

**APPENDIX H**

**MICHAEL S. HIGGINS TECHNICAL MEMORANDUM – PIPE G296**

## TECHNICAL MEMORANDUM

TO: Nathan Leshner, P.E., Washington Suburban Sanitation Commission

FROM: Michael S. Higgins, P.E., Pure Technologies

DATE: October 24, 2006

SUBJECT: Excavation of Pipe Section G296

The purpose of this Technical Memorandum is to document my field observations from the excavation of Pipe Section G296.

Upon arriving at site at approximately 1:45pm of October 24, 2006, pipe section G296 was already removed from the ground. Two pieces of the pipe section were still intact (referred to herein as the bell portion and the spigot portion). The middle four feet of the pipe was not seen and was reportedly already hauled away.

The spigot portion of the pipe was observed and there were no readily visible signs of distress in this portion of the pipe. This length of pipe section measured approximately 5'-10" long.

However, the bell portion of the pipe had obvious wire break damage. The bell portion was reportedly removed from the downstream (east) side of the pipe. Damage was observed on the south springline (this is based on the bell side being downstream). The bell portion of the pipe was approximately 6 feet long. Wire breaks were observed in the last 28 inches of the pipe. Further, the contractor reported that wire break damage also extended a couple of inches into the missing center piece of the pipe. Thus the total length of damaged pipe was approximately 30-inches. A small crack, approximately 6-inches long, was observed inside this pipe. The wire appeared black and there was not a significant presence of rust on the wires. The mortar coating appeared soft and thin in the area of wire break damage.

The number of wires in one foot length of pipe were counted and determined to be 23 wraps per foot. This is consistent with the lay schedule that indicates that the design provided 22.83 wraps per foot. Given the length of damaged wire and the wraps per foot, the estimated total number of wire breaks is 57 (30-inches of damage x 22.83 wraps per foot/12). It should be pointed out that this estimate of wire breaks assumes that all wraps were broken (which appeared to be the case). Further, it assumes that the contractor's estimate of length of damage into the middle section was correct at a couple of inches. WSSC personnel (Mike Woodcock) manually counted 52 wire breaks, but it is possible that a few wire breaks were not found due to the difficulty of manually counting wires and the fact that the middle portion of the pipe was not present. In any case, the actual number of wire breaks should be in the vicinity of 57 wire breaks.

To verify the wire breaks zone, a saw was used to cut through the prestressing wire on the bell portion of the pipe to see if wire break damage extended further. However, no wire breaks were identified based on this work and it appeared that the wire break damage was limited to the area defined above.

Photographs of the site visit are attached.



Wire Break Damage on the bell portion of the pipe section.





Photograph of the excavation. The pipe at the top of the photo is G295. It was confirmed that G295 was next to an air release valve, which is consistent with the inspection records. Thus the correct pipe was excavated.



Spigot Portion of the pipe. No damage was observed on this portion of the pipe.





Close up of some of the wire break damage. The wires had a black film on them. Significant quantities of rust were not observed.





Crack on interior of the pipe at the location of the wire break damage, along springline. Other cracks in the pipe could not be observed due to the presence of debris and silt in the pipe.





A saw was used to cut additional wires to facilitate mortar removal and to confirm that corrosion damage did not extend further than what was observed. The wires in this region appeared in good condition and no wire breaks were observed.





The wire break damage for the pipe extended over 28 inches. The contractor indicated that the damage extended further (to the right in this photo) by a couple of inches. This portion of the pipe had been hauled away and thus could not be inspected. Thus the total length of wire break damage was approximately 30-inches.



Cross section of pipe wall





Close up of wire breaks.

**APPENDIX I**

**MICHAEL S. HIGGINS TECHNICAL MEMORANDUM – PIPE B217**



**APPENDIX H**

**MICHAEL S. HIGGINS TECHNICAL MEMORANDUM – PIPE G296**

## TECHNICAL MEMORANDUM

TO: Nathan Leshner, P.E., Washington Suburban Sanitation Commission

FROM: Michael S. Higgins, P.E., Pure Technologies

DATE: October 24, 2006

SUBJECT: Excavation of Pipe Section G296

The purpose of this Technical Memorandum is to document my field observations from the excavation of Pipe Section G296.

Upon arriving at site at approximately 1:45pm of October 24, 2006, pipe section G296 was already removed from the ground. Two pieces of the pipe section were still intact (referred to herein as the bell portion and the spigot portion). The middle four feet of the pipe was not seen and was reportedly already hauled away.

The spigot portion of the pipe was observed and there were no readily visible signs of distress in this portion of the pipe. This length of pipe section measured approximately 5'-10" long.

However, the bell portion of the pipe had obvious wire break damage. The bell portion was reportedly removed from the downstream (east) side of the pipe. Damage was observed on the south springline (this is based on the bell side being downstream). The bell portion of the pipe was approximately 6 feet long. Wire breaks were observed in the last 28 inches of the pipe. Further, the contractor reported that wire break damage also extended a couple of inches into the missing center piece of the pipe. Thus the total length of damaged pipe was approximately 30-inches. A small crack, approximately 6-inches long, was observed inside this pipe. The wire appeared black and there was not a significant presence of rust on the wires. The mortar coating appeared soft and thin in the area of wire break damage.

The number of wires in one foot length of pipe were counted and determined to be 23 wraps per foot. This is consistent with the lay schedule that indicates that the design provided 22.83 wraps per foot. Given the length of damaged wire and the wraps per foot, the estimated total number of wire breaks is 57 (30-inches of damage x 22.83 wraps per foot/12). It should be pointed out that this estimate of wire breaks assumes that all wraps were broken (which appeared to be the case). Further, it assumes that the contractor's estimate of length of damage into the middle section was correct at a couple of inches. WSSC personnel (Mike Woodcock) manually counted 52 wire breaks, but it is possible that a few wire breaks were not found due to the difficulty of manually counting wires and the fact that the middle portion of the pipe was not present. In any case, the actual number of wire breaks should be in the vicinity of 57 wire breaks.

To verify the wire breaks zone, a saw was used to cut through the prestressing wire on the bell portion of the pipe to see if wire break damage extended further. However, no wire breaks were identified based on this work and it appeared that the wire break damage was limited to the area defined above.

Photographs of the site visit are attached.





Wire Break Damage on the bell portion of the pipe section.





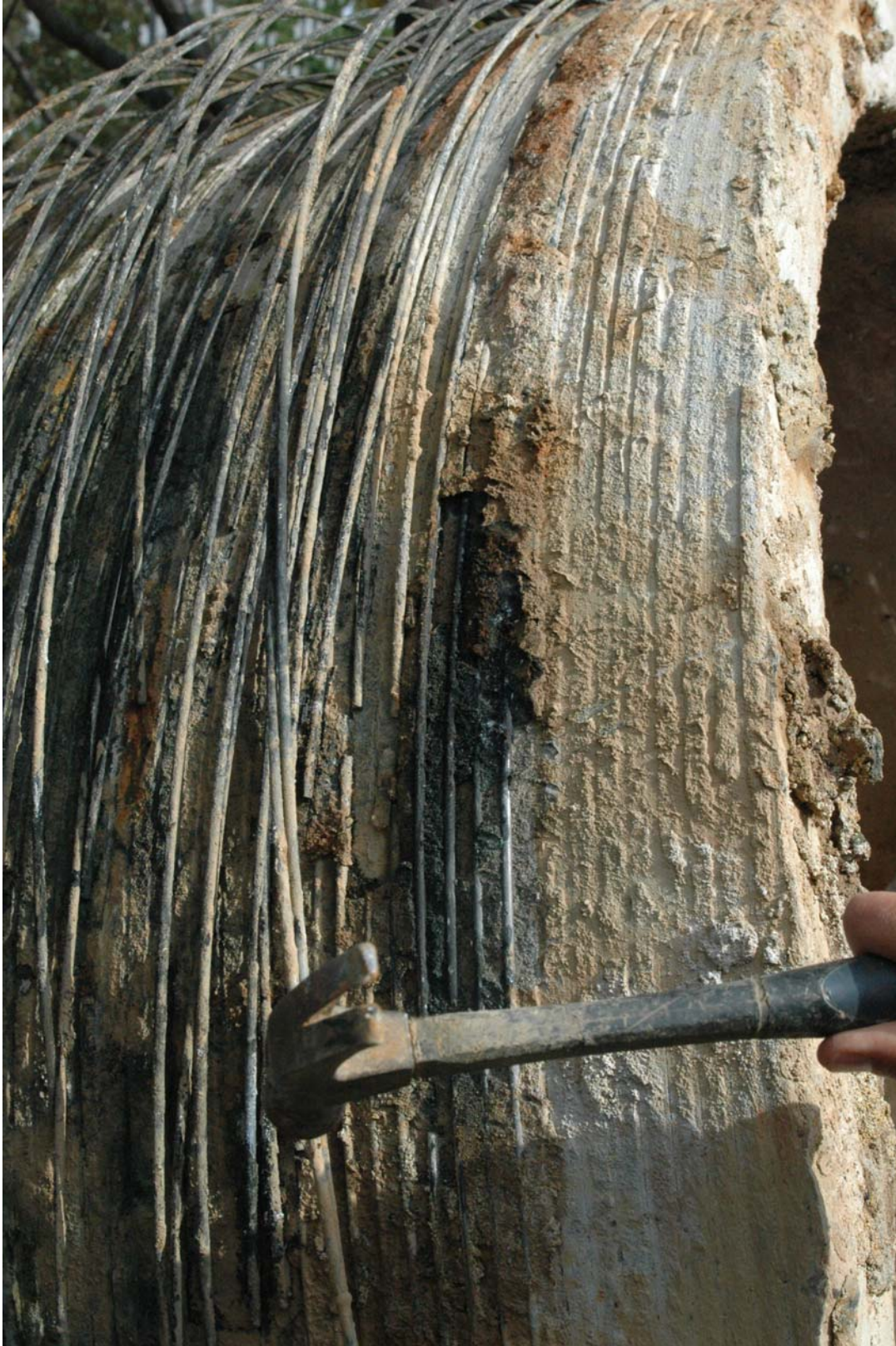
Photograph of the excavation. The pipe at the top of the photo is G295. It was confirmed that G295 was next to an air release valve, which is consistent with the inspection records. Thus the correct pipe was excavated.





Spigot Portion of the pipe. No damage was observed on this portion of the pipe.





Close up of some of the wire break damage. The wires had a black film on them. Significant quantities of rust were not observed.





Crack on interior of the pipe at the location of the wire break damage, along springline. Other cracks in the pipe could not be observed due to the presence of debris and silt in the pipe.





A saw was used to cut additional wires to facilitate mortar removal and to confirm that corrosion damage did not extend further than what was observed. The wires in this region appeared in good condition and no wire breaks were observed.





The wire break damage for the pipe extended over 28 inches. The contractor indicated that the damage extended further (to the right in this photo) by a couple of inches. This portion of the pipe had been hauled away and thus could not be inspected. Thus the total length of wire break damage was approximately 30-inches.



Cross section of pipe wall





Close up of wire breaks.

**APPENDIX I**

**MICHAEL S. HIGGINS TECHNICAL MEMORANDUM – PIPE B217**



## TECHNICAL MEMORANDUM

TO: Nathan Leshner, P.E., Washington Suburban Sanitation Commission

FROM: Michael S. Higgins, P.E., Pure Technologies

DATE: November 21, 2006

SUBJECT: Excavation of Pipe Section B217

The purpose of this Technical Memorandum is to document my field observations from the excavation of Pipe Section B217.

### OBSERVATIONS IN THE FIELD

Upon arriving at site at approximately 11:30 pm on November 20, 2006, pipe section B217 was already removed from the ground. One 12 foot portion of pipe section was still intact. One end of this section consisted of the spigot (upstream) side of the pipe section and the other end was saw cut to facilitate its removal from the trench. The portion of pipe had also been sawcut through the prestressing wire along the top of the pipe (as it was on the ground- i.e. not the crown as it was situated in the ground). The sawcut did not extend through all the prestressing as the last 12" +/- on either side was left intact so that the pipe would not fall apart. Mark Holley and Mike Woodcock were examining the pipe and removing the mortar coating.

The remaining 4 feet of the original pipe section was smashed during removal. Its remnants were located in the excavation pile. It was inspected for obvious signs of corrosion damage, but none could be identified. Much of this four foot piece of pipe was buried under the excavation material and thus could not be reliably inspected.

Once all the mortar coating was removed, on large area of corrosion was observed on the prestressing wire. The corroded area started at approximately 7 feet from the spigot and continued to at least the end of the pipe still intact (to the point where the pipe had been sawcut). Thus there was a minimum length of approximately 5 feet with corrosion damage. The area of corrosion was on the invert of the pipe up to approximately the north springline. The wire appeared black in this area.

Within the area of corrosion there were two broken wire zones:

- First wire break zone: The first area of wire breaks consisted of 16 wire breaks. The breaks were concentrated in a length approximately 8". The zone was centered approximately 7.5 feet from the spigot.
- Second wire break zone: The second area of wire breaks consisted of 5 to 10 wire breaks over approximately 3 inches. The exact number could not be ascertained as the location of the breaks was on the bottom of the pipe as it was sitting on the ground. This wire break zone was located at approximately 9' from the spigot.

It should be noted that there were approximately 10 wraps of prestressing in the areas of corrosion (and adjacent to the second wire break zone) that could not be inspected because they could not be cut due to the desire to keep the pipe intact for safety reasons. It is possible that there were additional breaks in these wraps.

It should also be documented that there was a wire splice approximately 6 feet from the spigot end of the pipe. According to Mike Woodcock, the prestressing wires were not popping when they were being cut in this portion of the pipe. Thus, this portion of the pipe may not have been prestressed. Wire samples were taken by Mr. Woodcock from both sides of the splice for laboratory testing.

It should also be noted that there was a crack in the concrete core at the location of the corrosion zone and wire break damage. It was not possible to determine if this crack was present when the pipe was in the ground or developed as a result of the forensic work.

There were approximately 28 wire wraps over one foot of pipe length.

Photographs of the site visit are attached. More photos available upon request.

### COMPARISON TO INSPECTION RESULTS

Based on the data collected during the electromagnetic inspection, Pure Technologies had estimated 60 wire breaks for this pipe section. This estimate compares favorably to what was observed in the field. The error in the actual vs. estimate number of wire breaks is almost certainly due to the proximity of the two wire break zones.

The estimated number of 60 wire breaks was based on an estimated length of wire break damage in the pipe. During the electromagnetic data analysis, it was estimated that there was approximately 26 inches of wire break damage on the pipe. To arrive at the estimate of wire breaks, it is assumed that all wires were broken within this length to arrive at the estimate of 60 wire breaks.

However, in the field there were two wire break zones that were separated by approximately 14 inches. Due to the width of the electromagnetic field generated during the inspection, the two areas of wire break damage generated a single electromagnetic anomaly, which was analyzed as described above. The following table summarizes the comparison between the predicted results and what was observed in the field.

#### Comparison of Predicted Results vs. Observed Conditions

	<b>Estimated Based on Electromagnetic Inspection</b>	<b>Actual as Observed in Field</b>
Number of Wire Breaks	60	21 to 26
Length of Wire Break Damage	26 inches	23.5 inches +/-

As can be seen, the length of wire break damage compares favorably. This is encouraging, because during the electromagnetic data analysis, we must assume that all wires are broken in an area of corrosion to ensure safety of the pipe. Furthermore, as was most likely the case for this particular pipe section, it is likely that the wires in between the two wire break zones would have failed in a relatively short timeframe if the pipe were put back in service. This would have placed the pipe near a point of failure based on the structural model for this pipe section.





Corrosion product on concrete core at the location of wire break zone 1.



Group of wire breaks that were removed from wire break zone 1. Photo shows 12 wire breaks (some wires are not clearly visible). There was a total of 16 wire breaks in this zone.





Five wire breaks taken from wire break zone 2. There were between 5 and 10 wire breaks in this zone.



Close up of corrosion product found on all wires in the area of corrosion. The corrosion area was at least 5 feet long. In this region all wires exhibited this type of corrosion product.







Two cracks in the concrete core were observed at the location of the of wire break damage. It is unknown whether or not these cracks existing when the pipe was in the ground or result from the forensic work. The cracks are within the red outline. A closer view of the cracks can be observed in the photo on page 3.



A wire splice was located approximately 6 feet from the spigot.