ASCE

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PIPELINES 2016 CONFERENCE

Kansas City, Missouri | July 17-20

Culvert Reline I-91, Middletown, CT

Hugh B. Mickel, P.E.

Jon R. Hagert, P.E.

Out of Sight, Out of Mind, Not Out of Risk

WHAT WE WILL COVER:

- Project Scope and Site Challenges
- Key Engineering Decisions
- Construction and Lining Methods
- Material Selection and Installation Techniques

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MULTI-PLATE Pipe Arch – 8’-10” Span x 6’-1” Rise

- Built in 1964 under Interstate 91
- Scheduled for replacement in 2018
- Rated in serious condition in 12/27/13 report
- Found to have worsened by 2015
- ADT: 57,000 vehicles per day

Condition Assessment

Structural Design of Pipe Arches - Follows AASHTO Section 12 of Bridge Manual (for LRFD)

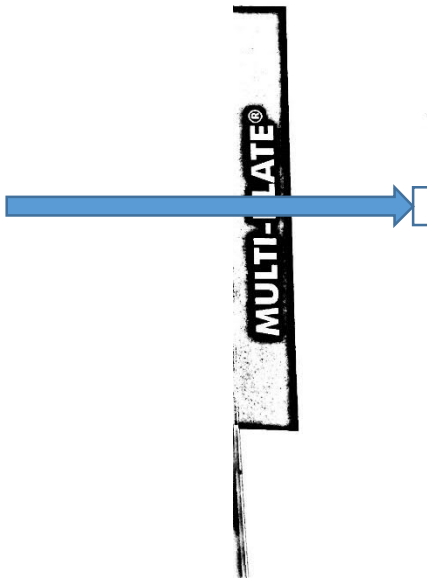


TABLE 21. MULTI-PLATE® PIPE-ARCH 6" X 2"

AASHTO HEIGHT OF COVER LIMITS H-20, HS-20, H-25, HS-25 LIVE LOADS

9 Pi Corner Pipe Arch Structure

Span Ft.-In.	Rise Ft.-In.	Minimum Cover (Inches)	Corner Radius (Inches)	Maximum Cover Heights Shown in Feet						
				0.111 (12 Ga.)	0.140 (10 Ga.)	0.170 (8 Ga.)	0.188 (7 Ga.)	0.218 5 Ga.)	0.249 (3 Ga.)	0.280 (1 Ga.)
6-1	4-7	12	18	16	16	16	16	16	16	16
6-4	4-9	12	18	15	15	15	15	15	15	15
6-9	4-11	12	18	14	14	14	14	14	14	14
7-0	5-1	12	18	14	14	14	14	14	14	14
7-3	5-3	12	18	13	13	13	13	13	13	13
7-8	5-5	12	18	13	13	13	13	13	13	13
7-11	5-7	12	18	12	12	12	12	12	12	12
8-2	5-9	18	18	12	12	12	12	12	12	12
8-7	5-11	18	18	11	11	11	11	11	11	11
8-10	6-1	18	18	11	11	11	11	11	11	11
9-4	6-3	18	18	10	10	10	10	10	10	10
9-6	6-5	18	18	10	10	10	10	10	10	10
9-9	6-7	18	18	10	10	10	10	10	10	10
10-3	6-9	18	18	9	9	9	9	9	9	9
10-8	6-11	18	18	9	9	9	9	9	9	9
10-11	7-1	18	18	9	9	9	9	9	9	9
11-5	7-3	18	18	8	8	8	8	8	8	8
11-7	7-5	18	18	8	8	8	8	8	8	8
11-10	7-7	18	18	8	8	8	8	8	8	8
12-4	7-9	24	18	8	8	8	8	8	8	8
12-6	7-11	24	18	8	8	8	8	8	8	8
12-8	8-1	24	18	7	7	7	7	7	7	7
12-10	8-4	24	18	7	7	7	7	7	7	7

Structural Design of Pipe Arches

Heights of cover are limited due to exerted pressures at the corners.

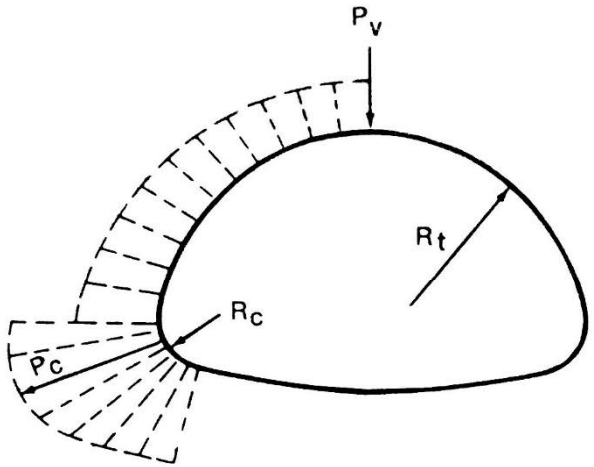
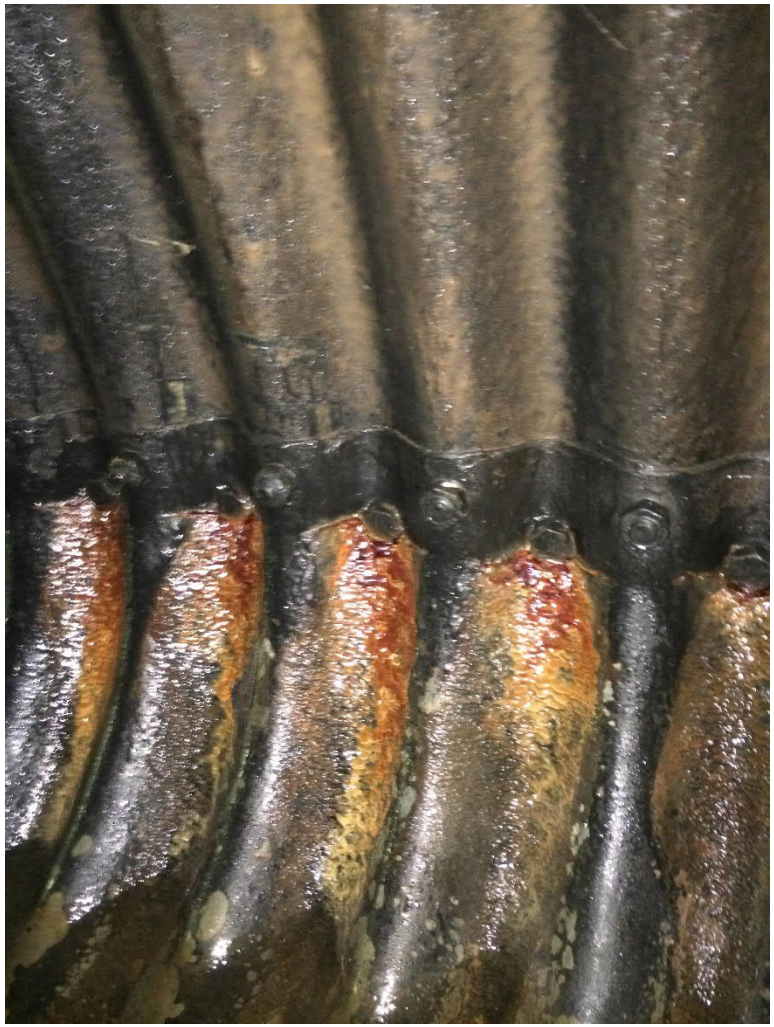


Figure 4.10 The pressure on a pipe-arch varies with location and radius, being greatest at the corners.

Corrosion and Invert Wall Buckling

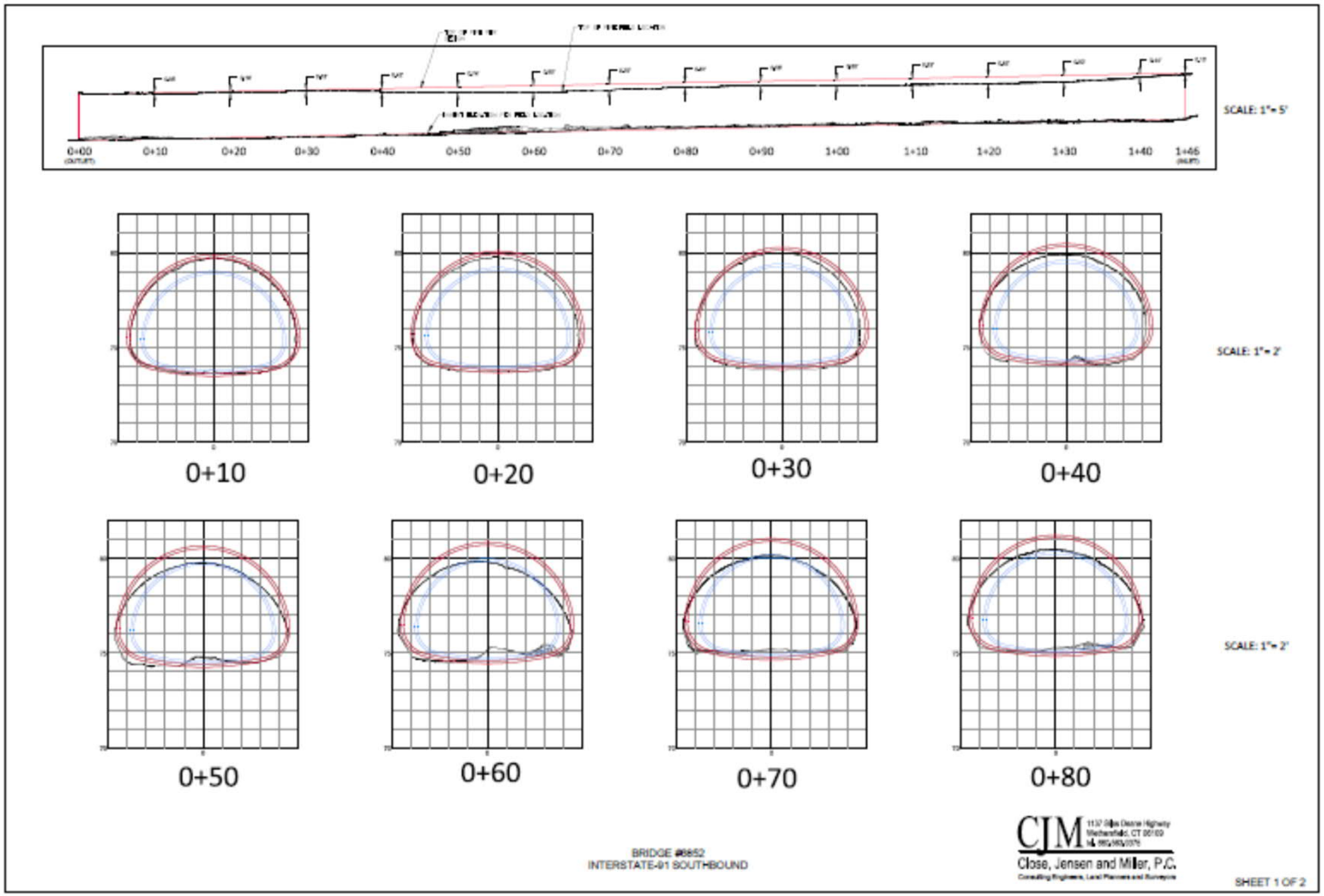
Bolted Seam Cracking and Longitudinal Sag



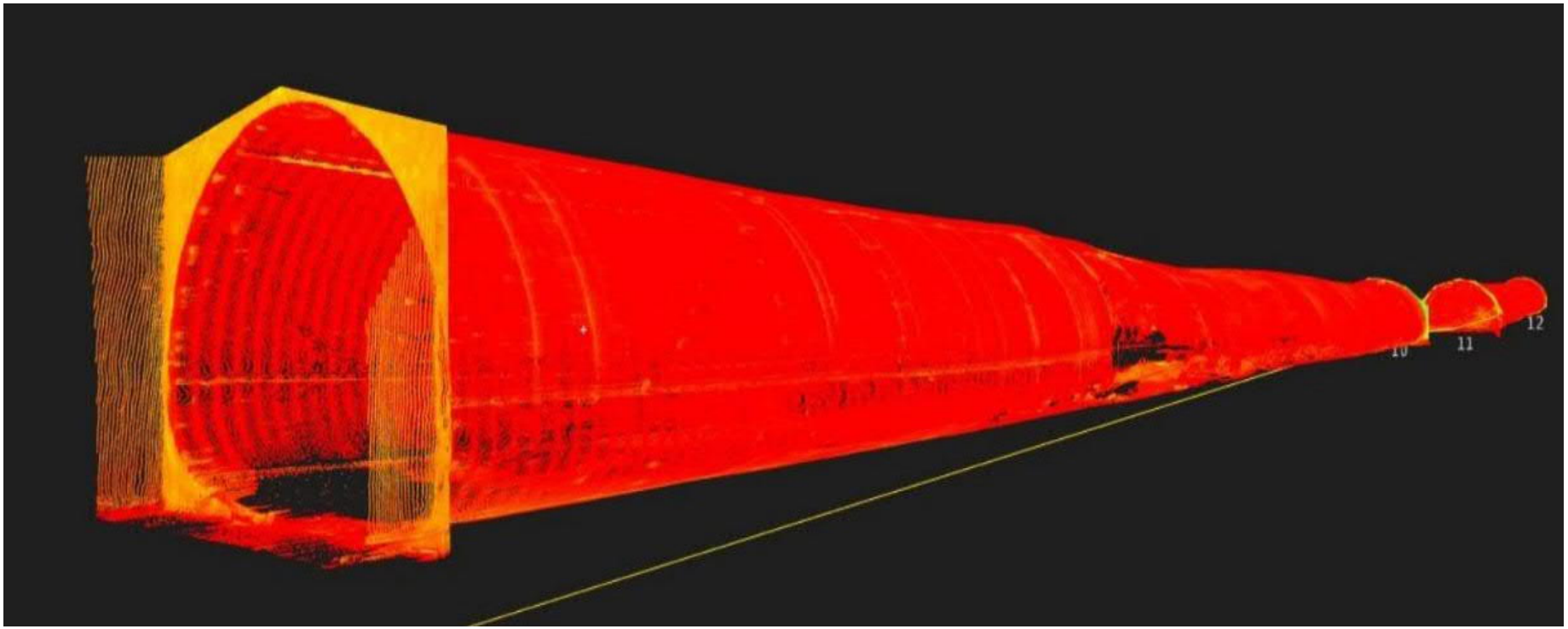
Challenges:

- Significant corrosion had caused distortions and invert wall buckling
- Bolted seam cracking along seams at top of haunch plates
- Longitudinal sag
- Highest fill height over crown is 22’
- Access locations were prohibitive, except in the median
- Hydraulic capacity wouldn’t allow a conventional internal sliplining
- Overflow culvert was needed
- Structure was moving

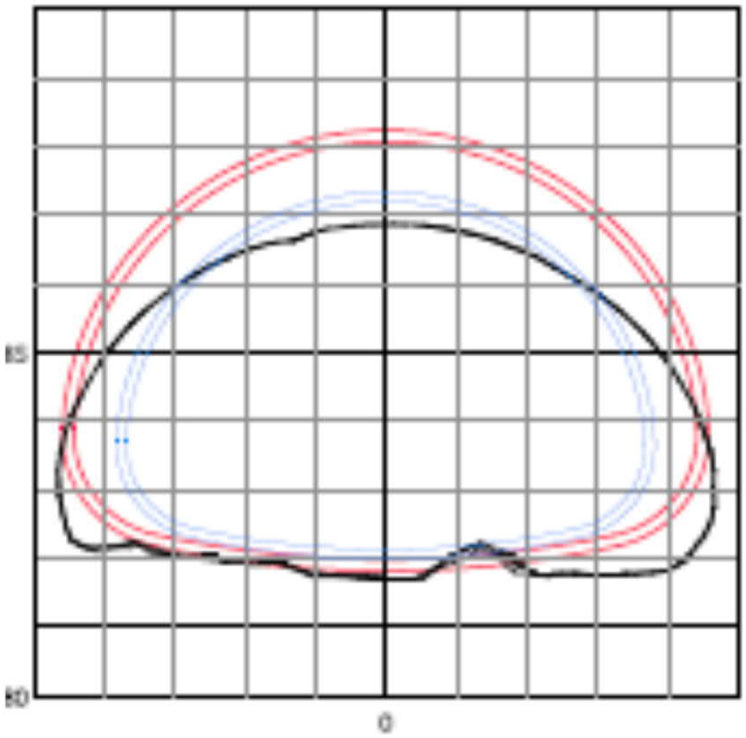
3D Laser Scan Sections and a Profile Generated for Both Culverts



3D Laser Survey

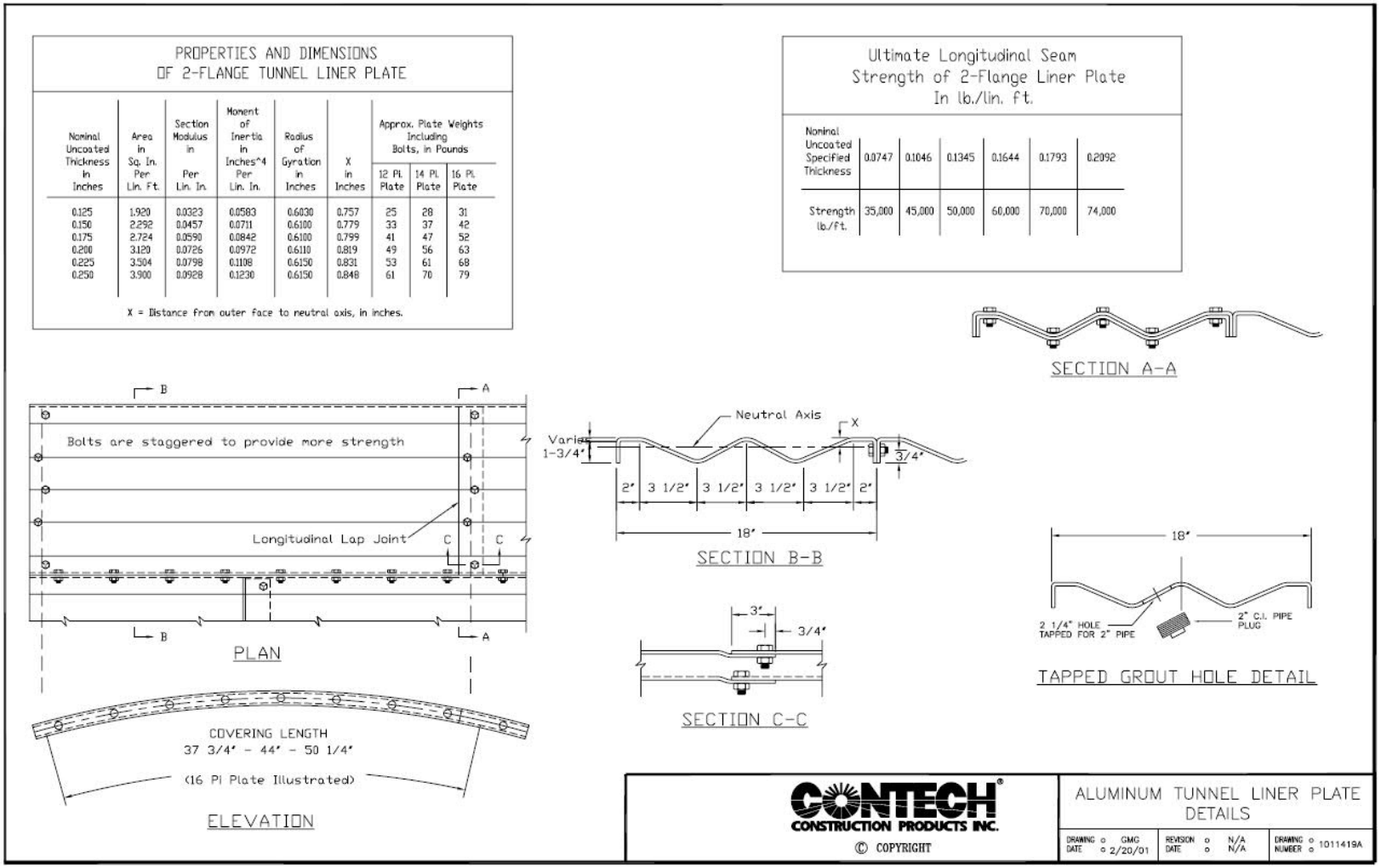


How can we build this?



1+20

Aluminum Tunnel Liner Plate



PROPERTIES AND DIMENSIONS OF 2-FLANGE TUNNEL LINER PLATE

Nominal Uncoated Thickness in Inches	Area in Sq. In. Per Lin. Ft.	Section Modulus in Per Lin. In.	Moment of Inertia in Inches^4 Per Lin. In.	Radius of Gyration in Inches	X in Inches	Approx. Plate Weights Including Bolts, in Pounds		
						12 Pl. Plate	14 Pl. Plate	16 Pl. Plate
0.125	1.920	0.0323	0.0583	0.6030	0.757	25	28	31
0.150	2.292	0.0457	0.0711	0.6100	0.779	33	37	42
0.175	2.724	0.0590	0.0842	0.6100	0.799	41	47	52
0.200	3.120	0.0726	0.0972	0.6110	0.819	49	56	63
0.225	3.504	0.0798	0.1108	0.6150	0.831	53	61	68
0.250	3.900	0.0928	0.1230	0.6150	0.848	61	70	79

X = Distance from outer face to neutral axis, in inches.

Ultimate Longitudinal Seam Strength of 2-Flange Liner Plate In lb./lin. ft.

Nominal Uncoated Specified Thickness	0.0747	0.1046	0.1345	0.1644	0.1793	0.2092
Strength lb./ft.	35,000	45,000	50,000	60,000	70,000	74,000

SECTION A-A

Bolts are staggered to provide more strength

Longitudinal Lap Joint

PLAN

Neutral Axis

Varies 1-3/4"

3/4"

2" 3 1/2" 3 1/2" 3 1/2" 3 1/2" 2"

18"

SECTION B-B

3"

3/4"

SECTION C-C

18"

2 1/4" HOLE TAPPED FOR 2" PIPE

2" C.I. PIPE PLUG

TAPPED GROUT HOLE DETAIL

COVERING LENGTH
37 3/4" - 44" - 50 1/4"
(16 Pl Plate Illustrated)

ELEVATION

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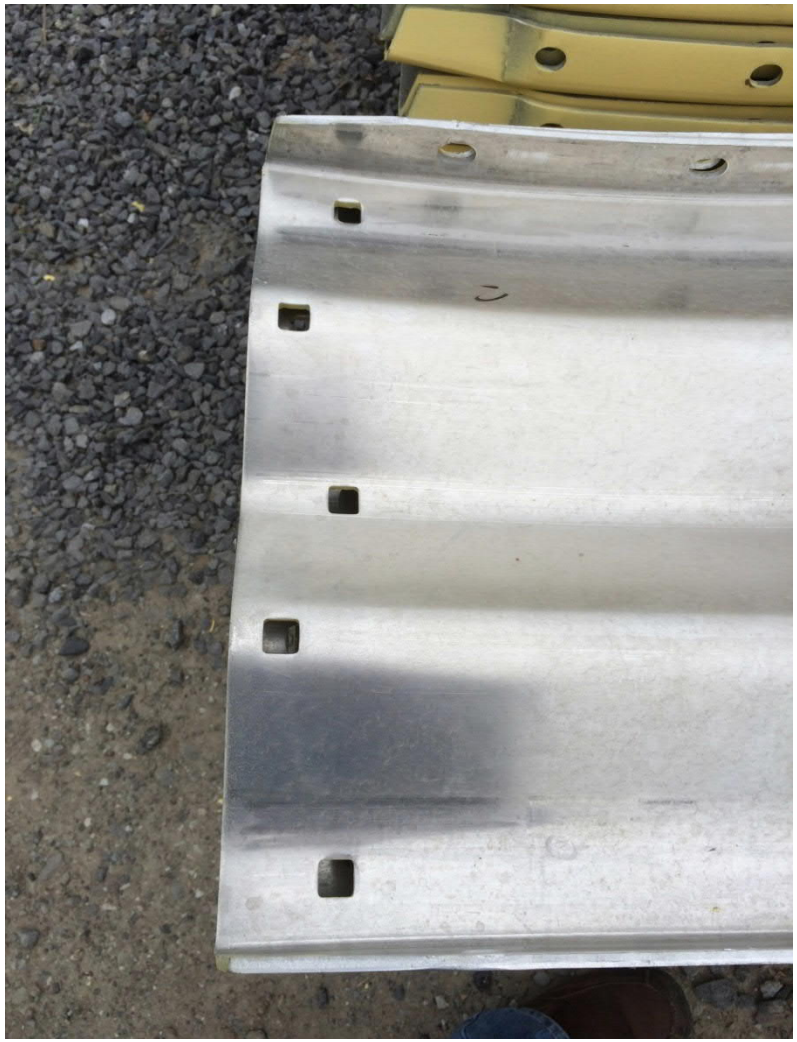
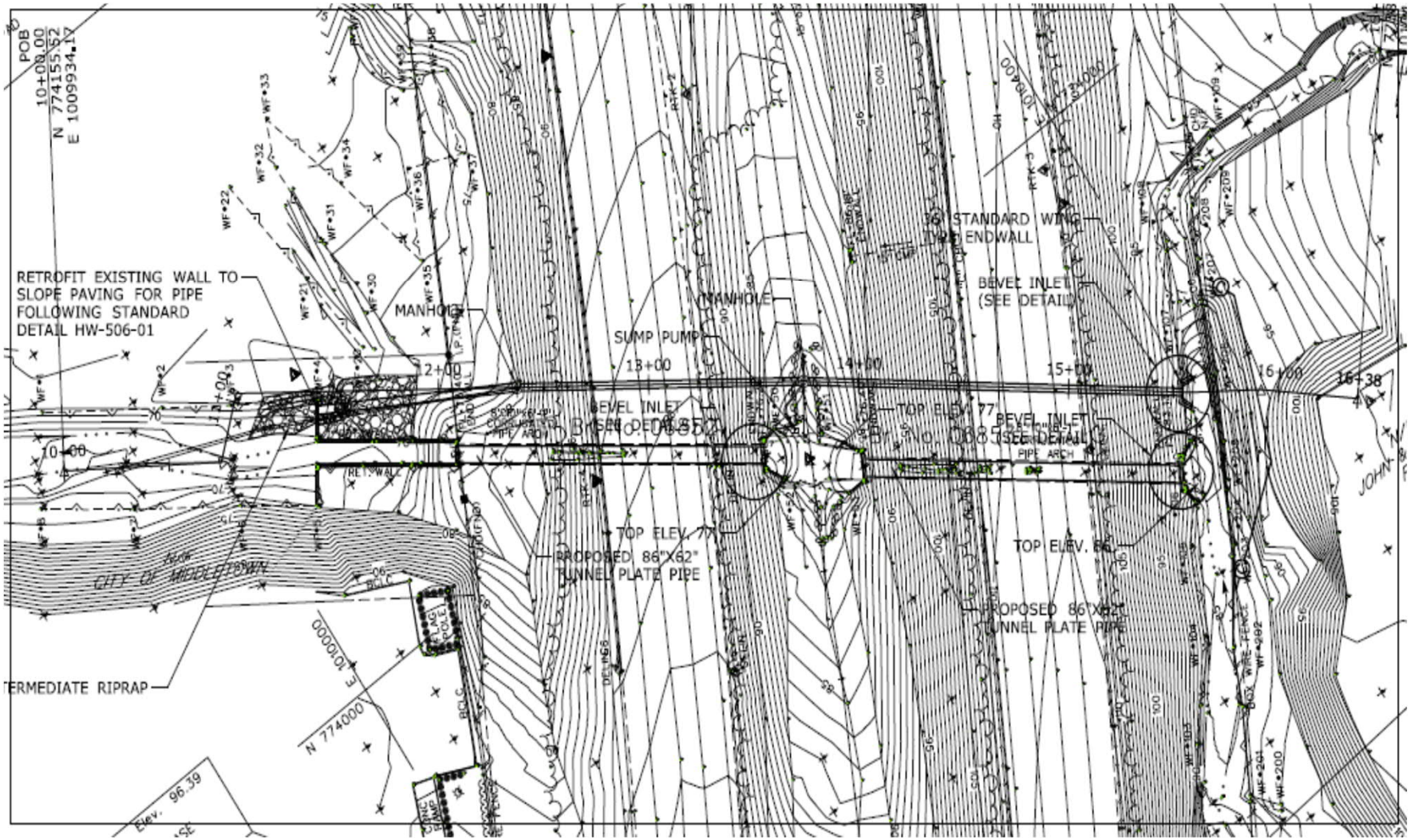
ALUMINUM TUNNEL LINER PLATE DETAILS

DRAWING DATE GMG 2/20/01 | REVISION DATE N/A N/A | DRAWING NUMBER 1011419A

Aluminum Tunnel Liner Plate



Site Plan


POB
10+00.00
N 774155.52
E 1009934.17
RETROFIT EXISTING WALL TO SLOPE PAVING FOR PIPE FOLLOWING STANDARD DETAIL HW-506-01
MANHOLE
SUMP PUMP
BEVEL INLET (SEE DETAIL)
36" STANDARD WING TYPE ENDWALL
TOP ELEV. 77
PROPOSED 86"X62" TUNNEL PLATE PIPE
TOP ELEV. 66
RETAINING WALL
CITY OF MIDDLETOWN
INTERMEDIATE RIPRAP
10+00
11+00
12+00
13+00
14+00
15+00
16+00
16+38
N 774000
E 1010000
Elev. 96.39

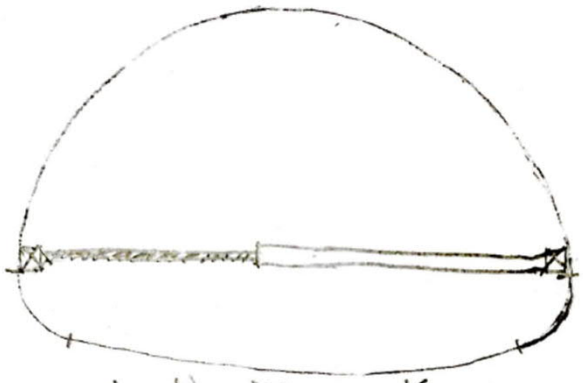
Construction Sequence:

HBM
8-12-15

Tunnel Liner Plate Pipe-Arch
—Assembly Sequence—

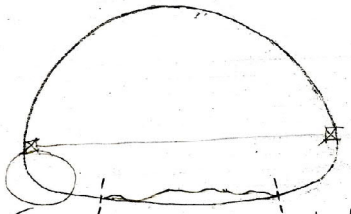
I-91
Middletown, CT

1.



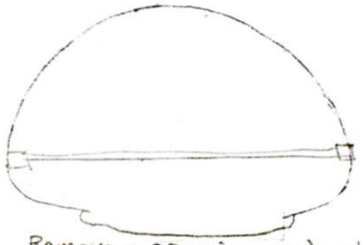
Cross strut with 4x4's sitting above bolts (at top of corner plate). Fit them snug but do not try to move wall of pipe-arch.

2.



Saw cut obstructing invert plates longitudinally on both sides of obstruction but no further out than 12 inches into the arc of the corner plate.

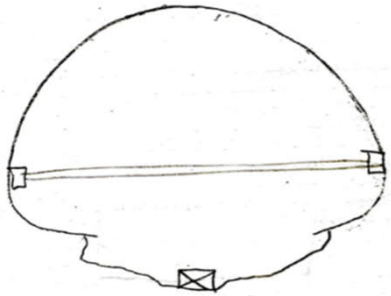
3.



Remove organic and clayey sediment from exposed bed and shape the bed to accommodate new TLP.

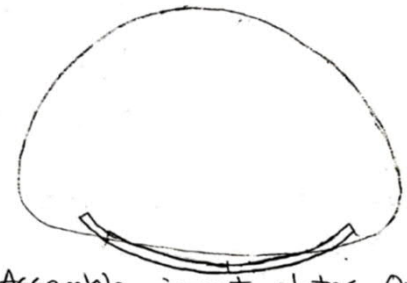
Construction Sequence:

4.



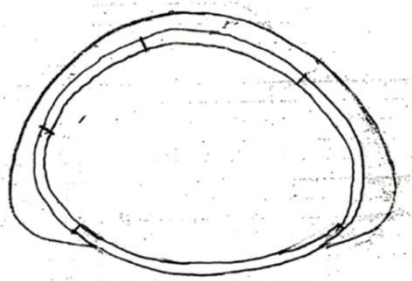
Place brick blocks at low spots to support new TLP rings as needed.

5.



Assemble invert plates. One will be a 'No Offset' plate. The other will be a 'Single Offset' plate.

6.



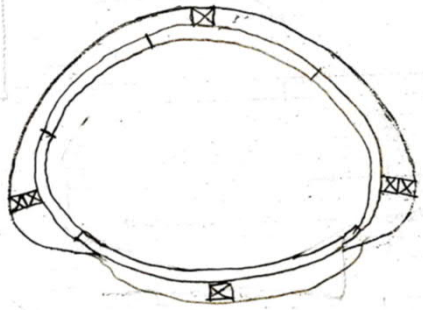
Assemble remaining plates to complete the first full ring.

Construction Sequence:

7.

Build additional rings.

8.



Place blocking on sides and at crown.

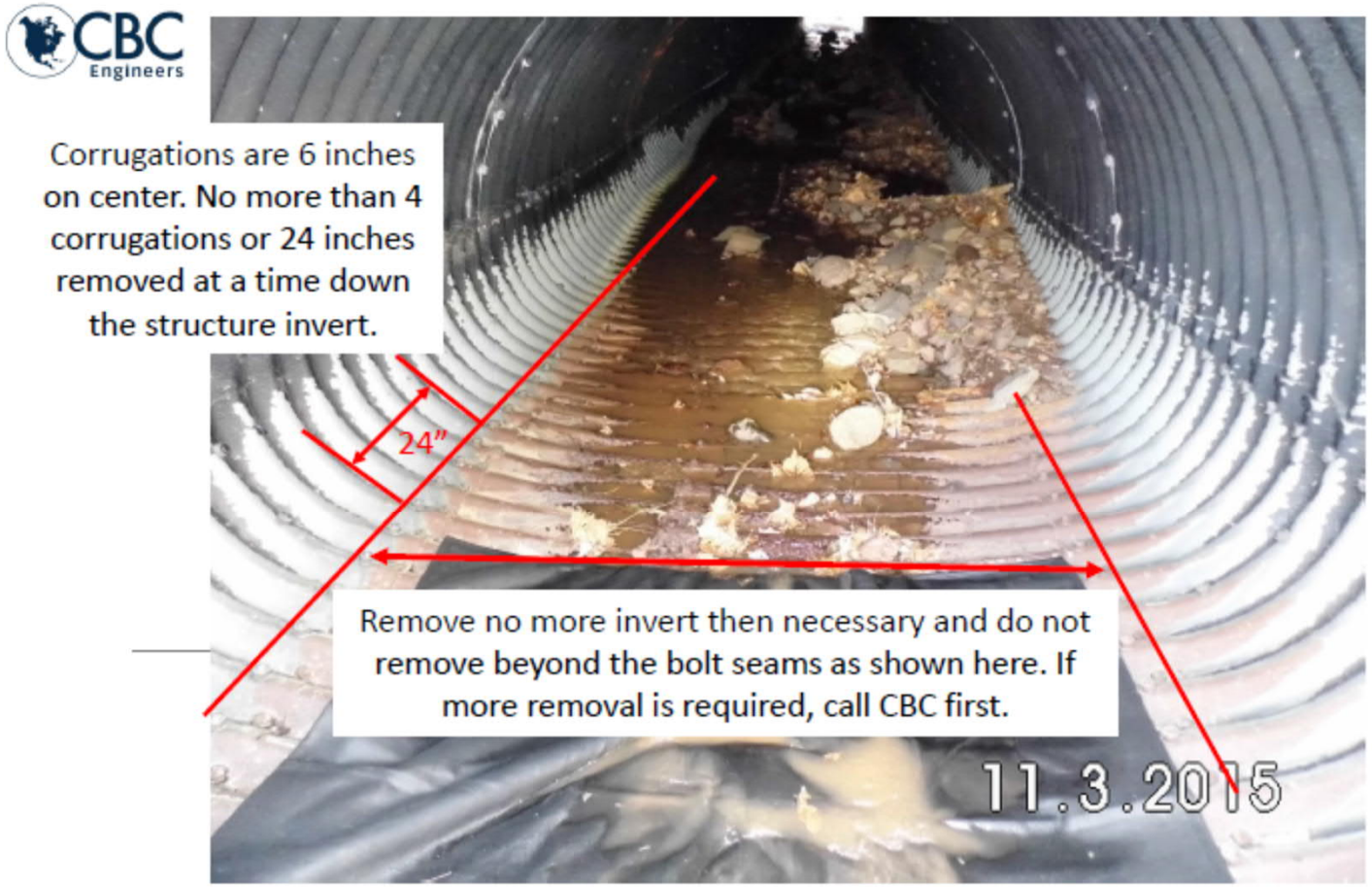
9. Repeat
10. Build bulkheads at ends and grout.

Access and Overflow Culvert

Bracing the Host Structure

Assembly

Controlled Invert Removal Limits

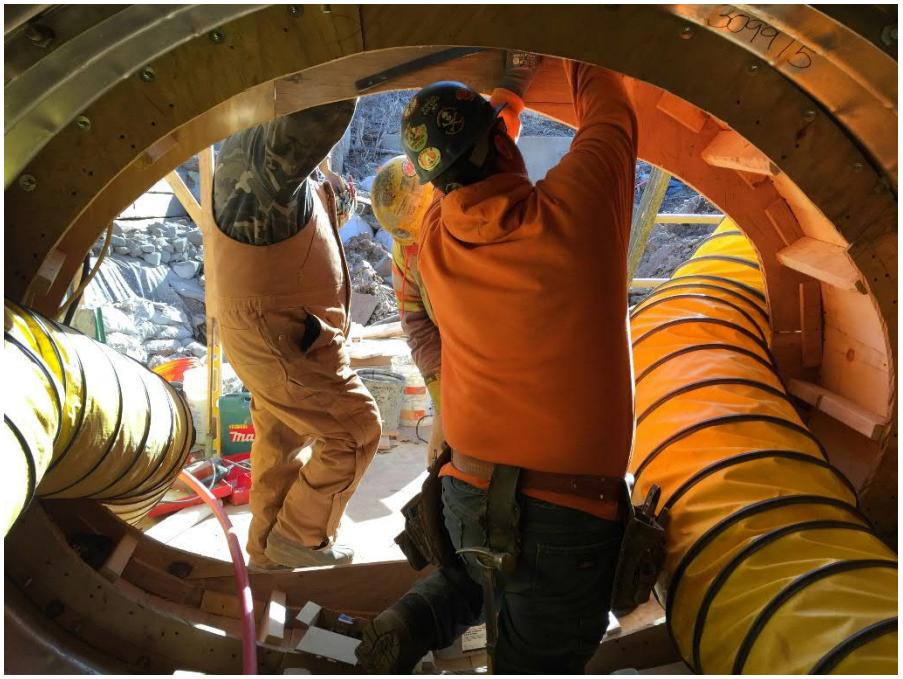


I-91 Aluminum Liner Plate Reline, Middletown, CT

MORE THAN GEOTECHNICAL ENGINEERING

Construction

Beveled Inlet Construction



Outlet End

Before

After with Eel Ladder

Questions?

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