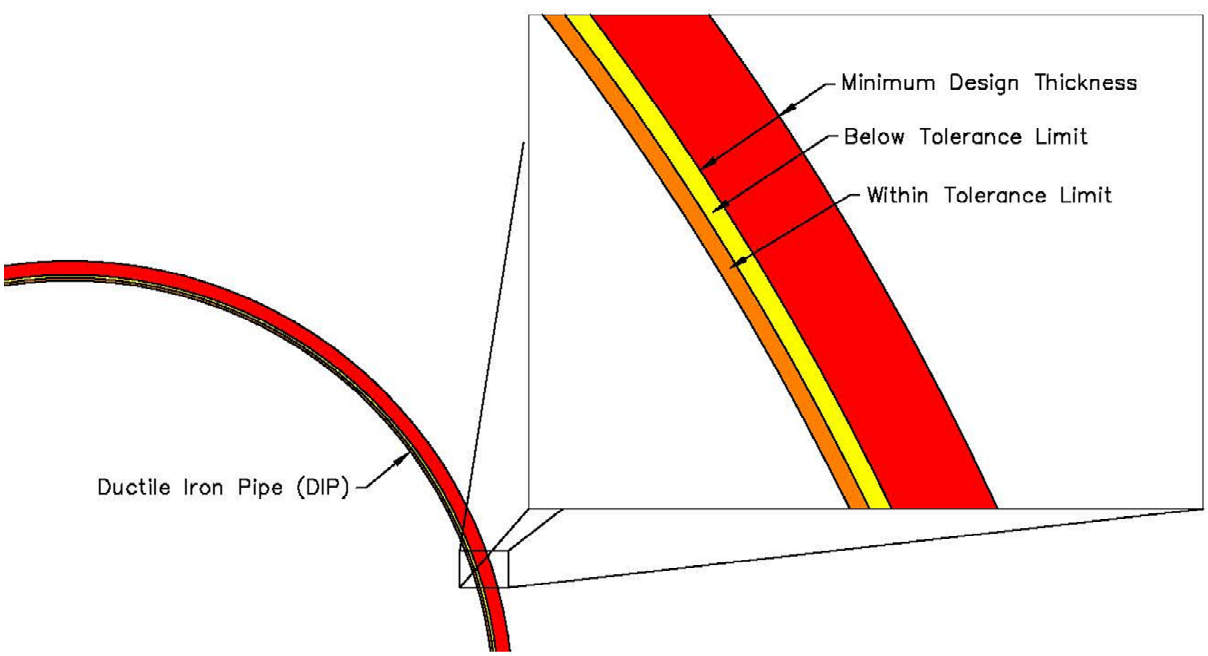
Condition Assessment Results

To determine the pipe thickness class at each testing location along the force main alignment, the testing results from the lower portion of the pipe (i.e., from the 4 o'clock to the 8 o'clock positions) were used. As previously mentioned, at these positions, the force main pipe is typical submerged; therefore, the pipe has had less opportunity to corrode and the thickness should be closer to the original thickness at the time of installation. We then compared the maximum recorded thicknesses to the thickness ranges above to determine the actual DIP Class Designation of the pipe.

Once we had established the assumed DIP Class Designation for each testing location using the maximum thickness measured, we could then use the minimum thickness measured to determine if the pipe was experiencing significant deterioration. DAA looked at the minimum possible pipe thickness at each test pit location, which would be 95% of the minimum recorded pipe thickness based on the ±5% testing accuracy. This thickness was then compared to the tolerance range for the corresponding Pipe Thickness Class. As set forth in the following table, which details a summary of the ultrasonic pipe wall thickness test results, nine Test Pits (1, 4, 5, 6, 6A, 6B, 6C, 6D, and 10) indicate pipe deterioration beyond the allowable tolerance. Four Test Pits (1, 6B, 6C, and 6D) are of critical concern as it appears the DIP has deteriorated below the design thickness, making these sections critically susceptible to failures.

Table 2 - Summary: Ultrasonic Pipeline Wall Thickness Test Results							
Location	**Assumed Pipe Class per Results**	**Measured Minimum Thickness**	**95% of Minimum Thickness**	**Thickness Tolerance Range**		**Min. Design Thickness**	**Existing Pipe Status**
	in.	*in.*	*in.*	*in.*	*in.*	*in.*	
Test Pit #1A	50	0.306	**0.291**	0.36	0.29	0.21	Within Tolerance Limit
Test Pit #1	51	0.238	**0.226**	0.41	0.34	0.26	Below Design Minimum
Test Pit #2	---	---	**---**	---	---	---	---
Test Pit #3	56	0.518	**0.492**	0.56	0.49	0.41	Within Tolerance Limit
Test Pit #4	55	0.407	**0.387**	0.53	0.46	0.38	Below Tolerance Limit
Test Pit #5	55	0.477	**0.453**	0.53	0.46	0.38	Below Tolerance Limit
Test Pit #6	53	0.379	**0.36**	0.47	0.4	0.32	Below Tolerance Limit
Test Pit #6A	56	0.456	**0.433**	0.56	0.49	0.41	Below Tolerance Limit
Test Pit #6B	55	0.394	**0.374**	0.53	0.46	0.38	Below Design Minimum
Test Pit #6C	51	0.265	**0.252**	0.41	0.34	0.26	Below Design Minimum
Test Pit #6D	50	0.192	**0.182**	0.38	0.31	0.23	Below Design Minimum
Test Pit #7	55	0.485	**0.461**	0.53	0.46	0.38	Within Tolerance Limit
Test Pit #8	53	0.441	**0.419**	0.47	0.4	0.32	Within Tolerance Limit
Test Pit #9	53	0.439	**0.417**	0.47	0.4	0.32	Within Tolerance Limit
Test Pit #10	52	0.341	**0.324**	0.44	0.37	0.29	Below Tolerance Limit

The following figure provides a graphical representation of the observed pipe wall thicknesses and the existing pipe status designation:



Recommendations

Based on these results, it is DAA's recommendation that the city focus on the replacement or rehabilitation of pipe that has deteriorated to below the minimum design standards (the "red" areas shown on the previous table). This will help to prevent failures and overflows in these high risk areas. We recommend this replacement or rehabilitation include approximately 500 feet of force main adjacent to the National Park Service (NPS) property and approximately 4,000 feet of force main from adjunct to the Civil War Trust Property and the Virginia Holding Property.