RUNNING BETWEEN RAINDROPS: Corrosion Repair of a Critical CSO Pump Discharge Pipe

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MWRA PRISON POINT CSO (PPCSO)

- Began operation 1981
- 7 Education Way, Cambridge

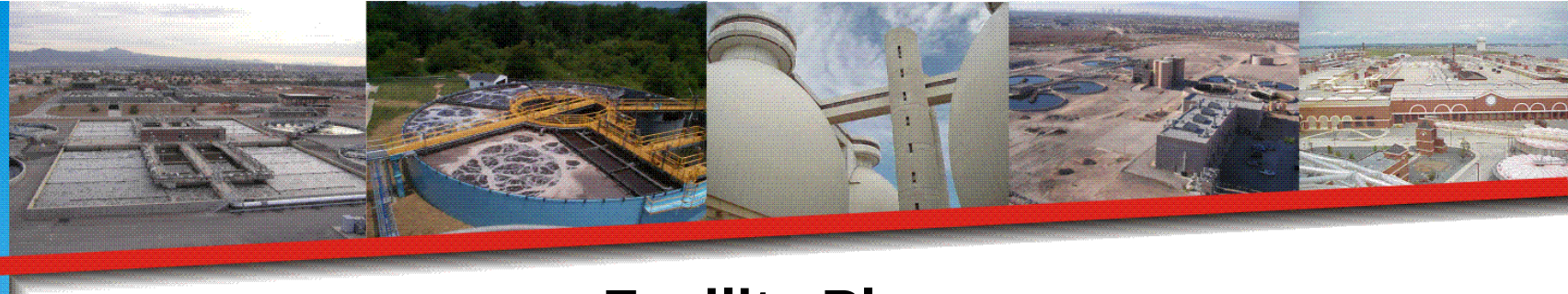
MWRA PRISON POINT CSO (PPCSO)

- Wet weather activation
  - Discharge: Boston Inner Harbor
  - Activations: 17 annual average

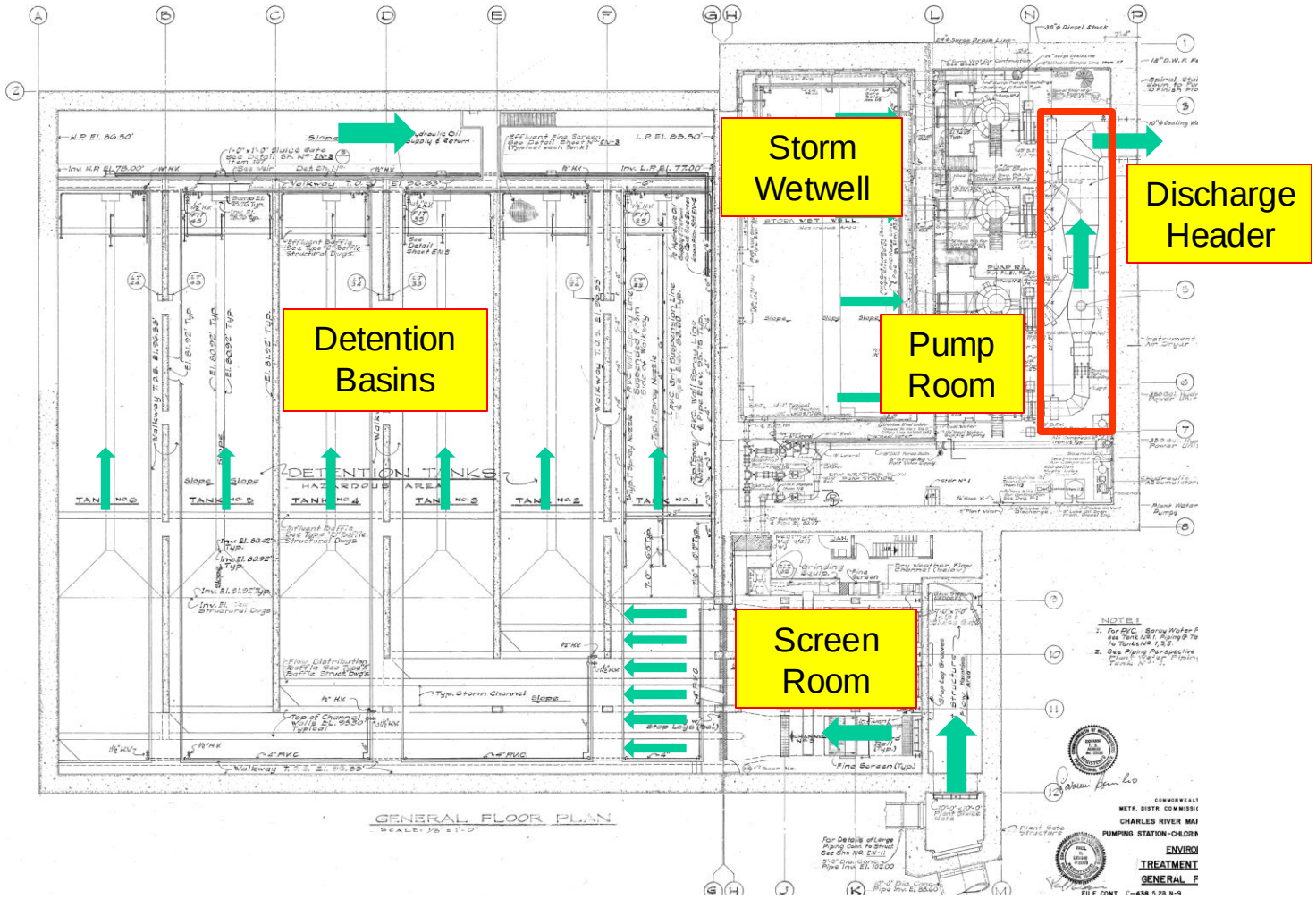
Critical stormwater system component

MWRA PRISON POINT CSO (PPCSO)

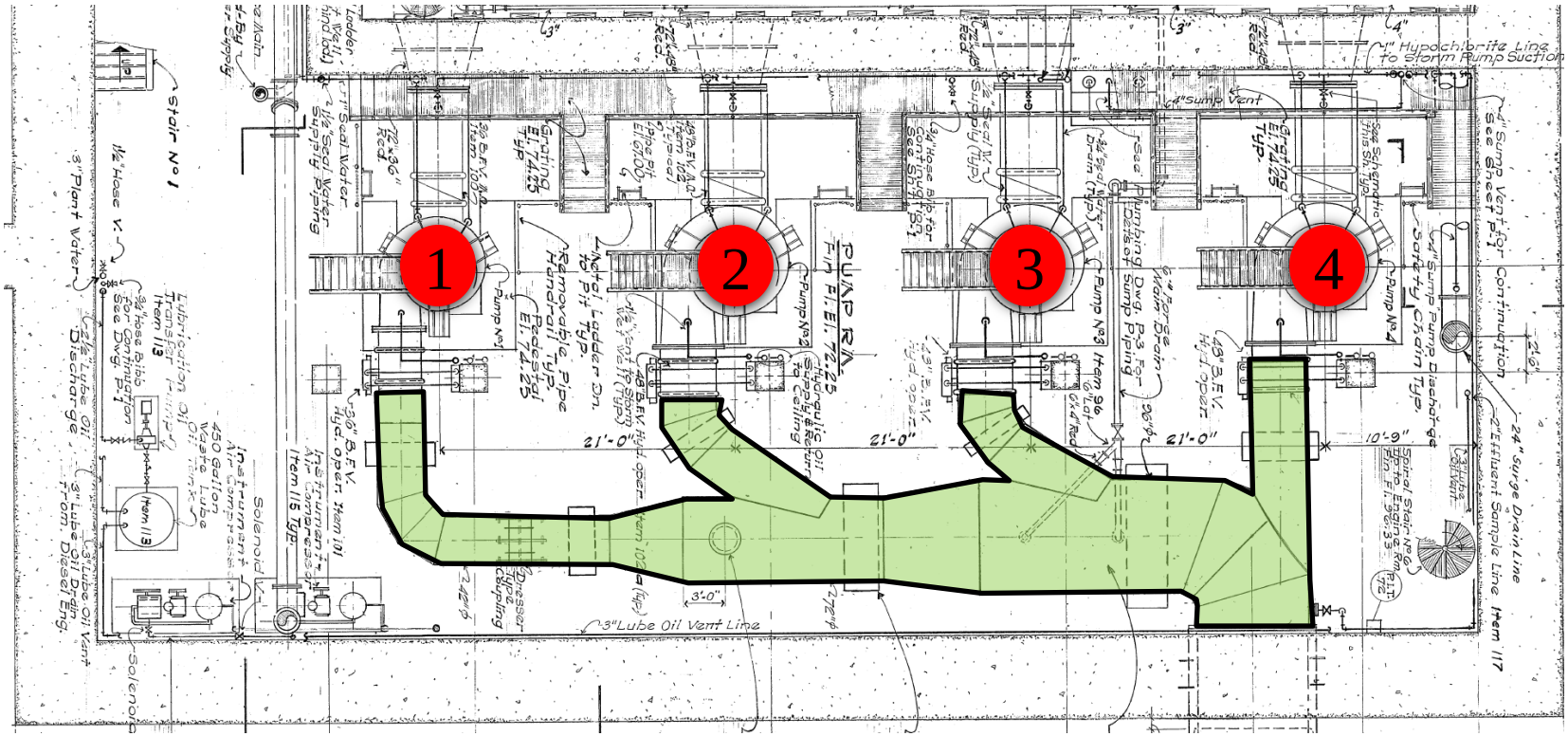
- Dry weather
  - Screening
  - Pumping
  - 1-2 MGD
- Wet weather
  - Screening
  - Disinfection
  - Detention
  - Dechlorination
  - 323 MGD capacity



Facility Plan



PUMP ROOM PLAN



PUMP ROOM SECTION

Discharge Header (Existing Condition)

The Problem

Coating Failure and Carbon Steel Corrosion

External: Isolated

Internal: General

The Problem

- Ongoing perforation & leakage
- External welded patch plate repairs

Initial Assessment – External UT

MANIFOLD PIPING UT READINGS

Location	Pipe Diam.	Circumferential Position on Pipe (Looking in Direction of Flow) 12:00	1:30	3:00	4:30	6:00	7:30	9:00	10:30	Avg.	Min.
S1-UF	42"	0.293	0.181	0.221	0.245	0.214	0.240	0.227	0.217	0.230	0.181
S1-DF	42"	0.104	0.189	0.268	0.236	0.227	0.214	0.072	0.202	0.189	0.072
S1-L	42"				0.243		0.242				
S1-M	42"				0.242		0.243			0.242	0.239
S1-R	42"				0.242		0.239				
Y	42"	0.315	0.184	0.221	0.233	0.198	0.240	0.266	0.246	0.238	0.184
CC	42"	0.097	0.078	0.267	0.112	0.271	0.336	0.251	0.232	0.206	0.078
S2-UF	42"	0.124	0.246	0.268	0.270	0.072	0.075	0.277	0.239	0.196	0.072
S2-DF	42"	0.294		0.273	0.283	0.230	0.311	0.271	0.077	0.248	0.077
S2-L	42"				0.314		0.290				
S2-M	42"				0.267		0.070			0.257	0.070
S2-R	42"				0.287		0.312				
D	42"	0.312	0.297	0.292	0.296	0.311	0.324	0.245	0.255	0.292	0.245
P	42"					0.268					
						0.264				0.272	0.264
						0.283					
DD	42"	0.081	0.147	0.075	0.097	0.090	0.334	0.079	0.078	0.123	0.075
E	42"-72"	0.242	0.226	0.250	0.292	0.236	0.233	0.320		0.257	0.226
EE	42"-72"	0.217	0.212	0.265	0.218	0.266	0.112	0.274	0.199	0.220	0.112
Q	42"-72"						0.261	0.221			
							0.267	0.254		0.246	0.205
							0.205	0.265			
V	42"-72"			0.258							
				0.260						0.260	0.258
				0.261							
R	42"-72"							0.178			
								0.172		0.185	0.172
								0.206			
FF	42"-72"	0.094	0.209	0.270	0.264	0.075	0.284	0.336	0.214	0.218	0.075
GG	72"	0.125	0.182	0.258	0.287	0.286	0.296	0.100	0.169	0.213	0.100
KK	72"	0.253	0.182	0.091	0.299	0.164	0.267			0.209	0.091
LL	72"	0.253	0.166	0.106	0.102	0.274	0.286	0.236	0.193	0.202	0.102
S3-UF	72"	0.101	0.135	0.074	0.230	0.232	0.240	0.239	0.215	0.183	0.074
S3-DF	72"	0.110	0.233	0.085	0.065	0.277	0.299	0.248	0.232	0.194	0.065
S3-L	72"				0.295		0.300				
S3-M	72"				0.067		0.258			0.216	0.066
S3-R	72"				0.066		0.311				
G	72"	0.299	0.243	0.230	0.297	0.194	0.322	0.239	0.249	0.259	0.194
MM	72"-96"	0.210	0.192	0.180	0.106	0.154	0.331	0.191	0.190	0.194	0.106
S	72"-96"						0.312	0.203			
							0.312	0.204		0.257	0.200
							0.311	0.200			
H	72"-96"	0.187	0.221	0.219	0.260	0.312	0.297	0.110	0.157	0.220	0.110
NN	72"-96"	0.182	0.210	0.233	0.296	0.315	0.305	0.195	0.195	0.241	0.182
T	72"-96"					0.315					
						0.310				0.314	0.310
						0.318					
W	72"-96"			0.217							
				0.216						0.217	0.216
				0.217							
OO	72"-96"	0.147	0.229	0.255	0.298	0.327	0.135	0.177	0.175	0.218	0.135
I	96"	0.259	0.224	0.233	0.265	0.290	0.317	0.276	0.253	0.265	0.224
RR	96"	0.224	0.205	0.245	0.072	0.072	0.315			0.189	0.072
K	96"	0.224	0.233	0.209	0.259	0.332	0.270	0.218	0.217	0.245	0.209
SS	96"	0.240	0.205	0.076	0.305	0.243	0.112	0.199	0.185	0.196	0.076
S4-UF	96"	0.163	0.065	0.100	0.267	0.075	0.259	0.091	0.102	0.140	0.065
S4-DF	96"	0.146	0.117	0.198	0.252	0.078	0.112	0.102	0.189	0.149	0.078
S4-L	96"				0.109		0.131				
S4-M	96"				0.116		0.258			0.163	0.109
S4-R	96"				0.254		0.112				
L	96"	0.263	0.212	0.221	0.302	0.330	0.268	0.204	0.227	0.253	0.204
U	96"	0.122									
		0.116								0.119	0.116
		0.120									
N	96"	0.273	0.262	0.230	0.289	0.318	0.302	0.261	0.276	0.276	0.230

DISCHARGE PIPING UT READINGS

Location	Pipe Diam.	Circumferential Position on Pipe (Looking in Direction of Flow) 12:00	1:30	3:00	4:30	6:00	7:30	9:00	10:30	Avg.	Min.
PUMP NO. 1 DISCHARGE											
A	36"	0.257	0.227	0.196	0.221	0.217	0.218	0.220	0.220	0.222	0.196
0	36"-42"							0.219			
								0.228		0.223	0.219
								0.223			
B	36"-42"	0.251	0.217	0.207	0.231	0.242	0.227	0.220	0.246	0.230	0.207
AA	42"	0.147	0.173	0.227	0.249	0.215	0.262	0.184	0.187	0.206	0.147
C	42"	0.243	0.223	0.232	0.226	0.215	0.243	0.212	0.211	0.226	0.211
BB	42"	0.116	0.187	0.218	0.261	0.194	0.262	0.108	0.210	0.195	0.108
PUMP NO. 2 DISCHARGE											
JJ	48"	0.073	0.127	0.121	0.327	0.091	0.299	0.271	0.122	0.179	0.073
F	48"	0.232	0.151	0.202	0.235	0.265	0.251	0.162	0.209	0.213	0.151
II	48"	0.113	0.190	0.293	0.309	0.081	0.106	0.267	0.205	0.196	0.081
HH	48"	0.163	0.152	0.125	0.258	0.261	0.248	0.091	0.218	0.190	0.091
PUMP NO. 3 DISCHARGE											
QQ	48"	0.305	0.112	0.125	0.128	0.234	0.299	0.096	0.321	0.203	0.096
J	48"	0.303	0.309	0.303	0.262	0.205	0.302	0.276	0.281	0.280	0.205
PP	48"	0.298	0.107	0.165	0.239	0.303	0.308	0.115	0.245	0.223	0.107
PUMP NO. 4 DISCHARGE											
TT	48"	0.217	0.176	0.230	0.078	0.205	0.256	0.209	0.074	0.181	0.074
M	48"	0.188	0.202	0.254	0.163	0.182	0.249	0.226	0.187	0.206	0.163
X	48"						0.340	0.281	0.249		
							0.320	0.234	0.200	0.278	0.200
							0.346	0.283	0.251		

Value less than minimum thickness for allowable hoop stresses

Value less than 0.125-inch

Original: 1/4” (0.250)

5/16” (0.313)

Corroded: 0.222 ave.

0.065 min.

Initial Assessment

- Structural Analysis
  - Allowable minimum thickness: 1/8” (0.125)
  - Overstressed at pipe saddles

Initial Assessment

- Chloride source:
  - Roadway deicing salts
  - Salt water backfill
- Oxygen source: Post-operation draining:
- Cyclic use
  - Drained: Corrosion formation
  - Operated: Corrosion removal
  - Fresh metal exposure

Erosion Corrosion Mechanism

Rehabilitation Challenges

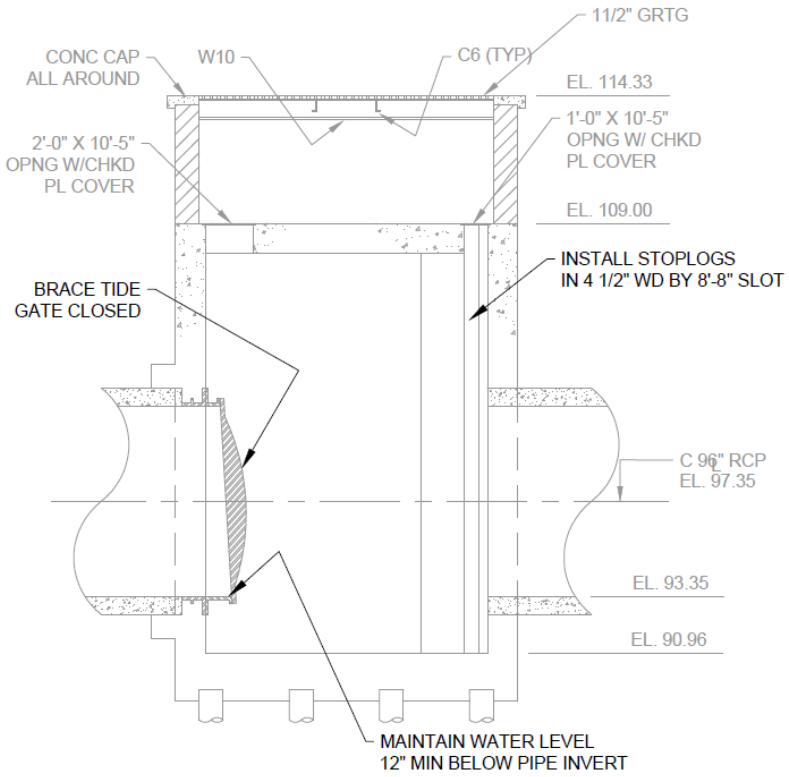
- Operable with 12-hour notice
- No bypass
- 20-inch manhole
- Tidal inflow
- Welded pipe
- Clearances
- Identifying thinned areas

Phase I Rehab

- Welded leak patches
- External UT & patches at thinned areas
- Pipe saddle enlargement
- Exterior coating

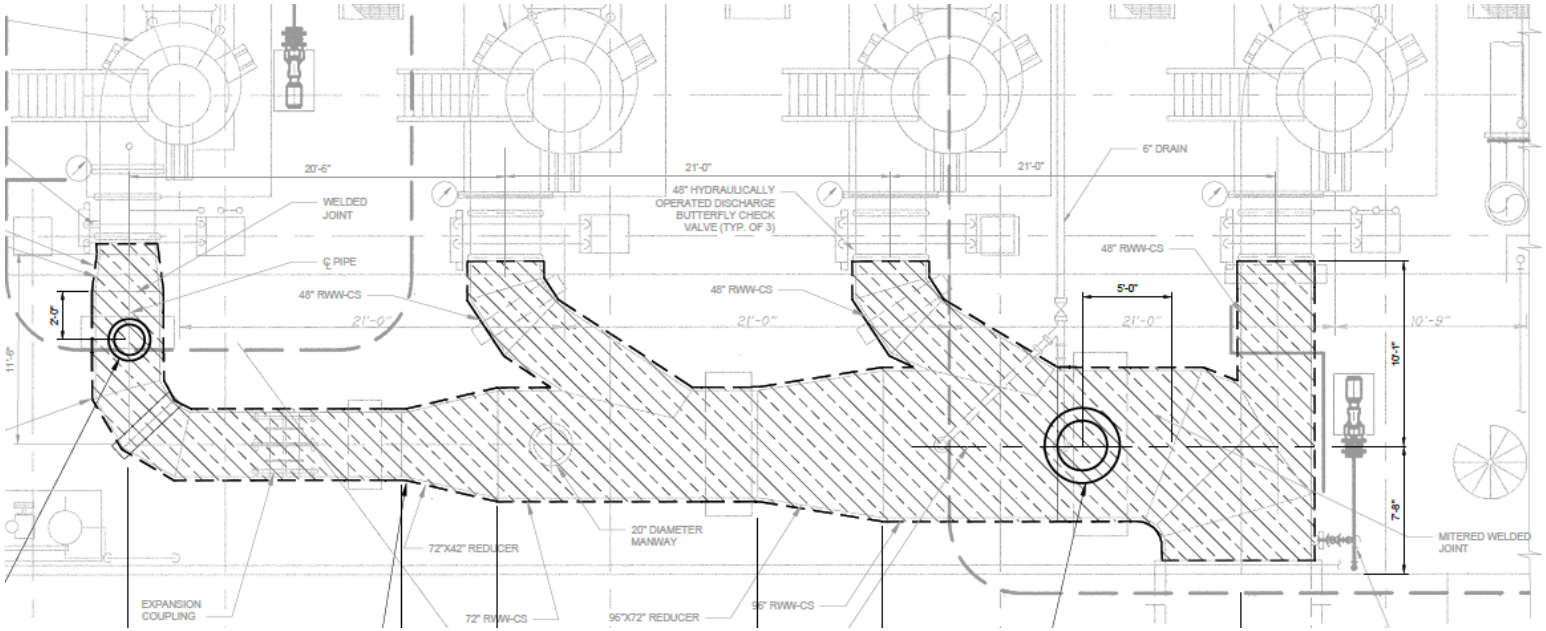
Phase II Rehab Design

Tidal inflow: Double block & bleed



Phase II Rehab Design

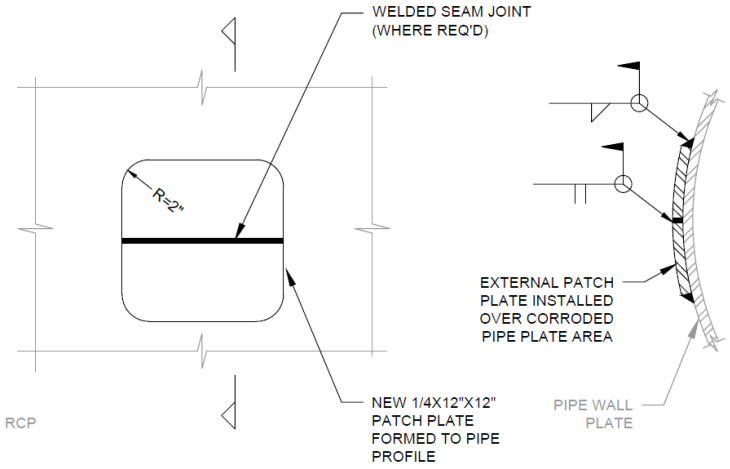
Access: 2 new manholes



Phase II Rehab Design

Repair

- Initial abrasive blasting
- Structural inspection
- Welded repairs
  - Patch plates
  - Pit welding
  - Joint welding
  - Magnetic particle testing



Phase II Rehab Design

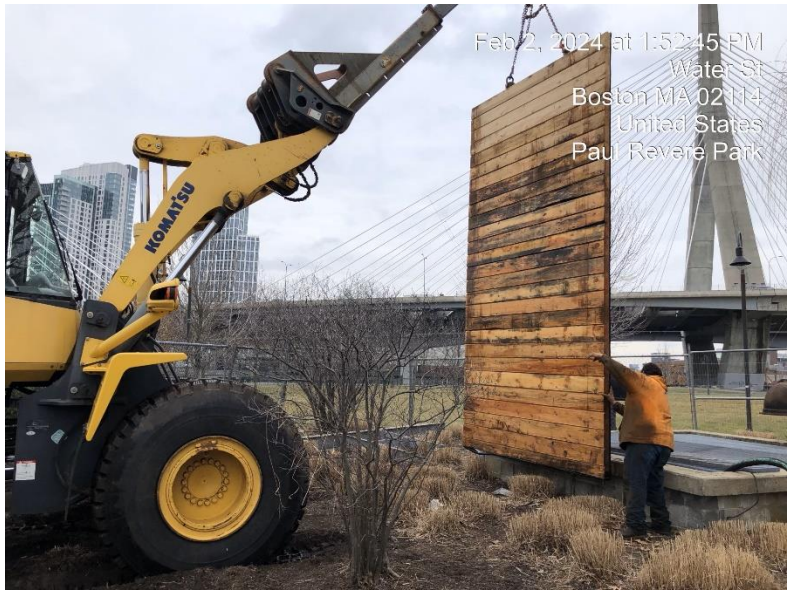
Protection

- Internal epoxy pit filler & 150-mil liner
- External weld damage touch-up
- Testing
  - Chlorides
  - Profile
  - Wet, dry film thickness
  - Adhesion
  - Holiday

Phase II Rehab Design

Work restrictions (Running between raindrops)

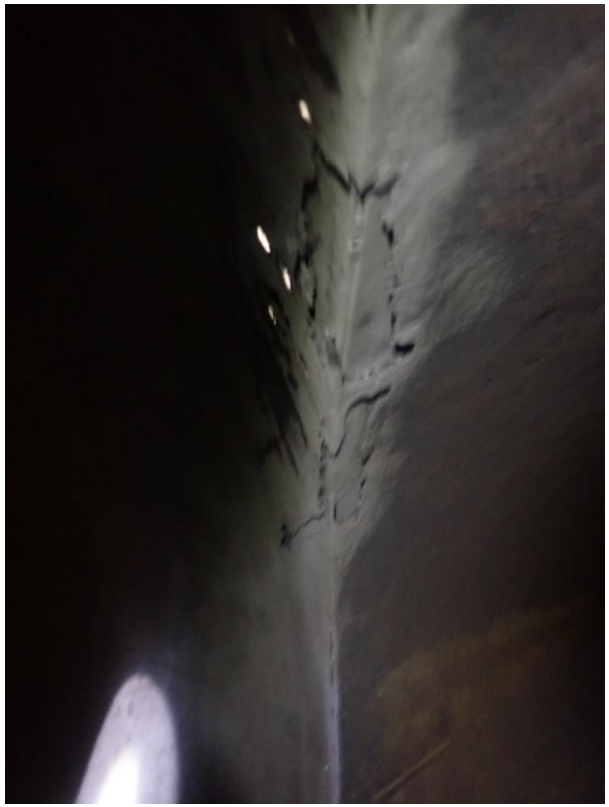
- Dry weather: Interior and exterior
- Wet weather expected: Exterior only
- Activation: No work
- Demobiliation
  - Partial: daily
  - Full: Weekend and wet weather



Phase II Rehab Construction

Manhole Installation

Phase II Rehab Construction



Initial abrasive blasting

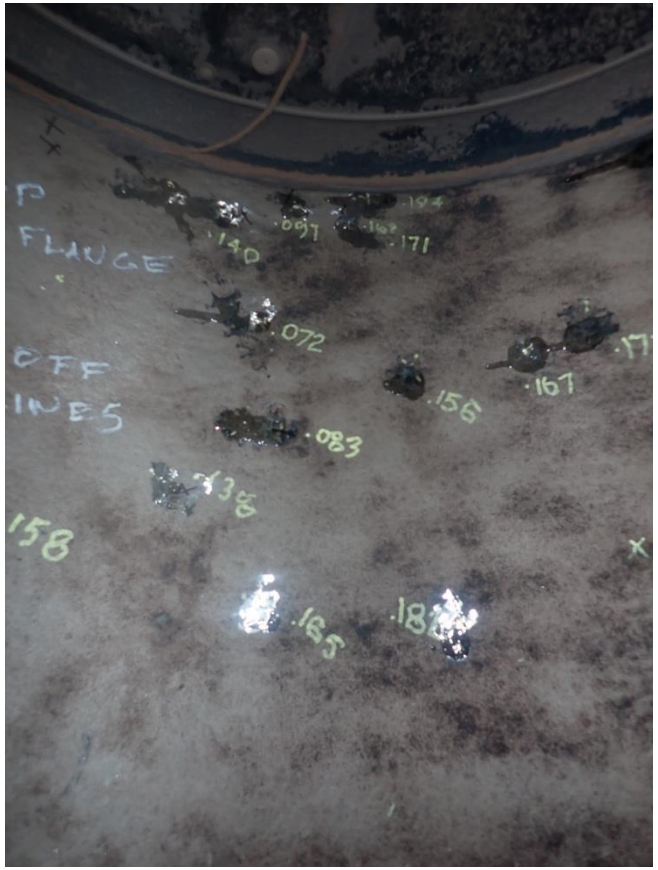
Phase II Rehab Construction

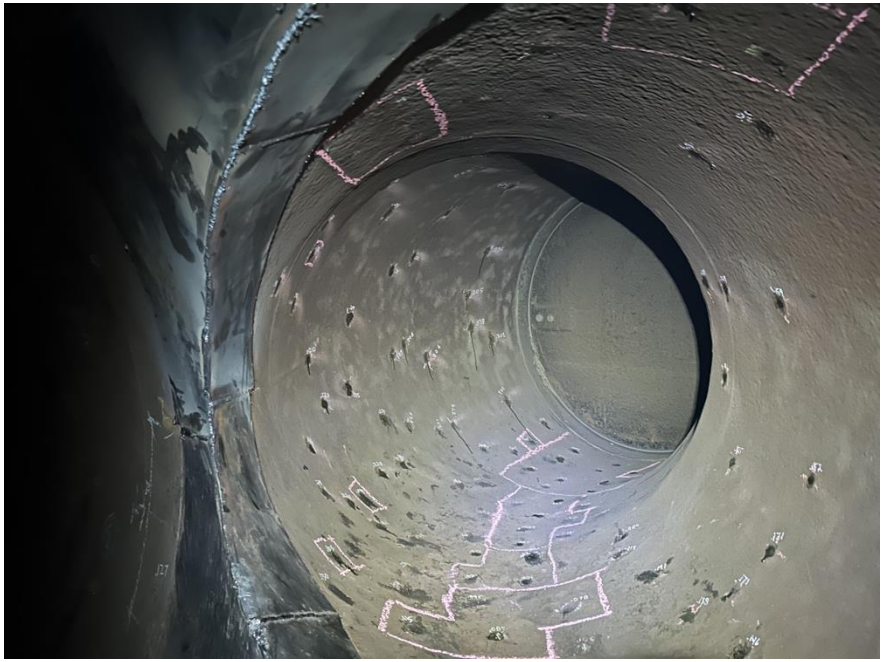
Structural Inspection: Visual

Phase II Rehab Construction

Structural Inspection: Visual

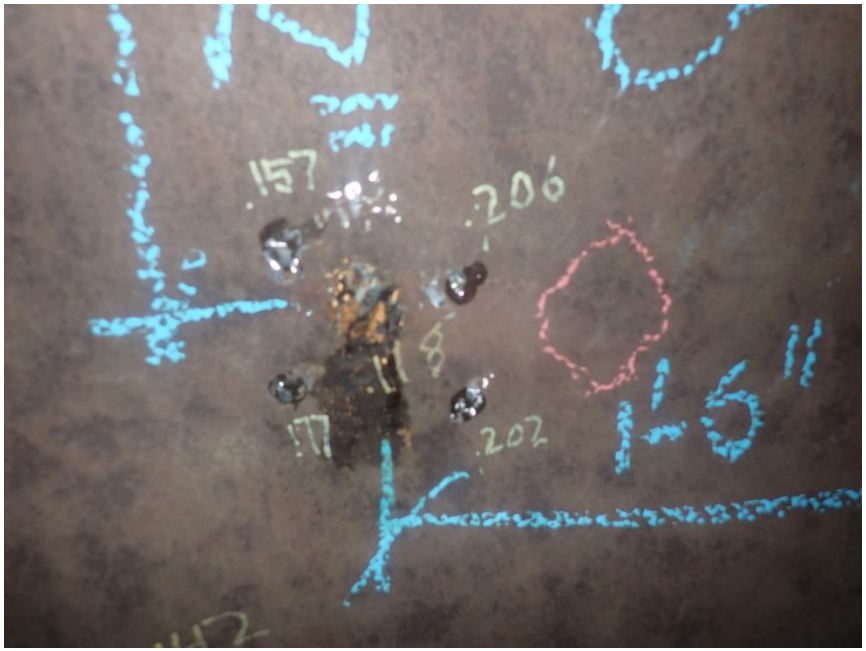
Phase II Rehab Construction

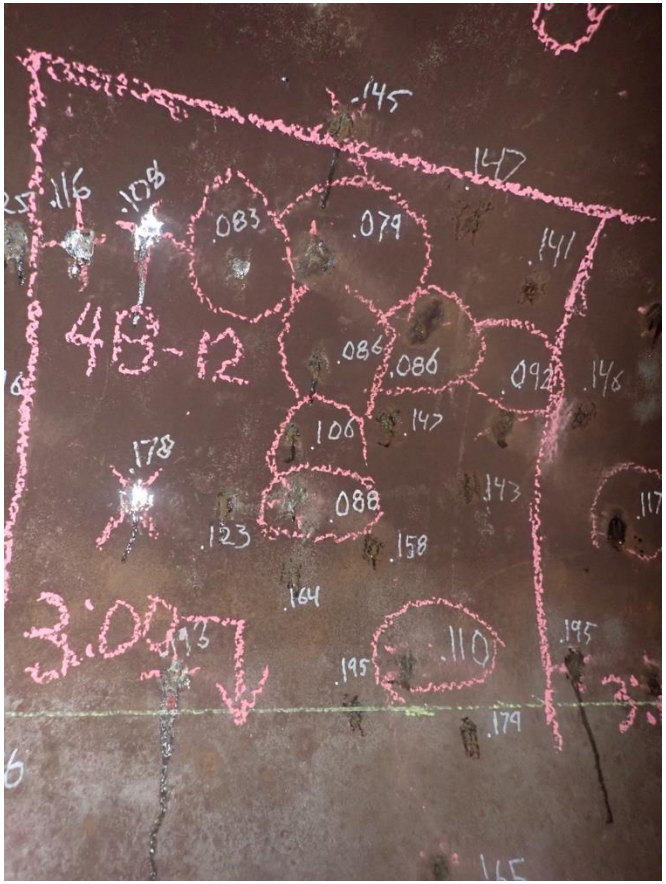




Structural Inspection: Ultrasonic Thickness

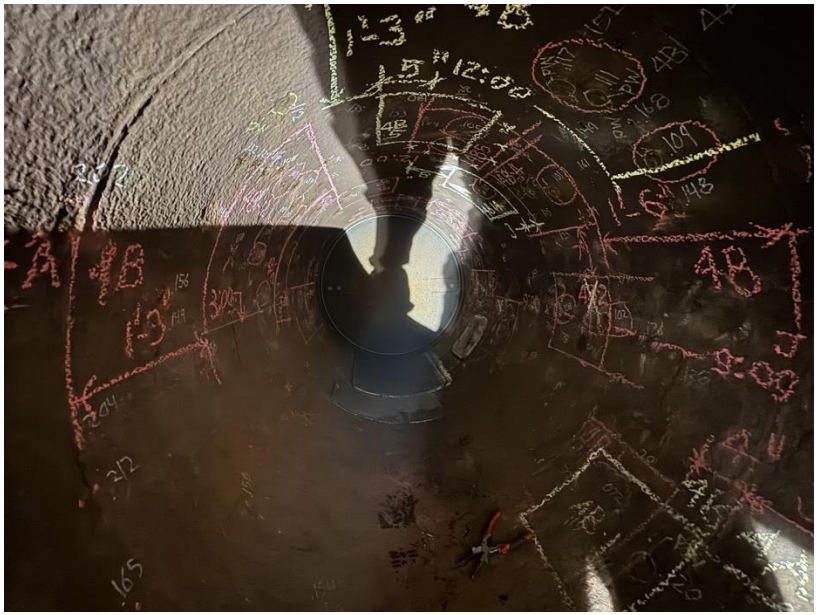
Phase II Rehab Construction





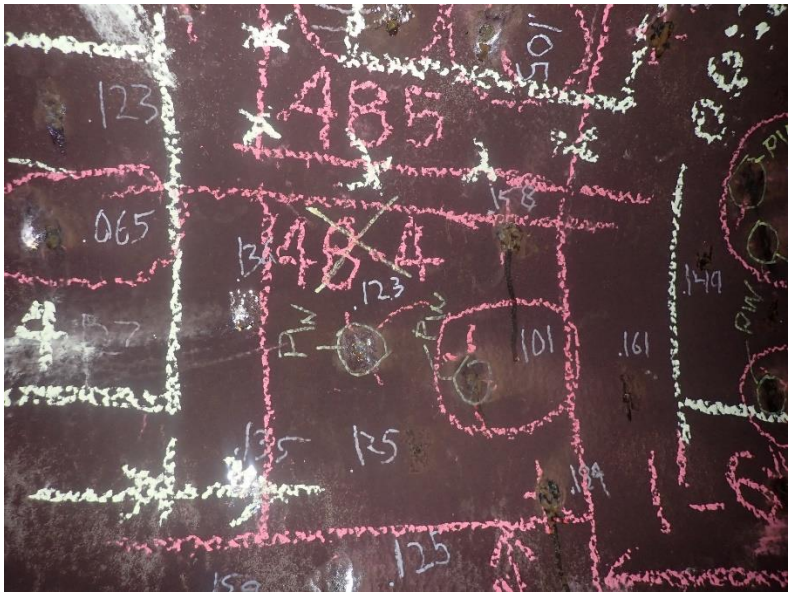
Structural Inspection: Repair definition

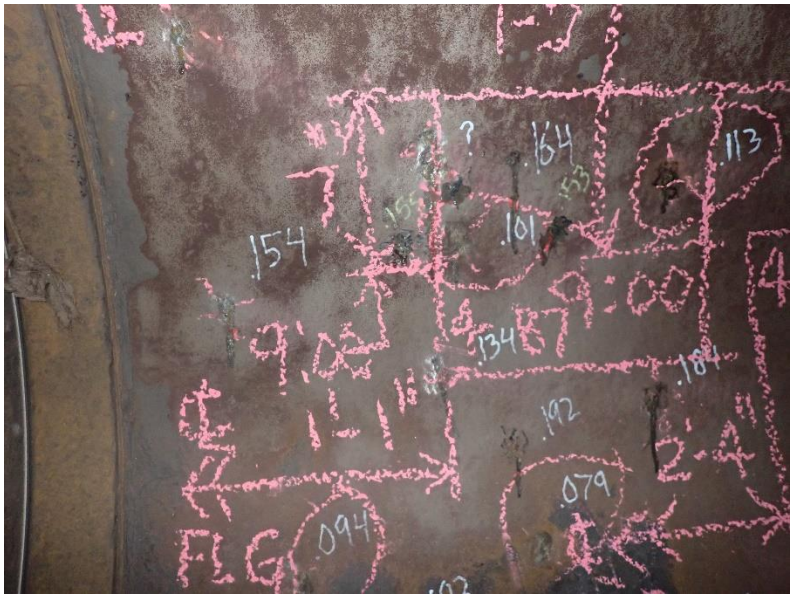
Phase II Rehab Construction



Structural Inspection: Repair definition

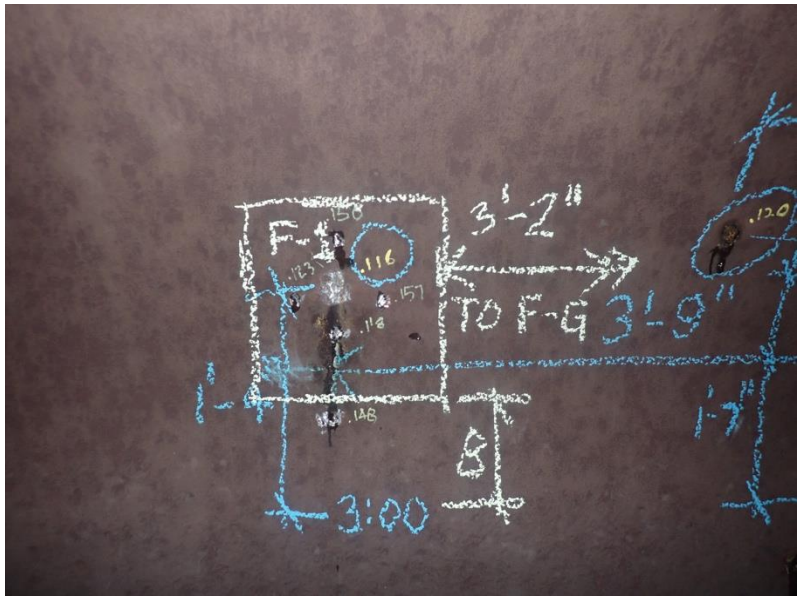
Phase II Rehab Construction

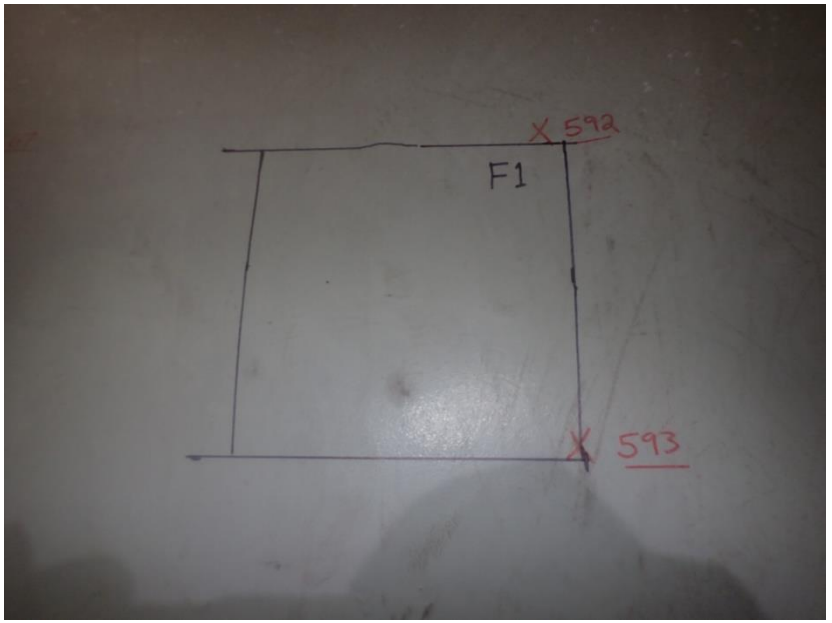




Structural Inspection: Repair definition

Phase II Rehab Construction





Structural Inspection: Plate location

Phase II Rehab Construction

Structural Inspection: Joint weld location

Phase II Rehab Construction

Structural Inspection: Crotch plate location

Phase II Rehab Construction

Welded Repairs

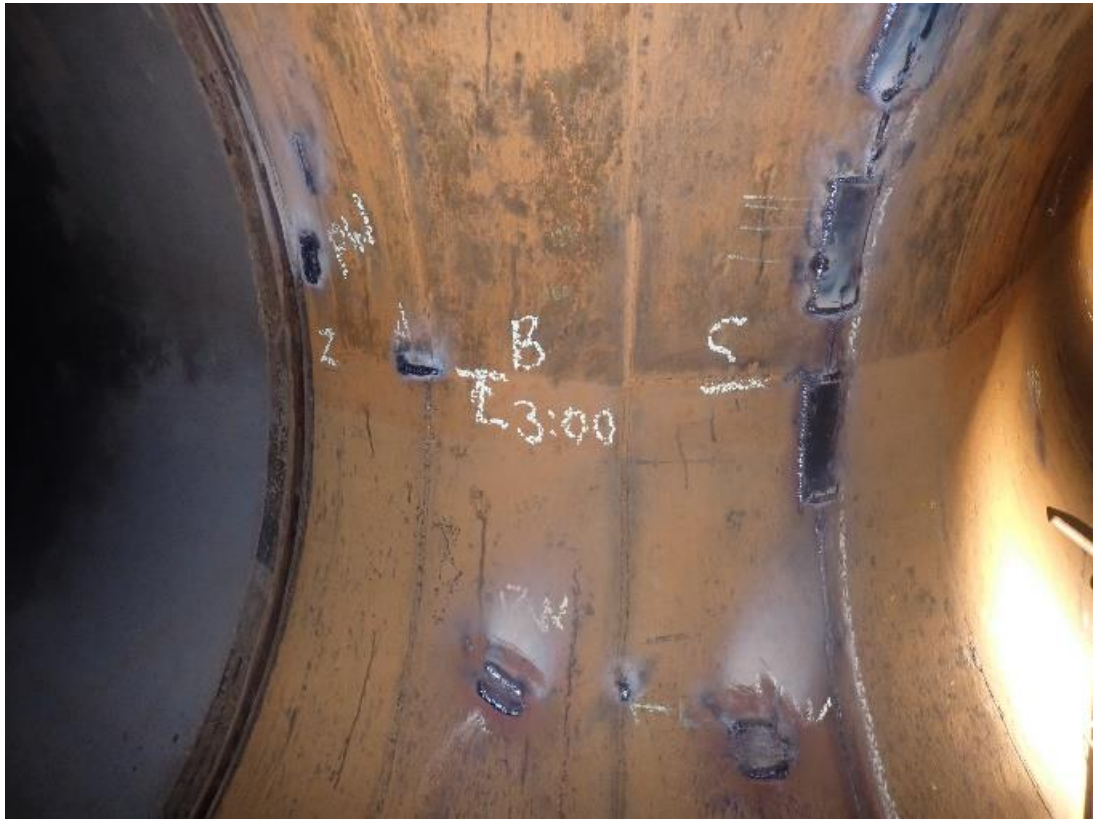
Phase II Rehab Construction

Weld repairs: External patch plates

Phase II Rehab Construction

Weld repairs: Internal patch plates

Phase II Rehab Construction



Weld repairs: Internal pit & joint

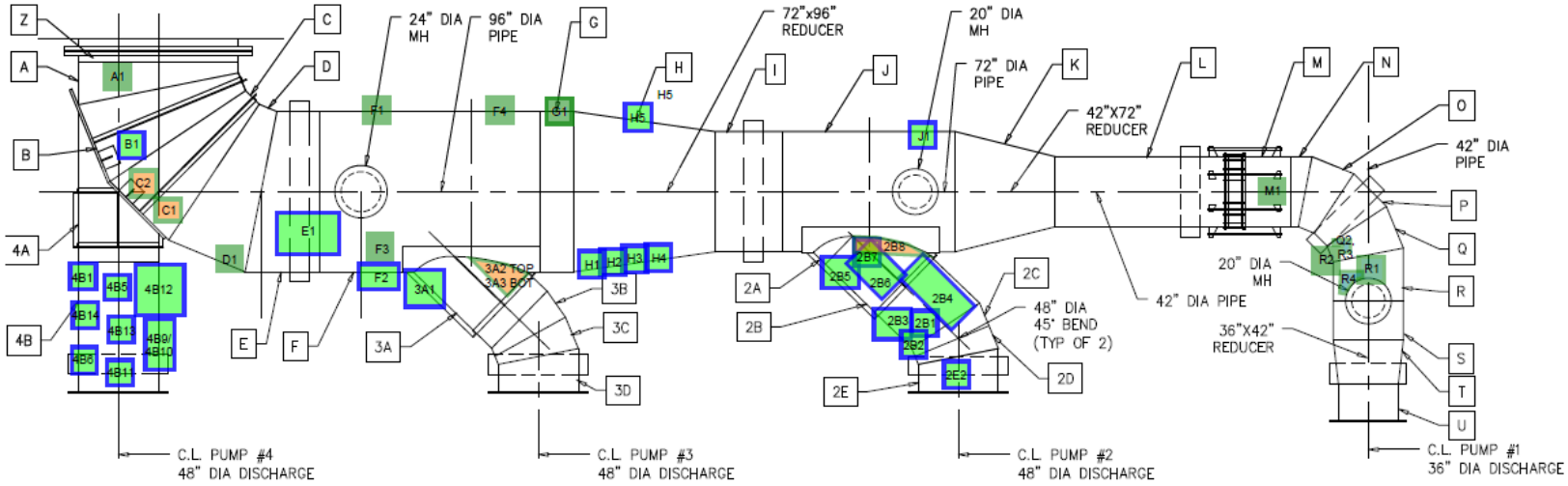
Phase II Rehab Construction

Weld repairs: Discharge crotches

Phase II Rehab Construction

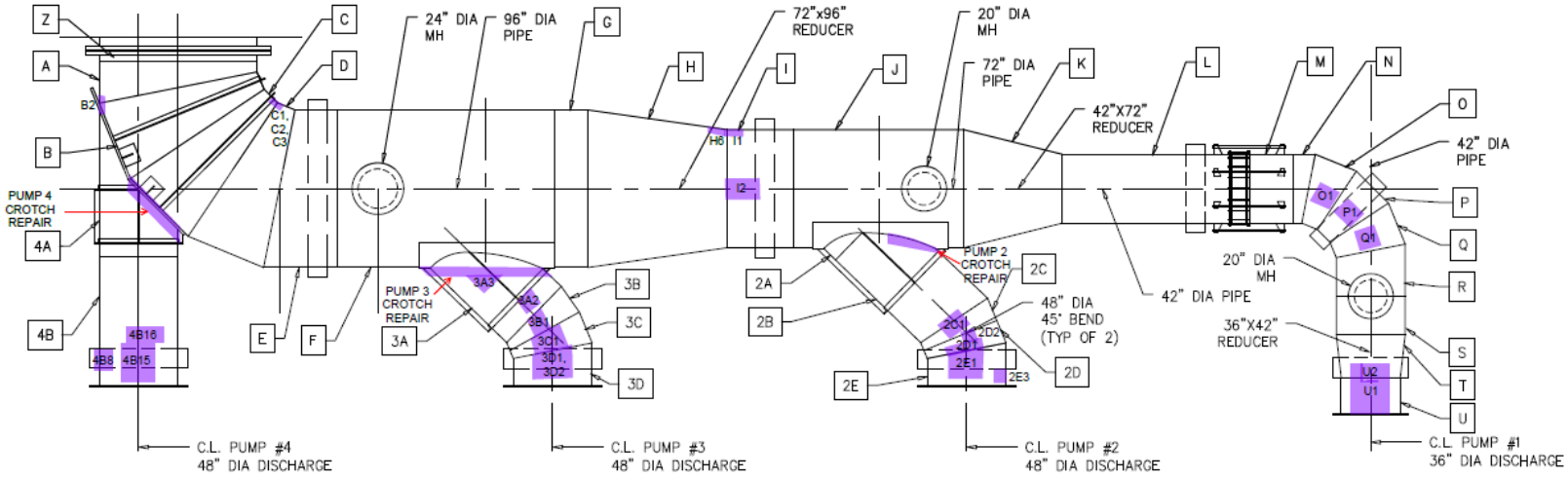
Activation Leaks

Phase II Rehab Construction



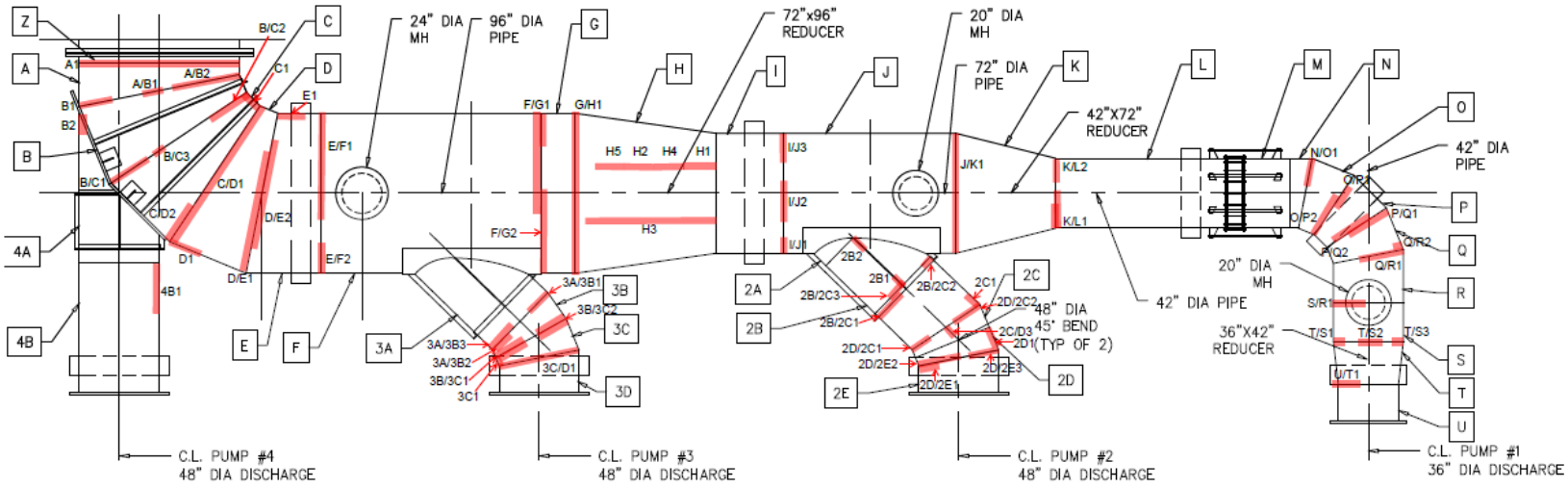
Exterior patch plates

Phase II Rehab Construction



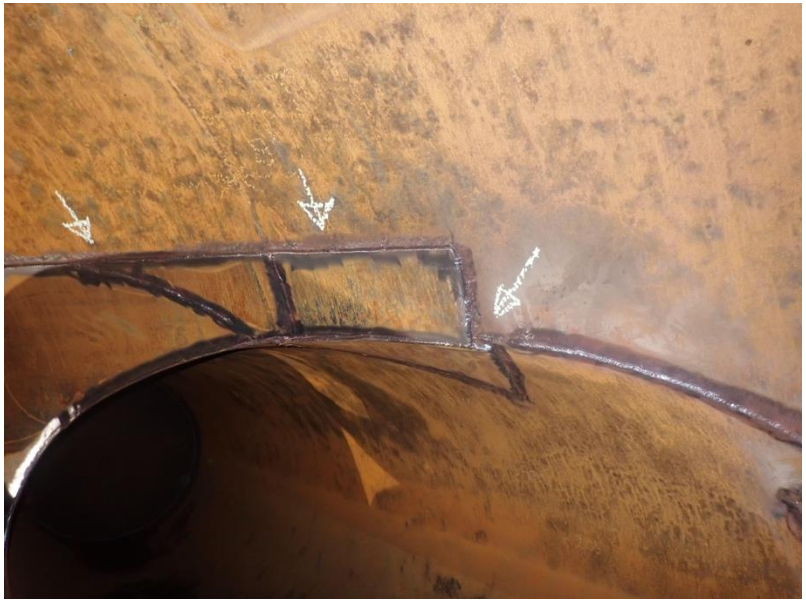
Interior patch plates

Phase II Rehab Construction



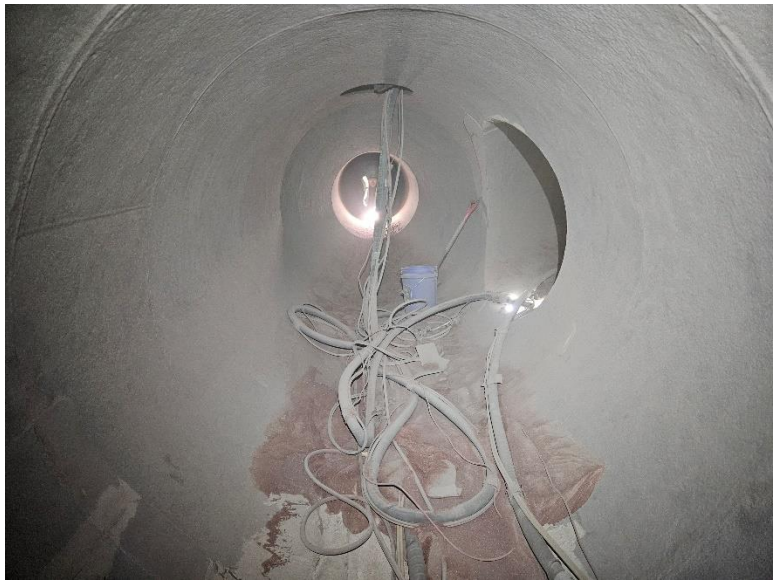
Joint welds

Phase II Rehab Construction



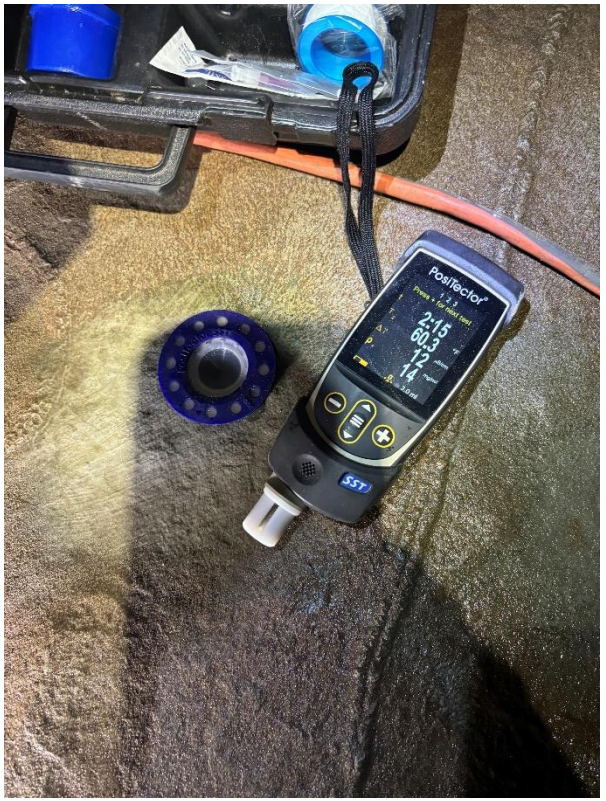
Weld Inspection

Phase II Rehab Construction



Coating: Final abrasive blasting

Phase II Rehab Construction



Coating inspection: Chlorides

Phase II Rehab Construction

Coating inspection: Surface profile

Phase II Rehab Construction

Coating: Pit filling

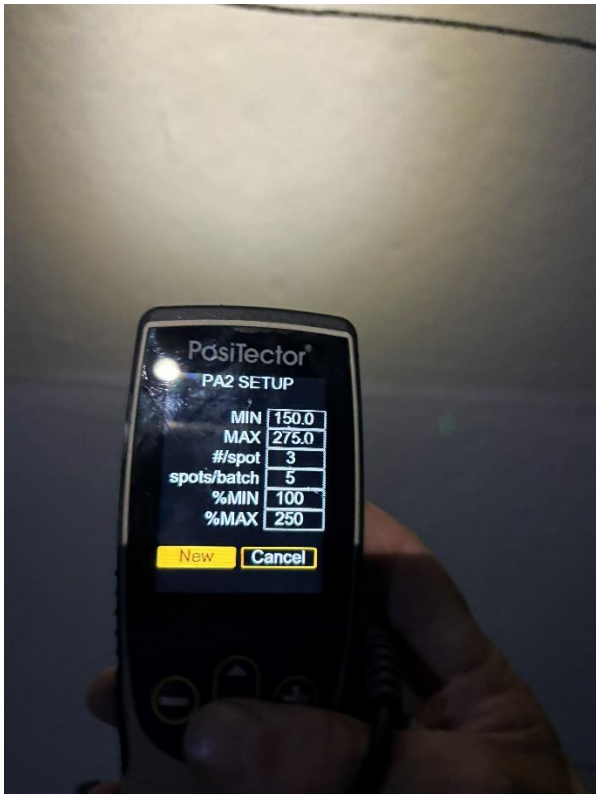
Phase II Rehab Construction

Coating: Interior finish

Phase II Rehab Construction

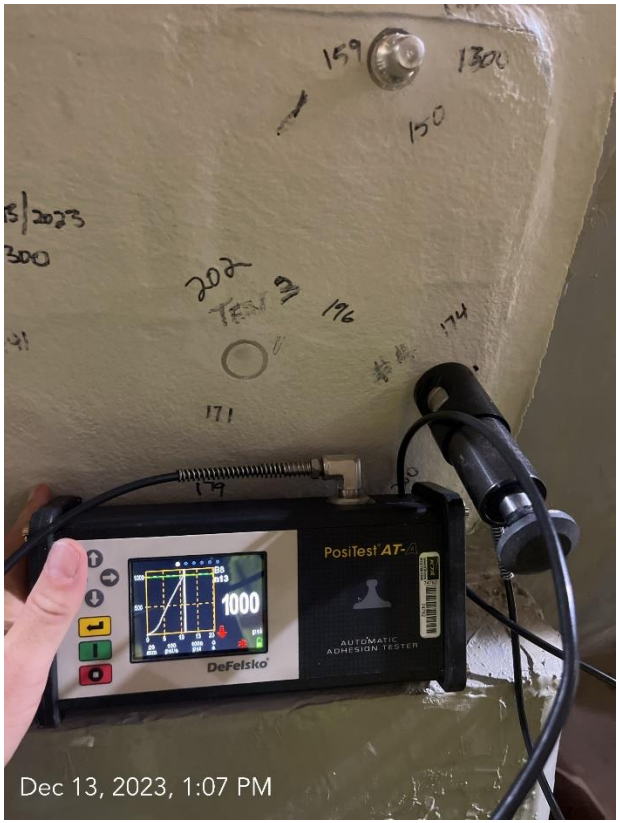
Coating: Exterior finish

Phase II Rehab Construction



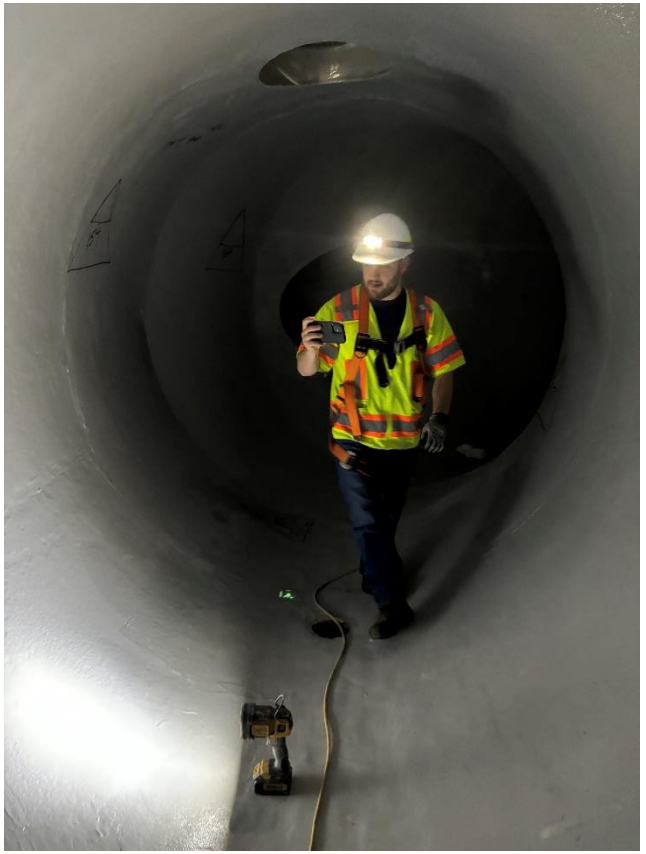
Coating inspection: Film thickness

Phase II Rehab Construction



Coating inspection: Adhesion & holiday testing

Phase II Rehab Construction



Final Inspection

Next Phases

Short Term

- Periodic internal inspection
- Coating repairs to maintain protection

Long Term

- Corrosion-resistant replacement
- Facility modification

Many thanks to:

Massachusetts Water Resources Authority

Stephen Cullen	Charles Ryan
Michael Barter	Meredith Norton
Marty McGowan	Eleanor Duffy
Andrea Adams	David Pottle
Roberto Jarrin	Dan Walton

PPCSO Facility Operators

Many thanks to:

Stantec (Prime Consultant, Phase I Design)

Brian Shea **Kenneth Scully**

Michael Carroll

Arcadis (Prime Consultant, Phase II Design)

Jennifer Lachmayr **Stephen Perry**

Confined Space Entry Solutions (Rescue)

Arthur Laporte **Leo Stapleton**

Many thanks to:

Hazen and Sawyer

(Prime Consultant, Construction)

James Barsanti **Jaclyn Lemieux**

Engineering Concepts, Inc. (Resident)

Richard Monteiro

Corrosion Probe, Inc. (Subconsultant)

Randy Nixon

Jarod Barbee **Rigo Gomez**

Bryce Annino **Mark Gartside**

Many thanks to:

R. Zoppo Corporation (General Contractor)

Alex Levey **Franco Nicolazzo**

Phil Doherty **Anthony Gratta**

DC Welding, Inc. (Welding)

Dan Charko, Sr. **Dan Charko, Jr.**

John Charko

Tnemec/Righter Group

Larry Mitkus

Many thanks to:

Mistras (Weld testing)

John Doucette **Bill Davis**

John W. Egan Company (Painting)

Robert “Junior” Belisle **Josh Graf**

OHS Training & Consulting (Rescue)

True North Safety (Site Health & Safety)

RUNNING BETWEEN RAINDROPS:

Corrosion Repair of a Critical CSO Pump Discharge Pipe

QUESTIONS?

Alejandro Alvarez
Construction Coordinator
Massachusetts Water Resources Authority

Kevin R. Krawiec, PE
Principal Structural Engineer
Corrosion Probe, Inc.