

APPENDIX 19

Park Pump Station Force Main Inspection Report

SUBJECT

Park Force Main Internal Inspection
from ARVs 4, 5, and 6

TO

John Parsons

DATE

December 22, 2021

OUR REF

30029146

COPIES TO

Phil DePoe

FROM

James Shelton
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PURPOSE OF ASSESSMENT

In Fall 2015, following a rash of air vacuum release valve failures and related SSOs, Lehigh County Authority (LCA) requested Arcadis U.S., Inc. (Arcadis) to perform a preliminary condition assessment of the Park Pump Station Force Main (PFM). Arcadis conducted a desk top study and preliminary field investigations. That work concluded that the intermittent operation of the PFM for first 35 years of its life coupled with active air vent and fill during the on-off cycle provided opportunity for the septic conditions inside the forcemain to attack the Prestressed Concrete Cylinder Pipe (PCCP) forcemain in sections where the PFM is not always full (Station 15 to the Little Lehigh Interceptor discharge at Station 98). As PCCP is very susceptible to corrosion when an air space is allowed to develop over the sewage in the line, there was concern about significant loss of the cement mortar liner of the pipe, and potentially of the steel cylinder, which is typically only 16 gauge (0.0598"/1.5mm) thick. While the PFM is operated under relatively low pressures, this pipeline could be in critical condition.

It was recommended in March 2016 that the interior of the pipe be inspected. Initially recommended by Arcadis as a full end to end internal cleaning, manned entry inspection, and televising, LCA opted for a phased approach whereby a handful of ARV hatchways would be opened and the pipe near the hatchway man entry inspected while the balance of the readily accessible PFM from that pipe was cleaned and CCTV inspected. This report covers these Pop-and-Crawl inspections at ARVs 4, 5, 6, 8, and 9 and Access Chamber 2 on the 40th anniversary of the PFM.

DESCRIPTION OF FORCE MAIN

The PFM is 9797 linear feet of PCCP. It has three sections of differing diameters. The PFM has a diameter of 24 inches from Station -1+00 (pump station manifold exit point of the building) to 19+29, 36 inches from 19+29 to 50+90 (3,161 linear feet), and 30 inches from 50+90 to 98+03+97 (4,707 linear feet). There are 10 Air and Vacuum Release Valve Vaults (ARV) with blowoffs and access hatches, 2 line size reducer fittings, 2 access chambers, 1 wye fitting, and 1 gravity discharge point.

Figure 1 shows the route the force main takes from Park Pump Station (PPS) to where it ties into the interceptor near Kline's Island WWTP and the locations of the Air and Vacuum Release Valve Vaults (ARV). From Little Lehigh

Park, the force main follows Lehigh Parkway S to Lehigh St to W Wyoming St to S 6th St to Chester St then across Trout Creek Park to Basin St then across Little Lehigh Creek to the gravity discharge point.

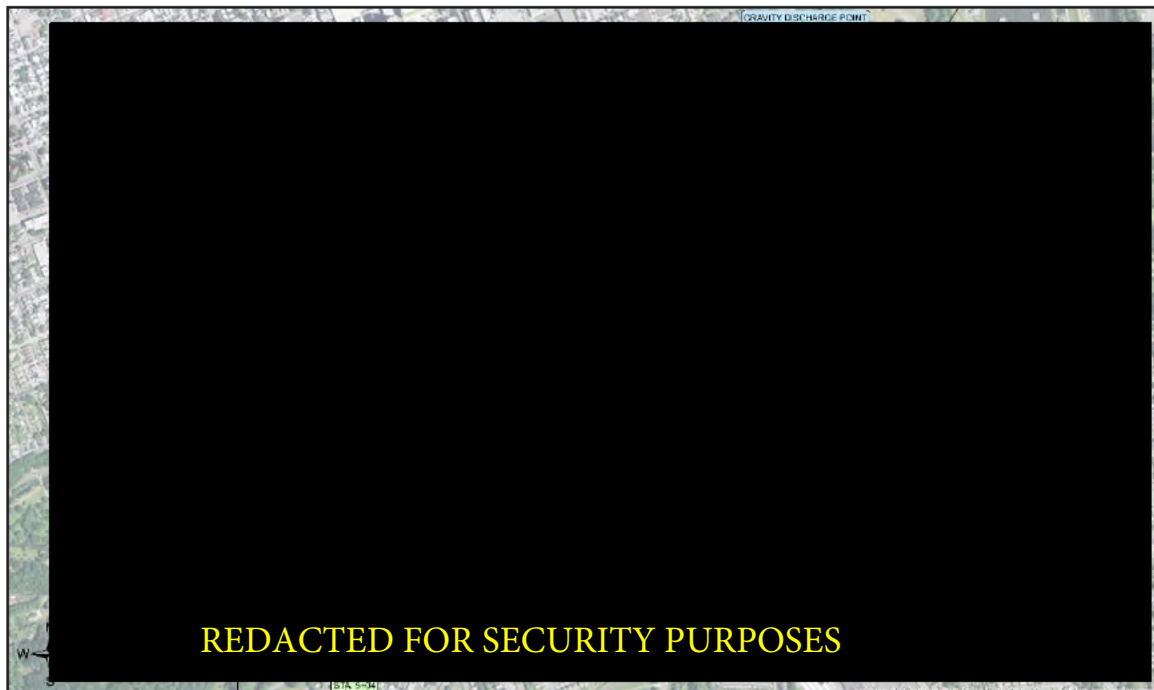


Figure 1: Park FM Route

Figure 2 shows the profile of the PFM. The 10 ARVs are located at 5+04, 12+75, 15+43, 27+02, 40+50, 50+85, 58+92, 64+16, 79+78, and 96+17. Reducers are located at 19+29 and 50+90. Access chambers are located at 70+16 and 91+04. The wye is located at 19+35.

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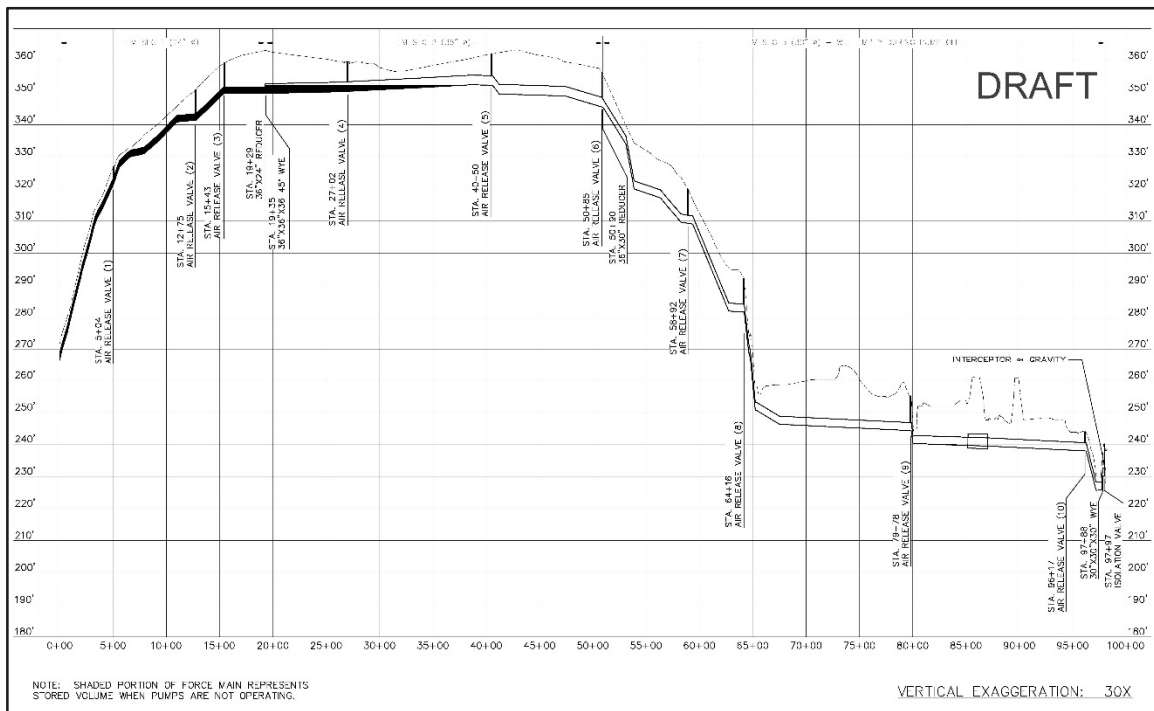


Figure 2: Park FM Consolidated Profile

The PFM system curve, assuming no loss of diameter due to deposits, no increase in diameter due to liner loss, and no change in friction characteristics due to either, is shown in Figure 3.

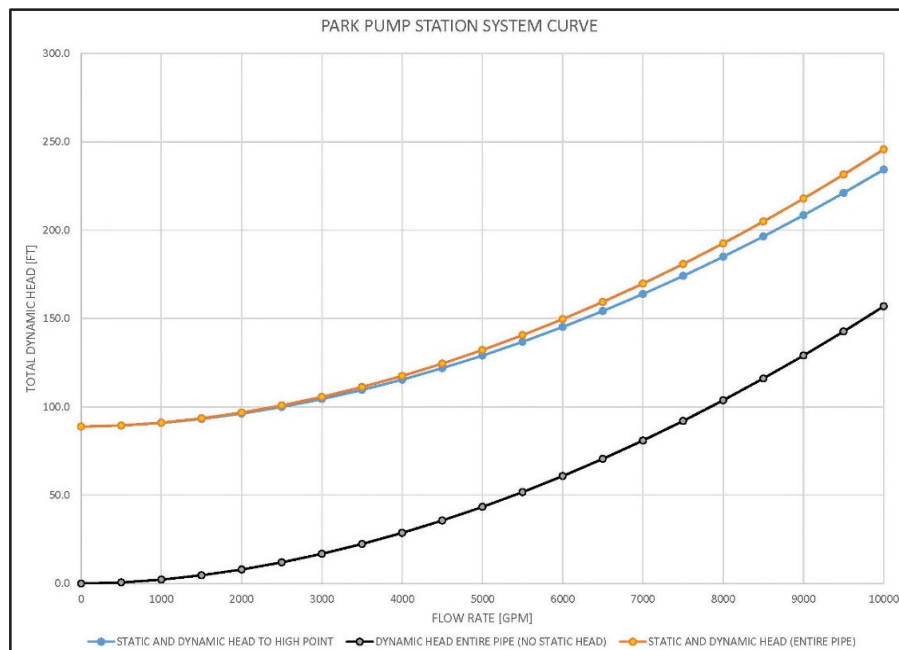


Figure 3: Park Pump Station System Curve

PLANNING AND PREPARATION WORK

Planning for the inspection involved multiple trials using the Pretreatment Plant's Flow Equalization Basin to store flow and shave the peak of the flows such that the PPS need not be operated during a dry Saturday. Those tests proved successful and are documented in various emails to LCA.

Blooming Glen Construction (BGC) was retained by LCA to provide mechanical services for opening and closing the hatches at the ARVs. Blooming Glen subcontracted services for cleaning and inspection to Franc Environmental (Franc) and traffic control to Flagger Force. A detailed work breakdowns structure and schedule was prepared and field reviewed with LCA, Arcadis, and BGC twice in the weeks ahead of the work. Work was completed on April 10th.

Once PPS was deenergized and locked out by various foremen, it took about 20 minutes for the force main to stop venting at the ARVs. Shortly after lock-out, LCA opened the PFM drain valve to 100% and drained the PFM from PPS to ARV5 in approximately 10 minutes. BCG then removed the hatches from ARVs 3, 4, 5, and 6.

Franc then attempted to clean the lines, but their jetters only provided 65 gpm, their nozzles were not equipped with centering mandrels, and the spray tips of the nozzles were badly degraded, and so the lines were not cleaned and the interior of the pipes remained coated with slime layer except in the narrow bands where the jets striped the pipe wall.

Franc then televised the PFM from ARV 4, 5, and 6 in both directions as far as the slick interior and turns of the pipe would allow.

Arcadis then conducted manned entry ankle tethered inspections into the PFM from ARVs 4, 5, and 6. The pipe walls were sounded with mason's hammer, scraped to evaluate concrete mortar hardness, coal tar interior paint tapped to evaluate hidden sulfide attack, and exposed corrosion areas probed to determine extent and nature of corrosion.

Following this initial round of work, a second round of pop and crawl inspections were conducted on October 23, 2021, into the PFM from ARVs 8 and 9 and Access Chamber 2. Because the cleaning and CCTV work done in Round 1 was ineffective, those efforts were not repeated in Round 2.

INSPECTION FINDINGS

ARV 4 toward ARV 3

The 36" pipe in this section was washed with a jetter nozzle from ARV 4 at Station 2702 to approximately Station 26, but the cleaning was not effective in removing the slime coating nor the ¼" of silt on the bottom of the pipe. This pipe was televised 251' before the camera tractor could not proceed further due to the slime coating, but the video is practically useless due to aerosol particles from the ventilation blower.

This segment has unmudded joints approximately ½" wide and 2" deep.

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Manned entry inspection was conducted to approximately 40' upstream of ARV 4 just passed the 69° bend at Station 2672. The coating is firmly bonding to the mortar. Hammer sounding indicates the cylinder-mortar bond is still good.



Figure 5 - ARV 4 toward ARV 3 - 40' Upstream - Pipe Image

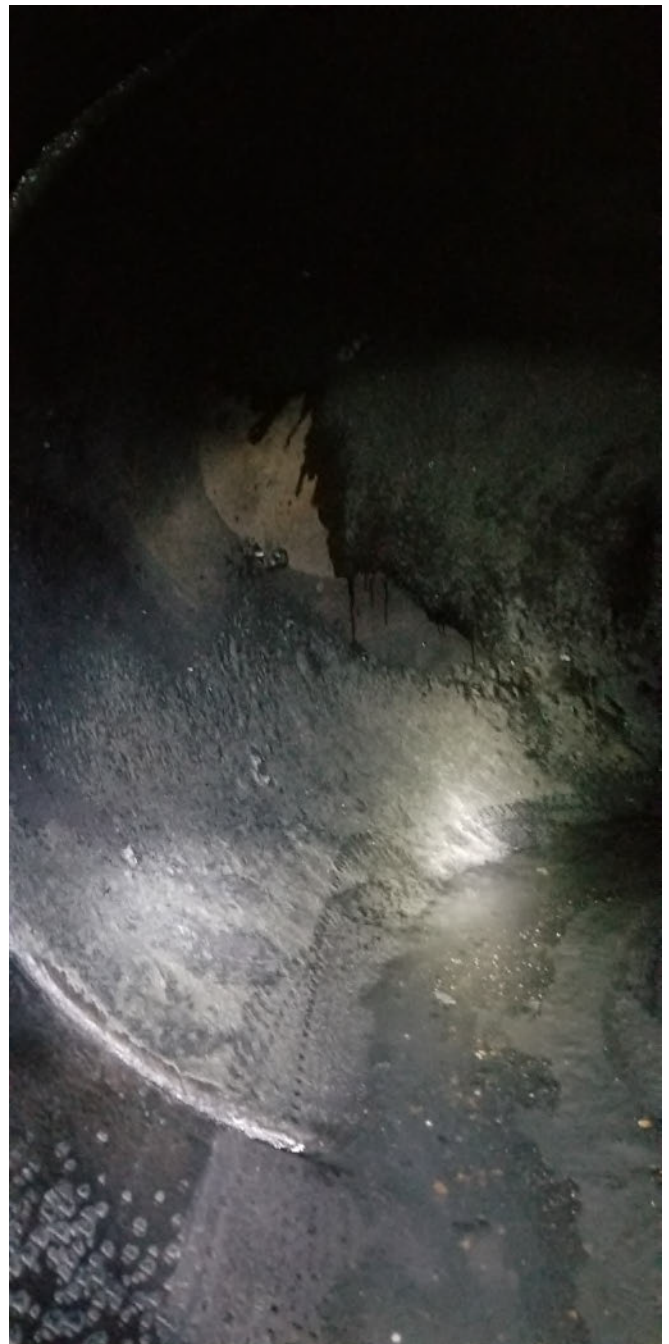


Figure 4 - ARV 4 toward ARV 5 - Bend at Station 2672

ARV 4 toward ARV 5

The 36" pipe in this section was washed with a jetter nozzle from ARV 4 at Station 2702 to approximately Station 29, but the cleaning was not effective in removing the slime coating. This pipe was televised only 64' before the second bend in pipe prevented camera from proceeding.

This segment has unmudded joints approximately ½" wide and 2" deep.

Manned entry inspection was conducted to approximately 40' upstream of ARV 4. The coating is firmly bonding to the mortar. Hammer sounding indicates the cylinder-mortar bond is still good.



Figure 6 - ARV 4 toward ARV 5 - 10' downstream looking at bend at Station 2724

ARV 5 toward ARV 4

The 36" pipe in this section was washed with a jetter nozzle from ARV 5 at Station 4050 to approximately Station 35, but the cleaning was not effective in removing the slime coating. This pipe was televised only 146' before the camera tractor could not proceed further due to the slime coating.

This segment has unmudded joints approximately ½" wide and 2" deep.

Manned entry inspection was conducted to approximately 40' upstream of ARV 5. The coating is disbonding from the mortar, first in circular patterns mimicking the coating spray pattern, then about 10' into the segment becoming systemic above the pump off water line 8-4 clock. The coating appears to be coal tar type coating and is very thin and brittle where it is flaking off. The H2S attack under the coating is wide-spread but very shallow with minimal impact to date on the thickness of the mortar, which on this pipe diameter for L301 pipe is 2.25" thick. Where the mortar is exposed, it is still bright white and relatively hard, with the softer gypsum layer being very minor. CCTV images are poor but indicate the blistering of the coating proceed upstream. Hammer sounding indicates the cylinder-mortar bond is still good.



Figure 7 - ARV 5 toward ARV 4 - Unmudded joint



Figure 8 - ARV 5 toward ARV 4 - 8' Upstream - Disbonding of coating along spray pattern

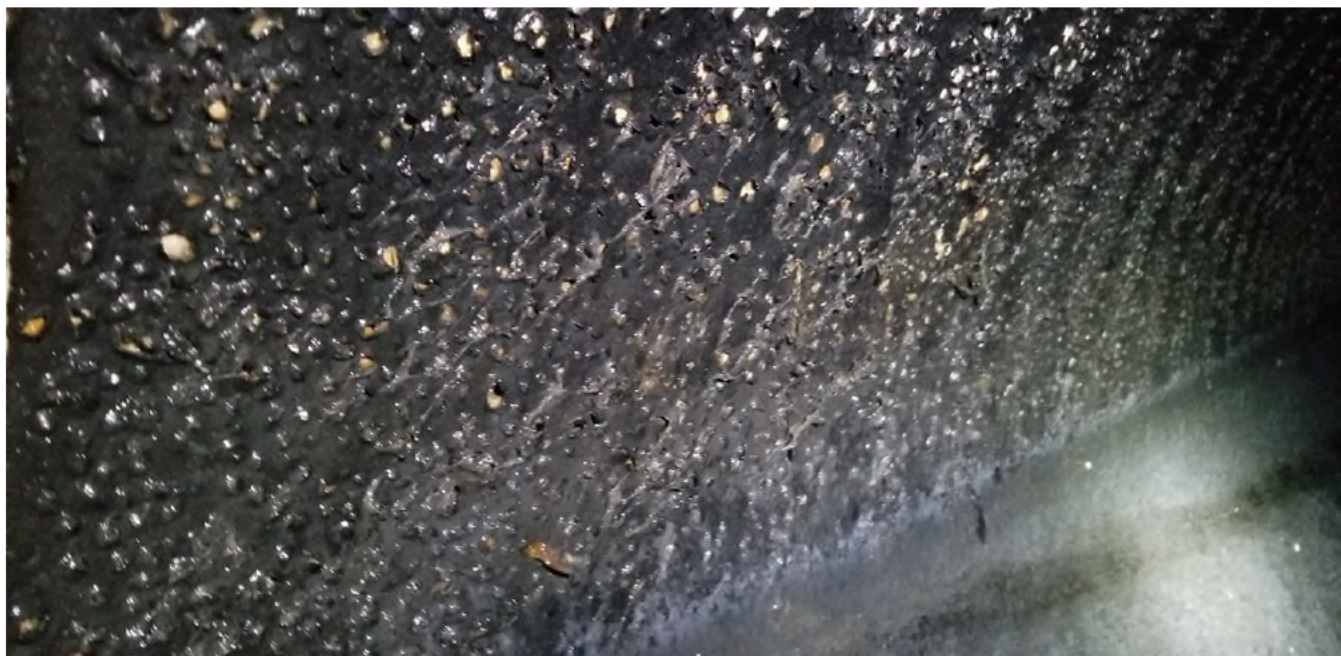


Figure 9 - ARV 5 toward ARV 4 - 20' Upstream - Systemic disbonding of coating



Figure 10 - ARV 5 toward ARV 4 - 8' Upstream - Soft mortar revealed under the disbonded coating (typ)



Figure 11 - ARV 5 toward ARV 4 - 20' Upstream - Cracking of coating and exposure of underlying mortar

ARV 5 toward ARV 6

The 36" pipe in this section was washed with a jetter nozzle from ARV 5 at Station 4050 to approximately Station 45, but the cleaning was not effective in removing either the slime coating or the rags hanging from top of pipe. This pipe was televised 550', but section between 300' and 484' is unusable due to aerosol particles fouling the image.

This segment has unmudded joints approximately ½" wide and 2" deep.

Manned entry inspection was conducted to approximately 80' downstream of ARV 5. The coating is disbonding or completely removed from the mortar, first in bands between the 2-5 and 7-10 clock positions, then extending from 8-4 clock positions. Mortar loss in these locations is 3/8" to ¼" deep. The coating appears to be coal tar type coating and is very thin and brittle where it is flaking off. The H2S attack under the coating is wide-spread. Blisters originate from the wire pattern, likely a result of pipe stress from ovality as a result of vertical pipe loading pushing the pipe laterally into the pipe bedding envelope. While unclear from CCTV inspection, correlating photographs from manned entry inspection, the mortar attack from 9-3 clock positions appears to occur the entire distance toward ARV 6. Where the mortar is exposed, it is still bright white and relatively hard, with the softer gypsum layer being very minor. Hammer sounding indicates the cylinder-mortar bond is still good except in haunch area where soundings were slightly duller.



Figure 13 - ARV 5 toward ARV 6 - Joint



Figure 12 - ARV 5 toward ARV 6 - Gypsum from H₂S attacked mortar



Figure 15 - ARV 5 toward ARV 6 - Coating disbondment at joint



Figure 14 - ARV 5 toward ARV 6 - H2S attack at coating blister

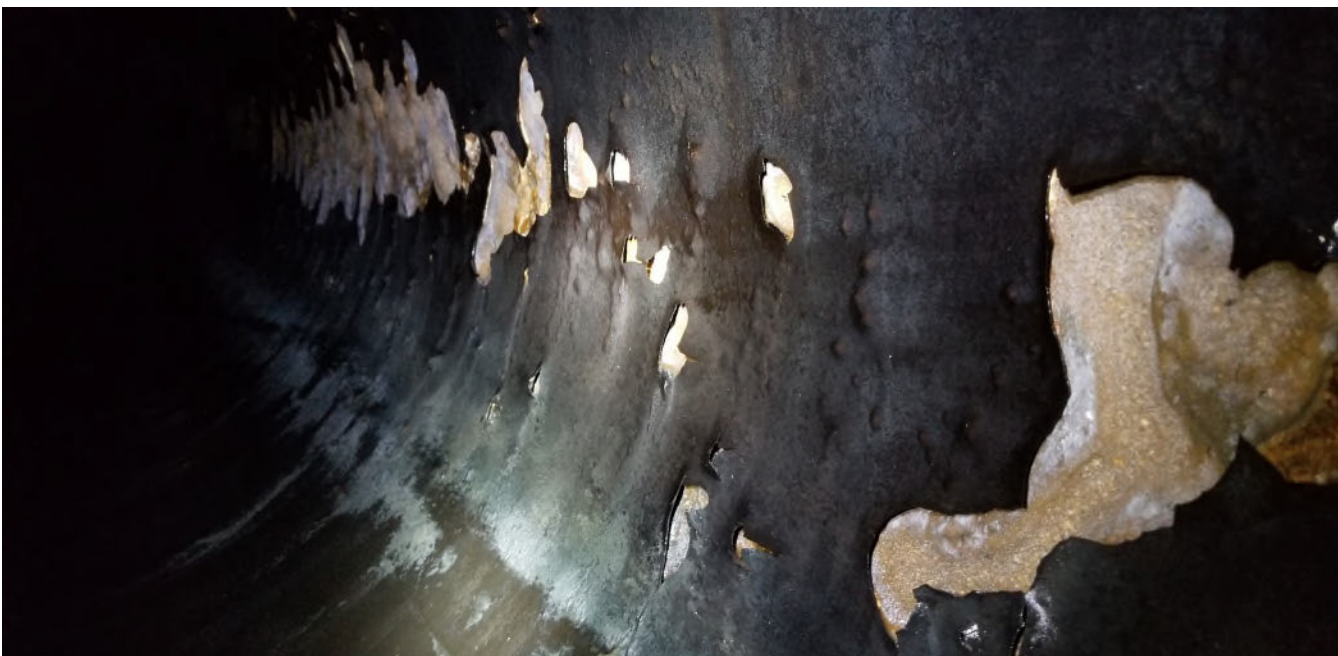


Figure 17 - ARV 5 toward 6 - Coating disbondment along springline with 1/2" mortar loss under blisters



Figure 16- ARV 5 toward 6 - Coating disbondment along springline following wire pattern



Figure 18- ARV 5 toward 6 - Coating disbondment and ½" mortar loss along springline, rust pattern from steel shell beginning to seep through mortar following wire pattern



Figure 19- ARV 5 toward 6 - Coating disbondment and 3/8" mortar loss springline to springline

ARV 6 toward ARV 5

The 36" pipe in this section was washed with a jetter nozzle from ARV 6 at Station 5085 to approximately Station 47, but the cleaning was not effective in removing the slime coating. This pipe was televised 392'.

This segment has unmudded joints approximately $\frac{1}{2}$ " wide and 2.5" deep.

Man entry inspection was conducted to approximately 40' upstream of ARV 6. The coating is blistered and disbonding from the mortar above the pump off water line, first in bands between the 2-4 and 8-10 clock positions, then extending from 8-4 clock positions. Within the length inspected via man entry, there is $\sim\frac{1}{4}$ " mortar loss under the blistered coating. The CCTV further upstream is hazy but blistering and H₂S attack looks similar to what was seen ARV 5 toward ARV 6, though the mortar loss is measurable but less than $\frac{1}{2}$ ". The coating is thin and brittle where it is flaking off. The H₂S attack under the coating is wide-spread. Hammer sounding indicates the cylinder-mortar bond is still good .



Figure 20 - ARV 6 toward ARV 5 - Joint



Figure 22 - ARV 6 toward ARV 5 - Coating Blisters and Disbondment



Figure 21 - ARV 6 toward ARV 5

ARV 6 toward ARV 7

The 30" pipe in this section was washed with a jetter nozzle from ARV 6 at Station 5085 to approximately Station 54, but the cleaning was not effective in removing either the slime coating. This pipe was not televised.

This segment has unmudded joints approximately $\frac{1}{2}$ " wide and 2" deep.

Man entry inspection was conducted to approximately 30' downstream of ARV 6. The coating is blistered and disbonding from the mortar above the pump off water line between the extending from 8-4 clock positions. The mortar behind the blisters is soft. Hammer sounding indicates the cylinder-mortar bond is still good .

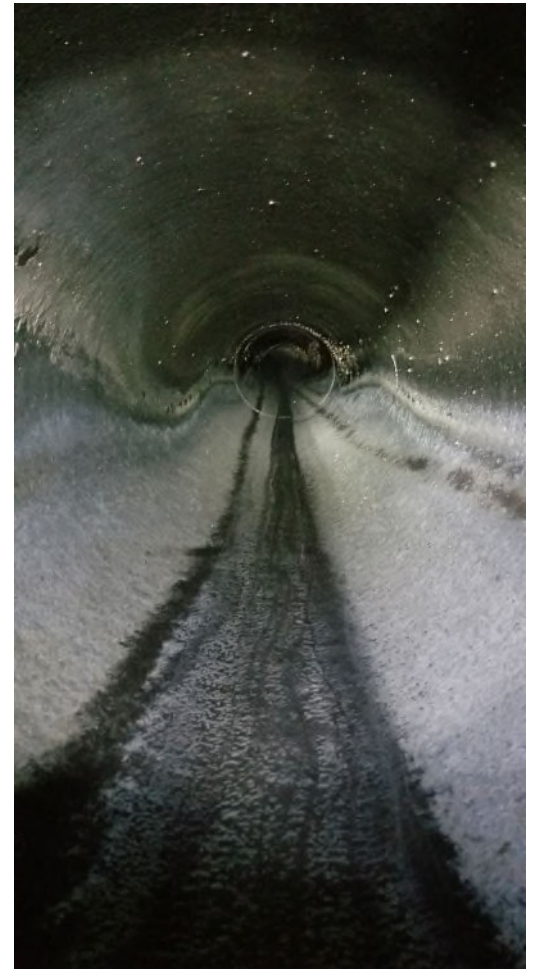


Figure 23 - ARV 6 toward ARV 7 - Pipe



Figure 24 - ARV 6 toward ARV 7 - Blisters in Coating

ARV 8 toward ARV 7

The 30" pipe in this section behind the hospital parking garage was drained and opened. This segment has unmudded joints approximately ½" wide and 2" deep, with mostly 20' sticks of pipe. The normal water line is 330 to 830.

Manned entry inspection was conducted to approximately 80' upstream of ARV 8. The coating and pipe below the water line is sound. Above the waterline, the black coal tar coating is blistered the entire length inspected. Upon probing with mason's hammer, the cement liner under the coating pock marked and generally soft to a depth of 3/8" to 1/2" deep. There are no places where the coating and mortar are completely stripped away. The H2S attack under the coating is wide-spread. Where the mortar is exposed, it is still yellow but relatively hard. Hammer sounding indicates the cylinder-mortar bond is still weakening at various clock positions depending on the station of the pipe.



Figure 26 - ARV 8 toward ARV 7 - Blisters in Coating



Figure 25 - ARV 8 toward ARV 7 - Blisters in Coating

Shards of the PCCP pipe liner were found in the bottom of the pipe. These shards of mortar have the coal tar coating fully bonded but slight yellowing of the mortar on the backside of the share, indicating the shard disbonded from a combination of stress cracks and sulfide attack.



Figure 27 - Shard of PCCP Inner Liner Mortar and Coal Tar Coating near ARV 8

ARV 8 toward ARV 9

The 30" pipe in this section was drained and opened. This segment has unmudded joints approximately $\frac{1}{2}$ " wide and 2" deep, with mostly 20' sticks of pipe. This section of pipe drops at a 29% slope to cross under the stream behind the hospital parking garage and so could only be inspected from the ARV. Water line in this segment drops to 0500 to 0700.

The coating and pipe below the water line is sound. Above the waterline, the black coal tar coating is blistered the entire length visible.



Figure 28 - ARV 8 toward ARV 9 - Blisters in Coating

ARV 9 toward ARV 8

The 30" pipe in this section near the stream across from Auburn Station Apartments was drained and opened. This segment has unmudded joints approximately $\frac{1}{2}$ " wide and 2" deep, with mostly 20' sticks of pipe. The normal water line is 0200 to 1000 just upstream of the ARV, but dropping to 0430 to 0730 within 80' upstream of the ARV. A sag in the pipeline yields a 6" deep puddle of water between ARV 9 upstream to the 50° bend at Station 79+32.

Manned entry inspection was conducted to approximately 70' upstream of ARV 9 to just passed the 50° fitting at Station 79+32. The coating and pipe at this location are in good shape with minimal/do degradation of the coating or the underlying pipe cement mortar coating. Hammer sounding indicates the cylinder-mortar bond is weakening at some places at the pipe haunch.



Figure 29 - ARV 9 - ARV 8 Pipe Condition at ARV 9



Figure 31 - ARV 9 -ARV 8



Figure 30 - ARV 9 - ARV 8 Pipe Wall

ARV 9 toward Access Chamber 2

The 30" pipe in this section near the stream across from Auburn Station Apartments was drained and opened. This segment has unmudded joints approximately $\frac{1}{2}$ " wide and 2" deep, with mostly 20' sticks of pipe. This section of pipe drops at a 20% slope to cross under the stream and so could only be inspected from the ARV. Water line in this segment drops to 0500 to 0700.

The coating and pipe below the water line is sound. Above the waterline, the black coal tar coating and mortar are sound and without significant defects visible.



Figure 32 - ARV 9 - Access Chamber 2

Access Chamber 2 toward ARV 9

The 30" pipe in this section in the old incinerator site was drained and opened. This segment has unmudded joints approximately $\frac{1}{2}$ " wide and 2" deep, with mostly 20' sticks of pipe. The normal water line is 1100 to 0100. A scum layer is present throughout this section of pipe.

Manned entry inspection was conducted to approximately 50' upstream of AC2 to just passed the 33° fitting at Station 90+65. The coating and pipe at this location are in good shape with minimal/no degradation of the coating or the underlying pipe cement mortar coating. Hammer sounding indicates the cylinder-mortar bond is sound.



Figure 33 - AC 2 - ARV 9 looking at 33 fitting at Station 90+65

Access Chamber 2 toward ARV 10

The 30" pipe in this section in the old incinerator site was drained and opened. This segment has unmudded joints approximately $\frac{1}{2}$ " wide and 2" deep, with mostly 20' sticks of pipe. The normal water line is 1100 to 0100. A scum layer is present throughout this section of pipe.

Manned entry inspection was conducted to approximately 40' downstream of AC2. The coating and pipe at this location are in good shape with minimal/no degradation of the coating or the underlying pipe cement mortar coating. Hammer sounding indicates the cylinder-mortar bond is sound.



Figure 34 - AC2 - PRV 10

INSPECTION SUMMARY AND RECOMMENDATIONS

The PFM from PPS to nearly ARV 5 remains full for during pump off cycles and is expected to be in like new condition; the inspections at ARV 4 support the conclusion that there is little damage to this portion of the pipe.

From around Station 35 (about halfway between ARV4 and ARV5) to ARV 5 (i.e., upstream of ARV 5), the top portion of the pipe is increasingly exposed but with significant sewage remaining in the pipe during pump off cycles. Here, the H₂S attack on the pipe begins. It is expressed as blisters in the coal tar coating, which has become brittle with age and chemical attack. The blistering is greatest at the side walls. The pattern of blistering follows the wire pattern of the pipe, indicating this pipe has minor slouching in the haunches that has focused small stress patterns at those locations.

On the downstream side of ARV 5, the H₂S attack is markedly worse, with the entire top half of some sticks of pipe have all of their coating and ¼" to ½" of mortar loss from the 2.25" interior mortar coating. ARV 5 represents the high flat portion of the PFM, so these findings make sense.

Around ARV 6, the attack is as prevalent but not as significant as around ARV 5. This is likely due to the sharp drop off at ARV 6 and the limited sewage that remains in this section during pump off cycles.

Around ARV 8, the deterioration increases again; it is prevalent but not as significant as around ARV6.

Around ARV 9 and Access Chamber 2, there is very little deterioration.

The PFM between ARV 4 and ARV 8 has been degraded by H₂S attack, but the loss of mortar is less than anticipated and indicative that this section of the PFM is not in short or medium term danger of structural failure. The forcemain below ARV 8 is in very good condition.

We recommend these inspections be repeated in 10 years before the 50 year anniversary of this force main. At that time, we recommend the forcemain be fully and properly cleaned and CCTV inspected from ARV 4 to its terminus to the extent possible and the entire force main be man entry inspected to scrape and sound the entire run of pipe.