Exhibit No.___ (GECB-16)
Docket No. PG-041624
Witness: Dr. Graham E.C. Bell

BEFORE THE WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, Complainant, v. PUGET SOUND ENERGY, Respondent.	DOCKET NO. PG-041624

EXHIBIT OF

GRAHAM E. C. BELL, Ph.D., P.E.

ON BEHALF OF STAFF
OF WASHINGTON UTILITIES AND
TRANSPORTATION COMMISSION

Letter from Kevin C. Garrity, PE of CC Technologies to Steven Secrist, Puget Sound Energy, "Spirit Ridge – Summary of Field Inspection of Seventy-five (75) and Metallurgical Analysis of Six (6) Service Risers – Spirit Ridge Subdivision (F4434-01G)," dated June 15, 2005

July 21, 2005

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CC Technologies

SOLVING PROBLEMS THROUGH INNOVATION

June 15, 2005

Steven Secrist
Puget Sound Energy
10885 N.E. Fourth St.
11th Floor
Bellevue, Washington 98009

RE: Puget Sound Energy, Spirit Ridge – Summary of Field Inspection of Seventy-five (75) and Metallurgical Analysis of Six (6) Service Risers – Spirit Ridge Subdivision (F4434-01G)

To Whom It May Concern:

Field Inspection of Risers

CC Technologies Services, Inc. (CC Technologies) performed an inspection of seventy-five (75) natural gas service risers that were removed from the Spirit Ridge area. These risers were randomly selected from those removed during the distribution pipe replacement project from 2/07/05 to 4/1/05. Each riser sample was labeled, wrapped in polyethylene, sealed at the excavation site and stored in a secure, dry storage site in Bellevue, Washington.

On 4/26 and 27/05 CCT personnel completed the inspection and testing of these riser samples according to the following protocol:

Puget Sound Energy – Service Riser Testing Protocol

1. Identify and inventory riser by street address.
2. Photograph as found condition.
3. Remove polyethylene wrapping.
4. Measure and record dimensions and determine (if possible) installed orientation.
5. Photograph risers in "as found" condition from both sides.
6. Visually inspect coating condition and identify possible corrosion features.
7. Photograph possible corrosion features or deposits.

8. Perform qualitative analysis of deposits for Calcium, Carbonate, Sulfide, Iron and pH.
9. Perform holiday detection test ("wet sponge") and document holiday locations.
10. Select risers exhibiting more than superficial corrosion for more detailed metallurgical laboratory analyses.
11. Rewrap and store risers.

A CCT identification number was assigned to each riser and the relevant data for each riser was recorded on a data form. The data recorded included date inspected, date remove, service address, coating type, pipe inside diameter and observed holiday or corrosion locations. Coating holidays that were obviously caused by removal (shovel damage) were not recorded. The results of the holiday test, pipe orientation and the results of any quantitative analysis (if completed) along with a photograph were also recorded for each riser inspected. A copy of each field data sheet is attached and a summary of the observations is shown in the table below.

Puget Sound Energy - Spirit Ridge Service Riser Inspection Summary

43 (57.3%) were 3/4" Coal Tar Coated pipe

17 of the 45 (39.5%) of the Coal Tar services were field wrapped at the bend

31 (41.3%) were 1/2" X-Tru Coat pipe

27 of the 31 (87.1%) of the Coal Tar services were field wrapped at the bend

1 was 1/2" FBE coated pipe with field wrapped tape

A total of 45 holidays (judged not to be made during removal -i.e.new) were recorded on 20 risers

A total of 12 corrosion defects (all minor) were identified on 10 risers

CCT #	Coating	Field Wrap at Bend 1=yes 0=no	Observed holidays not from removal	Observed Corrosion	Type of Corrosion	Sent to Lab
1	X-Tru Coat	1				
2	X-Tru Coat	1				
3	X-Tru Coat	1				
4	X-Tru Coat	0	2	1	small pit	yes
5	X-Tru Coat	1				
6	X-Tru Coat	1				
7	X-Tru Coat	1				
8	X-Tru Coat	1				
9	X-Tru Coat	1				
10	X-Tru Coat	0	1	1	Surface	yes
11	Coal Tar	1				

12	X-Tru Coat	1				
13	X-Tru Coat	1				
14	Coal Tar	1				
15	X-Tru Coat	0				
16	Coal Tar	0				
17	X-Tru Coat	1				
18	Coal Tar	0	5	2	shallow pit, minor piting	yes
19	X-Tru Coat	1				
20	X-Tru Coat	1				
21	Coal Tar	1				
22	X-Tru Coat	1				
23	X-Tru Coat	1				
24	X-Tru Coat	1				
25	Coal Tar	1				
26	X-Tru Coat	1				
27	Coal Tar	1				
28	Coal Tar	1	1			
29	Coal Tar	0				
30	Coal Tar	1				
31	Coal Tar	1	1			
32	Coal Tar	0				
33	Coal Tar	0				
34	Coal Tar	0	3			
35	Coal Tar	0	3	1	slight pitting	
36	X-Tru Coat	1				
37	X-Tru Coat	1				
38	X-Tru Coat	1				
39	Coal Tar	0				
40	Coal Tar	0	3			
41	Coal Tar	0				
42	Coal Tar	0				
43	X-Tru Coat	1				
44	Coal Tar	1				
45	Coal Tar	0	2	1	Minor surface	
46	Coal Tar	1				
47	Coal Tar	0	2			
48	Coal Tar	0				
49	Coal Tar	0	3	2	small pit	
50	X-Tru Coat	1				
51	Coal Tar	0				

52	X-Tru Coat	0				
53	Coal Tar	0	2			
54	Coal Tar	0	3	1	slight general	
55	Coal Tar	0	3			
56	Coal Tar	1				
57	Coal Tar	1				
58	Coal Tar	1				
59	Coal Tar	1				
60	FBE	1				
61	Coal Tar	1	3	1	Minor surface	yes
62	Coal Tar	0				
63	X-Tru Coat	1				
64	Coal Tar	1				
65	Coal Tar	0				
66	Coal Tar	0	4	1	general & minor pitting	yes
67	Coal Tar	1	1			
68	Coal Tar	0	1			
69	X-Tru Coat	1				
70	Coal Tar	0				
71	Coal Tar	0	1	1	Minor pitting & general	yes
72	X-Tru Coat	1				
73	Coal Tar	0				
74	X-Tru Coat	1				
75	X-Tru Coat	1	1			

Six (6) of the risers that appeared to have the most significant corrosion were selected for further laboratory analysis. These six samples were carefully packed and shipped to our Dublin laboratory on 5/29/05.

BACKGROUND

CC Technologies performed a metallurgical investigation of six (6) Spirit Ridge natural gas products service risers. The risers were received at CC Technologies on May 3rd, 2005. The service risers were either 0.5-inches or 0.75-inches in diameter, and either had a coating of extruded polyethylene or coal tar.

APPROACH

The metallurgical investigation was performed in accordance with the Puget Sound Energy laboratory investigation protocol revised on December 15, 2004 including the following steps: Visual inspection, sectioning, metallographic examination using light and scanning electron techniques, and energy-dispersive spectroscopy when appropriate.

RESULTS

Service Riser CCT 4

The visual inspection of the as-received pipe revealed two gouges in the extruded polyethylene coating located at 5.5-inches downstream and 21-inches downstream. The gouges were located upstream of the bend and on the downstream portion of the bend, respectively. After removing the coating, a pit approximately 0.4-inches in diameter was visible under the gouge at 21-inches. There was only minor surface corrosion located under the gouge at 5.5-inches and the rest of the pipe appeared to be free of corrosion product. Figure 1 is a photograph showing both the gouge in the coating and the pit in the pipe located at 21-inches.

A metallographic cross-section through the deepest portion of the pit was mounted and polished. Figure 2 is a light photomicrograph of the polished sample showing the morphology of the pit. The pit was approximately 83-mils deep, which corresponds to an 81% wall penetration. The pipe was 0.5-inches in diameter and had a wall thickness of approximately 0.105-inches.

Service Riser CCT 10

The visual inspection of the as-received pipe revealed four gouges in the extruded polyethylene coating located at 16-inches downstream, 17-inches downstream, 20.5-inches downstream, and 39.5-inches downstream. All four gouges were located either on the upstream or downstream portion of the bend. After removing the coating, a pit approximately 0.4-inches in diameter was visible under the gouge in the coating located at 17-inches. There was only minor surface corrosion located beneath the other three gouges and the rest of the pipe appeared to be free of corrosion product. Figure 3 is a photograph showing both the gouge in the coating and the pit in the pipe located at 17-inches.

A metallographic cross-section through the deepest portion of the pit was mounted and polished. Figure 4 is a light photomicrograph of the polished sample showing the morphology of the pit. The pit was approximately 41-mils deep, which corresponds to a 39% wall penetration. The pipe was 0.5-inches in diameter and had a wall thickness of approximately 0.105-inches.

Service Riser CCT 18

The visual inspection of the as-received pipe revealed 5 anomalies in the coal tar coating. There was a holiday in the coating located at 1.5-inches downstream and cracked/missing coating located at 18.5-inches, 22.5-inches, 24-inches and 26-inches downstream. The holiday was located on the upstream of the bend while the cracked/missing coating was located either on the upstream or downstream portion of the bend. After removing the coating, a pit approximately 0.2-inches in diameter and another small pit were visible under the cracked/missing coating located at 18.5-inches. There was only minor surface corrosion located beneath the other three gouges and the rest of the pipe appeared to be free of corrosion product. Figure 5 is a photograph showing the two small pits at 18.5-inches that were visible after removing the coating.

A metallographic cross-section through the deepest portion of both pits was mounted and polished. Figure 6 is a light photomicrograph of the polished larger pit showing the morphology of the pit. The pit was approximately 55-mils deep, which corresponds to a 47% wall penetration. The smaller pit was approximately 46-mils deep, which corresponds to a 40% wall penetration. The pipe was 0.75-inches in diameter and had a wall thickness of approximately 0.115-inches.

Service Riser CCT 49

The visual inspection of the as-received pipe revealed 6 anomalies in the coal tar coating. There was a holiday in the coating located at 17-inches downstream, missing coating located at 31.5-inches, corrosion anomalies located at 24 and 26-inches downstream, a gouge in the coating between 26-inches and 28.5-inches downstream, and a raised anomaly at 22.5-inches. All of the anomalies were located either on the upstream or downstream portion of the bend. After removing the coating, a pit approximately 0.16-inches in diameter was visible under raised anomaly located at 22.5-inches and cluster of pits at 31-inches were visible. The largest pit at 31.5-inches was approximately 0.20-inches. There was only minor surface corrosion located beneath the other 4 anomalies and the rest of the pipe appeared to be free of corrosion product.

Figure 7 is a photograph showing the pit that was located 31.5-inches that were visible after removing the coating.

A metallographic cross-section through the deepest portion of the pit located at 22.5-inches and the largest pit at 31.5-inches downstream were mounted and polished. Figure 6 is a light photomicrograph of the pit located at 31.5-inches showing the morphology of the pit. The pit was approximately 51-mils deep, which corresponds to a 46% wall penetration. The pit located at 22.5-inches had a maximum pit depth of 31-mils corresponding to a wall penetration of 27%. The pipe was 0.75-inches in diameter and had a wall thickness of approximately 0.115-inches.

Service Riser CCT 66

The visual inspection of the as-received pipe revealed three coating faults in the coal tar coating. There were two areas of missing coating located at 7-inches downstream and between 14-inches and 18-inches downstream. There was transverse cracking in the coating located between 21-inches and 27-inches downstream. The missing coating at 7-inches was located upstream of the bend while the other faults were located on the bend. After removing the coating, there were no visible areas of pitting. There were areas of corrosion beneath the cracking and beneath the missing coating. The rest of the pipe appeared to be free of corrosion product. Figure 9 is a photograph showing the corrosion product that was present between 22-inches and 26-inches.

Two metallographic cross-sections through the corrosion product were taken at 16-inches and 25.5-inches downstream. After cutting, a small pit was visible in the mount at 25.5-inches. Figure 10 is a light photomicrograph of the polished sample showing the morphology of the pit. The pit was approximately 29-mils deep, which corresponds to a 26% wall penetration. The pipe was 0.75-inches in diameter and had a wall thickness of approximately 0.115-inches.

Service Riser CCT 71

The visual inspection of the as-received pipe revealed four faults in the coal tar coating. There was a gouge in the coating located at 3.5-inches downstream, a corrosion anomaly located 22-inches downstream, and cracks in the coating located at 25.5-inches downstream and 28.5-inches downstream. All faults were located either on the upstream or downstream portion of the bend except the gouge, which was located upstream of the bend. After removing the coating there was only minor surface corrosion located beneath the four coating faults

and the rest of the pipe appeared to be free of corrosion product. Figure 11 is a photograph of the pipe after coating removal showing the condition of the pipe at the 22-inch location. The pipe was in generally good condition with small areas of surface corrosion.

CONCLUSIONS

The metallurgical analysis of the service risers revealed that pipe anomalies were confined to areas of faults in the coating. Only two of the observed pits were related to areas of cracks along the extrados of the coating. In general, it appears that there is no greater propensity for corrosion pitting to occur at the bends than away from the bends. The major determining factor on whether there was a pipe anomaly or not was faults in the coating. All observed pipe anomalies occurred beneath coating faults.

The representative sample of the service risers indicates that they were installed in a manner that is consistent with industry practice and that there were no shortcomings in the manner that the risers were installed or wrapped in the field. The representative sample did not identify any systemic integrity threats. The risers were performing in accordance with industry and regulatory standards in effect. The reversal of the Vasa Park Rectifier polarity did not appear to contribute to accelerated attack of the risers for the period that the rectifier was cross-wired.

Very truly yours,

CC Technologies Services, Inc.

Kevin C. Garrity, P.E.
Executive Vice President, Operations

Table 1. Summary of the Coating Faults and Pipe Anomalies

Pipe	Coating Faults	Pipe Anomalies	Proximity to Bend
CCT #4			
1	Gouge at 21-inches downstream	~0.4-inches diameter pit, 81% wall penetration (WP)	downstream portion of bend (neutral axis)
2	Gouge at 5.5-inches downstream	superficial surface corrosion observed (no wall loss)	upstream of bend
CCT #10			
1	Gouge 16-inches downstream*	superficial surface corrosion observed (no wall loss)	upstream portion of bend (intrados)
2	Gouge 17-inches downstream	~0.4-inches diameter pit, 39% wall penetration	bend (neutral axis)
3	Gouge 20.5-inches downstream*	superficial surface corrosion observed (no wall loss)	downstream portion of bend (intrados)
4	Gouge 39.5-inches downstream*	superficial surface corrosion observed (no wall loss)	downstream of bend (neutral axis)
CCT #18			
1	Cracked/missing coating 18.5-inches D/S	~0.2-inches diameter pit (40% WP) & smaller pit (47% WP)	upstream portion of bend (extrados)
2	Missing coating 22.5-inches downstream	no pitting observed	bend (extrados)
3	Cracked coating 24-inches downstream	no pitting observed	bend (extrados)
4	Cracked coating 26-inches downstream	no pitting observed	downstream portion of bend (extrados)
5	Hole in coating 1.5-inches downstream	no pitting observed	upstream of bend
CCT #49			
1	Raised 22.5-inches downstream	~.16-inches diameter pit, 27% wall penetration	upstream portion of bend (intrados)
2	gouge in coating b/ween 26-28.5-inches D/S	no pitting observed	bend (intrados)
3	missing coating 31.5-inches downstream	cluster of pits, ~0.20-inch in diameter (largest), 46% WP	downstream portion of bend (intrados)
4	hole in coating 17-inches downstream	no pitting observed	upstream portion of bend (extrados)
5	corrosion anomalies 21-inches downstream*	no pitting observed	bend (extrados)
6	corrosion anomalies 33.5-inches downstream*	no pitting observed	downstream portion of bend (extrados)
CCT #66			
1	missing coating 7-inches downstream*	no pitting observed	upstream of bend (neutral axis)
2	missing coating b/ween 14-18-inches D/S	no pitting observed	bend (intrados and extrados)
3	Cracking in coating b/ween 21-27-inches D/S	no pitting observed, small pit after cutting (26% WP)	upstream portion of bend (extrados)
CCT #71			
1	Corrosion anomaly 22-inches downstream	no pitting observed	bend (intrados)
2	crack in coating 25.5-inches downstream*	no pitting observed	downstream portion of bend (extrados)
3	crack in coating 28.5-inches downstream*	no pitting observed	downstream portion of bend (extrados)
4	gouge 3.5-inches downstream*	no pitting observed	upstream of bend (neutral axis)

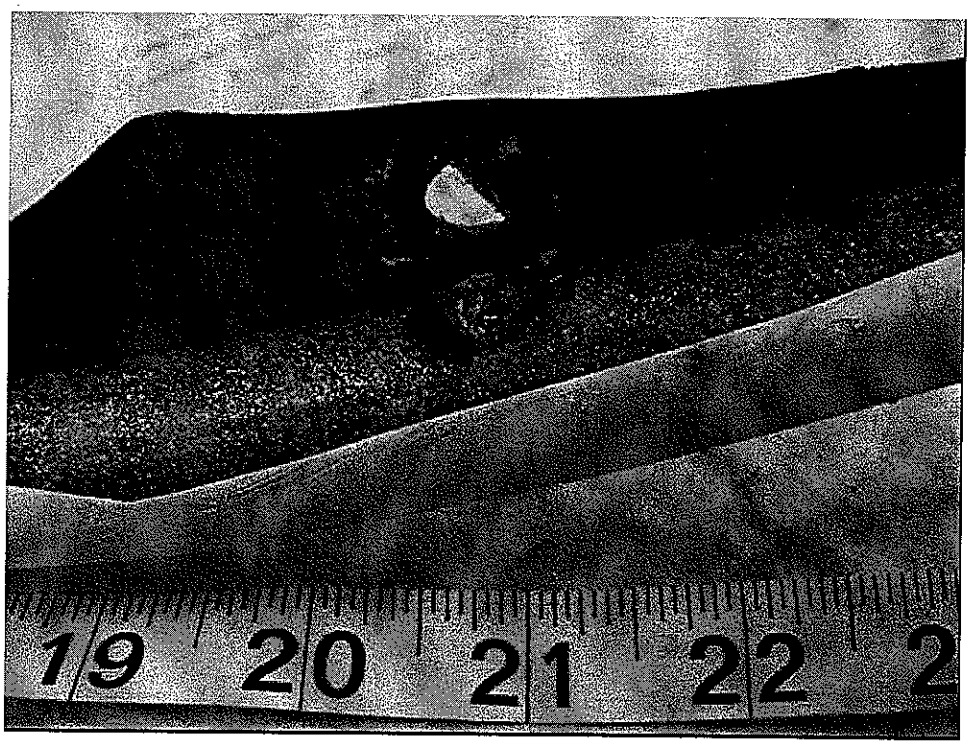

Figure 1. Photograph showing the pipe after removing the coating around the gouge that was located 21-inches from the upstream end of the pipe.

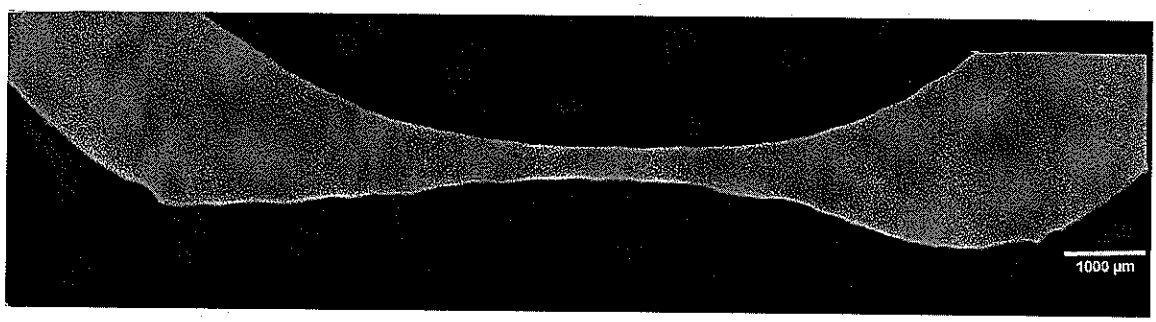

Figure 2. Light photomicrograph of the pit located at 21-inches.

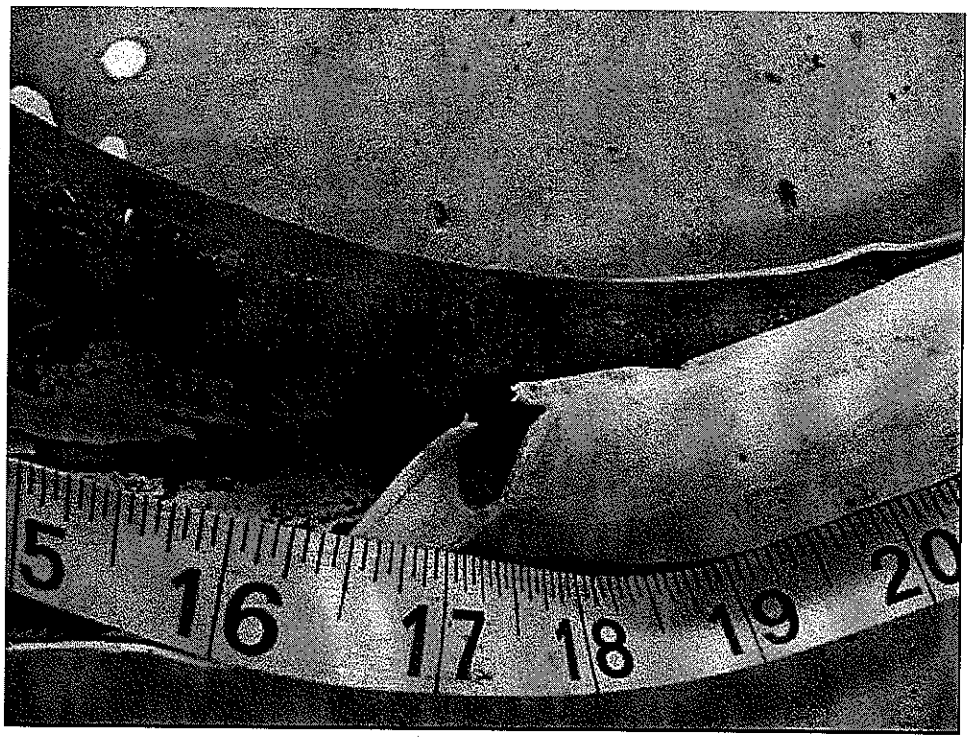

Figure 3. Photograph showing the pipe after removing the coating around the gouge located 17-inches from the upstream end of the pipe.

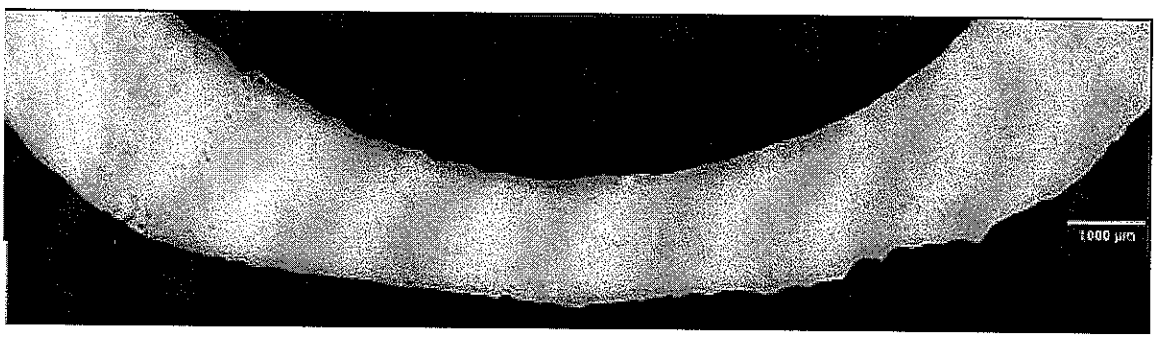

Figure 4. Light photomicrograph of the pit located at 16-inches.

Figure 5. Photograph of the two pits located at 18.5-inches downstream.

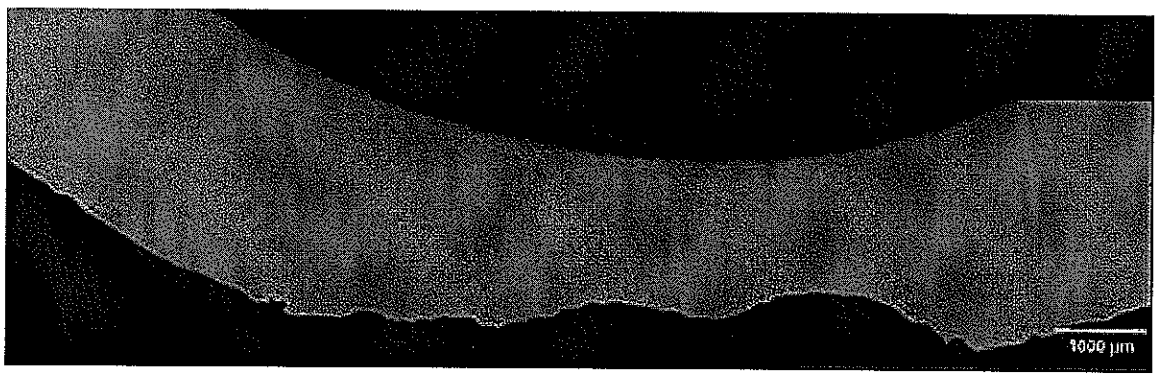

Figure 6. Light photomicrograph of the deepest pit.

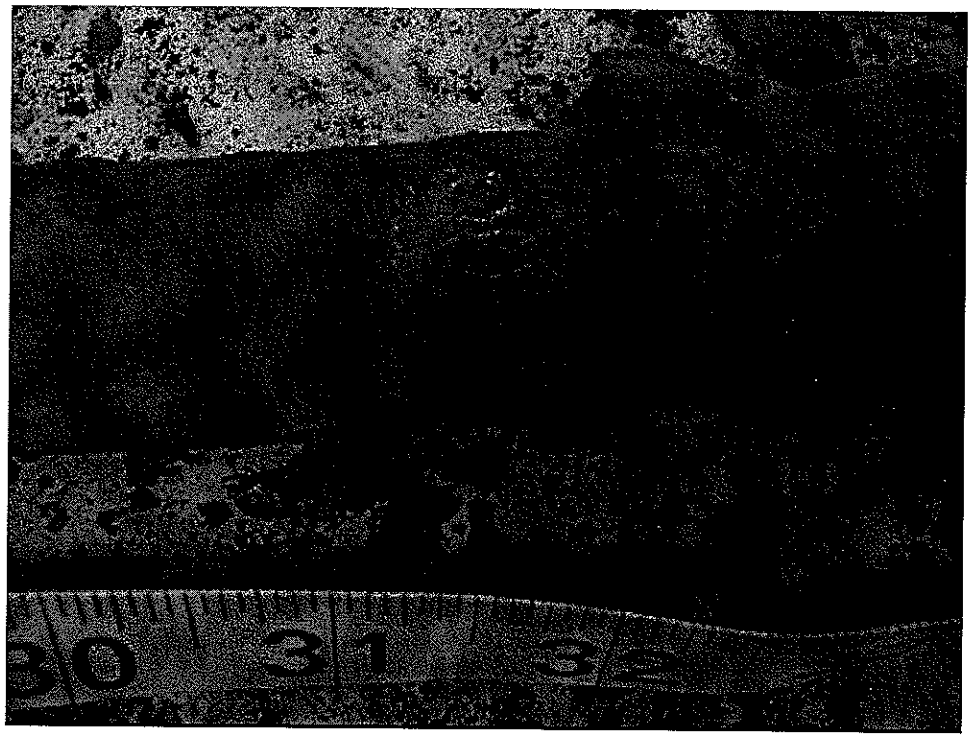

Figure 7. Photograph of pit on the inside curve, after the coating was removed, located 31½" from the upstream end of the pipe.

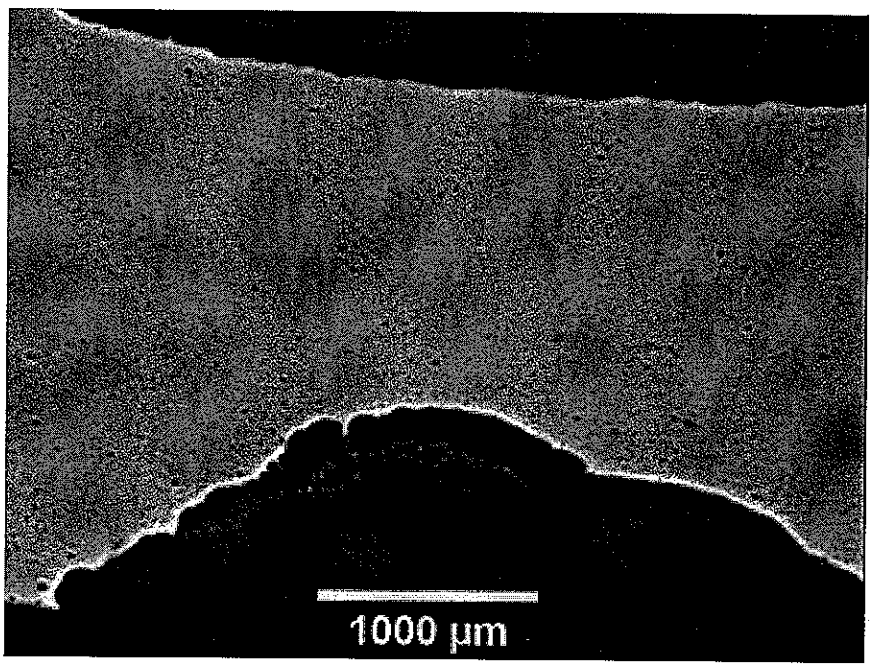

Figure 8. Light photomicrograph of the pit located at 31.5-inches downstream.

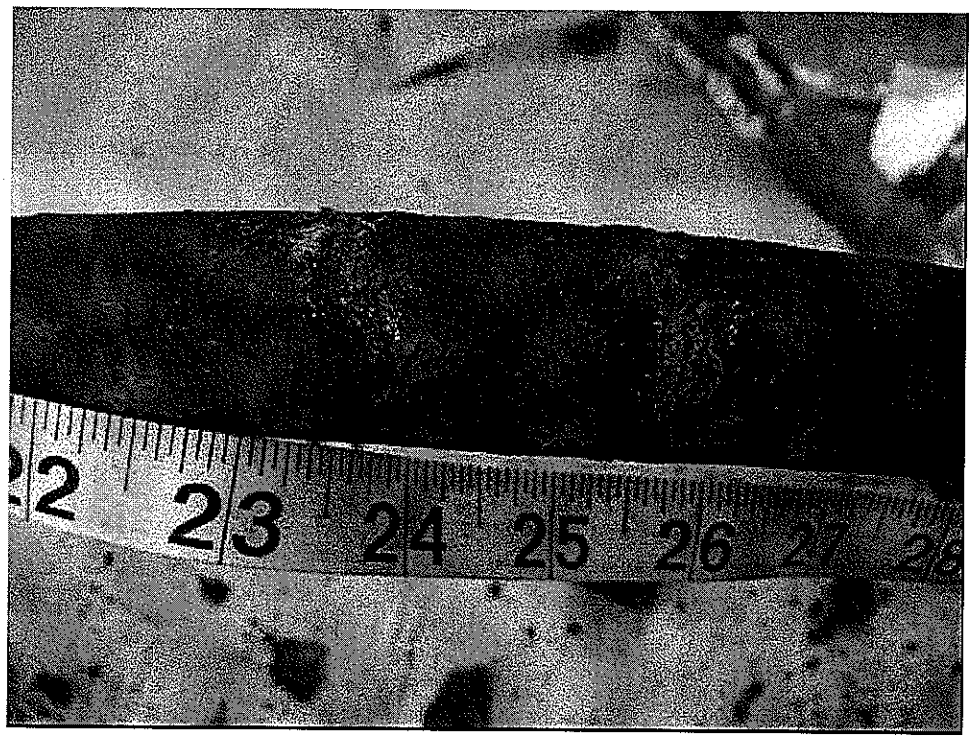

Figure 9. Photograph showing corrosion product after the coating was removed located between 23 and 26" from the upstream end of the pipe.

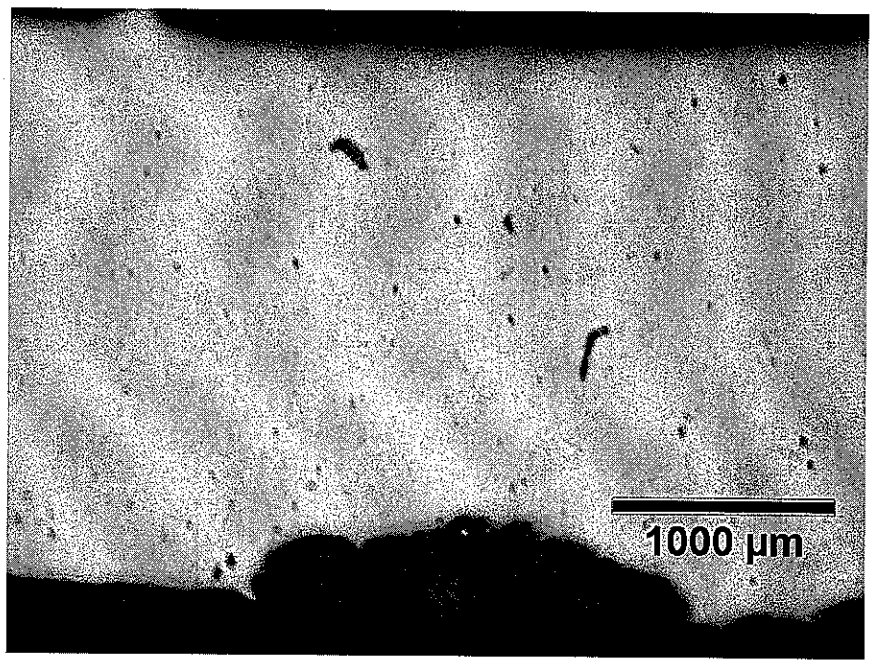

Figure 10. Light photomicrograph of the pit located at 25.5-inches downstream.

Figure 11. Photograph showing the surface of the pipe after the coating was removed located 22" from the upstream end of the pipe.