# Appendix G
# Soil Corrosivity Results and Corrosion Evaluation Report

CORRTECH
CORROSION UNDERSTOOD

# SOIL CORROSIVITY INDEX

Client: Stantec Consulting
Project: MWRA WASM 3 Corrosion Exposure
Job No.: 9301

| No. | Boring | Pipe Section | Soil Resistivity: Laboratory (Ω-cm) | Moisture Content (%) | Chloride Salinity (PPM) | pH Value | Sulfides (L/M/H) | Redox Potential (mV) | Corrosivity Index | Corrosivity Category | Corrosion Rate (Mils/Yr) | Soil Classification | Historical Leak | Stray Current TS MWRA ID | Stray Current TS Sta. No. | Concrete encased | Closest Address | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | B-2 | 9 | 52000 | 5.5% | <31 | 5.81 | Low | 221.6 | 4 | Non-Corrosive | 1.57 | Sand and Gravel, trace silt | | W9-2-A | 10+10 | No | 58 River Rd | "Very dense sand & gravel" |
| 2 | B-5 | 9 | 67000 | 8.1% | <31 | 6.43 | Low | 301.3 | 4 | Non-Corrosive | 0.30 | Sand and Gravel, trace silt | 1 | | | No | | |
| 3 | B-7 | 9 | 140000 | 3.7% | <31 | 6.60 | Low | 304.6 | 4 | Non-Corrosive | 0.45 | Sand, some gravel, little silt | | | | No | | |
| 4 | B-9 | 9 | 9400 | 16.1% | <31 | 6.78 | Low | 275.2 | 0 | Non-Corrosive | 2.82 | Sand, some silt, little gravel | | | | No | | Cambridge W.W. 36-in CI Pipe |
| 5 | B-11 | 9 | 23000 | 11.0% | <31 | 7.34 | Low | 253.9 | 2 | Non-Corrosive | 1.05 | Sand & Gravel, trace silt | | | | No | | |
| 6 | B-13 | 9 | 130000 | 3.9% | <31 | 5.72 | Low | 330.8 | 4 | Non-Corrosive | 0.60 | Sand and Silt, trace gravel | | W9-12-A | 78+15 | No | Howe Ave/Maynard Ave | WASM3 running through cemetary |
| 7 | B-17 | 9 | 66,000 | 2.0% | 86 | 8.70 | Low | 213.1 | 4 | Non-Corrosive | 9.80 | Sand & Gravel, trace silt | 1 | W9-13-D | 84+10 | No | Howe Ave/Riverview Ave | WASM3 running through cemetary , then crosses RR. Good spot for pipe calibration, 545-ft |
| 8 | B-20 | 9 | 24000 | 14.0% | <31 | 7.05 | Low | 303.9 | 2 | Non-Corrosive | 3.85 | Fine Sand, trace med. Sand, trace silt | | | | No | | WASM3 parallel w/ RR |
| 9 | B-23 | 9 | | | | | | | | | | | | | | | | WASM3 parallel w/ RR |
| 10 | B-24 | 9 | 13,000 | 10.5% | 18 | 6.32 | Low | 269.0 | -4 | Moderately-Corrosive | 8.17 | Sand, some gravel, some silt | 8 | N/A | Leak Location | No | Bellevue St/Prospect St | WASM3 parallel w/ RR |
| 11 | B-27 | 10 | 71,000 | 5.0% | 4 | 7.35 | Low | 215.1 | 4 | Non-Corrosive | 2.21 | Sand & Gravel, little silt | 1 | W10-9-A | | No | 103 Felton St | WASM3 parallel w/ RR |
| 12 | B-29 | 10 | 8,800 | 12.3% | 52 | 7.72 | Low | 274.1 | 0 | Non-Corrosive | 2.25 | Sand & Gravel, trace silt | 7 | W10-11-G | 148+07 | No | Felton St/Moody St | WASM3 parallel w/ RR |
| 13 | B-29 | 10 | 7,000 | 2.1% | 29 | 9.48 | Low | 168.0 | 2 | Non-Corrosive | 0.20 | Gravel fill | 7 | W10-11-G | 148+07 | No | Felton St/Water St | W10-10 Leak Location (10/1/18): **East** end of excavation |
| 14 | B-29 | 10 | 7,200 | | 29 | 8.70 | Low | 187.0 | 0 | Non-Corrosive | 0.45 | Clay | 7 | W10-11-G | 148+07 | No | Felton St/Water St | W10-10 Leak Location (10/1/18): **West** end of excavation |
| 15 | B-29 | 10 | 59,000 | 11.3% | 29 | 8.51 | Low | 287.0 | 4 | Non-Corrosive | 0.44 | Gravel fill | 7 | W10-11-G | 148+07 | No | Felton St/Water St | W10-10 Leak Location (10/1/18): **Center** end of excavation |
| 16 | B-31 | 10 | 1,100 | 10.6% | 165 | 6.95 | Low | 324.9 | -6 | Corrosive | 6.35 | Sand, some silt, trace gravel | | 1 | | No | Moody St/Felton St | WASM3 parallel w/ RR |
| 17 | B-32 | 10 | 63000 | 7.1% | <31 | 7.60 | Low | 250.7 | 4 | Non-Corrosive | 0.26 | Sand & Gravel, trace silt | 2 | W10-13-A | 159+00 | No | 86 Central St | WASM3 parallel w/ RR |
| 18 | B-35 | 10 | 4,500 | 16.4% | 128 | 8.38 | Low | 233.0 | -2 | Moderately-Corrosive | 4.29 | Sand & Gravel, trace silt | 1 | W10-14-A | 169+90 | No | Central St/Newton St | WASM3 parallel w/ RR |
| 19 | B-38 | 10 | 42,000 | 8.7% | 4 | 8.93 | Low | 172.0 | 2 | Non-Corrosive | 3.48 | Sand, trace silt | 1 | | | No | | WASM3 parallel w/ RR |
| 20 | B-39 | 10 | 120,000 | 4.5% | 6 | 9.05 | Low | 215.1 | 6 | Non-Corrosive | 0.45 | Sand, trace silt | 1 | | | No | | WASM3 parallel w/ RR |
| 21 | B-41 | 10 | 40000 | 8.8% | <31 | 7.32 | Low | 273.4 | 2 | Non-Corrosive | 1.53 | Sand & Gravel, trace silt | 1 | | | No | | WASM3 parallel w/ RR |
| 22 | B-42 | 10 | 5,600 | 37.6% | 8 | 5.85 | Low | 158.2 | -1 | Moderately-Corrosive | 11.50 | Organic Silt, some gravel | 8 | W-10-24-A | 201+75 | No | Linden St/Waverly Oaks Rd | WASM3 parallel w/ RR, pipe invert dips to ~14-ft, under Beaver Brook Culvert |
| 23 | B-43 | 10 | 11,000 | 10.8% | 4 | 7.25 | Low | 304.1 | 0 | Non-Corrosive | 5.19 | Sand & Gravel, little silt | | | | No | | WASM3 parallel w/ RR |
| 24 | B-46 | 10 | 36000 | 15.9% | <31 | 6.87 | Low | 329.4 | 2 | Non-Corrosive | 0.29 | Silt | 2 | W10-26-A | 233+10 | No | Waverly Oaks Rd/Beaver St | |
| 25 | B-48 | 10 | 10,000 | 5.8% | 10 | 6.57 | Low | 343.0 | 0 | Non-Corrosive | 1.17 | Sand, little silt | | | | No | | |
| 26 | B-50 | 10 | 14,000 | 11.6% | 6 | 8.58 | Low | 268.0 | 0 | Non-Corrosive | 1.31 | Sand & Gravel, little silt | 1 | W10-28-B | 247+30 | No | Waverly Oaks Rd/Chapel Rd | |
| 27 | B-52 | 10 | | | | | | | | | | | | | | | | No sample taken, refusual due to bolder |
| 28 | B-55 | 11 | 32,000 | 8.3% | 6 | 7.17 | Low | 318.2 | 2 | Non-Corrosive | 1.58 | Sand & Gravel, trace/little silt | | | | No | | |
| 29 | B-58 | 11 | 270,000 | 3.1% | 15 | 7.38 | Low | 250.4 | 3 | Non-Corrosive | 0.39 | Sand & Gravel, trace silt | 1 | | | No | | |
| 30 | B-62 | 11 | 130000 | 5.8% | <31 | 6.60 | Low | 290.8 | 4 | Non-Corrosive | 0.32 | Sand & Gravel, little silt | | | | No | | |
| 31 | B-64 | 11 | 18000 | 7.9% | <31 | 6.66 | Low | 243.1 | 2 | Non-Corrosive | 2.08 | Silt, little gravel, trace sand | 1 | | | No | | |
| 32 | B-66 | 11 | 260 | 29.5% | 226 | 6.75 | Low | 289.0 | -9 | Corrosive | 13.60 | Silt, trace sand | | W11-7-A | 310+90 | No | 900 Pleasant St | |
| 33 | B-69 | 11 | 12,000 | 7.2% | 77 | 5.81 | Low | 315.0 | 0 | Non-Corrosive | 0.67 | Sand, some silt, trace gravel | | | | No | | |
| 34 | B-71 | 11 | 59,000 | 8.8% | 20 | 8.16 | Low | 222.5 | 4 | Non-Corrosive | 0.91 | Sand, little gravel | | | | No | | |
| 35 | B-72 | 11 | 1,030 | 13.5% | 68 | 7.18 | Low | 244.1 | -6 | Corrosive | 14.50 | Sand & Gravel, little silt | 1 | W11-12-A | 344+70 | No | 628 Pleasant St | |
| 36 | B-75 | 11 | 7700 | 16.6% | <31 | 6.81 | Low | 301.1 | 0 | Non-Corrosive | 4.57 | Sand & Gravel, little silt | 1 | | | No | | |
| 37 | B-78 | 11 | 10,000 | 13.2% | 68 | 8.55 | Low | 224.0 | 0 | Non-Corrosive | 2.09 | Sand, little silt | 2 | 59-28-A | 349+90 | No | Pleasant St/Alexander Ave | |
| 38 | B-79 | 11 | 15,000 | 4.3% | 68 | 7.76 | Low | 217.3 | 0 | Non-Corrosive | 3.14 | Sand, some gravel, trace silt | | | | No | | |
| 39 | B-81 | 11 | 18,000 | 7.8% | 8 | 7.02 | Medium | 250.1 | -3 | Moderately-Corrosive | 1.60 | Gravel, little sand | 1 | | | No | | Leak at pipe near this boring 3/21/18, photos to be received |
| 40 | B-82 | 11 | 3,800 | 9.1% | 16 | 9.10 | Low | 202.8 | 0 | Non-Corrosive | 9.31 | Sand, some gravel, little silt | | W11-17B-B | 391+85 | No | Concord Trnpk/Venner Rd | |
| 41 | B-84 | 11 | 14,000 | 15.0% | 31 | 7.38 | Low | 249.1 | 0 | Non-Corrosive | 0.85 | Sand, little gravel, trace silt | 1 | | | No | | |
| 42 | B-85 | 11 | 26,000 | 8.2% | 15 | 6.81 | Low | 304.6 | 0 | Non-Corrosive | 0.37 | Sand & Gravel | 1 | | | No | | |
| 43 | B-88 | 11 | 12,500 | 8.1% | 18 | 6.68 | Medium | 372.0 | -3 | Moderately-Corrosive | 1.60 | Sand, little gravel | | W11-22-A | | No | 87 Pleasant St (Arlington) | OR excavate in the yard of 135 Pleasant St |
| 44 | B-91 | 11 | 6,900 | 9.2% | 17 | 7.83 | Low | 262.3 | 0 | Non-Corrosive | 2.29 | Sand, little gravel | | | | No | | |
| 45 | B-93 | 11 | 74,000 | 5.5% | 9 | 9.00 | Medium | 205.5 | -3 | Moderately-Corrosive | 0.08 | Sand & Gravel | 1 | | | No | | |
| 46 | B-94 | 12 | 8,300 | 6.9% | 9 | 9.37 | Medium | 183.0 | -1 | Moderately-Corrosive | 4.53 | Sand, some gravel, little silt | 1 | W12-2-A | 445-65 | No | Broadway/Alton St (Arlington) | |
| 47 | B-97 | 12 | 34,000 | 5.8% | 9 | 7.47 | Low | 258.8 | 0 | Non-Corrosive | 2.94 | Sand, some gravel, trace silt | 1 | W12-4-A | 462+40 | No | Palmer St/Warren St (Arlington) | |
| 48 | B-98 | 12 | 6,600 | 9.0% | 21 | 8.01 | Low | 239.0 | 0 | Non-Corrosive | 1.00 | Sand, some gravel | | | | No | | |
| 49 | B-100 | 12 | 130,000 | 3.7% | 9 | 8.40 | Low | 219.5 | 0 | Non-Corrosive | 0.23 | Sand, trace silt | | W12-7A-A | 487+50 | No | 152 Mystic Valley Pkwy (Arlington) | approx 1700-ft PCCP Calibration |
| | B-101 | | | | | | | | | | | | | | | | Coral St @ Park St (Arlington) | |
| 50 | B-103 | 12 | 1300 | 25.7% | <31 | 4.74 | Low | 268.5 | -6 | Corrosive | 25.50 | Wet compacted mud | 2 | W12-8B-B | 504+45 | No | 22 Mystic Valley Pkwy | 26-in Steel Gas Pipe crossing |
| 51 | B-105 | 12 | 5,200 | 12.7% | 9 | 7.39 | Low | 27.3 | -6 | Corrosive | 8.28 | Sand & Silt, little gravel | 1 | W12-10-K | 510+34 | No | Mystic Valley Pkwy/Capen St | WASM3 crosses a 43-in sewer line just west of valve, and then crosses a blue line twice just e |
| | B-107 | | | | | | | | | | | | | | | | Irvington Rd (Medford) | |
| 52 | B-108 | 16 | | | | | | | | | | | | W16-1-B | 521+14 | Yes | Boston Ave/Mide Tech. Corp | NO corrsivity sample taken at this location, not sure why |
| 53 | B-109 | 16 | 920 | 20.0% | 31 | 7.87 | High | 339.9 | -12 | Very Corrosive | 2.71 | Sand & Gravel, little Organic Silt | | | | Yes | No Access | WASM3 crosses RR |
| 54 | B-110 | 16 | 1200 | 34.5% | <31 | 4.74 | High | 232.8 | -12 | Very Corrosive | 19.80 | Wet compacted mud | 1 | | | Yes | Auburn St @ Whole Foods (Medfor | "Clayey Peat" |
| 55 | B-112 | 16 | 8800 | 14.5% | <31 | 4.23 | High | 320.0 | -7 | Corrosive | 7.12 | Wet gravel | | W16-12-A | | Yes | Mystic Valley Pkwy/Winthrop St | |
| 56 | B-113 | 16 | 370 | 57.6% | <31 | 6.51 | High | -20.1 | -18 | Very Corrosive | 29.50 | Wet compacted mud | | W16-13-A | | Yes | | WASM3 crosses 6-in oil line w/10-in sleeve, then parallel w/8.5-ft MWRA sewer |
| 57 | B-115 | 16 | | | | | | | | | | | | W16-13A-B | 557+19 | Yes | 2500 Mystic Valley Pkwy | |
| | **Minimum** | | 260 | 2.00% | 4 | 4.23 | | -20.1 | -18 | | 0.08 | Total Leaks | **71** | | | | | |
| | **Maximum** | | 140000 | 57.60% | 226 | 9 | | 372.0 | 6 | | 29.50 | | | | | | | |
| | **Average** | | 37552 | 11.82% | 37 | 7 | | 251.1 | -1 | | 4.37 | | | | | | | |

| | |
|---|---|
| ≥ 0 | Non-Corrosive |
| -1 to –4 | Moderately-Corrosive |
| -5 to -10 | Corrosive |
| ‹ -10 | Very Corrosive |

# Corrosion Evaluation Report
# Weston Aqueduct Supply Main 3 (CP2)
# Massachusetts Water Resource Authority

**Prepared for:**

**Stantec Consulting Services Inc.**
**65 Network Drive**
**Burlington, MA 01803**

**Prepared by:**

CORRTECH
CORROSION UNDERSTOOD

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**Report No. 9301-FOR-03-3**

**April 2023**

## STATEMENT OF LIMITATION

The conclusions presented in this document are based on the services described and not on tasks or procedures beyond the scope of the described procedures or the time and budgetary constraints imposed by the contract limitations.

CorrTech, Inc. has performed this assessment in a professional manner using that degree of skill and care exercised for similar projects under similar conditions by reputable and competent consultants, and in accordance with the procedures established within CorrTech's quality assurance, quality control protocol.

CorrTech, Inc. shall not be responsible for conditions or consequences arising from relevant facts that were concealed, withheld or not fully disclosed at the time the evaluation was performed.

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## Introduction

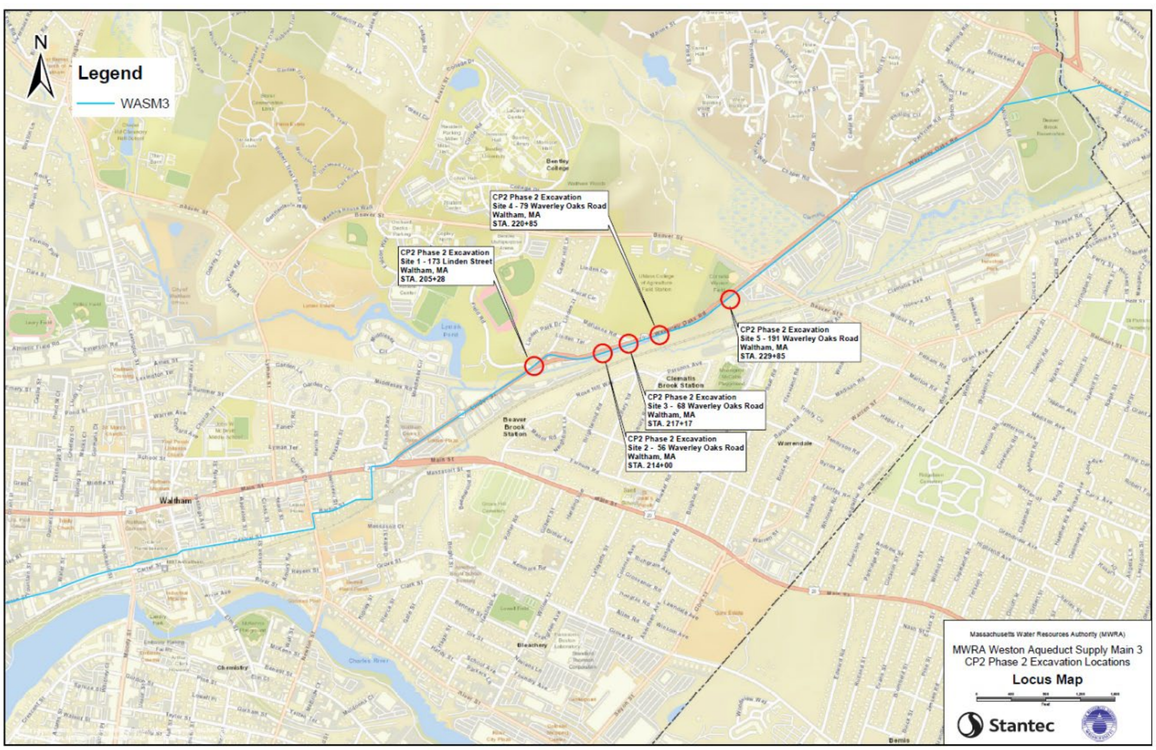
Under Contract No. 6539 for the design, construction administration, and resident inspection services of the Weston Aqueduct Supply Main 3 (WASM-3), hereinafter called the “Project”, awarded to Stantec by Massachusetts Water Resource Authority (MWRA), CorrTech has been tasked with the condition assessment and corrosion control development for the rehabilitation of the water main.

This report, 9301-03-1, details the findings of CorrTech’s direct pipe assessment of the WASM-3 CP-2 along Waverly Oaks Road in Waltham. MA. Data from a previous report, 9301-2-3, produced in 2021 is included, Site #3 from that report was located at Sta. 227+50 and will be referred to as Site #3 (2021 designated) within this report.

## Executive Summary

Between the days of March 16th, 2023, and March 21st, 2023 CorrTech personnel were onsite to perform pipeline integrity evaluations at five excavation sites along Waverly Oaks Road between station 205+28 and 235+00, from Linden St to Beaver St, approximately 2,972-ft as part of the CP2 limit of work. These sites are denoted herein as follows:

Site #1: Sta. 205+28 Int. of Linden St. and Waverley Oaks Rd
Site #2: Sta. 214+00, 56 Waverley Oaks Road
Site #3: Sta. 217+17 68 Waverley Oaks Road
Site #4: Sta. 220+85 79 Waverly Oaks Road
Site #3 (2021 designation): Sta. 227+50 79 Waverly Oaks Road
Site #5: Sta. 229+85 191 Waverly Oaks Road



Through a series of systematic tests and evaluations including pit depth measurements, A- and B-Scan readings, and coating thickness measurements in addition to the prior leak history of the system under evaluation, conclusions and recommendations can be made.

Excavation typically exposed 60-70% of the pipe in the test pit with portions still being completely buried due to site restrictions such as other pipelines and pipe support. Measurements were taken at the crown, one side of the spring line and as close to the invert as possible.

**Corrosion Pits**

Steel, or iron pipe including cast iron, corrodes when buried as a result of several major factors. The primary factor for these conduits is corrosion due to soils. This type of corrosion on steel pipes typically results in pitting of the steel surface and is particularly vicious when initiated in areas of coating faults. Of concern would be pitting activity that would lead to through-wall penetrations, resulting in loss of structural integrity and product.

When steel pipe corrodes in most soils, the resulting loss of metal is far from uniform. Generally, there tends to be small areas of metal loss (pits) in larger areas of uncorroded or lightly corroded metal surface. The depth of pits will vary greatly. Usually there will be far greater numbers of shallow pits than deep pits. As pit depth decreases, the number of pits increases. As pit depth approaches zero, the number of pits approaches infinity. This is in agreement with the theory of extreme value probability.

Pitting corrosion initiates on the steel surface at points where coating holidays exist in the external coating and soil and water conditions provide electrochemical conditions to support corrosion. These sites are typically initiated in the presence of the chloride ion. Once initiated, the corrosion rate of a corrosion pit is aggressive due to the autocatalytic nature of the chemistry within the pit. That is, the corrosion processes within an active pit produce conditions which are stimulating and contribute to continual corrosion activity within the pit.

In the industry literature, pitting rates are reported to vary for different materials and environments. Under some conditions, pit rates increase over time and in others, pit rates decrease with time. In soil, the pit growth rate tends to decrease with time and generally follows a power equation $P = ktn$, where $P$ is the depth of the deepest pit in time $t$, and $k$ and $n$ are constants. Where soils are well aerated, $n$ is low in the range of 0.1, and where soils are not well aerated, $n$ is higher in the range of 0.9. Therefore, in clay and fine-grained soils $n$ is higher and the pit rate is greater than for sandy and large grain size soils. Where soils are not well aerated, and $n$ approaches 1, the penetration rate is directly proportional to time.

Corrosion pits penetrate the pipe wall at a certain corrosion rate, primarily due to the corrosion mechanism associated with the pit geometry and pit depth. Corrosion mechanisms that tend to increase the diameter of the pit are not as aggressive as those that tend to increase the depth and therefore pits tend to be deep and narrow. The environment at the bottom of a pit is much more acidic than that at the surface, and therefore more corrosive.

It should be noted that through wall pits cause leaks, but structural integrity is not substantially compromised until the density of pits is very high (i.e. a pipe will not fail catastrophically until pitting has removed a substantial portion of the pipe.) Additionally, some rehabilitation methods (ex. cement mortar lining) may allow a pipe with through wall pits to remain in useful service, as the leaks will be stopped by the rehabilitation method.

For this analysis, the time to failure is considered to be at a time when the corrosion hole is large enough in diameter that the cement mortar lining is compromised. This compromise considers internal pressure, lining thickness and corrosion hole diameter.

It is considered that there are many areas along Waverly Oaks Rd conduits where the soils consist of clay and fine-grained material, specifically the pipe bedding material. These soil conditions were observed in a large percentage of the soil samples obtained during the study.

Of interest, is the diameter of the corrosion hole that would no longer provide support to the internal mortar lining system. Based on an analysis performed by CorrTech on a previous project, CorrTech has utilized a hole size failure of 0.50-inch diameter, with the internal lining thickness of 0.25-inch at 1,000 psi strength. This size hole would fail at an internal water pressure of 132 psi.

The tables for the cement mortar lining "blowout" pressures were prepared using the "strength-design" method from the "Building Code Requirements for Structural Concrete", ACI-318-02 prepared by the American Concrete Institute. Specifically, Chapter 22, "Plain Structural Concrete". With the "strength-design" method a margin of safety is provided by multiplying the design loads by a load factor and the member capacity by a strength reduction factor.

Load factors are assigned based on the degree of accuracy that the loads can be calculated. The more accurate and less variable the load the smaller the load factor. Load factors also account for variability in the structural analysis used to compute the moments and shears. The load factor used in our analysis was 1.4 for well-defined fluid pressures with liquids of known density.

Strength reduction factors are to allow for the probability of understrength due to variations in material strengths and dimensions, to allow for inaccuracies in the design equations, to reflect the degree of ductility and required reliability of the member under load and to reflect the importance of the member in the structure (the latter is really intended for beam/column structures). The strength reduction factors used in our analysis ranged from 0.75 to 0.9 depending on the failure mode.

The tables without the safety factors use 1.0 for both the strength reduction factor and load factor but should be used with caution since there can be in-place variability of lining thickness, concrete strength and pressures.

This discussion indicates that cleaning and lining a steel water main such as WASM 3 provides the following characteristics:

- Improved C factor
- Steel passivating environment with the mortar lining and pH of approximately 12
- Internal pressure withstand capacity to bridge external large diameter holes with two layers of ½-in thick each layer mortar lining, applied in 2 passes for 1-in total

**Pipe Evaluation**

In order to perform a thorough and detailed analysis, the investigating engineers on-site started by creating a grid system on the exposed portion of each pipe. The deepest pit due to exterior corrosion in each grid section was measured and recorded. Pipe wall thickness was also measured in each section using an A-Scan measurement technique with an ultrasonic thickness gage and transducer. Site #1 had a nominal wall thickness of 0.500-in while Sites #2-5 had a nominal wall thickness of 0.375-in, complete results of both measurements can be found in Appendix I.

Pipe wall thickness was also measured using a B-Scan measurement technique when possible, the B-Scan method requires a very smooth surface, any obstructions uneven surfaces or poorly adhered coating can cause inaccurate readings. Typically, the surface would be prepared with an angle grinder but due to field concerns related to aggressive tool preparation it was decided to prepare the surface using hand tools. B-Scans were performed at Sites #2 and #4. Plots of this data can be found in Appendix I with the corresponding pipe measurement chart. Additionally, coating thickness readings were taken at various positions on the exposed portions of pipe and data summarized in Appendix III.

Overall, the pipe was found to be structurally sound with no significant issues. All portions of the lockbar that were observed were free from significant pitting or metal loss. The coating was approximately 50% delaminated but where it was still adhered there was at least 20-mils of coating remaining. Pitting was generally sporadic and did not compromise the pipes integrity.

**Statistical Analysis**

The present state of technology offers no other practical way of determining corrosion pit depths on operating underground piping systems other than direct physical examination of the pipe surface. This, of course, requires the excavation of the pipe, an expensive procedure. This leads us to attempt to find a way of predicting the nature of pitting for the entire structure with the excavation and examination of only a small portion of the structure. This presents a difficult problem, both from a practical and theoretical standpoint. The pits of greatest interest are the deeper ones, yet these are the pits that occur most rarely. The probability of finding the deepest pit, on a mile of pipe, by randomly inspecting only one percent of the pipe would be very small.

For this study, six test pit excavations were evaluated along Waverley Oaks Road, Waltham, MA to determine from a practical approach, the corrosion activity along the pipe route. Inspection of 1% of the pipe surface is considered ideal for the statistical analysis. Test pits on Waverley Oaks provided approximately 0.78% of the pipe for inspection. Data analysis indicates that the line of expected extremes is reasonably valid for the size of our pipe sample. This indicates that the data generally agrees with the extreme probability theory. Therefore, this evaluation of approximately 0.78% of the pipe surface is considered to be an acceptably accurate analysis.

In analyzing extreme values encountered in statistical samples, the deepest pit in the pipe is of concern. Gumbel's method of analysis to pit depth data has been utilized to evaluate the data. This method of analysis, together with studies of factors influencing the corrosion of the structure of concern, such as soil resistivity and soil moisture content, allows prediction of the magnitude of corrosion penetration problems that will be encountered on a given structure. This can be done by inspecting only a very small portion of the structure.

Once the unit of study has been established, locations can be selected for physical examination of the pipe surface. For this study, the statistical unit of one-square foot was selected based on maximizing the accuracy of the statistical analyses and this size unit is preferred based on experience in applying extreme values statistical analysis. Ideally, a sufficient number of locations are selected to be representative of the corrosion conditions affecting the structure throughout the study area. The size and number of inspection locations will vary with the length of the structure, the nature of the corrosion conditions to which it is subjected and cost considerations.

The pipe must be excavated at one (1) or more locations, with ten linear feet of pipe available for inspection at each location. The size of each statistical unit is further reduced by dividing the pipe within the excavation into small statistical units. Therefore, a ten-foot long excavation can lead to the division of the pipe within this excavation into one hundred and forty (140)-one (1) square foot sections, for a 60-in diameter pipe. In this study, a statistical unit of one square foot was used. The size of the statistical unit is chosen such that each excavation theoretically results in approximately 140 statistical units for each pipe in an excavation.

Having established the size of the statistical unit, the depth of the deepest pit in a given statistical unit is measured and recorded. In practice it is necessary to actually measure a number of the apparently deepest pits. Based on the excavation limits, the test pits did not allow evaluation of 140 statistical units. The number of statistical units available ranged from 34 at Site #1 up to 103 at Site #5. Across 6 sites and with 140 units there was a potential maximum of 840, of which 364 were measured, or approximately 0.78% of the statistical units

If the above conditions are satisfied, we can then utilize the graph in predicting the nature of corrosion pits on the portion of the structure outside of the area inspected. If, as previously stated, our first interest is in the possibility of corrosion penetrations existing on the structure, the best fit equation is used to calculate the percentage of statistical units along the pipe where these conditions would be expected.

By a similar analysis, a prediction can be made, with a relatively high correlation, regarding the total number of penetrations that will occur by some future date. The number of pits to a given depth that exist on the entire structure is determined using the extreme probability graphs. The annual corrosion rate is calculated by dividing the pit depth by the age of the pipe. An assumption is made that the corrosion rate is linear (i.e. a pit of 0.1 inches in ten years will progress to 0.2 inches in 20 years). Much of the literature suggests that pitting may actually slow over time. In addition, corrosion on the pipe under study has been heavily influenced by stray currents, that have been reduced over time. Therefore, assuming a linear rate is conservative. This rate is typically expressed in mils (0.001 inches) per year.

The depth of the existing pits is subtracted from the wall thickness to yield the remaining thickness. The remaining thickness is then divided by the corrosion rate to yield the number of years to penetration. Since the rate of corrosion is not a linear function of time and the wall thickness is not absolutely uniform, adjustments must be made. Specifically, the analysis would deal with a range, or band of time.

| Test Sites | Thinnest Wall Thickness Measured | Nominal Pipe Wall | A-Scan Thickness Measured |
|---|---|---|---|
| Site #1 | 0.270-in external pit | 0.500-in | 0.450-in to 0.550-in |
| Site #2 | 0.129-in external pit | 0.375-in | 0.334-in to 0.407-in |
| Site #3 | 0.245-in external pit | 0.375-in | 0.345-in to 0.390-in |
| Site #4 | 0.121-in external pit | 0.375-in | 0.332-in to 0.392-in |
| Site #3 (2021 site 3) | 0.070-in B scan | 0.375-in | 0.297-in to 0.394-in |
| Site #5 | 0.305-in external pit | 0.375-in | 0.350-in to 0.393-in |

**Soil Resistivity**

CorrTech evaluated the soil in each test pit by measuring soil resistivity at the pipe invert, springline and crown.

The measurement of soil resistivity has been used for years as an indicator of the corrosivity of soil. Soil resistivity is the reciprocal of conductivity, the lower the resistivity, the easier current will flow through the soil. Of the measurable soil characteristics, resistivity is generally accepted as the primary indicator of soil corrosivity. Resistivity is a property of the bulk volume of soil and electrolytes.

Although no standard has been developed and accepted by such organizations as the American Society for Testing and Materials or the National Association of Corrosion Engineers, it is generally agreed that the classification shown below, or other similar classifications, reflect soil corrosivity.

| Resistivity (Ohm-Cm) | Corrosivity |
|---|---|
| below 500 | Very Corrosive |
| 500 to 1,000 | Severely Corrosive |
| 1,000 to 2,000 | Moderately Corrosive |
| 2,000 to 10,000 | Mildly Corrosive |
| Above 10,000 | Progressively Less Corrosive |

The above Table provides qualitative insight to the expected corrosion exposure of a metallic structure in a soil of known resistivity. Accordingly, deterioration can generally be expected to be rapid and relatively severe in soils below 1,000 ohm-cm. This does not mean, however, that severe corrosion will not occur in soils of higher resistivities. In fact, depending on chemical conditions, severe corrosion can occur in soils above 10,000 ohm-cm. The Table only indicates that the latter occurrence is generally not observed.

Not only is the resistivity useful in predicting relative corrosion rates, but it is equally important to identify whether soil resistivity varies along a given route. Structures such as pipes, which are electrically continuous along significant portions of their length, will be susceptible to long line galvanic influences arising from variations in soil resistivity and moisture along the pipe route. Portions of a pipeline in the lower soil resistivity environments tend to become anodic, and therefore corrode, relative to other portions of the same pipeline.
Resistivity data are summarized in Appendix I.

**Discussion and Conclusions**

Various forms of statistical analysis were used to analyze the data collected and determine the best course of action to mitigate the corrosion taking place and eliminate the risk of leaks to the pipeline.

External pitting was found to be infrequent with only 118 of the 364 statistical units having any pitting and 98 of the 118 being less than 1/3 of the design thickness or 20 pits greater than 120 mils. The following table summarizes the pits measured:

| Quantity | Pit Depth, Mils |
|---|---|
| 246 | 0 |
| 22 | 10 |
| 13 | 20 |
| 9 | 30 |
| 3 | 40 |
| 10 | 50 |
| 9 | 60 |
| 9 | 70 |
| 3 | 80 |
| 3 | 90 |
| 8 | 100 |
| 7 | 110 |
| 2 | 120 |
| 3 | 130 |
| 2 | 140 |
| 4 | 150 |
| 4 | 160 |
| 1 | 170 |
| 3 | 180 |
| 1 | 190 |
| 1 | 200 |
| 1 | 210 |
| 364 | Total statistical units |

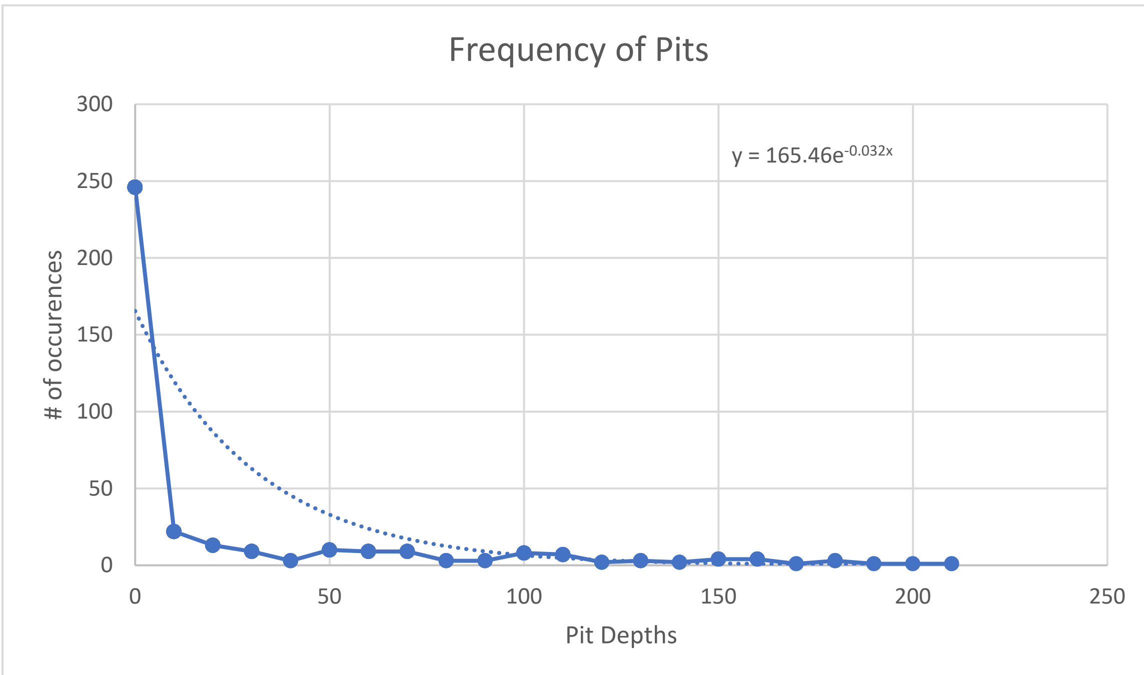
Based on the extreme statistical analysis, there are expected to be 47 through holes in the pipe between Linden and Beaver St. There have been sixteen 16 leaks since 1991 in this pipe segment as summarized:

| | | | | |
|---|---|---|---|---|
| WASM 3 - CP2 Leak Locations | | | | |
| 4/12/2023 | | | | |
| STA. 205+00 to 235+00 | | | | |
| | | | | |
| **Leak Year** | **Approx. St** | **Street Name** | | |
| 1991 | 207+50 | Linden St @ Waverly Oaks Rd | | |
| 2011 | 207+50 | Linden St @ Waverly Oaks Rd | | |
| 2007 | 207+50 | Linden St @ Waverly Oaks Rd | | |
| 1996 | 207+50 | Linden St @ Waverly Oaks Rd | | |
| 2009 | 207+50 | Linden St @ Waverly Oaks Rd | | |
| 2011 | 207+50 | Linden St @ Waverly Oaks Rd | | |
| 2019 | 207+50 | Linden St @ Waverly Oaks Rd | | |
| 2022 | 207+50 | Linden St @ Waverly Oaks Rd | | |
| 1989 | 207+50 | Linden St @ Waverly Oaks Rd | | |
| 2003 | 207+50 | Linden St @ Waverly Oaks Rd | | |
| 2022 | 212+00 | Waverly Oaks Rd | | |
| 2022 | 212+00 | Waverly Oaks Rd | | |
| 2016 | 222+00 | Waverly Oaks Rd | | |
| 2018 | 222+00 | Waverly Oaks Rd | | |
| 2006 | 222+50 | Waverly Oaks Rd | | |
| 2005 | 233+00 | Waverly Oaks Rd @ Beaver St | | |

It is considered that an additional seven 26 external leaks will manifest within the next approximately 25-year time frame.

The following graphical assessment is presented:

| | |
|---|---|
| Frequency of Through Hole | 0.001016621 |
| Area of Pipe (ft.^2) statistical units | 46,660 |
| Number of leaks | 47 |




A-Scan and B-Scan ultrasonic thickness (UT) measurements were taken to evaluate the interior condition of each exposed portion of pipe. A-Scan measurements provide pinpoint spot readings of the remaining wall thickness at any given location on a pipe. A-Scans were sometimes difficult to acquire due to poor coating adhesion or uneven surface profile and were not collected for every statistical unit. B-Scan measurements, however, provide a profile of wall thickness readings over a given distance. In combination, these two non-destructive measurement techniques can be invaluable in assessing the condition of pipelines. As previously mentioned, B-Scans were only able to be taken from Sites 2 and 4. Scans conducted in March of 2023 revealed internal pits where the wall thickness was 0.121-in or a pit depth of 254-mils. Scans conducted in May of 2021 revealed thicknesses as low as 0.070-in or a pit depth of 305 mils. Typically, the steel thickness would decrease the closer to the 6'oclock position they were taken.

Considering a 305-mil internal pit and 100-years of operation, assuming corrosion initiated on day one of operation, the calculated linear corrosion rate is 3.05 mils per year. For a 375 mil thick steel pipe, penetration of the existing 305-mil pit would take approximately 22 years.

The coating on the exterior of the pipe trended similar to the UT readings, coating was thinner towards the bottom of the pipe with most of the coating being delaminated below the spring line. At the crown the coating was typically between 30-60-mils, 20-30-mils near the spring line and

20 mils down to bare steel below that point. Coating thickness were collected for a general understanding and not necessary for each statistical unit.

It should be noted that through wall pits cause leaks, but structural integrity is not substantially compromised until the density of pits is very high (i.e. a pipe will not fail catastrophically until pitting has removed a substantial portion of the pipe.) Additionally, some rehabilitation methods (ex. cement mortar lining) may allow a pipe with through wall pits to remain in useful service, as the leaks will be stopped by the rehabilitation method.

**Recommendations**

With this new information and considering the existing plans to replace and line portions of the pipeline under survey, CorrTech recommends the following:

1. Consider internal cleaning and lining of the pipes from Linden to Beaver. cleaning and lining a steel water main such as WASM 3 provides the following characteristics:

    - Improved C factor.
    - Creates a steel passivating environment with the mortar lining and pH of approximately 12.
    - Provides a pressure withstand capacity to bridge external large diameter holes with the two layers of ½-in thick mortar lining each applied in two passes.

2. Design and install appropriate cathodic protection systems to all newly replaced portions of pipeline to protect from external corrosion and extend the usable life of these systems.

# APPENDIX I

Pipe Measurement Charts

# Test Site #1

West

| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| | | | | | | | | 520 | | 550 | 470 | | | | |
| | | | | | | | | | | | | | | | |
| B | | | | | | | 0 | 0 | 50 | 0 | 150 | 0 | | | |
| | | | | | | | | 536 | 535 | 450 | 480 | | | | |
| | | | | | | | | | | | | | | | |
| C | | | | | | | 0 | 30 | 0 | 0 | 200 | 0 | | | |
| | | | | | | | | 520 | 519 | 511 | 490 | 470 | | | |
| | | | | | | | | | | | | | | | |
| D | | | | | | | 0 | 20 | 50 | 0 | 0 | 0 | | | |
| | | | | | | | | 535 | 526 | 498 | 485 | | | | |
| | | | | | | | | | | | | | | | |
| E | | | | | | | 0 | 0 | 0 | 0 | 150 | | | | |
| | | | | | | | | 514 | 506 | 512 | 477 | | | | |
| | | | | | | | | | | | | | | | |
| F | | | | | | | 0 | 0 | 0 | 0 | 0 | | | | |
| | | | | | | | | 504 | 503 | 540 | | | | | |
| | | | | | | | | | | | | | | | |

Invert Crown Invert

East

| Key |
|---|
| Pit Depth Measurements (mils) |
| Ultrasonic Thickness (mils) |
| Coating Thickness (mils) |
| Buried Pipe |

Deepest Pit: 200
Lowest UT: 450
Design Thickness : 0.500-in

Location: Sta. 205+28
Date: 23-Mar-23

# Test Site #2

West

| 9 | 10 | 11 | 12 | 13 | 14 | 15 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 50 | 50 | 10 | 10 | 160 | 110 | 70 | | | |
| | | | | | 391 | 362 | 367 | 368 | | | | | | |
| | | | | | 20 | 30 | 30 | 30 | 20 | 15 | 5 | | | |
| | | | | | 50 | 40 | 10 | 10 | 40 | 100 | 130 | 70 | | |
| | | | | | 382 | 394 | 389 | 390 | 377 | | | | | |
| | | | | | 20 | 20 | 30 | 30 | 20 | 15 | 5 | 8 | | |
| | | | | | 70 | 30 | 10 | 30 | 170 | 110 | 140 | 160 | | |
| | | | | | | | 400 | 407 | | | | 387 | | |
| | | | | | 20 | 20 | 30 | 30 | 20 | 15 | 5 | 8 | | |
| | | | | | 50 | 70 | 10 | 10 | 210 | 160 | 90 | 50 | | |
| | | | | | | | | 384 | | 396 | | 383 | | |
| | | | | | 20 | 20 | 30 | 30 | 20 | 15 | 5 | 8 | | |
| | | | | | 30 | 30 | 10 | 10 | 140 | 100 | 50 | 30 | | |
| | | | | | | | | | | | | | | |
| | | | | | 20 | 20 | | | | | | | | |
| | | | | | 30 | 20 | 10 | 10 | 160 | 110 | 180 | 60 | | |
| | | | | | | | | | | | | 334 | | |
| | | | | | 20 | 20 | | | | | | | | |
| | | | | | 20 | 20 | 10 | 10 | 130 | 150 | 70 | 190 | | |
| | | | | | | | | | | 375 | | | | |
| | | | | | 20 | 20 | | | | | | | | |
| | | | | | 20 | 20 | 10 | 10 | 100 | 150 | 180 | | | |
| | | | | | | | | | | | | | | |
| | | | | | 20 | 20 | | | | | | | | |

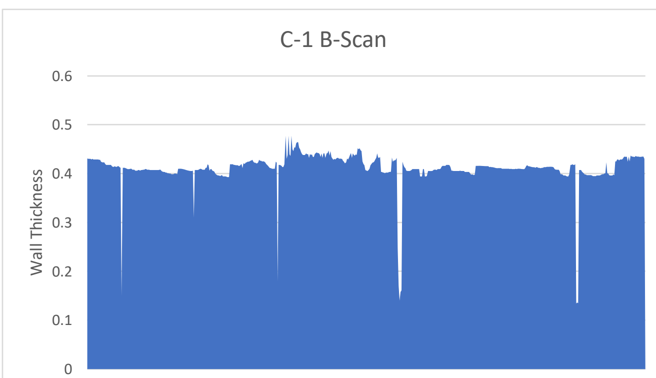
Invert — Crown — Invert

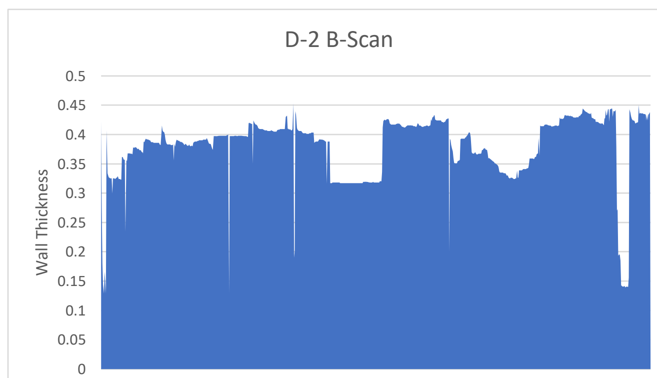
East

| Key |
|---|
| Pit Depth Measurements (mils) |
| Ultrasonic Thickness (mils) |
| Coating Thickness (mils) |
| Buried Pipe |

Deepest Pit: 210
Lowest UT: 334
Design Thickness : 0.375-in

Location: Sta. 214+00
Date: 16-Mar-23



# Test Site #3

West

| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| | | | | | | | 345 | | | | | | | | |
| | | | | | | | | | | | 25 | | | | |
| B | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 130 | 0 | | |
| | | | | | | | | 345 | | | | | | | |
| | | | | | | | | | | | 30 | | | | |
| C | | | | | | 0 | 0 | 0 | 0 | 0 | 110 | 110 | 0 | | |
| | | | | | | | 359 | | | 345 | | | | | |
| | | | | | | | | 15 | | | 26 | | | | |
| D | | | | | | 0 | 0 | 0 | 0 | 0 | 100 | 80 | 0 | | |
| | | | | | | 381 | | | 345 | 361 | | 367 | 390 | | |
| | | | | | | | 36 | | | | 35 | 23 | | | |
| E | | | | | | 0 | 0 | 60 | 0 | 0 | 100 | 0 | 0 | | |
| | | | | | | | | 363 | | | | | | | |
| | | | | | | | 32 | | | | 24 | 30 | | | |
| F | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| | | | | | | 351 | | | | | | 370 | | | |
| | | | | | | | | 20 | | | 30 | 35 | | | |
| G | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| | | | | | | | | | 377 | | 370 | | | | |
| | | | | | | | | | | | 35 | | | | |
| H | | | | | | 0 | 120 | 0 | 0 | 0 | 0 | | | | |
| | | | | | | | | 382 | | | | | | | |
| | | | | | | | 45 | | | | | | | | |

Invert — Crown — Invert

East

| Key |
|---|
| Pit Depth Measurements (mils) |
| Ultrasonic Thickness (mils) |
| Coating Thickness (mils) |
| Buried Pipe |

Deepest Pit: 130

Lowest UT: 345

Design Thickness : 0.375-in

Location: Sta. 217+17

Date: 23-Mar-23

# Test Site #4

West

| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| | | | | | | | 369 | 380 | | | 376 | | | | |
| | | | | | | | 30 | 53 | | | | | | | |
| B | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| | | | | | | | 343 | 355 | | | 372 | | | | |
| | | | | | | | 28 | 32 | | | | | | | |
| C | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| | | | | | | | 387 | 389 | | | 382 | | | | |
| | | | | | | | 40 | 30 | 70 | | | | | | |
| D | | | | | | 0 | 0 | 0 | 0 | 60 | 0 | 60 | 110 | | |
| | | | | | | | 376 | 348 | | | 375 | | | | |
| | | | | | | | 41 | 29 | | | | | | | |
| E | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 80 | 110 | | |
| | | | | | | | 392 | 392 | | | 374 | | | | |
| | | | | | | | 28 | 35 | | | | | | | |
| F | | | | | | 0 | 0 | 0 | 0 | 90 | 0 | 100 | 180 | | |
| | | | | | | | 395 | 390 | | | 344 | | | | |
| | | | | | | | 31 | 29 | | | | | | | |
| G | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 90 | | |
| | | | | | | | 382 | 389 | | | 332 | | | | |
| | | | | | | | 36 | 26 | | | | | | | |
| H | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 60 | | |
| | | | | | | | 372 | 365 | | | | 379 | | | |
| | | | | | | | 32 | 32 | | | | | | | |
| I | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 80 | 0 | | |
| | | | | | | | 388 | 377 | | | | 368 | | | |
| | | | | | | | 41 | 48 | | | | | | | |

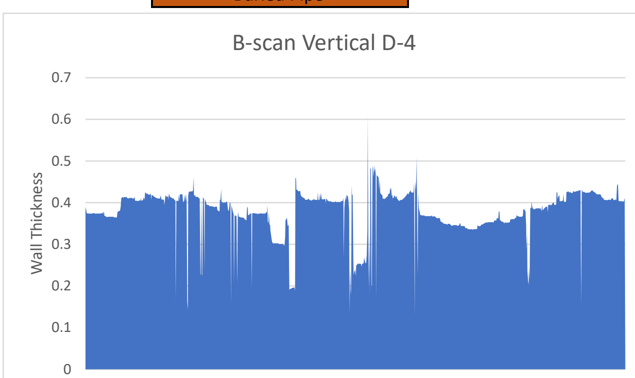
Invert | Crown | Invert

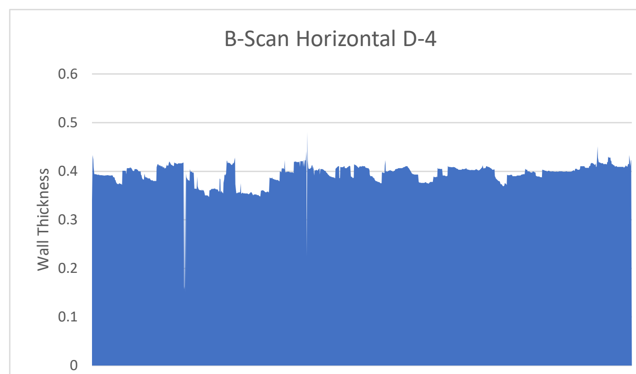
East

| Key |
|---|
| Pit Depth Measurements (mils) |
| Ultrasonic Thickness (mils) |
| Coating Thickness (mils) |
| Buried Pipe |

Deepest Pit: 180
Lowest UT: 332
Design Thickness : 0.375-in

Location: Sta. 220+85
Date: 16-Mar-23



# Test Site #3 (2021 designation)

West | East

| Pit Depth Measurements (mills) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| A1 | B1 | C1 | D1 | H1 | I1 | J1 | K1 | L1 |
| 10 | 20 | . | 10 | 10 | 20 | 20 | 10 | 30 |
| A2 | B2 | C2 | D2 | H2 | I2 | J2 | K2 | L2 |
| 70 | . | . | 30 | 10 | 60 | 50 | . | 10 |
| A3 | B3 | C3 | D3 | H3 | I3 | J3 | K3 | L3 |
| . | . | 60 | 60 | . | . | 70 | 20 | . |
| A4 | B4 | C4 | D4 | H4 | I4 | J4 | K4 | L4 |
| 10 | 20 | 40 | 120 | 60 | 70 | 20 | 20 | . |

05/19/2021 - Sta. 227+50

West | East

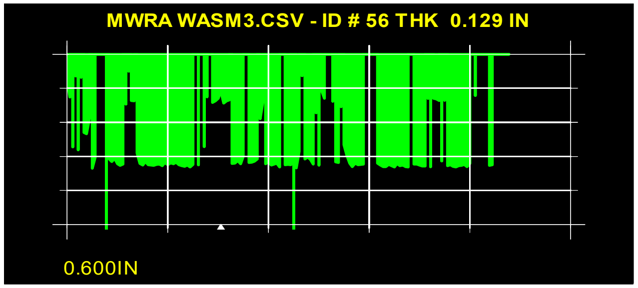
| A-Scan Thickness Measurements (mills) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| A1 | B1 | C1 | D1 | H1 | I1 | J1 | K1 | L1 |
| 362 | 375 | 384 | 394 | 374 | 352 | 379 | 360 | 376 |
| A2 | B2 | C2 | D2 | H2 | I2 | J2 | K2 | L2 |
| 351 | 377 | 387 | 360 | 375 | 350 | 380 | 372 | 372 |
| A3 | B3 | C3 | D3 | H3 | I3 | J3 | K3 | L3 |
| 362 | 373 | 373 | 297 | 372 | 373 | 355 | 369 | 365 |
| A4 | B4 | C4 | D4 | H4 | I4 | J4 | K4 | L4 |
| 367 | 379 | 388 | 371 | 312 | 358 | 373 | 373 | 355 |

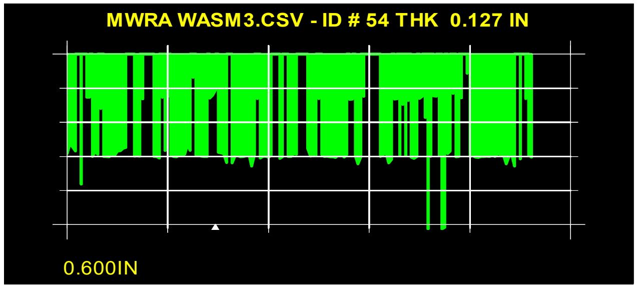
Deepest Pit: 120

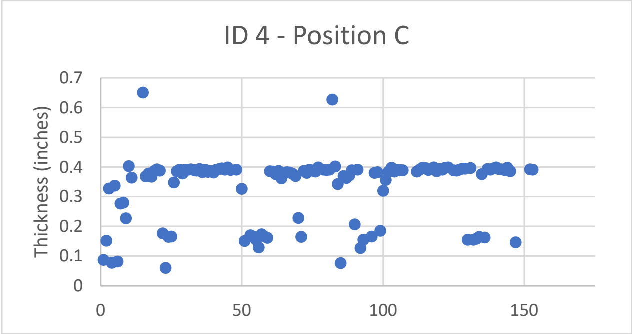
Lowest UT: 297

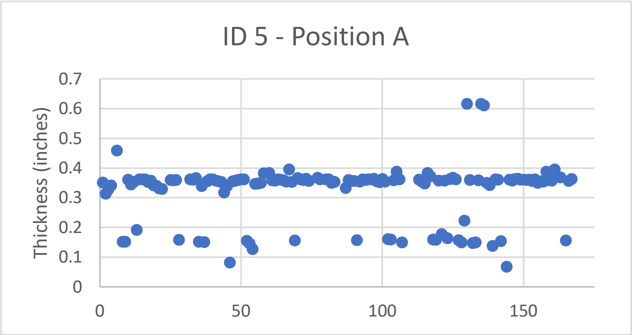
Design Thickness : 0.375-in

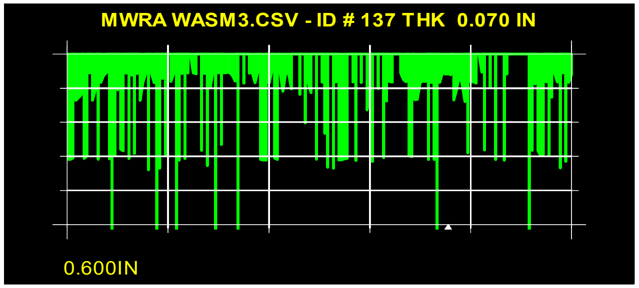
# Test Site #3 (2021 designation) B-Scans

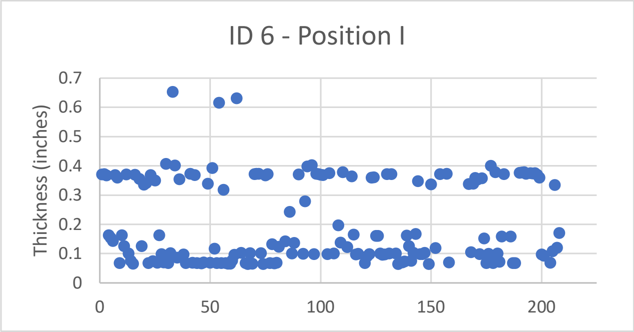


# Test Site #5

West

| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| | | | | 350 | | | | 374 | | | | | | | |
| | | | | | 40 | | 40 | | | | | | | | |
| B | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | 49 | | | | | | | | |
| C | | 0 | 0 | 70 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| | | | | | 393 | | | | | | | | | | |
| | | | | | 60 | | | | | | | | | | |
| D | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| | | | | | | | | | 366 | 378 | | | | | |
| | | | | | | | | | | | | | | | |
| E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| | | | | | 375 | | | 358 | | | | | | | |
| | | | | | 64 | | | | | | | | | | |
| F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| | | 357 | | | | | | 375 | 374 | | | | | | |
| | | 65 | 46 | | 59 | | | | | | | | | | |
| G | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| | 357 | | 375 | | 352 | | | 385 | | | | | | | |
| | 35 | 32 | | | | | 41 | | | | | | | | |
| H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| | 378 | | | | | | | | | 360 | | | | | |
| | | | | | 36 | 42 | | | | | | | | | |
| I | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| | | | | | 385 | | | | 389 | | | | | | |
| | | | 38 | | | | | | | | | | | | |
| J | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| | | | | | | | | | 363 | | | | | | |
| | | | | | 45 | | 46 | | | | | | | | |
| K | | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| | | | | 378 | | | | 365 | | | | | | | |
| | | | | | | | | | | | | | | | |

Invert — Crown — Invert

East

| Key |
|---|
| Pit Depth Measurements (mils) |
| Ultrasonic Thickness (mils) |
| Coating Thickness (mils) |
| Buried Pipe |

Deepest Pit: 70
Lowest UT: 352
Design Thickness : 0.375-in

Location: Sta. 229+85
Date: 17-Mar-23

**APPENDIX II**

Coating Thickness Log

# Site #1

| | |
|---|---|
| Created | 2023-03-21 12:44:30 |
| Gage S/N | 889755 |
| Probe Type | F |
| Probe S/N | 381458 |
| Gage Type | PosiTector |

## Calibration

| | |
|---|---|
| Cal Name | Cal 1 |
| Adjustment Date | 20-30-02-03 20:56:46 |
| Adjustment Method | Zero Offset: 0.65 mils |

## Summary

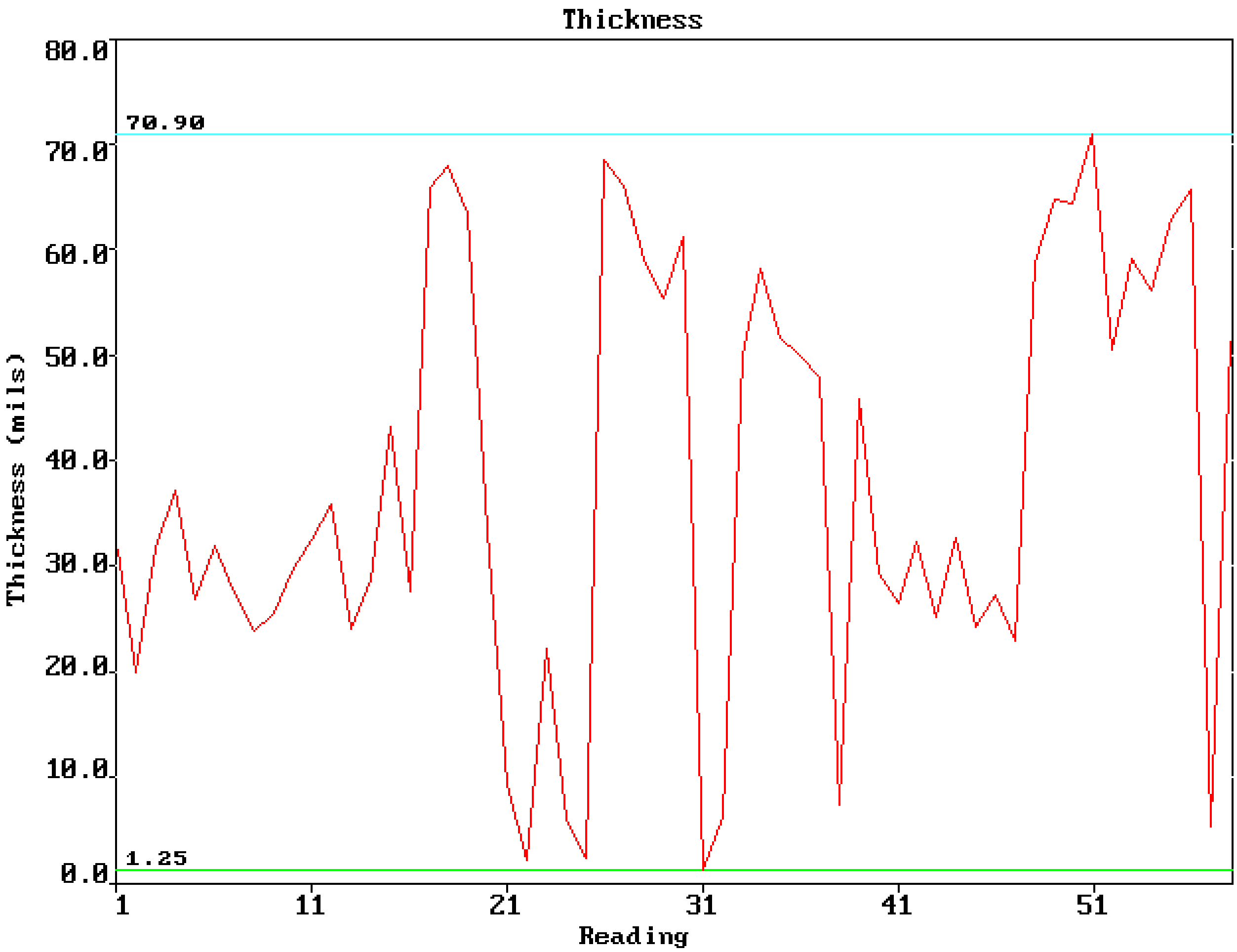
| | # | $\bar{x}$ | $\sigma$ | ⤓ | ⤒ |
|---|---|---|---|---|---|
| Thickness(mils) | 58 | 38.077 | 20.233 | 1.25 | 70.90 |

## Readings

| # | Thickness (mils) | Time |
|---|---|---|
| 1 | 31.6 | 2023-03-21 12:44:39 |
| 2 | 19.9 | 12:44:41 |
| 3 | 31.7 | 12:44:42 |
| 4 | 37.1 | 12:44:45 |
| 5 | 26.9 | 12:44:46 |
| 6 | 32.0 | 12:44:48 |
| 7 | 27.4 | 12:44:51 |
| 8 | 23.8 | 12:44:52 |
| 9 | 25.5 | 12:44:53 |
| 10 | 29.5 | 12:45:03 |
| 11 | 32.5 | 12:45:05 |
| 12 | 35.8 | 12:45:06 |
| 13 | 24.0 | 12:45:22 |
| 14 | 28.8 | 12:45:24 |
| 15 | 43.2 | 12:45:27 |
| 16 | 27.6 | 12:45:31 |
| 17 | 65.9 | 12:45:35 |
| 18 | 68.0 | 12:45:37 |
| 19 | 63.5 | 12:45:38 |
| 20 | 33.4 | 12:45:41 |
| 21 | 9.2 | 12:46:00 |
| 22 | 2.1 | 12:46:01 |
| 23 | 22.2 | 12:46:03 |
| 24 | 6.0 | 12:46:04 |

| | | |
|---|---|---|
| 25 | 2.3 | 12:46:06 |
| 26 | 68.4 | 12:46:10 |
| 27 | 66.0 | 12:46:12 |
| 28 | 59.1 | 12:46:14 |
| 29 | 55.3 | 12:46:16 |
| 30 | 61.2 | 12:46:18 |
| 31 | 1.25 | 12:46:20 |
| 32 | 6.3 | 12:46:22 |
| 33 | 49.9 | 12:46:28 |
| 34 | 58.2 | 12:46:30 |
| 35 | 51.7 | 12:46:31 |
| 36 | 49.9 | 12:46:32 |
| 37 | 47.9 | 12:46:34 |
| 38 | 7.4 | 12:46:36 |
| 39 | 45.9 | 12:46:43 |
| 40 | 29.4 | 12:46:44 |
| 41 | 26.6 | 12:46:46 |
| 42 | 32.3 | 12:46:47 |
| 43 | 25.2 | 12:46:52 |
| 44 | 32.7 | 12:46:54 |
| 45 | 24.2 | 12:46:57 |
| 46 | 27.2 | 12:47:02 |
| 47 | 22.9 | 12:47:09 |
| 48 | 58.7 | 13:04:07 |
| 49 | 64.8 | 13:04:10 |
| 50 | 64.3 | 13:04:12 |
| 51 | 70.9 | 13:04:14 |
| 52 | 50.5 | 13:04:16 |
| 53 | 59.1 | 13:04:18 |
| 54 | 56.1 | 13:04:22 |
| 55 | 62.9 | 13:04:23 |
| 56 | 65.6 | 13:04:25 |
| 57 | 5.4 | 13:04:27 |
| 58 | 51.3 | 13:04:31 |

# B45


Thickness
80.0
70.90
70.0
60.0
50.0
40.0
30.0
20.0
10.0
1.25
0.0
Thickness (mils)
1
11
21
31
41
51
Reading

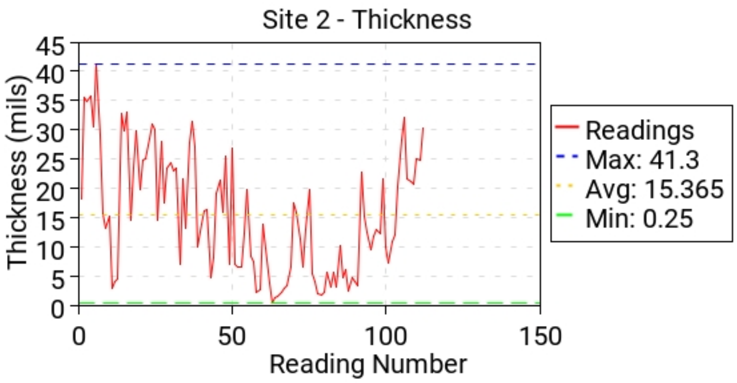
Home

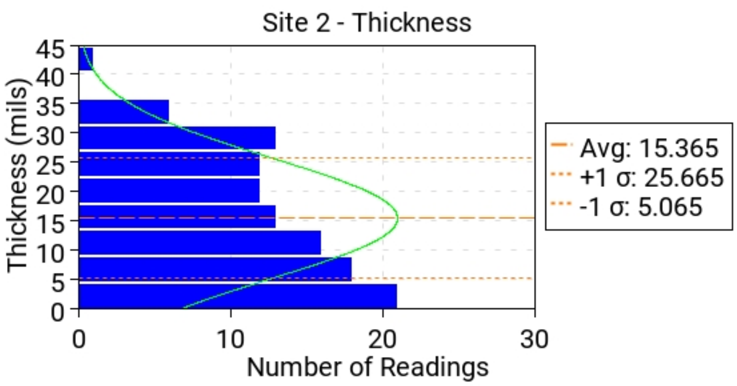
# Site 2
## Coating Thickness Inspection Report

| | |
|---|---|
| Created: | 2023-02-13 11:31:29 |
| PosiTector Body S/N: | 889755 |
| Probe Type: | PosiTector 6000 F |
| Probe S/N: | 381458 |

## Summary

| | # | x̄ | σ | ↓ | ⤒ |
|---|---|---|---|---|---|
| Coating Thickness (mils) | 112 | 15.365 | 10.300 | 0.25 | 41.3 |




## Readings

| # | Thickness (mils) | Time 2023-03-16 |
|---|---|---|
| 1 | 18.1 | 09:07:24 |
| 2 | 35.5 | 09:07:27 |
| 3 | 34.9 | 09:07:28 |
| 4 | 35.8 | 09:07:30 |
| 5 | 30.5 | 09:07:32 |
| 6 | 41.3 | 09:07:34 |
| 7 | 29.1 | 09:07:36 |
| 8 | 15.6 | 09:07:54 |
| 9 | 13.1 | 09:07:56 |
| 10 | 15.2 | 09:07:58 |
| 11 | 2.9 | 09:08:00 |
| 12 | 4.1 | 09:08:02 |
| 13 | 4.4 | 09:08:03 |
| 14 | 32.7 | 09:08:21 |
| 15 | 29.9 | 09:08:22 |
| 16 | 33.1 | 09:08:23 |

## Readings

| # | Thickness (mils) | Time 2023-03-16 |
|---|---|---|
| 17 | 14.6 | 09:08:26 |
| 18 | 23.5 | 09:08:28 |
| 19 | 29.9 | 09:08:29 |
| 20 | 19.7 | 09:08:36 |
| 21 | 24.7 | 09:08:37 |
| 22 | 24.9 | 09:08:39 |
| 23 | 28.5 | 09:08:42 |
| 24 | 31.0 | 09:08:43 |
| 25 | 30.1 | 09:08:44 |
| 26 | 14.5 | 09:08:46 |
| 27 | 27.9 | 09:08:47 |
| 28 | 17.5 | 09:08:48 |
| 29 | 23.4 | 09:08:51 |
| 30 | 24.3 | 09:08:53 |
| 31 | 22.9 | 09:08:53 |
| 32 | 23.4 | 09:08:55 |
| 33 | 7.0 | 09:09:03 |
| 34 | 21.5 | 09:32:57 |
| 35 | 13.1 | 09:32:58 |
| 36 | 27.7 | 09:33:00 |
| 37 | 31.4 | 09:33:02 |
| 38 | 27.0 | 09:33:03 |
| 39 | 10.0 | 09:33:06 |
| 40 | 13.8 | 09:33:07 |
| 41 | 16.0 | 09:33:08 |
| 42 | 16.3 | 09:33:10 |
| 43 | 4.7 | 09:33:12 |
| 44 | 8.0 | 09:33:13 |
| 45 | 19.0 | 09:38:22 |
| 46 | 21.3 | 09:38:24 |
| 47 | 15.9 | 09:38:26 |
| 48 | 25.4 | 09:38:28 |
| 49 | 6.9 | 09:38:32 |
| 50 | 26.8 | 09:38:34 |
| 51 | 7.0 | 09:38:36 |
| 52 | 6.4 | 09:38:37 |
| 53 | 6.5 | 09:38:40 |
| 54 | 12.2 | 09:38:42 |
| 55 | 19.8 | 09:38:44 |
| 56 | 8.3 | 10:25:29 |
| 57 | 7.5 | 10:25:30 |
| 58 | 2.1 | 10:25:31 |
| 59 | 2.6 | 10:25:32 |
| 60 | 13.8 | 10:25:34 |
| 61 | 9.6 | 10:25:35 |
| 62 | 3.8 | 10:25:37 |
| 63 | 0.25 | 10:25:38 |
| 64 | 1.35 | 10:25:39 |
| 65 | 1.50 | 10:25:40 |
| 66 | 2.1 | 10:25:42 |
| 67 | 2.9 | 10:25:43 |

## Readings

| # | Thickness (mils) | Time |
|---|---|---|
| 68 | 3.2 | 2023-03-16 10:25:44 |
| 69 | 6.5 | 10:25:45 |
| 70 | 17.5 | 10:25:46 |
| 71 | 15.8 | 10:25:47 |
| 72 | 11.4 | 10:25:48 |
| 73 | 6.6 | 10:25:50 |
| 74 | 12.9 | 10:25:51 |
| 75 | 19.7 | 10:25:55 |
| 76 | 5.4 | 10:25:56 |
| 77 | 4.1 | 10:25:57 |
| 78 | 2.0 | 10:26:26 |
| 79 | 1.65 | 10:26:27 |
| 80 | 2.1 | 10:26:28 |
| 81 | 5.7 | 10:26:30 |
| 82 | 3.0 | 10:26:31 |
| 83 | 5.7 | 10:26:32 |
| 84 | 3.1 | 10:26:33 |
| 85 | 10.2 | 10:26:34 |
| 86 | 4.7 | 10:26:35 |
| 87 | 6.1 | 10:26:38 |
| 88 | 2.4 | 10:26:38 |
| 89 | 4.6 | 10:27:00 |
| 90 | 3.9 | 10:27:01 |
| 91 | 3.3 | 10:27:02 |
| 92 | 22.7 | 10:27:07 |
| 93 | 15.3 | 10:27:08 |
| 94 | 12.5 | 10:27:09 |
| 95 | 9.5 | 10:27:12 |
| 96 | 11.7 | 10:27:13 |
| 97 | 12.8 | 10:27:14 |
| 98 | 12.2 | 10:27:16 |
| 99 | 21.7 | 10:27:17 |
| 100 | 10.0 | 10:27:18 |
| 101 | 7.2 | 10:27:24 |
| 102 | 10.9 | 10:27:25 |
| 103 | 12.0 | 10:27:26 |
| 104 | 20.2 | 10:27:28 |
| 105 | 28.3 | 10:27:29 |
| 106 | 32.0 | 10:27:30 |
| 107 | 21.7 | 10:27:34 |
| 108 | 21.2 | 10:27:35 |
| 109 | 20.7 | 10:27:36 |
| 110 | 25.1 | 10:27:39 |
| 111 | 24.8 | 10:27:40 |
| 112 | 30.3 | 10:27:40 |

# Site #3

| | |
|---|---|
| Created | 2023-03-21 09:13:40 |
| Gage S/N | 889755 |
| Probe Type | F |
| Probe S/N | 381458 |
| Gage Type | PosiTector |

## Calibration

| | |
|---|---|
| Cal Name | Cal 1 |
| Adjustment Date | 20-30-02-03 20:56:46 |
| Adjustment Method | Zero Offset: 0.65 mils |

## Summary

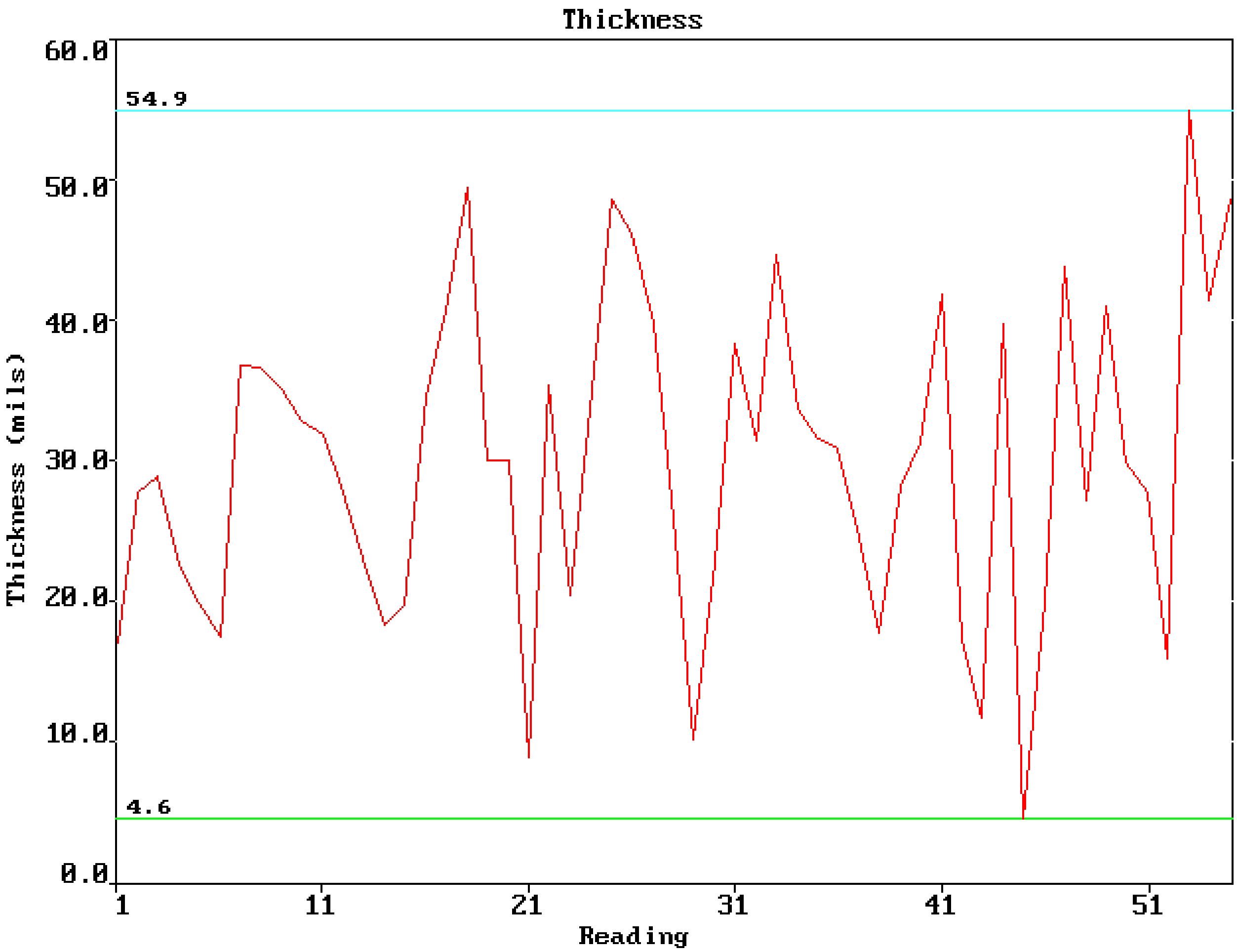
| | # | $\bar{x}$ | $\sigma$ | ⤓ | ⤒ |
|---|---|---|---|---|---|
| Thickness(mils) | 55 | 29.99 | 11.16 | 4.6 | 54.9 |

## Readings

| # | Thickness (mils) | Time |
|---|---|---|
| 1 | 17.1 | 2023-03-21 09:13:46 |
| 2 | 27.7 | 09:13:47 |
| 3 | 28.9 | 09:13:49 |
| 4 | 22.6 | 09:13:51 |
| 5 | 19.9 | 09:13:53 |
| 6 | 17.5 | 09:13:54 |
| 7 | 36.8 | 09:14:35 |
| 8 | 36.6 | 09:14:36 |
| 9 | 35.1 | 09:14:38 |
| 10 | 32.8 | 09:14:57 |
| 11 | 31.8 | 09:14:58 |
| 12 | 27.8 | 09:14:59 |
| 13 | 22.6 | 09:15:12 |
| 14 | 18.4 | 09:15:13 |
| 15 | 19.7 | 09:15:14 |
| 16 | 34.5 | 09:15:44 |
| 17 | 40.7 | 09:15:46 |
| 18 | 49.4 | 09:15:47 |
| 19 | 30.0 | 09:16:15 |
| 20 | 30.0 | 09:16:16 |
| 21 | 8.9 | 09:54:33 |
| 22 | 35.4 | 09:54:35 |
| 23 | 20.5 | 09:54:38 |
| 24 | 33.6 | 09:54:39 |

| | | |
|---|---|---|
| 25 | 48.5 | 09:55:03 |
| 26 | 46.2 | 09:55:05 |
| 27 | 39.7 | 09:55:07 |
| 28 | 25.9 | 09:55:10 |
| 29 | 10.2 | 09:55:22 |
| 30 | 22.8 | 09:55:24 |
| 31 | 38.3 | 09:55:26 |
| 32 | 31.4 | 09:55:29 |
| 33 | 44.6 | 09:55:40 |
| 34 | 33.7 | 09:55:42 |
| 35 | 31.5 | 09:55:44 |
| 36 | 30.8 | 09:55:47 |
| 37 | 24.5 | 09:55:55 |
| 38 | 17.8 | 09:55:56 |
| 39 | 28.2 | 09:55:58 |
| 40 | 31.3 | 09:56:10 |
| 41 | 41.8 | 09:56:12 |
| 42 | 17.3 | 09:56:14 |
| 43 | 11.8 | 09:56:17 |
| 44 | 39.7 | 09:56:19 |
| 45 | 4.6 | 09:56:26 |
| 46 | 19.9 | 09:56:28 |
| 47 | 43.8 | 09:56:30 |
| 48 | 27.2 | 09:56:32 |
| 49 | 40.9 | 09:56:35 |
| 50 | 29.9 | 09:57:09 |
| 51 | 27.8 | 09:57:11 |
| 52 | 16.0 | 09:57:12 |
| 53 | 54.9 | 09:57:31 |
| 54 | 41.4 | 09:57:33 |
| 55 | 48.5 | 09:57:35 |

## B44


Thickness
60.0
54.9
50.0
40.0
30.0
20.0
10.0
4.6
0.0
Thickness (mils)
1
11
21
31
41
51
Reading

Home

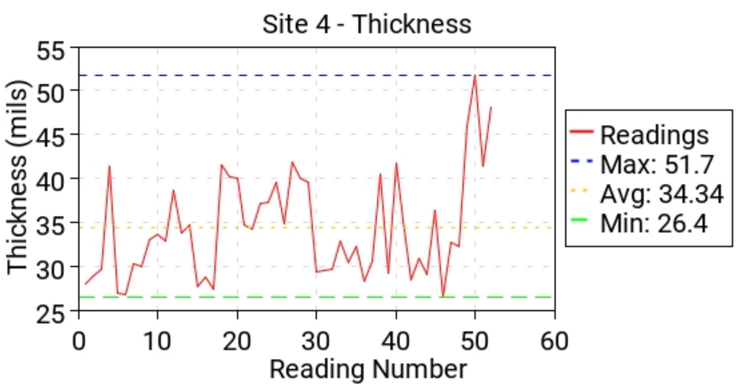
# Site 4
## Coating Thickness Inspection Report

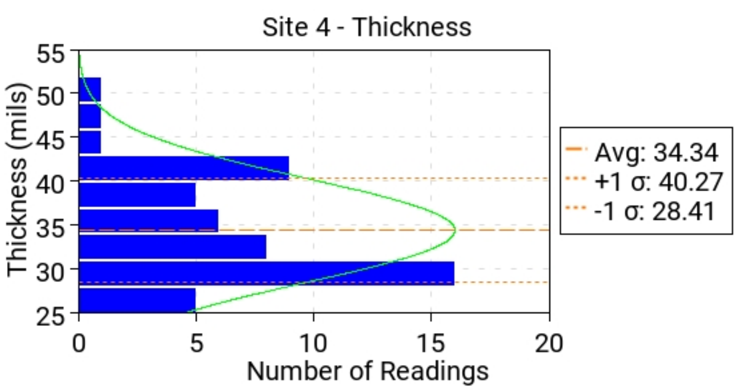
CORRTECH
CORROSION UNDERSTOOD

| | |
|---|---|
| Created: | 2023-03-16 11:50:14 |
| PosiTector Body S/N: | 889755 |
| Probe Type: | PosiTector 6000 F |
| Probe S/N: | 381458 |

## Summary

| | # | $\bar{x}$ | σ | ↓ | ⤒ |
|---|---|---|---|---|---|
| Coating Thickness (mils) | 52 | 34.34 | 5.93 | 26.4 | 51.7 |




## Readings

| # | Thickness (mils) | Time |
|---|---|---|
| | | 2023-03-16 |
| 1 | 28.0 | 11:50:18 |
| 2 | 28.9 | 11:50:19 |
| 3 | 29.6 | 11:50:20 |
| 4 | 41.4 | 11:50:22 |
| 5 | 26.9 | 11:50:26 |
| 6 | 26.8 | 11:50:27 |
| 7 | 30.2 | 11:50:28 |
| 8 | 30.0 | 11:50:29 |
| 9 | 33.0 | 11:50:32 |
| 10 | 33.6 | 11:50:33 |
| 11 | 32.9 | 11:50:34 |
| 12 | 38.6 | 11:50:36 |
| 13 | 33.7 | 11:50:36 |
| 14 | 34.7 | 11:50:37 |
| 15 | 27.7 | 11:50:39 |
| 16 | 28.8 | 11:50:39 |
| 17 | 27.4 | 11:50:40 |
| 18 | 41.5 | 11:50:42 |
| 19 | 40.2 | 11:50:43 |
| 20 | 40.0 | 11:50:44 |
| 21 | 34.6 | 11:50:47 |
| 22 | 34.2 | 11:50:48 |
| 23 | 37.1 | 11:50:48 |
| 24 | 37.3 | 11:51:31 |
| 25 | 39.6 | 11:51:32 |
| 26 | 34.8 | 11:51:33 |
| 27 | 41.9 | 11:51:35 |
| 28 | 40.0 | 11:51:36 |
| 29 | 39.5 | 11:51:37 |
| 30 | 29.4 | 11:51:39 |
| 31 | 29.5 | 11:51:40 |
| 32 | 29.7 | 11:51:41 |
| 33 | 32.8 | 11:58:00 |
| 34 | 30.4 | 11:58:05 |
| 35 | 32.3 | 11:58:10 |
| 36 | 28.3 | 11:58:15 |
| 37 | 30.5 | 11:58:25 |
| 38 | 40.5 | 11:58:28 |
| 39 | 29.2 | 11:58:36 |
| 40 | 41.6 | 11:58:40 |
| 41 | 35.3 | 11:58:55 |
| 42 | 28.4 | 11:59:02 |
| 43 | 30.9 | 11:59:12 |
| 44 | 29.1 | 11:59:18 |
| 45 | 36.3 | 11:59:23 |
| 46 | 26.4 | 11:59:28 |
| 47 | 32.7 | 11:59:35 |
| 48 | 32.3 | 11:59:41 |
| 49 | 45.9 | 11:59:46 |
| 50 | 51.7 | 11:59:48 |
| 51 | 41.3 | 11:59:54 |
| 52 | 48.1 | 12:00:02 |

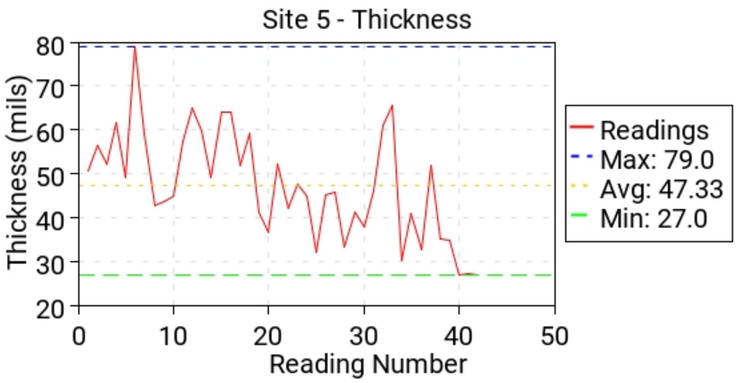
# Site 5
## Coating Thickness Inspection Report

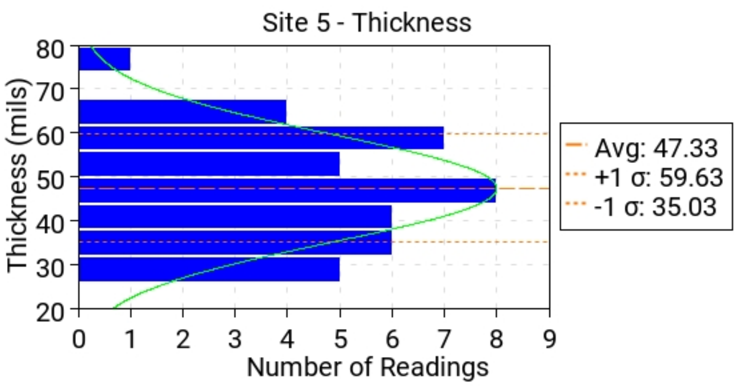
CORRTECH
CORROSION UNDERSTOOD

| | |
|---|---|
| Created: | 2023-03-17 09:04:03 |
| PosiTector Body S/N: | 889755 |
| Probe Type: | PosiTector 6000 F |
| Probe S/N: | 381458 |

## Summary

| | # | x̄ | σ | ↓ | ⤒ |
|---|---|---|---|---|---|
| Coating Thickness (mils) | 42 | 47.33 | 12.30 | 27.0 | 79.0 |




## Readings

| # | Thickness (mils) | Time 2023-03-17 |
|---|---|---|
| 1 | 50.6 | 09:04:07 |
| 2 | 56.5 | 09:04:09 |
| 3 | 52.1 | 09:04:11 |
| 4 | 61.7 | 09:04:15 |
| 5 | 49.2 | 09:04:17 |
| 6 | 79.0 | 09:04:23 |
| 7 | 59.2 | 09:04:26 |
| 8 | 42.7 | 09:04:31 |
| 9 | 43.7 | 09:04:33 |
| 10 | 44.8 | 09:04:35 |
| 11 | 57.3 | 09:04:40 |
| 12 | 64.8 | 09:04:42 |
| 13 | 59.8 | 09:04:43 |
| 14 | 49.2 | 09:05:04 |
| 15 | 64.1 | 09:05:25 |
| 16 | 64.1 | 09:05:28 |
| 17 | 51.8 | 09:05:37 |
| 18 | 59.0 | 09:05:47 |
| 19 | 41.1 | 09:05:58 |
| 20 | 36.6 | 09:06:01 |
| 21 | 52.0 | 09:06:21 |
| 22 | 42.0 | 09:06:23 |
| 23 | 47.6 | 09:06:36 |
| 24 | 44.7 | 09:06:42 |
| 25 | 31.9 | 09:06:53 |
| 26 | 45.1 | 09:06:55 |
| 27 | 45.8 | 09:07:05 |
| 28 | 33.2 | 09:07:17 |
| 29 | 41.3 | 09:07:22 |
| 30 | 37.8 | 09:07:25 |
| 31 | 46.0 | 09:08:01 |
| 32 | 61.0 | 09:08:34 |
| 33 | 65.4 | 09:08:37 |
| 34 | 30.2 | 09:18:39 |
| 35 | 40.9 | 09:18:42 |
| 36 | 32.6 | 09:18:44 |
| 37 | 51.7 | 09:19:04 |
| 38 | 35.2 | 09:19:06 |
| 39 | 34.9 | 09:19:54 |
| 40 | 27.0 | 09:19:58 |
| 41 | 27.1 | 09:20:00 |
| 42 | 27.0 | 09:20:02 |

# APPENDIX III
Soil Resistivity Measurements

| | Test Site #1 | | 3/21/2023 |
|---|---|---|---|
| West | Soil Resistance (Ohm-cm) | | East |
| Crown | 9,000 | 4,500 | Crown |
| Springline | 10,000 | 12,000 | Springline |
| Invert | | 5,000 | Invert |

| | Test Site #2 | | 3/16/2023 |
|---|---|---|---|
| West | Soil Resistance (Ohm-cm) | | East |
| Crown | | 10,000 | Crown |
| Springline | | 1,500 | Springline |
| Invert | 1,000 | | Invert |

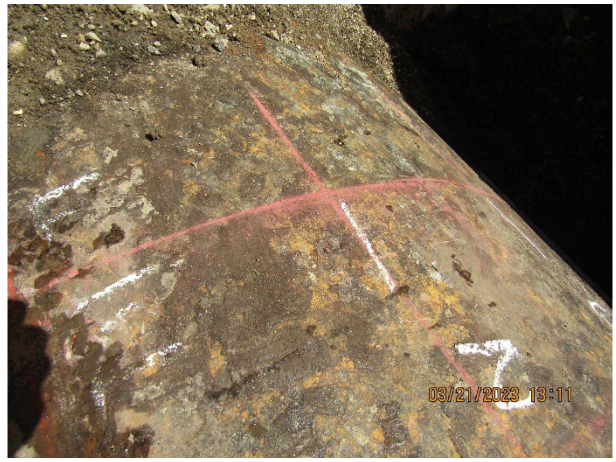
| | Test Site #3 | | 3/21/2023 |
|---|---|---|---|
| West | Soil Resistance (Ohm-cm) | | East |
| Crown | 17,000 | 50,000 | Crown |
| Springline | | 12,000 | Springline |
| Invert | 2,500 | 2,000 | Invert |

| | Test Site #4 | | 3/16/2023 |
|---|---|---|---|
| West | Soil Resistance (Ohm-cm) | | East |
| Crown | 8,000 | 3,000 | Crown |
| Springline | 3,500 | 1,000 | Springline |
| Invert | 2,000 | 1,500 | Invert |

| | Test Site #6 | | 3/17/2023 |
|---|---|---|---|
| West | Soil Resistance (Ohm-cm) | | East |
| Crown | 60,000 | 100,000 | Crown |
| Springline | 60,000 | 100,000 | Springline |
| Invert | 25,000 | 75,000 | Invert |

**APPENDIX IV**
Photo Log

1 – Site 1 overview Sta 205+28



2 – Site 1 Crown

3 – Site 1 Springline and lock bar

4 – Deepest Pitting in Pipe at Site 1

5 – Site 1 Invert

6 – Site 1 Spring line and lock bar


7 – Site 2 overview Sta 214+00


8 – Site 2 Crown


9 – B-scan along Crown


10 – Springline and lock bar


11 – Deepest pit in Springline


12 – Site 2 Invert


13 – Site 3 overview Sta 217+17


14 – Site 3 corwn and shoring


15 – Site 3 Springline and lock bar


16 – Typical condition of Springline


17 – Deepest pit in site 3

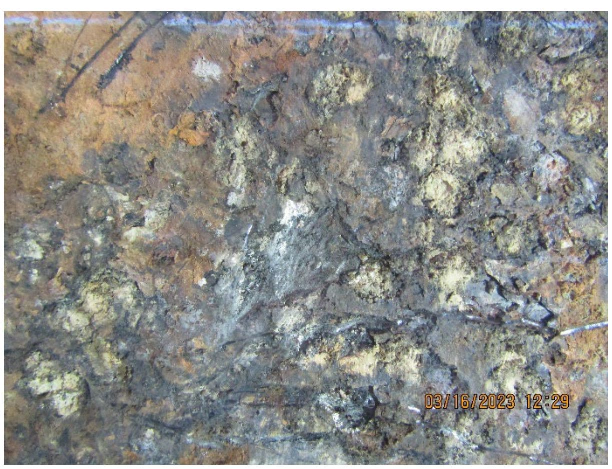

18 – Site 3 Invert


19 – Site 4 overview Sta 220+85


20 – Site 4 Crown


21 – Site 3 Springline and lock bar


22 – Typical coating condition



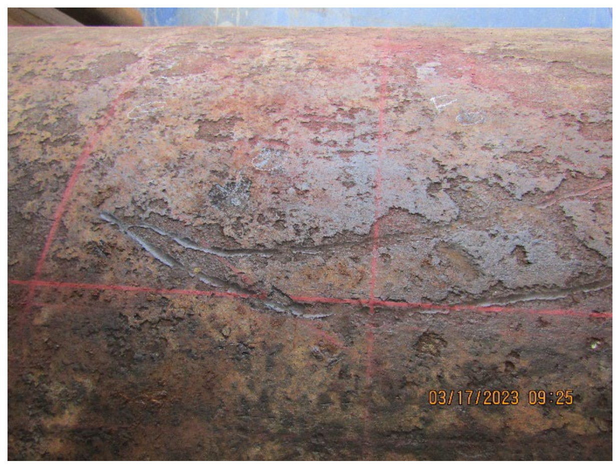

23 – Pitting in Springline


24 – Deepest pitting in Invert


25 – Site 5 overview Sta 229+85


26 – Site 5 Crown


27 – Site 5 Springline and lock bar




28 – Gashes in Springline coating


29 – Deepest pit in Springline of Site 5


30 – Site 5 Invert

Site 3 (2021 designation) 227+50

Site #3: Waverly Oaks Road: General Overview

Site #3: Waverly Oaks Road: Notable Pit

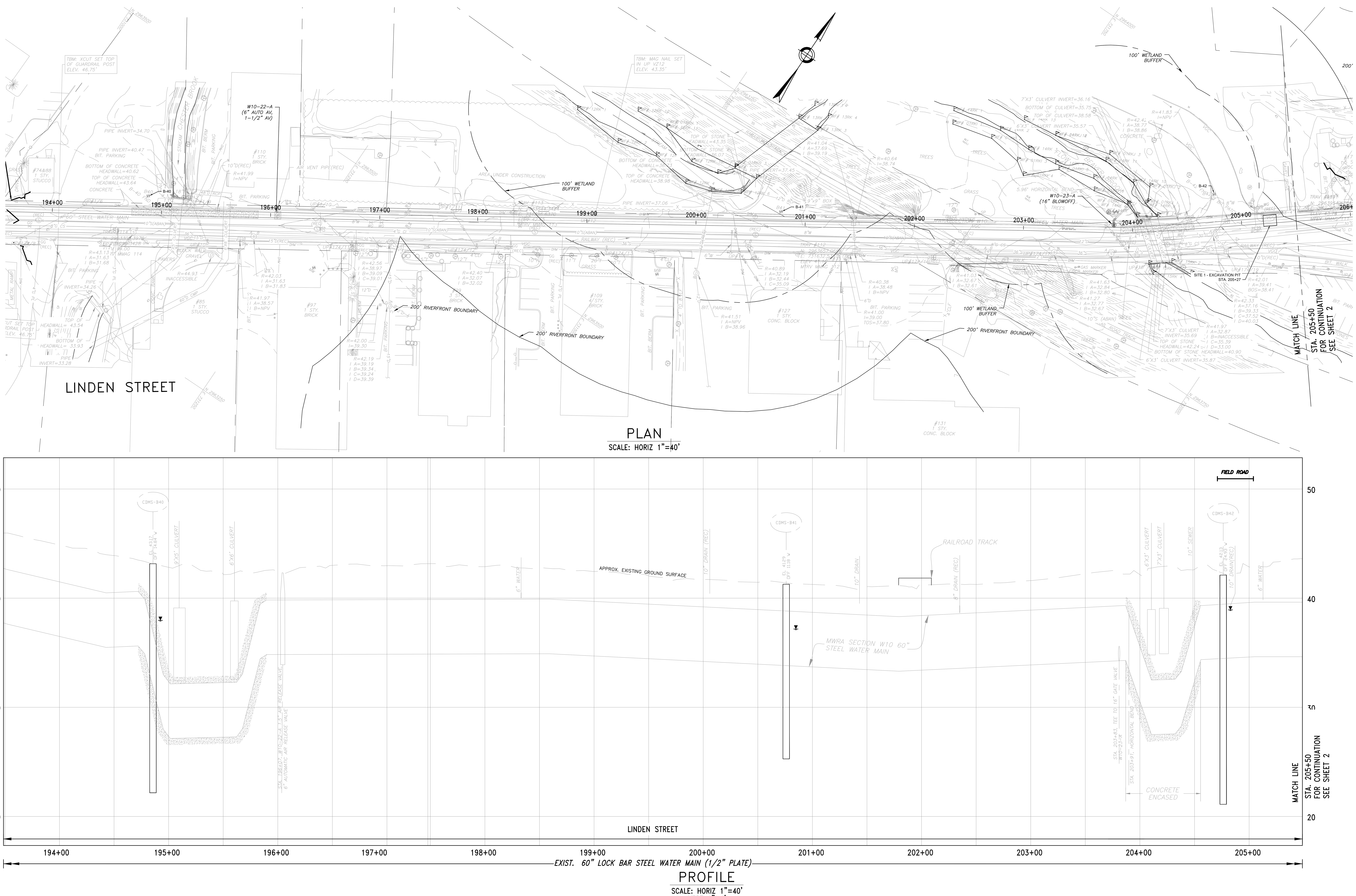
Site #3: Waverly Oaks Road: Notable Pit

Site #3: Waverly Oaks Road: Notable Pit

Site #3: Waverly Oaks Road: Coating De-lamination

**APPENDIX V**

Pipe Test Pit As-built Drawings Waverly Oaks Road




1"= 40'-0" HORIZONTAL

0 40 100 200 FEET

0 4 8 10 20

1"= 4'-0" VERTICAL

| NO. | DATE | BY | CHK'D | REVISION |
|---|---|---|---|---|

CONTRACT NO. : 6539

ACCESSION NO. : ----

DATE: DECEMBER 2022

SCALE: AS NOTED

CAD FILE NO. : --

SECTION NO. : --

DESIGNED BY: TJC

DRAWN BY: TJC

CHECKED BY: RJS

APPROVED BY: ----

MASSACHUSETTS WATER RESOURCES AUTHORITY

PREPARED BY :

Stantec

45 NETWORK DRIVE 3RD FLOOR
BURLINGTON, MA 01803
www.stantec.com

WESTON AQUEDUCT SUPPLY MAIN 3
MWRA CONTRACT NO. 6539
CP2 PHASE 2 EXCAVATION LOCATIONS

EXCAVATION SITE 1 PLAN
173 LINDEN STREET – WALTHAM, MA

DRAWING NO.

1 OF 3

FILE NAME: \\US0552-PPFSS01\Workgroup\1951\active\195150185\CAD\2.1.2 Alternatives Analysis\2.1.2.2 Field Testing Program\Excavation Locations\WASM3 Excavation – Location Plans_CP2_Phase2 – asbuilt.dwg LAYOUT NAME: C-110 PLOTTED: Thursday, April 13, 2023 – 12:53pm USER: tcosma


1"= 40'-0" HORIZONTAL
0 40 100 200 FEET
0 4 8 10 20
1"= 4'-0" VERTICAL

| NO. | DATE | BY | CHK'D | REVISION |
|---|---|---|---|---|

CONTRACT NO.: 6539 WASM3 Excavation - Location Plans_CP2_Phase2 - asbuilt
ACCESSION NO.: ----
SECTION NO.: --
DATE: DECEMBER 2022
SCALE: AS NOTED
DESIGNED BY: RJS
DRAWN BY: TJC
CHECKED BY: RBS
APPROVED BY: ----

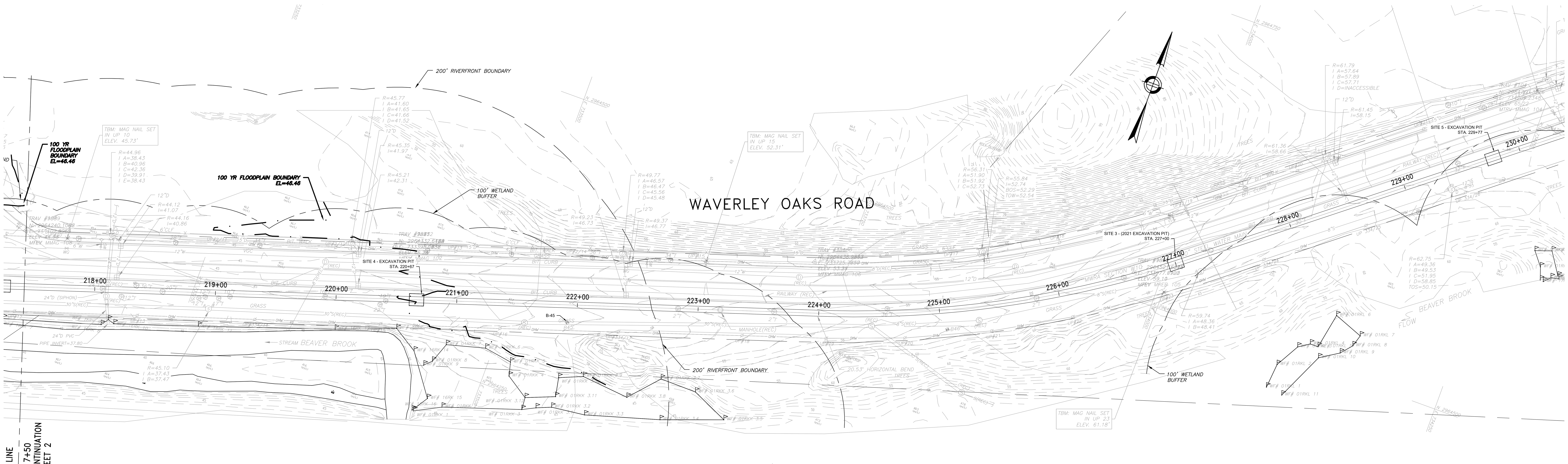
MASSACHUSETTS WATER RESOURCES AUTHORITY
PREPARED BY:
Stantec
45 NETWORK DRIVE 3RD FLOOR
BURLINGTON, MA 01803
www.stantec.com

WESTON AQUEDUCT SUPPLY MAIN 3
MWRA CONTRACT NO. 6539
CP2 PHASE 2 EXCAVATION LOCATIONS

EXCAVATION SITES 2 & 3 PLAN
56 WAVERLEY OAKS ROAD – WALTHAM, MA

DRAWING NO.
2 OF 3

FILE NAME: \\US0552-PPFSS01\Workgroup\1951\active\195150185\CAD\2.1.2 Alternatives Analysis\2.1.2.2 Field Testing Program\Excavation Locations\WASM3 Excavation – Location Plans_CP2_Phase2 – asbuilt.dwg LAYOUT NAME: C-111 PLOTTED: Thursday, April 13, 2023 – 12:54pm USER: tcosma




PLAN
SCALE: HORIZ 1"=40'


PROFILE
SCALE: HORIZ 1"=40'
VERT 1"=4'

1"= 40'-0" HORIZONTAL
0 40 100 200 FEET
0 4 8 10 20
1"= 4'-0" VERTICAL

| NO. | DATE | BY | CHK'D | REVISION |
|---|---|---|---|---|

CONTRACT NO.: 6539 WASM3 Excavation - Location Plans_CP2_Phase2 - asbuilt
ACCESSION NO.: ----
SECTION NO.: --
DATE: DECEMBER 2022
SCALE: AS NOTED
DESIGNED BY: RJS
DRAWN BY: TJC
CHECKED BY: RBS
APPROVED BY: ----

MASSACHUSETTS WATER RESOURCES AUTHORITY
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WESTON AQUEDUCT SUPPLY MAIN 3
MWRA CONTRACT NO. 6539
CP2 PHASE 2 EXCAVATION LOCATIONS

EXCAVATION SITES 3 & 4 PLAN
191 WAVERLEY OAKS ROAD – WALTHAM, MA

DRAWING NO.
3 OF 3

FILE NAME: \\US0552-PPFSS01\Workgroup\1951\active\195150185\CAD\2.1.2 Alternatives Analysis\2.1.2.2 Field Testing Program\Excavation Locations\WASM3 Excavation – Location Plans_CP2_Phase2 – asbuilt.dwg LAYOUT NAME: C-112 PLOTTED: Thursday, April 13, 2023 – 12:55pm USER: tcosma