WATER POLLUTION CONTROL AUTHORITY

Town of Trumbull

CONNECTICUT

TOWN HALL
(203) 452-5048

5866 MAIN STREET
TRUMBULL, CT 06611

SEPTEMBER 23, 2020
MINUTES

Call to Order: The Chair called the meeting to order at 7:03 p.m.

Roll Call: The clerk called the roll and recorded it as follows:

Present: Chairman Richard Boggs, Charles Berezin, Jon Greene, Frank Regnery

Absent: Scott Thornton

Also Present: William C. Maurer, Town Engineer/ Sewer Administrator. Town Attorney James Nugent, Christine Kurtz of Wright Pierce, Vanessa McPhearson of Arcadis

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The Chair reminded the participants each speaker should identify themselves every time they speak and when appropriate state their title. The Chair also reminded those present only one person should speak at a time and all votes will be taken by roll call.

1. Approval of Minutes: Moved by Greene, seconded by Regnery to approve the July 22, 2020 meeting minutes as submitted.

   The clerk called the roll call vote and recorded it as follows:

	Aye	Nay	Abstain
Richard Boggs	☒	☐	☐
Charles Berezin	☒	☐	☐
Jon Greene	☒	☐	☐
Frank Regnery	☒	☐	☐

   VOTE: Motion CARRIED unanimously

2. New Business:
   - *Request for Sewers Finchwood Drive Area*
     The Chair noted the Finchwood Drive area is just east of the fields at St. Joseph's High School close to the Shelton line.

Mr. Maurer explained they had received a request for sewers to be installed in the Finchwood Drive area, the previous contract stopped at Copper Kettle Drive and MacDonald Road. There is a section between Huntington Turnpike and the Shelton line that don't have sewers. The lots are bigger but doesn't know the reasoning for stopping at that section. The Health Department has records back to 2015 and only have a record of one septic failure, there could be more but they only have record of the one.

The Chair noted there was no action the commission needed to take on this item. This area is not part of the next stage of sewers. The next phase is focused on higher density lots.

Mr. Maurer explained the resident has concerns over the age of the septic system and the likelihood of it failing and potential availability of sewers. Repairs to a septic system are expensive and if sewers were to be put in a couple of years after the repair was done it would result in an assessment in addition to the cost of the repair, which is quite burdensome.

Mr. Maurer would have to go further back into the history to see why the previous project didn't include this area. Mr. Greene noted the previous project was large, it may have been an arbitrary decision or it may have been geographically driven. It does seem logical to stop before the Shelton line.

The commission questioned whether there was a strategy for sewers in other areas in town. The previous contract was Contract IV and was completed in 2010-2011. Mr. Maurer noted there are larger lots in the Finchwood area which do have potential room to repair and/or put in a septic system. The Chair noted Contract 5 lots don't have the room for leaching fields. Mr. Maurer indicated the Finchwood area has a fair amount of wetlands which may have been the concern.

Mr. Maurer indicated the town is required to submit a draft sewer plan to the State periodically and has previously done so. Ms. Kurtz explained there is a draft plan under the previous administration, Contract 5 is essentially the last area to sewer, with infill that may happen here and there. She indicated the commission is coming to the end of the draft planning of projects in town and confirmed for the Chair the Finchwood area wasn't included in the plan. The commission requested a copy of the plan. Mr. Maurer indicated it would be distributed to the commission and confirmed Primrose Drive has sewers.

The town sewer map was screen shared. Finchwood Drive is uphill from Copper Kettle and is a good distance away. Mr. Maurer clarified the resident's request includes the question why this area wasn't included in the previous project. The Chair indicated the resident's letter was included in the agenda packet.

Mr. Berezin noted the resident, Ms. Todisco and her neighbor had joined the virtual meeting. The Chair noted people need to have a sense of whether this is in the planning stages or if there is a likelihood that this would happen anytime soon. The Chair indicated sewers in this area would not happen anytime soon, the area is independent of

other areas contemplated for sewers. They could ask Ms. Kurtz to review the plan to see if this is an area that could be considered in the future. The Chair directed the residents' questions be forwarded to Bill Maurer after the meeting. The commission is aware of the request now, there will be opportunity to speak at the next meeting and the commission will be in a better position to answer questions this is researched. With regard to failing septic systems in the area or close to failing it will be years away, 4-5 years and possibly substantially more than that before sewers are there. Septic repairs would be required.

3. Old Business:
   - *Corrosion Probe Update*

     Mr. Maurer explained they had recently done two test holes in Beardsley Park;
     - At the entrance of the park and;
     - One before the crossing of the river.

     The draft report was distributed to the commission just today, (Attached). The report indicates the pipe is in better shape than they thought. There are issues but the exterior of the pipe didn't show any visible corrosion. There were some test locations around the perimeter of the pipe that showed some potential pipe loss on the interior. They aren't out of the woods yet and still need to do more.

     Ms. McPhearson shared the map that shows the test pit and point of failure locations. The Chair noted the report has some errors in the orientation, it refers to south as upstream, which needs to be corrected. Ms. McPhearson explained it was a draft report and wanted to be able to review this with the commission this month, they have communicated the typos to Corrosion Probe and will be addressed. The Chair suggested attaching the map to the report. Ms. McPhearson confirmed she would make that suggestion.

     Ms. McPhearson reviewed the map and orientated the commission. The approach identified to the commission was to do a test pit upstream, which is test pit #1 and a test pit right before the pipe crosses under the river. Those are the two test pits referred to in the Draft Corrosion Probe Report. The intent of the test pits was to get some bounds on the extent of the bottom of pipe corrosion. They didn't find any smoking guns, but cautioned no one can foresee the future. There were some results that showed thinning of the pipe wall at the bottom of the invert. The outside of the pipe looks like it is in excellent condition field soil testing was done. This didn't indicate there were issues that would cause pipe corrosion. It confirmed the mechanism of failure of the January 2020 break. They will recommend looking at a repair or an outright replacement of a longer section of pipe. When they did the repair in January they could see what Corrosion Probe is seeing with their ultrasonic measurements. While not catastrophic and not something they would anticipate needing an emergency repair it is something that still needs to be paid attention to and addressed.

     Ms. McPheasron indicated the record drawings for the pipe call out different classes of pipe but there is no key that indicates wall thickness. A lot of the information in the Corrosion Probe Report is an average wall thickness that they measured with an instrument not an as-built thickness. She didn't know the thickness of the pipe at the point of failure off the top of her head, she would need to look it up in the prior report. Mr. Maurer stated there is a big difference when you compare what was taken out to what was

installed. Ms. McPhearson added the original pipe installation would have been with a cement mortar lining to protect the interior of the pipe from interior corrosion. It does appear the cement lining is compromised. This was observed in the removed section and is also evidenced in the sporadic thinning seen around the circumference, which is why it is sporadic and not continuous. Mr. Maurer indicated they would be better served and to be conclusive to do testing on Stelsam on the other side of RT 25 where there is a similar slope condition. Then they should go into design for replacing this section of pipe in the park until they see what the Stelsam results are. It would be approximately 1500' of pipe in the park out of a total of 9,500'. This is the easiest section to bypass, it's also the section that has the lowest slope and velocity.

Ms. McPhearson explained the original pump station was outfitted for three pumps but only two were installed. The 20" force main was sized for a future condition but never designed to, now we have the full capacity to take advantage of the 20" pipe. As soon as they are confident that the pipe can handle it they won't have issues with scour velocity with the pumps that have been installed. While they are on bypass with the lining and/or replacement of the pipe they could camera other sections of the line to look under the river to get eyes on things that are hard to see. More test pits have limited value when the pipe looks great on the outside, it will be critical to see what is going on inside when we have a section out of service.

Ms. McPhearson explained a lot of preliminary work has been done. They will be able to move fairly quickly to develop a design package, the question will be the logistics on the bypass, and how much to bypass to be able to camera additional sections of the line. They are in constant communication with Mr. Maurer on this and will be able to coordinate bid-ready design documents within 2-3 months. Mr. Maurer confirmed they would bypass up and downstream and recommended doing the same Corrosion Probe testing on the other side of RT 25, it's off the shoulder of the road between a fence and a guardrail, there will be logistics.

Mr. Maurer indicated the City of Bridgeport has been very cooperative. Attorney Nugent stated they would want to coordinate with the Bridgeport Public Works Department. Trumbull's Public Works Director is very knowledgeable and would know the people to speak with regarding whether Bridgeport's DPW can authorize the work or if they need other authorizations.

Mr. Maurer confirmed there is $400,000 in the current budget for the force main, as part of the design suggesting moving forward the commission consider what should be budgeted in the Capital Plan. The cost can't be estimated until there is a design, the bypass will be costly. It is possible to put a pipe alongside and do cut-ins, they also want to look at lining. This will be investigated in the design phase. The Chair confirmed Mr. Maurer could proceed to design.

- *Beardsley Pump Station Rehabilitation Update*
  Mr. Maurer reported they are currently working on punch-list items, the pump station is operational, and the WPCA staff has been moved back into the pump station work space, they are 98% complete. Everything is running well. The plaque has been installed and will

send pictures to the commission. In the future when appropriate he would like to have a dedication ceremony.

- *Old Town and Reservoir Avenue Pump Stations Update*
  The bid documents are being finalized and are almost ready. This work can be done at any time. Ms. McPhearson explained there will be excavation for the pump station replacements and the sewer replacement added in for Reservoir Avenue. The timing works well, by the time they receive and review plans and get equipment submittals they will be ready for more favorable weather in the spring.

4. Any Other Business That May Come Before the Authority – None

5. Adjournment: There being no further business to discuss and upon motion made by Berezin, seconded by Regnery the clerk called the roll call vote and recorded it as follows:

	Aye	Nay	Abstain
Richard Boggs	☒	☐	☐
Charles Berezin	☒	☐	☐
Jon Greene	☒	☐	☐
Frank Regnery	☒	☐	☐

VOTE: Motion CARRIED unanimously

The Trumbull Water Pollution Control Authority unanimously adjourned at 7:51 p.m.

Respectfully Submitted,

Margaret D. Mastroni

Margaret D. Mastroni, WPCA Clerk

CORROSION PROBE, INC.

THE COMPLETE ENGINEERING APPROACH – FROM DETECTION TO CORRECTION

CONDITION ANALYSIS REPORT

On

Beardsley Force Main

For The

Town of Trumbull, CT

Prepared for

ARCADIS

Prepared by:

Corrosion Probe, Inc.

September 2020

MPI074

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CORROSION PROBE, INC.

THE COMPLETE ENGINEERING APPROACH – FROM DETECTION TO CORRECTION

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1.0 INTRODUCTION AND BACKGROUND

In fulfillment of the Corrosion Probe, Inc. (CPI) proposal to analyze the condition of the Beardsley Park Force Main, following the investigation of a localized failure of the subject force main in January 2020, the following report documents a number of field inspections performed at various locations on the subject force main. This report should be considered in conjunction with CPI Report titled *Force Main Failure Inspection Report at the Beardsley Pump Station for the Town of Trumbull, CT* issued to Arcadis on May 6, 2020 and the CPI Analysis Report titled *Beardsley Park Force Main Analysis located in Trumbull, CT* issued to Arcadis on July 20, 2020.

The subject piping consists of 20" ductile iron (DI) piping. Between August 8, 2020 and September 17, 2020, Mr. Bryce Annino and Mr. Tom Sherer performed inspections of the subject piping at two (2) Air Release Valve (ARV) manhole structures and two (2) excavated test pits. During the site visits, CPI inspected all visible exterior pipe surfaces as well as performing the following (if able):

- Careful visual examination to assess the condition of the pipe, existing external coal tar coatings, and confirming the pipe material.
- Taking of digital photographs of findings.
- Pit depth gauge measurements on the exterior of the pipe - recording the results.
- Ultrasonic thickness (U.T.) measurements were taken at multiple locations on the exposed pipe to measure remaining wall thickness of the pipe. This testing was focused on finding internal corrosion losses and on measuring the extent of any general external thinning of the pipe wall.
- Pipe to soil potential measurements were obtained using a copper-copper sulfate reference electrode and high-resolution volt meter.
- Stray current identification measurements were obtained by extending pipe to soil potential readings.
- Soil samples were obtained at each test pit for future corrosivity testing and analyses (if required).

2.0 FIELD FINDINGS

Note that test pits were excavated, shored and dewatered by others prior to CPI's arrival to the testing locations. The air release valves (ARVs) were mechanically inspected and/or replaced by others and were not subject to CPI's scope of work.

2.1 ARV 1 (08/12/20)

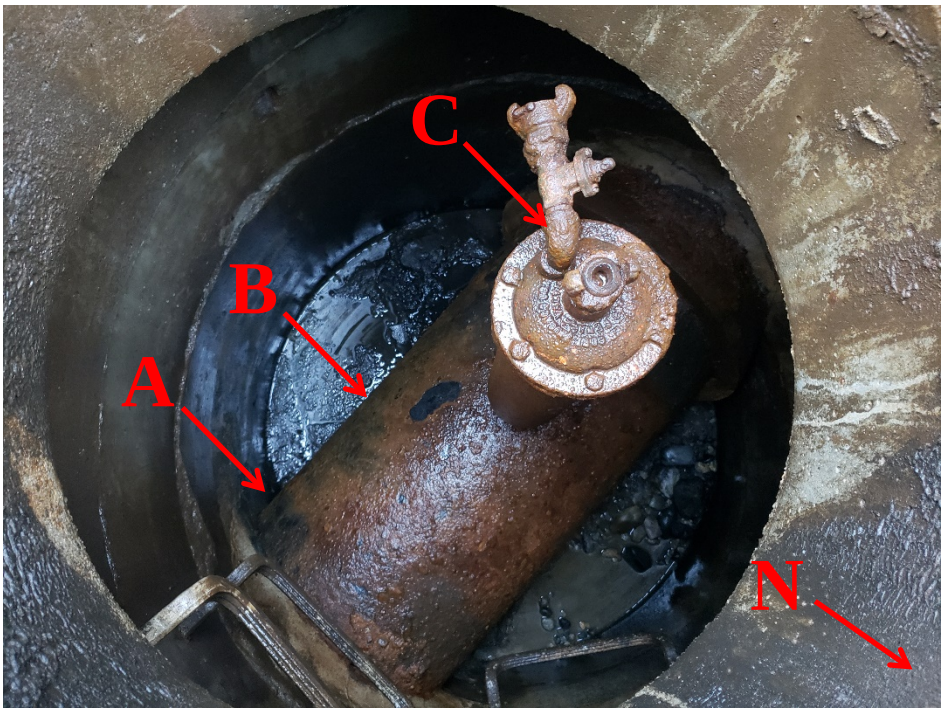
Location: Sylvan Ave & Reservoir Ave in Bridgeport, CT
Pipe: 20" ductile iron pipe
Flow: East to West

External Conditions: This ARV is located in the intersection of Sylvan Avenue and Reservoir Avenue in Bridgeport, CT. The crown of this pipe is approximately 4' below the top of asphalt. General surface corrosion was observed typically across all surfaces of this pipe. The areas of exfoliated corrosion product buildup (scale) on the surface of the pipe were approximately 1/8" thick. Minor graphitic corrosion was present beneath the general surface corrosion. Isolated pitting was measured to maximum depths of 1/16 inch. No obvious signs of leaking were observed at the exposed joint within this structure.

Internal Conditions: Three (3) circumferential locations were chosen for ultrasonic thickness (UT) testing. These locations are denoted as locations A, B and C; A being on the east end of the pipe. Clock positions are looking in-line with the flow of the pipe, with 12:00 being the top of the pipe and 3:00 being to the North. Results for the UT testing can be found in **Table 1** below. Further discussion of UT results can be found in **Section 3**.

TABLE 1: 20" DI PIPING ULTRASONIC THICKNESS MEASUREMENTS (inches)											
LOCATION		CLOCK POSITION						MAX.	MIN.	AVE.	MIN./ AVE.
COMPONENT	AREA	3:00	1:30	12:00	10:30	9:00	7:30				
ARV 1	A	0.471	0.423	0.649	0.481			0.649	0.423	0.506	84%
SYLVAN &	B	0.397	0.466	0.443	0.450	0.437	0.480	0.480	0.397	0.446	89%
RESERVOIR	C	0.632	0.553	0.570	0.581	0.523		0.632	0.523	0.572	91%

Table 1 – Ultrasonic Thickness Measurements at ARV 1



Photograph No. 001 – Overview of ARV 1 Location

Photograph No. 002 – Typical view of general surface corrosion & scale
Note that no dimpling was visible beneath removed corrosion scale

2.2 ARV 2 (08/12/20)

Location: Seltsam Road @ Dale Street in Bridgeport, CT
Pipe: 20” ductile iron pipe
Flow: North to South

External Conditions: This ARV is located in the intersection of Sylvan Avenue and Reservoir Avenue in Bridgeport, CT. The crown of this pipe is approximately 7’ below the top of asphalt. General surface corrosion was observed at either end of the pipe with the remainder of the pipe surface in generally good condition with manufacturing coating and dimpling generally intact. The areas of exfoliated corrosion product buildup (scale) were approximately 1/8” thick. Minor graphitic corrosion was present beneath the general surface corrosion. Isolated surface pitting was measured at 1/16”. No obvious signs of leaking were observed at the exposed joint within this structure.

Internal Conditions: Four (4) circumferential locations were chosen for ultrasonic thickness (UT) testing. These locations are denoted as locations A, B, C and D, A being on the south end of the pipe. Clock positions are looking in-line with the flow of the pipe, with 12:00 being the top of the pipe and 3:00 being to the East. Results for the UT testing can be found in **Table 2** below. Further discussion of UT results can be found in **Section 3**.

TABLE 2: 20" DI PIPING ULTRASONIC THICKNESS MEASUREMENTS (inches)											
LOCATION		CLOCK POSITION						MAX.	MIN.	AVE.	MIN./ AVE.
COMPONENT	AREA	3:00	1:30	12:00	10:30	9:00	7:30				
ARV 2 DALE ST	A	0.486	0.424	0.402	0.417	0.419	0.417	0.486	0.402	0.428	94%
	B	0.423	0.420	0.442	0.417	0.406	0.410	0.442	0.406	0.420	97%
	C	0.432	0.431	0.425	0.416	0.367	0.415	0.432	0.367	0.414	89%
	D	0.413	0.427	0.355	0.492	0.427		0.492	0.355	0.423	84%

Table 2 – Ultrasonic Thickness Measurements at ARV 2

Photograph No. 003 – Overview of ARV 2 Location

Photograph No. 004 – Close up of scale and cleaned-off UT location A
Note the visible dimpling where minor corrosion product is removed from surface

2.3 Test Pit 1 (09/15/20)

Location: Beardsley Park (Upstream of January 2020 failure)
Pipe: 20” ductile iron pipe
Flow: North to South

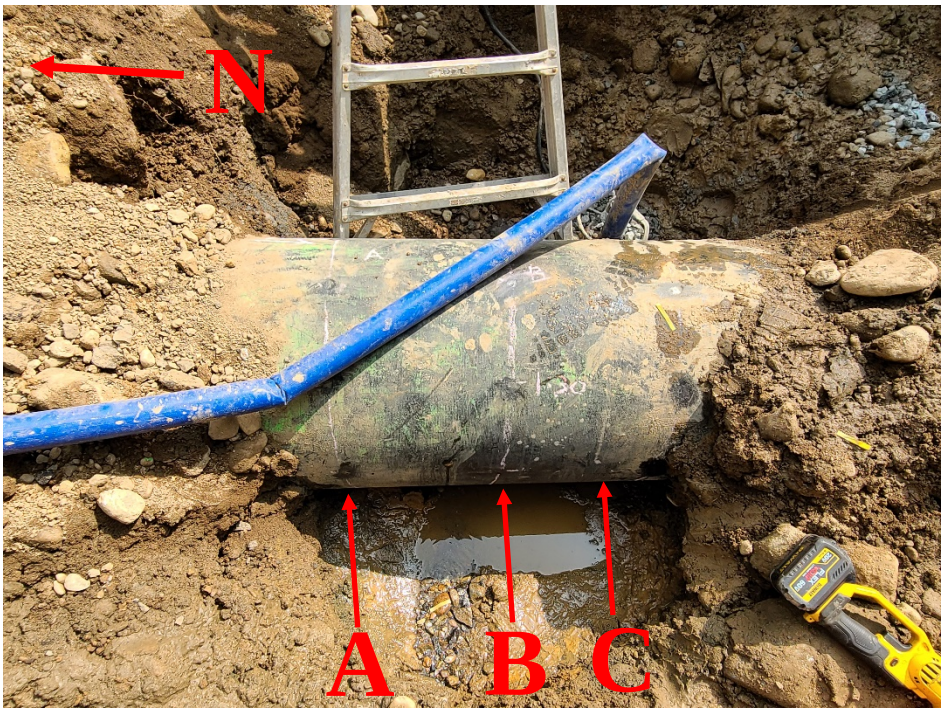
External Conditions: This test pit is located in Beardsley Park roughly 650’ south of the January 2020 failure. The crown of this pipe is approximately 14-’6” below grade with a consistent flow of ground water at pipe elevation. No significant surface corrosion was observed on the pipe with the pipe surface in good condition with original manufacturer’s coating and dimpling generally intact. No joint was exposed in this test pit location.

Internal Conditions: Three (3) circumferential locations were chosen for ultrasonic thickness (UT) testing. These locations are denoted as locations A, B and C, with A being on the north end of the pipe. Clock positions are looking in-line with the flow of the pipe, with 12:00 being the top of the pipe and 3:00 being to the West. Results for the UT testing can be found in **Table 3** below. Further discussion of UT results can be found in **Section 3** of this report.

Soil Characteristics: The bedding and local environment of the force main at this location appeared to be in sandy clay. The pH of the soil and the surface of the pipe were found to be 7.5 and 7.0, respectively. Both quite neutral values. Pipe-to-soil current measurement for DC current was found to be -0.489 V, with no stray current detected (note: an abandoned gas pipeline was exposed in this excavation, but no indication of electrical influence from impressed cathodic protection was detected). A soil sample was taken from the side of the test pit at the pipe elevation. This sample can be sent to CPI’s affiliate laboratory for aggressivity analysis, though no indications of an aggressive environment were found in the field and further laboratory testing is not deemed necessary by CPI at this point in time.

TABLE 3: 20" DI PIPING ULTRASONIC THICKNESS MEASUREMENTS (inches)													
LOCATION		CLOCK POSITION								MAX.	MIN.	AVE.	MIN./ AVE.
COMPONENT	AREA	12:00	1:30	3:00	4:30	6:00	7:30	9:00	10:30				
TEST PIT 1 BEARDSLEY	A	0.437	0.437	0.455	0.403	0.339		0.652	0.305	0.652	0.305	0.433	71%
	B	0.411	0.486	0.477	0.404	0.491	0.465	0.477	0.392	0.491	0.392	0.450	87%
	C	0.550	0.353	0.547	0.555			0.499	0.589	0.589	0.353	0.516	68%

Table 3 – Ultrasonic Thickness Measurements at Test Pit 1



Photograph No. 005 – Overview of Force Main at Test Pit 1

Photograph No. 006 – Close up of pipe surface
Note the dimpling and intact shop-applied coal tar coating

2.3 Test Pit 2 (09/15/20)

Location: Beardsley Park (Downstream of January 2020 failure)
Pipe: 20” ductile iron pipe
Flow: East to West

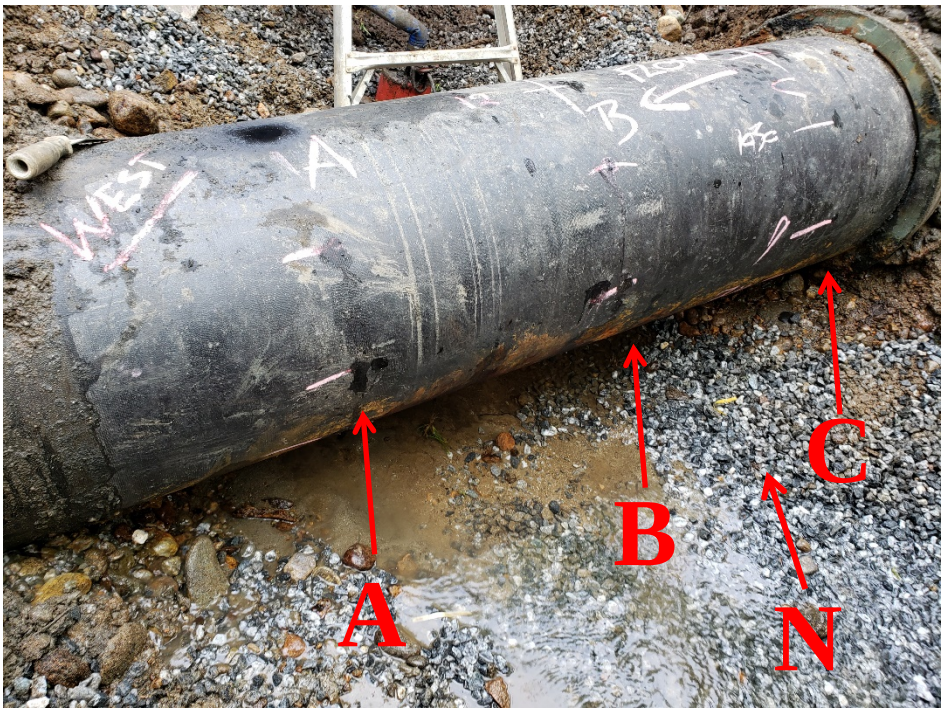
External Conditions: This test pit is located in Beardsley park roughly 600’ north of the January 2020 failure. The crown of this pipe is approximately 8’-0” below grade with a consistent flow of ground water at pipe elevation. Minimal surface corrosion was observed on the pipe with the pipe surface in generally good condition with manufacturer’s coating and dimpling generally intact. A joint was exposed in this test pit location on the north end of the excavation. It was observed in the field that the pipe was laid in the non-traditional direction, as evidenced by the exposed joint (the bell opening was in the downstream direction).

Internal Conditions: Three (3) circumferential locations were chosen for ultrasonic thickness (UT) testing. These locations are denoted as locations A, B and C, A being on the west end of the pipe. Clock positions are looking in-line with the flow of the pipe, with 12:00 being the top of the pipe and 3:00 being to the north. Results for the UT testing can be found in **Table 4** below. Further discussion of UT results can be found in **Section 3**.

Soil Characteristics: The bedding and local environment of the force main at this location appeared to be sandy clay. The pH of the soil and the surface of the pipe were found to be 7.0 and 7.0, respectively. Both quite neutral values. Pipe-to-soil current measurement for DC current was found to be -0.572 V, with no stray current detected. A soil sample was taken from the extent of the test pit at the pipe elevation. This sample can be sent to CPI’s affiliate laboratory for aggressivity analysis, though no indications of an aggressive environment were found in the field and further laboratory testing is not deemed necessary by CPI at this point in time.

TABLE 4: 20" DI PIPING ULTRASONIC THICKNESS MEASUREMENTS (inches)													
LOCATION		CLOCK POSITION								MAX.	MIN.	AVE.	MIN./ AVE.
COMPONENT	AREA	12:00	1:30	3:00	4:30	6:00	7:30	9:00	10:30				
TEST PIT 2 BEARDSLEY	A	0.651	0.745	0.737	0.595	0.673	0.674	0.688	0.703	0.745	0.595	0.683	87%
	B	0.550	0.598	0.654	0.582	0.645	0.478	0.648	0.573	0.654	0.478	0.591	81%
	C	0.492	0.492	0.536	0.482	0.329	0.451	0.457	0.448	0.536	0.329	0.461	71%

Table 4 – Ultrasonic Thickness Measurements at Test Pit 2



Photograph No. 007 – Overview of Force Main at Test Pit 2

Photograph No. 008 – Close up of bell at north end of excavation with minor corrosion
Note that there is a green coating on the edge of the bell, generally intact

3.0 CONCLUSIONS

Pipe exteriors at ARV locations exhibit general surface corrosion and isolated pitting with pit depths measured at approximately 1/16". No leakage was observed at either ARV location. Pipe exteriors in both test pits were in good condition with no significant external corrosion observed on either pipe. No leakage was observed from either pipe in the two test pits and no leakage was noted at the exposed bell and spigot joint in Test Pit #2. Pipe to soil testing in each of the test pits was found to be within the expected range and neither pipe exhibited any stray current effects.

Generally, the external scaling and pitting observed at ARV locations is minimal compared to internal corrosion losses derived from UT testing. CPI determines that external corrosion is not the primary factor limiting service life of the pipes at ARV locations. Pipes observed at test pits 1 & 2 exhibited no significant external corrosion and therefore the internal corrosion losses derived from UT testing are the primary factor limiting service life at the test pit locations.

The pipes in the ARV and in the test pit locations were assessed internally by means of UT testing. UT testing is used to measure the existing/remaining wall thickness of metallic pipes and structures. UT measurements are based on a transmitter-receiver principle; a signal is sent out by a transducer which is in contact with the external surface of the metal structure with the aid of a gel couplant. The signal goes back and forth through the tested material gradually weakening on each return. The gauge, projecting and receiving the signal through the transducer, measures the time between the signal being projected and received. The transit time of the signal is then correlated to the velocity of the material and graphically expressed as a thickness reading on the gauge.

As compared with steel, the grainy graphite and iron matrix substructure in ductile iron piping acoustically disperses the UT signal, making the acquisition of accurate data more challenging. The pipe used in this force main is from the early 1970's and is denoted in the record documents as Class I-IV (note that "Class X" is neither a standard Thickness Class or Pressure Class designation). Ductile iron piping was not largely utilized until the 1970's in lieu of traditional cast iron pipe. Ductile iron is a form of cast iron where the microstructure is granular with the graphite particles being in nodular form largely surrounded by the iron matrix. This allows for ductile iron to be less prone to graphitic corrosion, and less brittle ("ductile" - hence the name) than its traditional grey cast iron counterpart.

Since ductile iron has significant variation in its metallurgical microstructure, there is no set UT velocity for this material. A generic ductile iron coupon was used to calibrate the UT gauge at each inspection. The use of a generic coupon for calibration may return less-than accurate results, though repeatability of values and precision of results would indicate that the values obtained during each inspection are reliable as a means of comparing circumferential consistency.

TABLE 5: 20" DI PIPING ULTRASONIC THICKNESS MEASUREMENTS - PIPE WALL THINNING > 10% (inches)												
LOCATION		CLOCK POSITION								PIPE	MIN./	Percent
COMPONENT	AREA	12:00	1:30	3:00	4:30	6:00	7:30	9:00	10:30	AVG.	AVG. (%)	loss
ARV 1	B			0.397						0.508	78%	22%
ARV 2	C							0.367		0.421	87%	13%
	D	0.355								0.421	84%	16%
TP 1	A					0.339				0.466	73%	27%
	A								0.305	0.466	65%	35%
	B								0.392	0.466	84%	16%
TP2	C					0.329				0.578	57%	43%
Totals		1	0	1	0	2	0	1	2			

Table 5 – Ultrasonic Thickness Measurements - Pipe Wall Thinning > 10%

Table 5 documents the instances where pipe wall thinning exceeded 10% at each UT testing location. The likely corrosion mechanism at the ARV locations was determined during the desktop analysis to be potential headspace formation at the crown of the pipe (12:00 position) with corrosive attack due to atmospheric H_2S formation. Indications of this mechanism of corrosion were observed at ARV 2 where a 16% loss was observed compared to the pipe wall average. Note that although this loss at the pipe crown is significant, similar and greater losses were also recorded at 9:00 and 3:00 locations on ARV piping. Given the data obtained from the ARV piping, the desktop analysis cannot be dismissed, but is not conclusive. The atmospheric H_2S mechanism in the pipe crown is likely combined with isolated instances of localized oxygen-driven pitting corrosion developing at anodic sites associated with spot failures of the cement mortar lining.

The likely primary corrosion mechanism at the test pit locations was determined during the desktop analysis to be potential microbiologically-influenced under-deposit corrosion coupled with erosive scouring at the pipe invert (6:00 position). Indications of this mechanism of corrosion were observed at TP 1 where a 27% loss was recorded compared to the pipe wall average. A second indication of this mechanism of corrosion was recorded at TP 2 where a 43% loss was observed compared to the pipe wall average. Note that although these losses at the pipe inverts are significant, similar losses were also recorded at the 10:30 location on test pit piping. Given the UT data obtained from the test pit piping, the desktop analysis cannot be dismissed, but is not conclusive. The microbiologically-influenced under-deposit corrosion mechanism in the pipe invert is the apparent cause of the damage.

CPI tested two high points in the pipeline (ARV locations) based on the desktop analysis of pipe crown corrosion and two test pit locations were selected at locations that were similar to and in proximity to the failure site (flat areas in pipe profile) in an attempt to determine the extent of potential pipe invert corrosion as determined by the desktop analysis. Evidence of both corrosion mechanisms were observed, but testing at both the ARV and test pit locations raised concern for the integrity of the internal cement mortar lining. These concerns surrounding internal lining integrity were reinforced by the inspection of the January 2020 failure site where deterioration of the internal cement mortar lining was conclusively documented. It is CPI's overall technical opinion that the cause of

the leak and related corrosion deterioration was the result of low flow and low velocity conditions in the force main over its nearly 50-year service life.

It is well known, from reports from the city, that this force main has not always run full and that it operates at very low flow and velocity. Because scouring velocities were not typically achieved in this pipe, the build-up of biosolids occurred over time. This accumulation causes sulfide production and anaerobic conditions which are acidic. This results in attack of the alkaline cement mortar lining and corrosion of ductile iron. When higher velocities did occur under specific pumping regimes, abrasion-erosion of the cement mortar lining would tend to occur. These typical low velocity and periodic higher velocity conditions are both related to the damage which resulted in the leak which initiated this force main evaluation.

The extent of this damage between the test pit assessments reported herein is not known at this time. However, given the age of the pipe, the typically low velocity conditions conducive to solids build-up and their corrosive effects, and periodic erosive exposure due to higher pumping velocities, it seems reasonable to assume that this pipe is vulnerable to similar failures over some distance between the test pit locations examined and reported in this document.

4.0 RECOMMENDATIONS

CPI makes the following recommendations:

A. Additional test pits should be performed such that the invert of the pipe can be checked for possible corrosive damage using UT and visual examination. These test pits should be closer to the failure location (south of Test pit #1 and north of Test Pit #2) to help define the likelihood of similar failures.

B. Consider tape wrapping the ARVs and related piping with a Wax Tape #2 system by Trenton Corporation to prevent on-going external corrosion at these locations. Note that this system requires minimal surface preparation (wire brushing) and is easily applied.