DES MOINES WATER WORKS
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MEMORANDUM

DATE: February 15, 2017

TO: William Stowe, CEO and General Manager

FROM: Danny J. Klopfer, P.E., Engineering Services Manager
Nathan Casey, P.E., Project Manager

SUBJECT: Water Main Replacement Analysis

There are an estimated 240,000 water main breaks each year in the United States. Des Moines Water Works alone has averaged 326 main breaks a year over the last 5 years and experienced the highest year on record in 2014 with 423 breaks. Due to the ever increasing number of failing pipes, staff decided to study the problem further. An analysis was performed looking at the factors leading to deterioration of buried infrastructure, forecasting of future breaks, investment scenarios which will lead to a sustainable system, projected useful life of water mains, and an updated method to prioritize main replacement projects.

History

Des Moines Water Works owns or operates approximately 1,430 miles of buried water pipeline infrastructure with a replacement cost of $1.2 billion dollars. This pipe creates a complex distribution system that has grown over the years leading to a wide variety of different pipe materials each with its own characteristics. The oldest active main still in the system dates back to 1871 and is 146 years old. Because of the ever increasing number of main breaks, staff began keeping detailed main break records in 1967. These records allowed a comprehensive analysis to be completed.

Buried Infrastructure Deterioration Factors

Several factors were evaluated to quantify buried pipe deterioration. The main factors effecting deterioration were identified as material vintage and pipe diameter. Pipe deterioration rates were measured as a function of infrastructure age versus break rate. The break rate is calculated by taking the number of breaks divided by the number of hundreds of miles of mains. Break rate is used by the industry as a measure of level of service.

In order to analyze the performance of varying pipe material and material vintages, the system was broken up into several “cohorts.” These cohorts included cast iron (prior to 1926), cast iron (1926-1947), cast iron (1948-1966), cast iron (after 1966), PVC, ductile iron, and pipes 14” and

larger (all materials). Poor performing material vintages were identified as cast iron (CI) 1948-1966, CI 1926-1947, and CI after 1966. Moderate performing material were identified as DI pipe, and pipe 14-inch and larger. Good performing material included CI prior to 1926 and PVC. The majority of the Des Moines distribution system is cast iron prior to 1926, cast iron 1948-1966, and PVC. The worst performing material, with a break rate of near 100, is CI installed between 1948 and 1966. The DMWW system contains approximately 219 miles of this pipe.

An evaluation of pipe diameter showed that smaller pipe break more often the larger pipes. Pipes 4-inch and smaller have break rates close to 200 breaks per 100 miles. There are approximately 276 miles of active 4-inch and smaller mains in the system.

The overall system break rate is 22.5 breaks per 100 miles of pipe. The American Water Works Association (AWWA) currently recommends a break rate of 15 or less.

Break Forecasting

A break forecasting analysis was performed to better understand why particular pipes break. In order to forecast breaks, an in depth analysis was performed to identify duration until next break and break rate by break count. This understanding was then used to estimate future breaks under a variety of investment scenarios. The break forecasting indicated that if nothing is done, DMWW could surpass 1,100 main breaks per year by 2040.

Useful Life of Buried Infrastructure

The useful life of a water main represents the median number of years the water main is expected to remain in service. The life of a particular pipe is highly dependent on the quality of construction, the quality of the manufacturing, and the pipe's unique environment. The overall length-weighted useful life of the DMWW system is approximately 166 years. Specific material life estimates vary from 249 years for PVC to 70 years for cast iron installed between 1948 and 1966. Useful life estimates are valuable for planning a renewable and sustainable distribution system.

Investment Scenarios

Several investment scenarios were developed to apply prudent, transparent, and reproducible methods to estimate how various funding levels would impact future service. Scenarios include sustaining the existing investment level, sustaining the existing service level, reducing the brake rate to 20, and reducing the break rate to the AWWA recommended rate of 15.

Each investment scenario includes a funding increase in 2018, an annual increase in funding each year after 2018, total renewal budget in 2040, the estimated 2040 break rate, an estimation of the number of breaks in 2040, the system replacement cycle, the costs for main repair in 2040, and the total annual cost of water main renewal and break repairs. Table 1-1 shows a summary of each investment scenario.

Table 1-1: Investment Scenarios

Scenario	Funding in 2018	Funding Increase (Annual)	2040 Renewal Funding	2040 Break Rate	2040 Break Count	2040 Replacement Cycle (years)	2040 Main Repair Costs	2040 Total Annual Costs
A: Sustain Existing Investment Levels	$2.1M	0%	$2.1M	36	865	1,271 years	$17M	$19M
B1: Sustain Existing Service Levels - 1	$7.0M	2.12%	$10.9M	22	540	234 years	$11M	$22M
B2: Sustain Existing Service Levels - 2	$4.9M	4.50%	$15.2M	22	540	169 years	$11M	$26M
B3: Sustain Existing Service Levels – 3 ($5M in DM, $1.4M others)	$6.4M	2.9%	$12.1M	22	540	212 years	$11M	$23M
C: Break Rate = 20	$7.3M	3.75%	$16.6M	20	482	155 years	$9.5M	$26M
D: Break Rate = 15	$10.7M	4.40%	$27.5M	15	360	94 years	$7.1M	$35M

The table above shows that if the existing investment level is sustained by 2040, it is estimated that break rate will increase to 36, number of breaks will increase to 865, and the system will have a replacement cycle of 1,271 years. This level of investment is not considered sustainable and will continue to decline beyond 2040. All of the B scenarios also lead to an unsustainable system with replacement cycles over the estimated life of the system. Scenario C and D are sustainable and provide an increase level of service for customers.

Recommendation and Capital Costs

In order to provide a system with an improved level of service for the customer and a sustainable replacement rate the recommended investment Scenario is C. Scenario C assumes existing investment levels are increased over the next 23 years; with 7.0 miles of replacement starting in 2018 at a cost of $7.3 million dollars and a 3.75% increase in funding each subsequent year until 2040. This scenario reduces break rate to 20 (a 10% reduction) which, while it's still greater than the recommended 15, staff considered a reasonable rate. Scenario C also provides a system replacement rate of 155 years which is considered a sustainable system.

The needed $7.3 million would need to come from rate increases. Polk County already has applied a $1.50/1,000 gallons for water main replacement which provides approximately $1.4 million per year. Windsor Heights Customers pay an additional $2.00/1,000 gallons for water main replacement which provides approximately $200,000 per year. The Des Moines System customers would need around $5.7 million in 2018 to fund replacement in Des Moines. A rate of $1.00/1,000 gallons would provide approximately $6.1 million dollars.