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2025 SPRING CONVENTION

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De-Mystifying Unusual Results on Extraordinary Structures - Case Studies of Concrete Challenges

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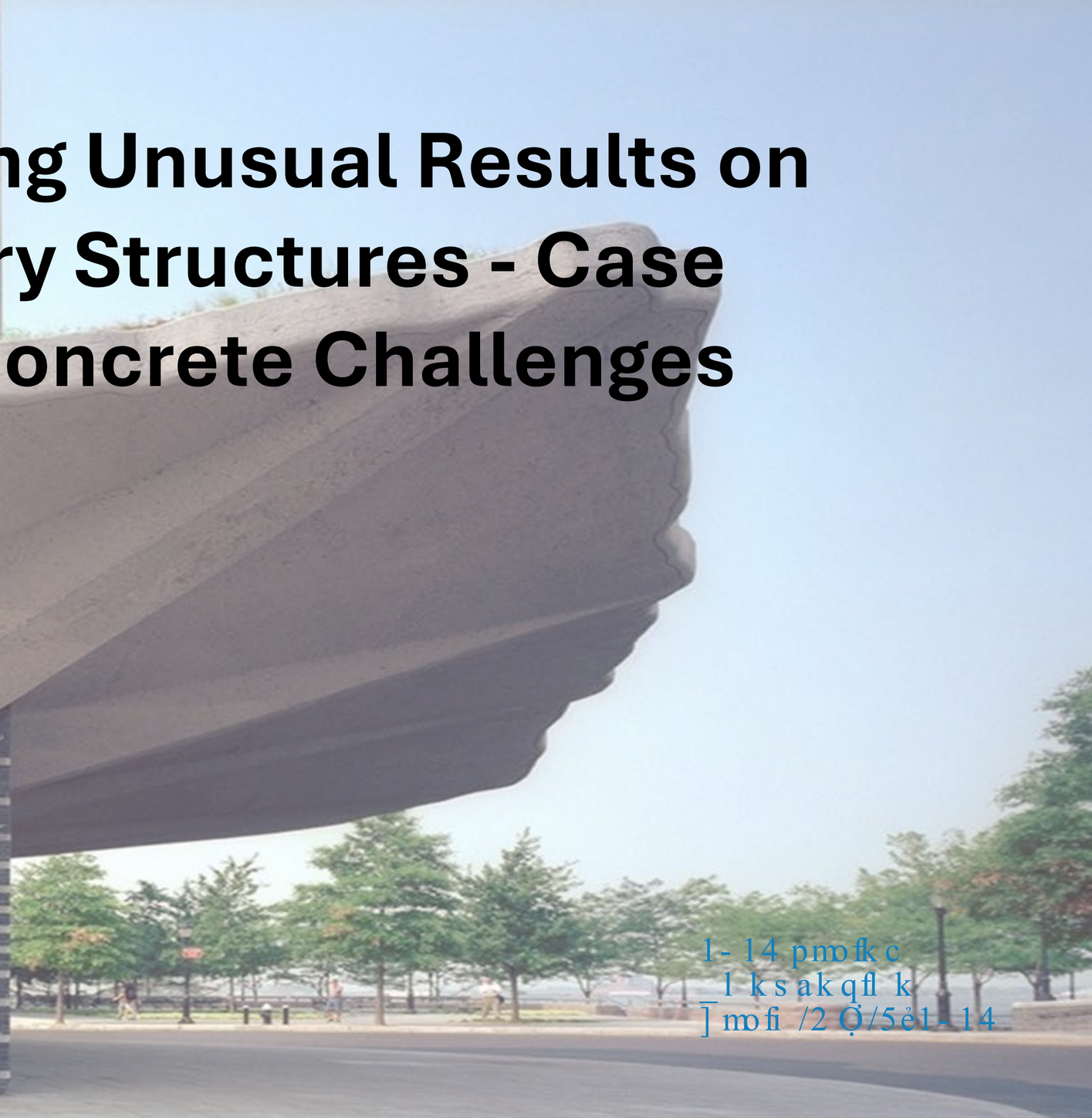

AGENDA

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- **Standards for Testing**
- **Limitations in Testing**
- **Case Studies Interpreting Results**

NOT ALL CONCRETE IS EQUAL

NOT ALL CONCRETE IS EQUAL

- Architectural and sculptural concrete may have similar or common construction materials – but their significance may be much greater than the average concrete structure

NOT ALL CONCRETE IS EQUAL

- Or they may have little in common with traditional reinforced concrete creating challenges in assessing existing conditions and analyzing test data

NOT ALL CONCRETE IS EQUAL

- Significance and function may change with time or events

NOT ALL CONCRETE IS EQUAL

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NOT ALL CONCRETE IS EQUAL

- Differences in construction materials
  - Aggregate
  - Reinforcing
  - Surface treatments

NOT ALL CONCRETE IS EQUAL

Differences in surface treatments

NOT ALL CONCRETE IS EQUAL

- Differences in repair PHILOSOPHY and methodology

NOT ALL PROBLEMS ARE EQUAL

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NOT ALL PROBLEMS ARE EQUAL

STEEL PROBLEMS

CORROSION IN CONCRETE – THE BASICS

Reinforcing Steel Corrosion exists when you have one or a number of the following Conditions

1. Exposure to the atmosphere (via cracks)
2. The pH of the concrete has dropped below 10
3. Chlorides are present on the steel surface

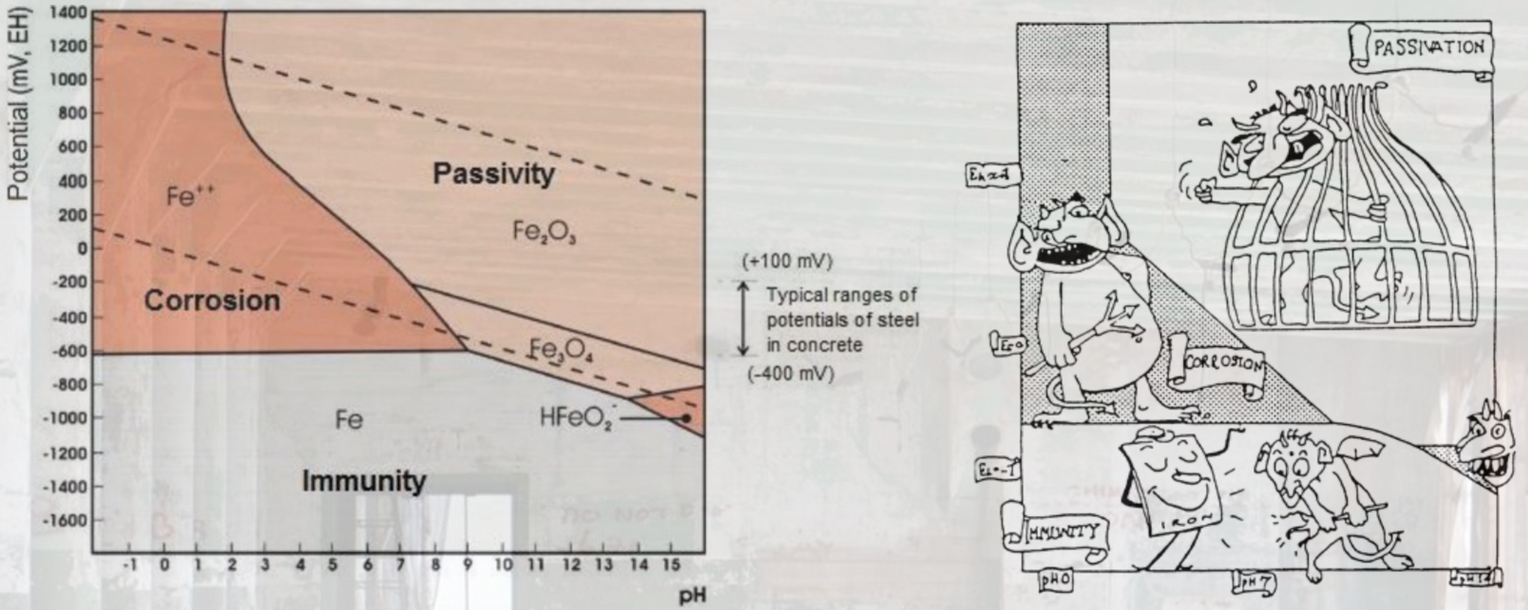

Figure 1. Thermodynamic stability of iron in aqueous solution after Pourbaix. (Right: Corrosion, immunity and passivation diagram for iron by A. Pirson [ii])


NOT ALL PROBLEMS
ARE EQUAL
CONCRETE
PROBLEMS

ALKALI SILICA REACTION (ASR) – THE BASICS

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Non-Destructive Standards:

USA Standards include:

AMPP (NACE) SP308 2018 "Inspection Methods for Corrosion Evaluation of Conventionally Reinforced Concrete Structures"

ACI 228.2R-13 - "Report on Nondestructive Test Methods for Evaluation of Concrete in Structures"

ACI PRG228.4-23 - "Visual Condition Survey of Concrete—Guide"

International Atomic Energy Agency (IAEA): Guidebook on Non-Destructive Testing of Concrete Structures

International Standards include:

ISO 16311-2:2024 - "Maintenance and repair of concrete structures —Part 2: Assessment of existing concrete structures"

ISO 19207:2004 - "Testing of concrete —Part 7: Non-destructive tests on hardened concrete"

ISO 13822:2010 – "Bases for design of structures —Assessment of existing structures"

European Standards are:

RILEM TC 154-EMC "Electrochemical techniques for measuring metallic corrosion in concrete"

EN 12504-2:2012 - "Testing concrete in structures —Part 2: Non-destructive testing —Determination of rebound number"

EN 12504-4:2004 - "Testing concrete —Part 4: Determination of ultrasonic pulse velocity"

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- Non-Destructive Testing Example Standard such as:

- **AMPP (NACE) SP308-2018 Section 3:**
  - (a) Visual inspection techniques;
  - (b) Crack inspection;
  - (c) Delamination survey;
  - (d) Cover thickness survey and reinforcement location;
  - (e) Assessment of concrete strength and condition; *Invasive*
  - (f) Corrosion potential measurements; *Invasive*
  - (g) Corrosion rate measurement; *Invasive*
  - (h) Carbonation depth measurement; *Invasive*
  - (i) Concrete resistivity measurement;
  - (j) Electrical continuity testing of reinforcement; *Invasive*
  - (k) Chloride content measurement and chloride profile determination in the concrete; and *Invasive*
  - (l) Other advanced techniques

- **AMPP (NACE) SP308-2018 Section 4:**

  4.2 Environmental Factors:

  "A number of environmental factors should be considered when a corrosion survey is performed. Descriptions of some of the most important factors follow. Some indication as to their effects on design or feasibility of restoration methods is given."

  - Temperature & Humidity
  - Precipitation
  - Load Factors

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CORROSION ANALYSIS

- **Corrosion Potential and activity**
  1. Half-cell potential (HCP) measurement (E_{corr}) & mapping

ASTM C876

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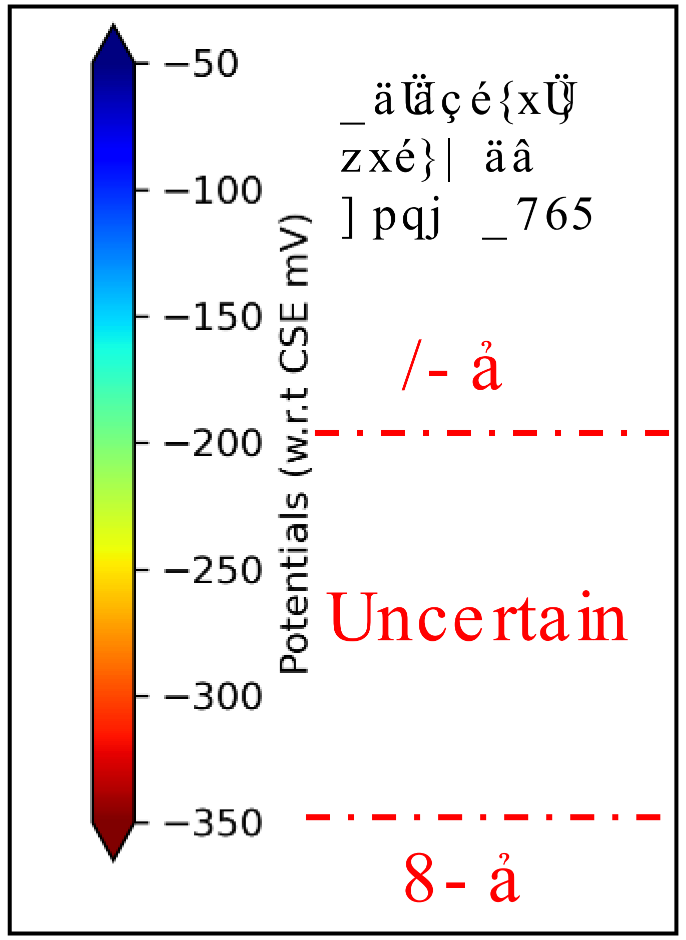
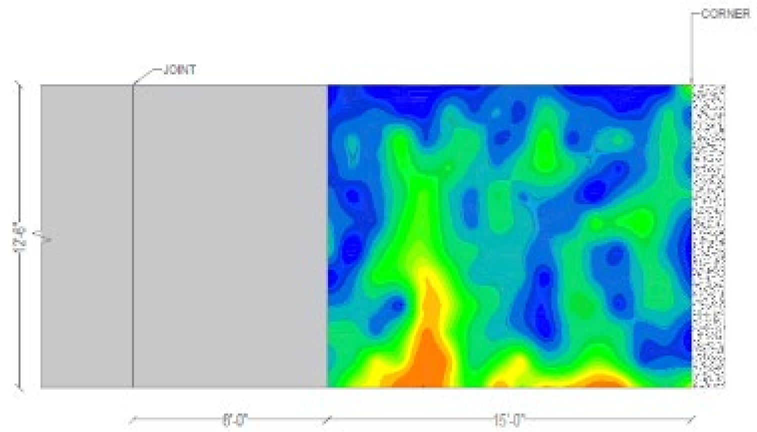
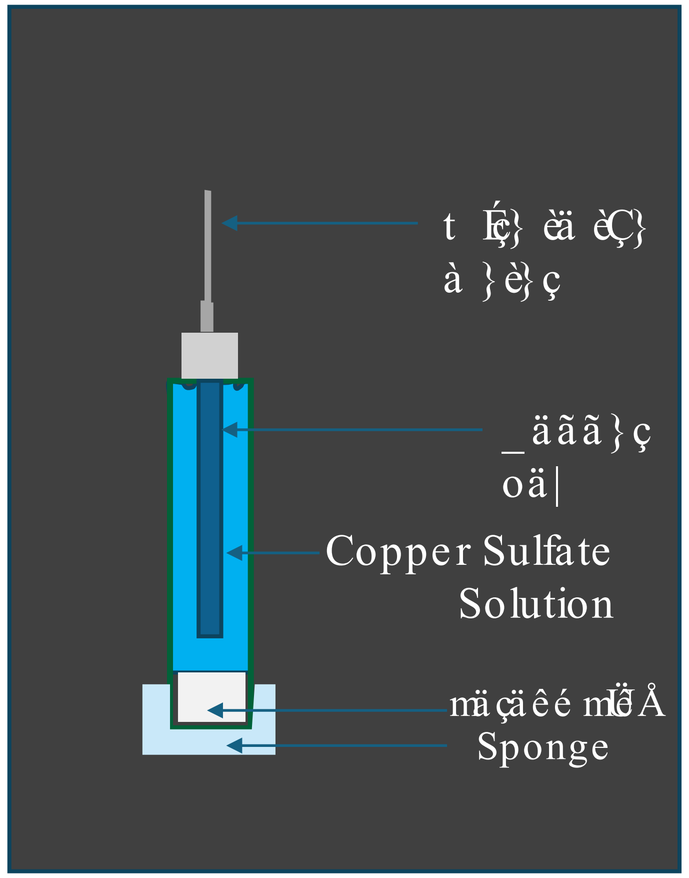
>-200	10
-200 to -350	Uncertain
<-350	90





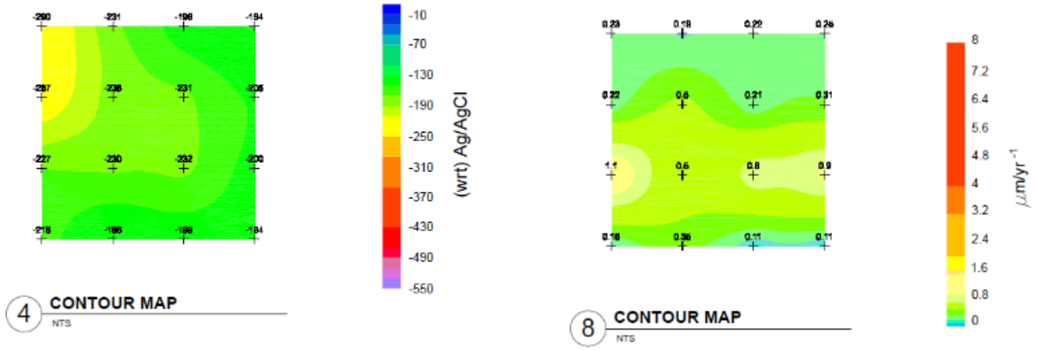
i-VOS TEST AREA RESULTS			
Potential (mV) w.r.t. Cu/CuSo4	Probability of Corrosion	No. of Readings (#)	(x)
> -200	90% Probability of No Corrosion	156	81.25
-200 to -350	Uncertain	31	16.15
< -350	90% Probability of Corrosion	5	2.60

1 NORTH ELEVATION - TEST LOCATION 1



CORROSION ANALYSIS

- **Corrosion Potential and activity analysis in the field***
  1. HCP gradient
  2. Corrosion current density (i_{corr})
  3. Corrosion Index (CI) Category



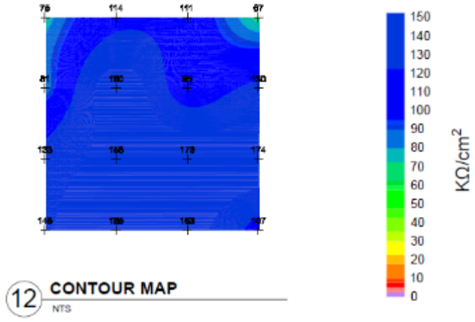


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Table 1 - Typical ranges of potentials of normal steel in concrete (Volts CSE)	
water saturated concrete without oxygen	-0.9 .... -1.0 V
wet, chloride contaminated concrete	-0.4 .... -0.6 V
humid, chloride free concrete	+0.1 .... -0.2 V
humid, carbonated concrete	+0.1 .... -0.4 V
dry, carbonated concrete	+0.2 .... 0 V
dry concrete	+0.2 .... 0 V

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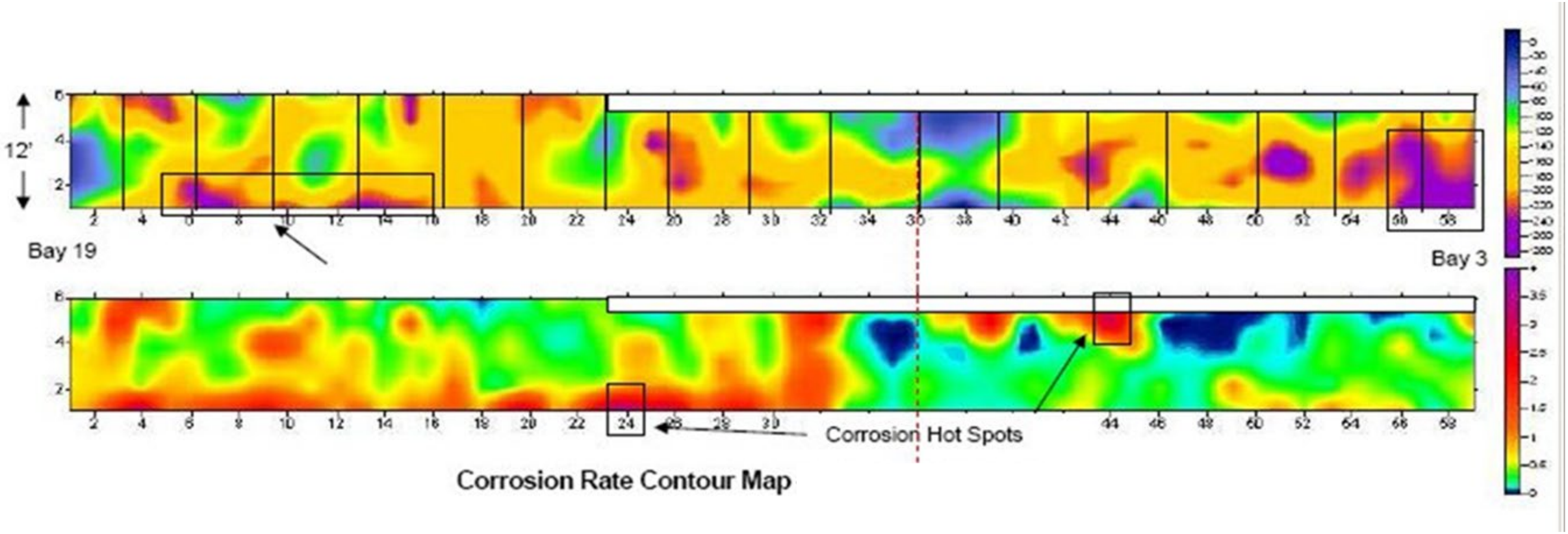
i_{corr} (µA/cm2)	Corrosion Level
⩽0. 1	Negligible
0.1 - 0.5	Low
0.5-1	Moderate
>1	High

Condition Index (CI) Category

CI Category	Corrosion condition	Corrosion Measurement
0	Good	$-200 < E_{corr}$ **and** $0 < I_{corr} < 0.1$
1	Fair	$-200 > E_{corr} > -350$ **or** $.0.1 < I_{corr} < 0.5$
2	Poor	$-350 > E_{corr} > -500$ **or** $0.5 < I_{corr} < 1$
3	Severe	$E_{corr} < -500$ **and** $1 < I_{dorr}$



Corrosion Rate Contour Map

LIMITATIONS

- Challenges with Assessments
  - Access
  - Sample size
  - Treatments
  - Permanent Coatings

LIMITATIONS

- Access

LIMITATIONS

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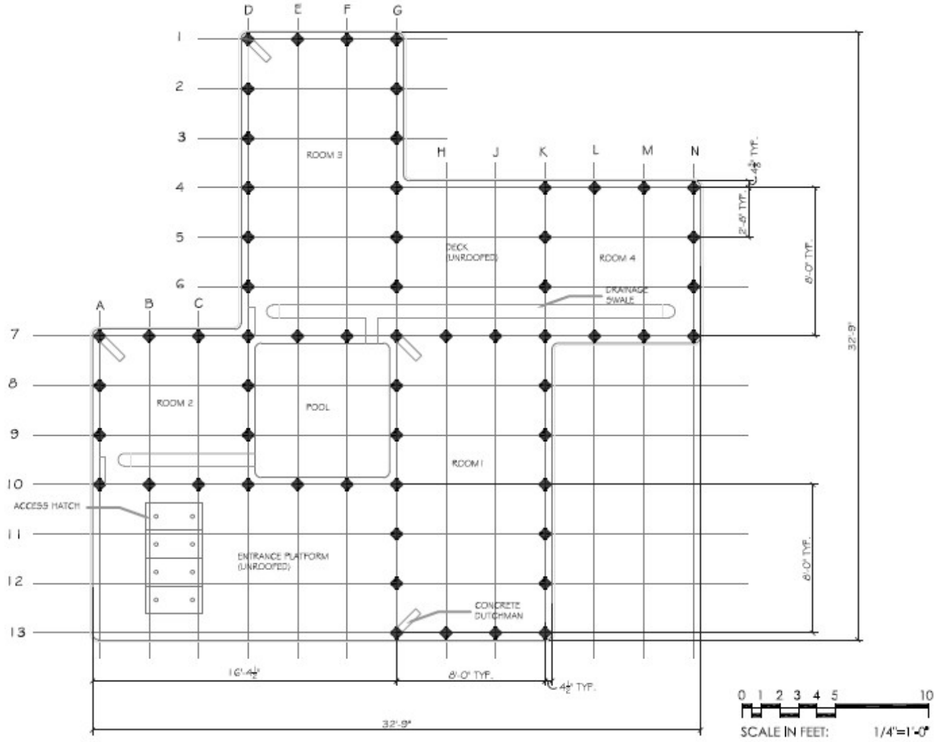
LIMITATIONS

- Limitations in sample size often dictates supporting laboratory analysis
- In some instances, only spalled concrete can be tested

CASE STUDIES

Pavilion on the pond
New Canaan, Connecticut

- 1962, Philip Johnson’s folly at home estate “Glass House”
- Pre-cast ‘Shockbeton’ system
- Historic Landmark
- Precursor to Lincoln Center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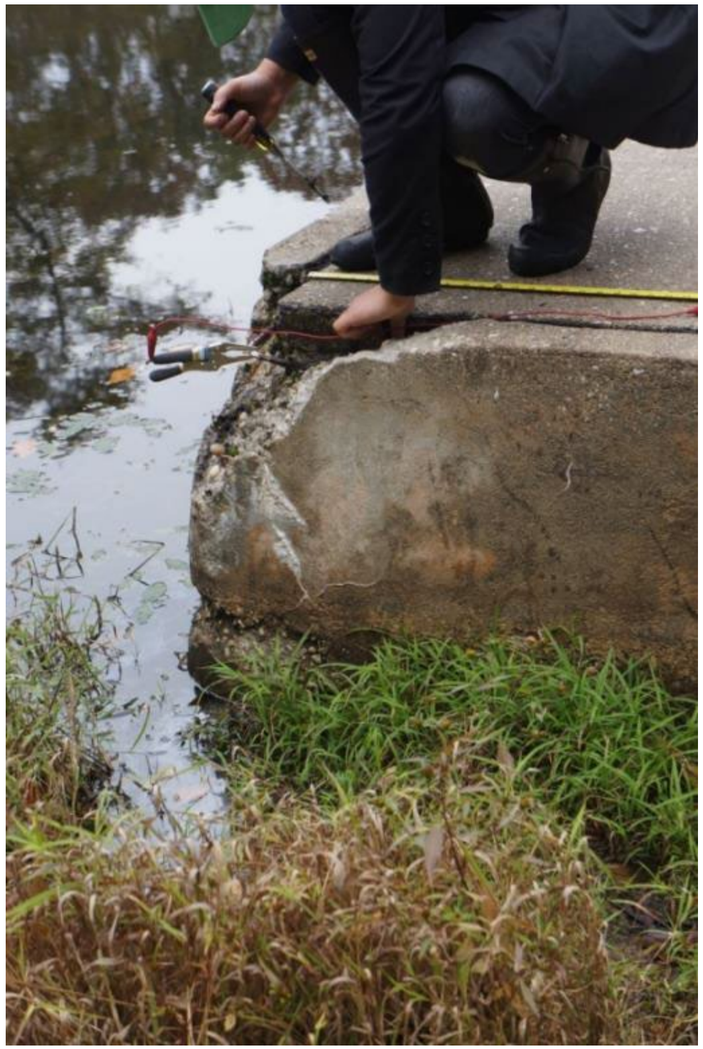
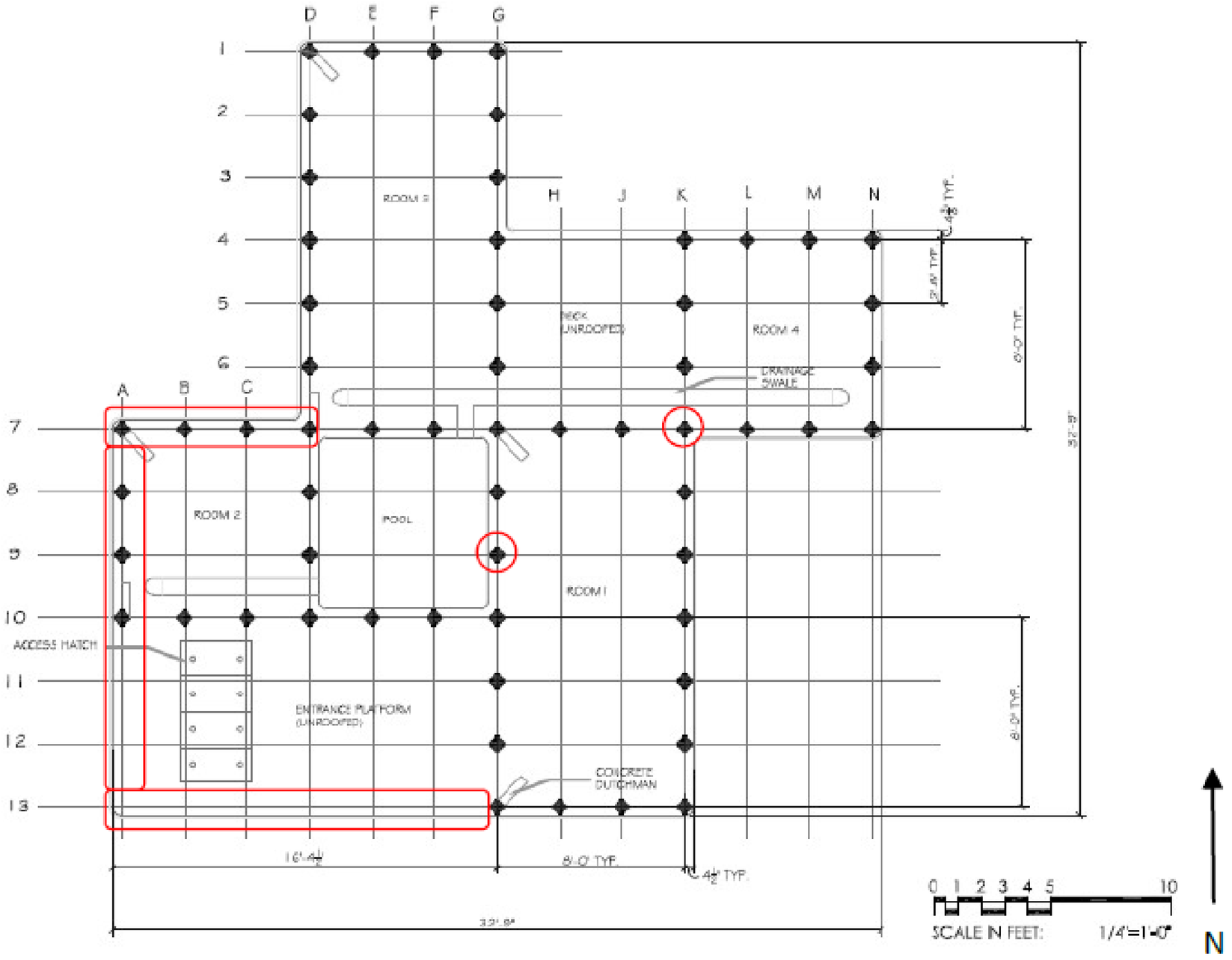
ROOM 3
DECK
(UNROOFED)
ROOM 4
DRAINAGE
SWALE
ROOM 2
POOL
ROOM 1
ACCESS HATCH
ENTRANCE PLATFORM
(UNROOFED)
CONCRETE
DUTCHMAN
2'-6" TYP.
8'-0" TYP.
32'-9"
16'-4½"
8'-0" TYP.
0 1 2 3 4 5 10
SCALE IN FEET: 1/4"=1'-0"

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ROOM 3
ROOM 4
UNROOFED
DRAINAGE SWALE
ROOM 2
POOL
ROOM 1
ACCESS HATCH
ENTRANCE PLATFORM (UNROOFED)
CONCRETE GUTCHMAN
16'-4½"
8'-0" TYP.
4½" TYP.
33'-8"
2'-6" TYP.
6'-0" TYP.
8'-0" TYP.
0 1 2 3 4 5 10
SCALE IN FEET: 1/4"=1'-0"
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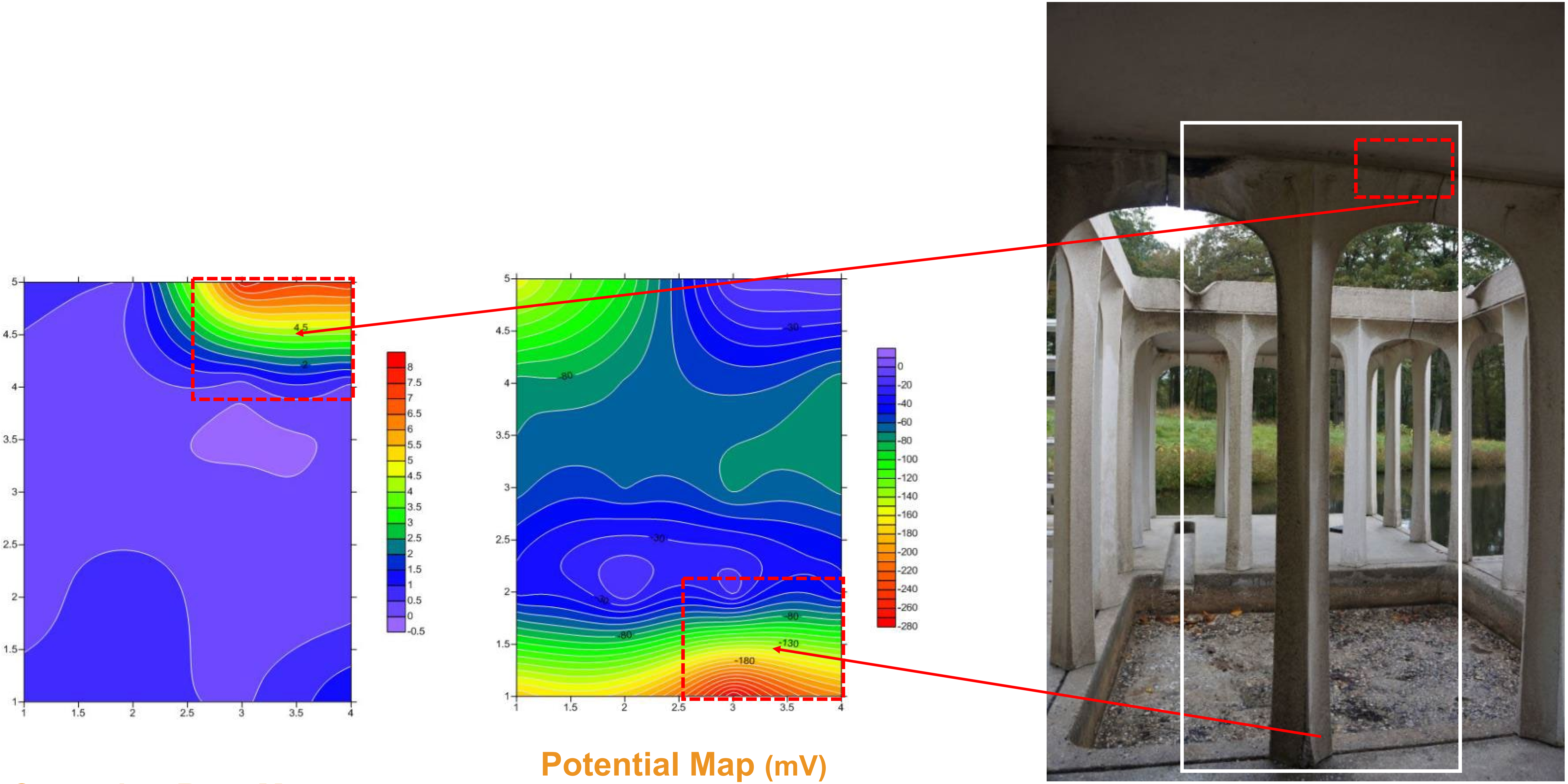

Corrosion Rate Map (µm/yr)

Potential Map (mV)

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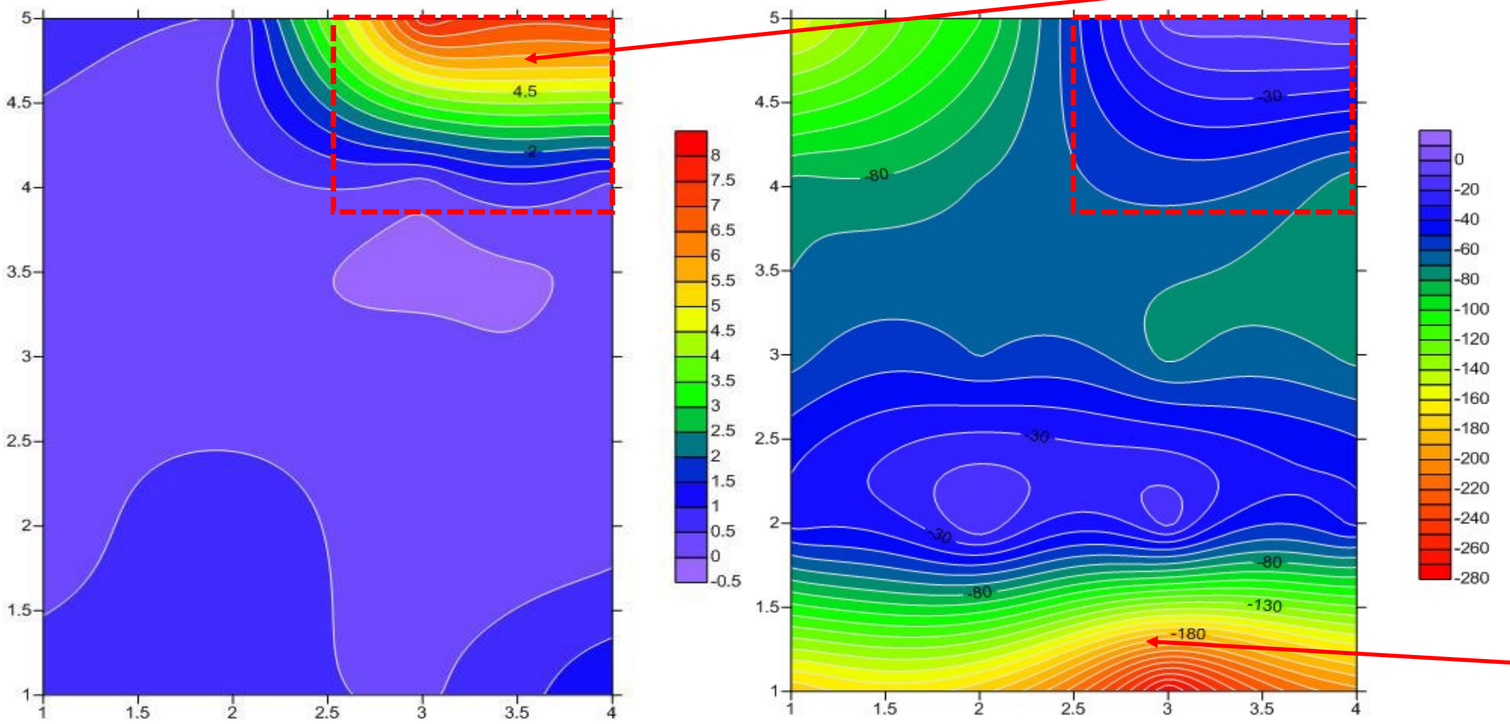

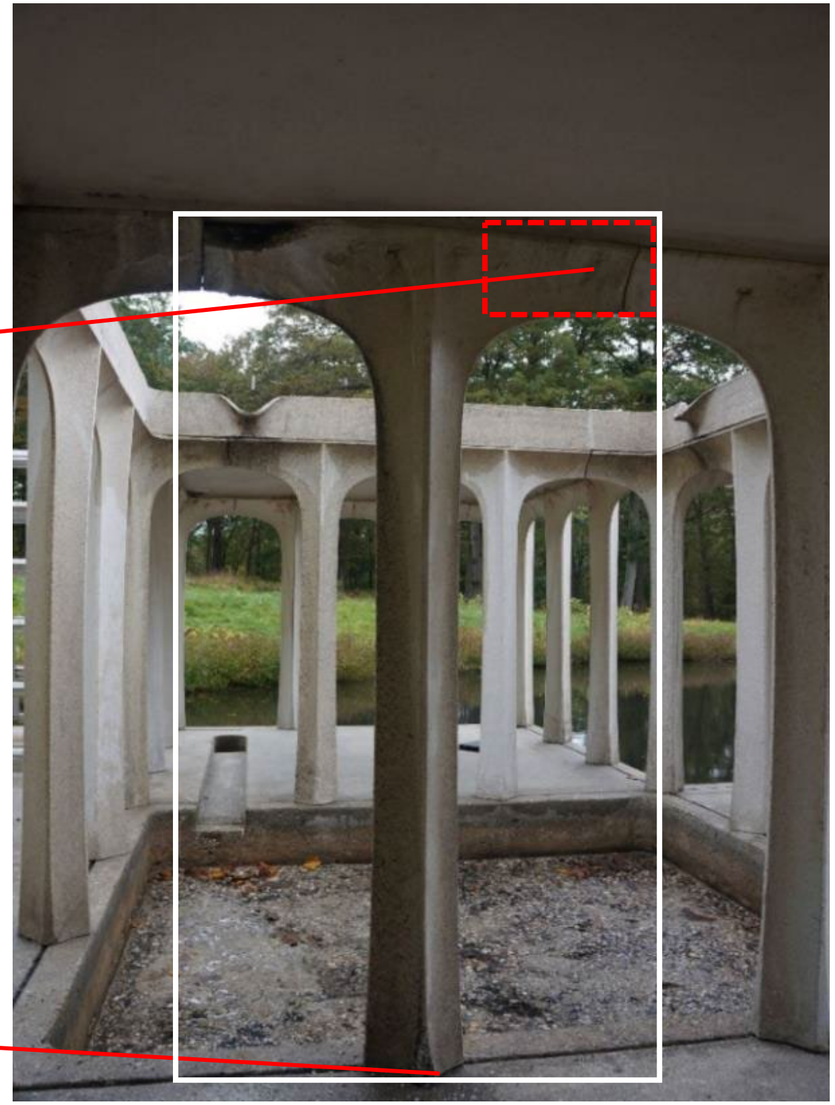

Corrosion Rate Map
(µm/yr)-

Potential Map (mV)
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	Potential (mV) w.r.t. Ag/AgKCl	Corrosion Rate ($\mu m/yr^{-1}$)	Section Loss (mpy)
Minimum	0.1	0.15	0.00591
Maximum	-290.9	7.82	0.308108
Average	-113.2	1.16	0.045838

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	Potential (mV) w.r.t. Ag/AgKCl	Corrosion Rate ($\mu m/yr^{-1}$)	Section Loss (mpy)
Minimum	-180	0.34	0.0134
Maximum	-300	2.81	0.1107
Average	-244	1.48	0.0583

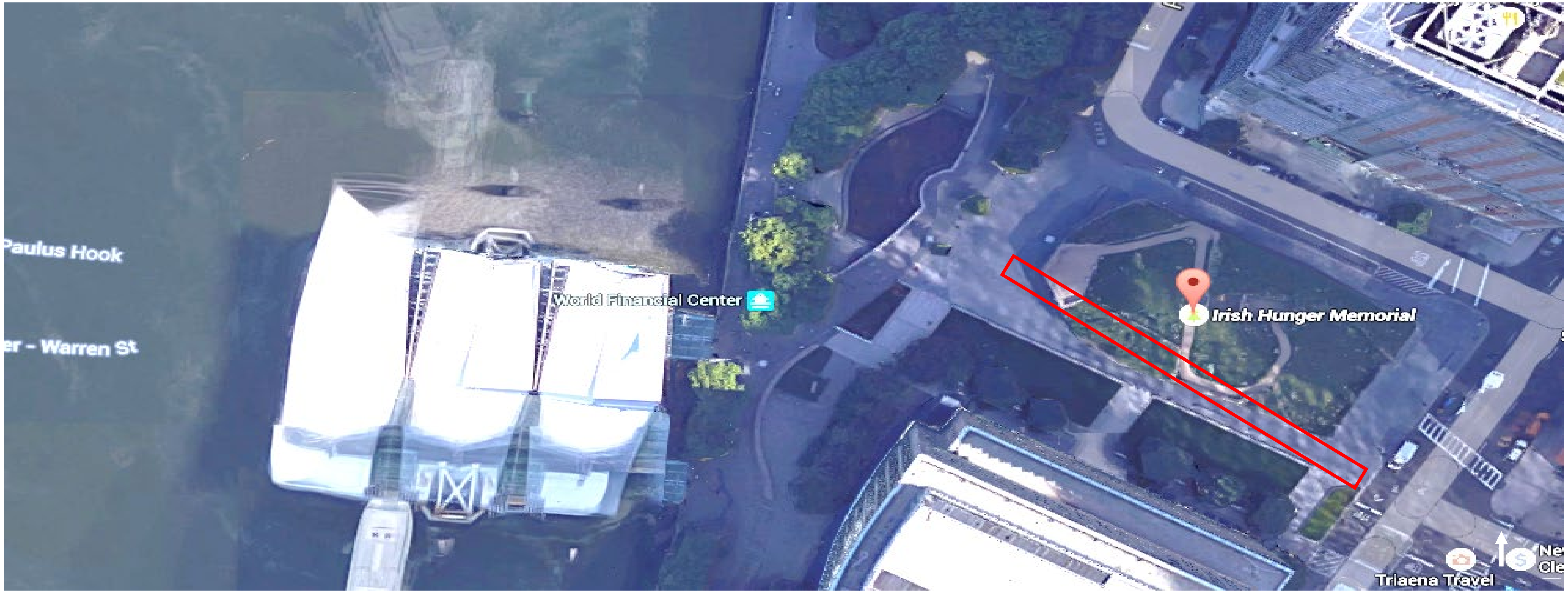
Pavilion on the pond
Results

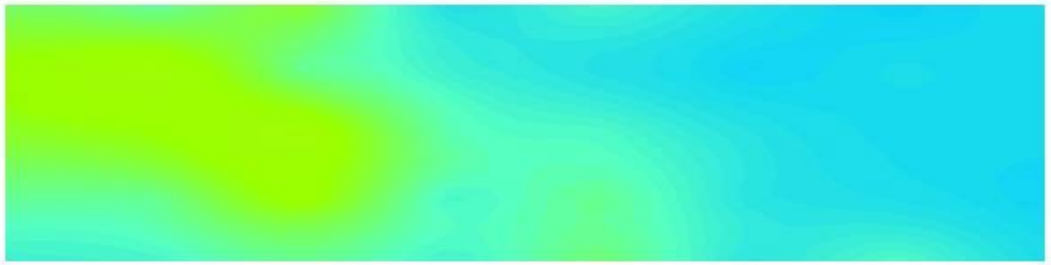
- Carbonated pre-cast structure
- Corrosion is a result of carbonated concrete
- Potential was largely influenced by moisture- seen at the base of the column
- Without the use of LPR Testing, corrosion hot spots would not have been identified.

Irish Hunger Memorial

New York, New York

- 2002, designed collaboratively by artist Brian Toll, landscape architect Gail Wittwer-Laird and architecture firm 1100 Architect.
- Designed to resemble a hill in the Irish countryside
- Concrete structure with epoxy coated rebar


Paulus Hook
World Financial Center
Irish Hunger Memorial
Trlaena Travel



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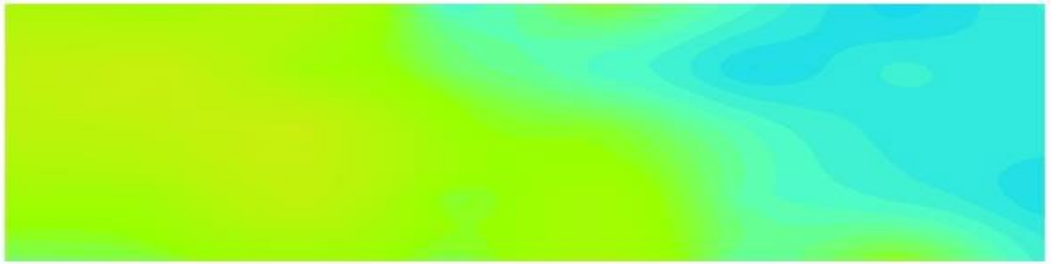

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25% Exposed Steel

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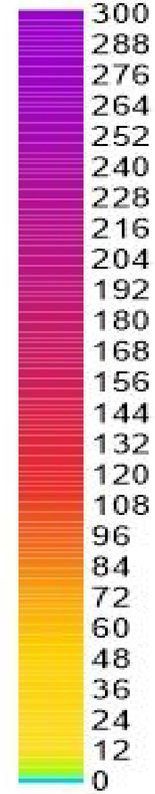

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Minimum	0.23
Maximum	3.17
Average	1.22

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50% Exposed Steel	Corrosion Rate (µm/yr-1)
Minimum	0.47
Maximum	6.35
Average	2.44

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25% Exposed Steel	Corrosion Rate (µm/yr-1)
Minimum	0.94
Maximum	12.70
Average	4.88

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5% Exposed Steel	Corrosion Rate (µm/yr-1)
Minimum	4.68
Maximum	63.50
Average	24.38

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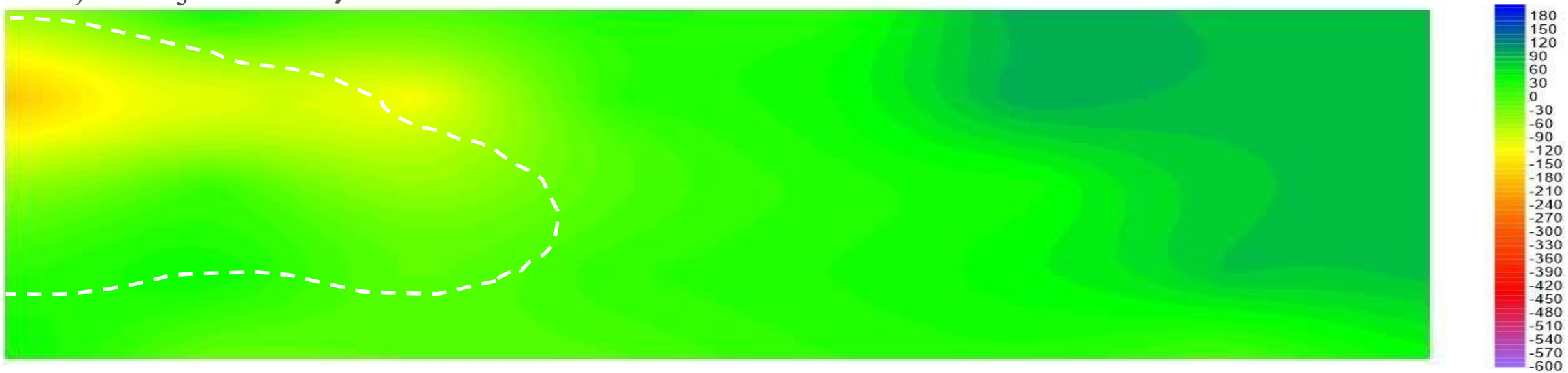

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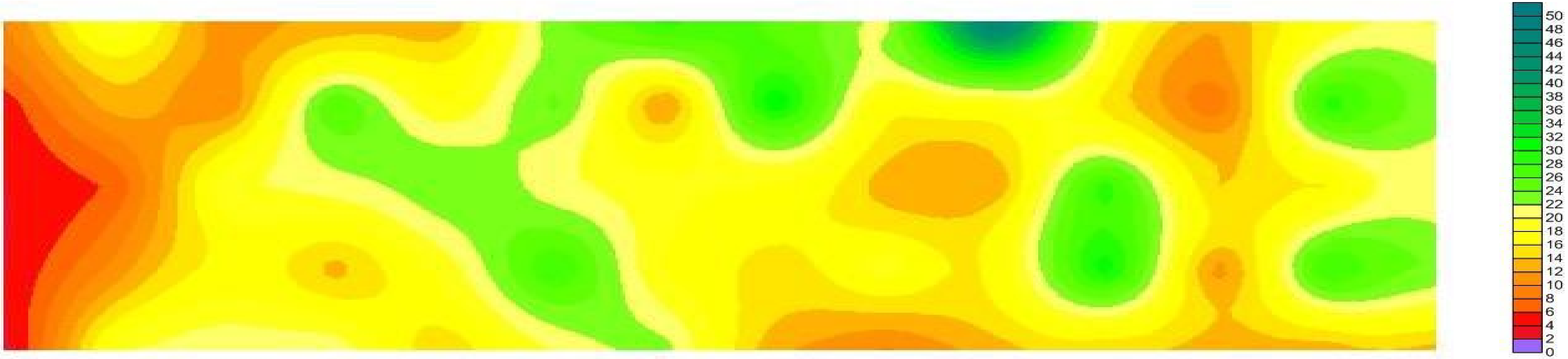


Data referring to depassivated steel (Langford and Broomfield, 1987):

> 20 kΩ cm	Low Corrosion Rate
10 - 20 kΩ cm	Low to moderate Corrosion Rate
5 - 10 kΩ cm	High Corrosion Rate
< 5 kΩ cm	Very High Corrosion Rate

Irish Hunger Memorial

Results

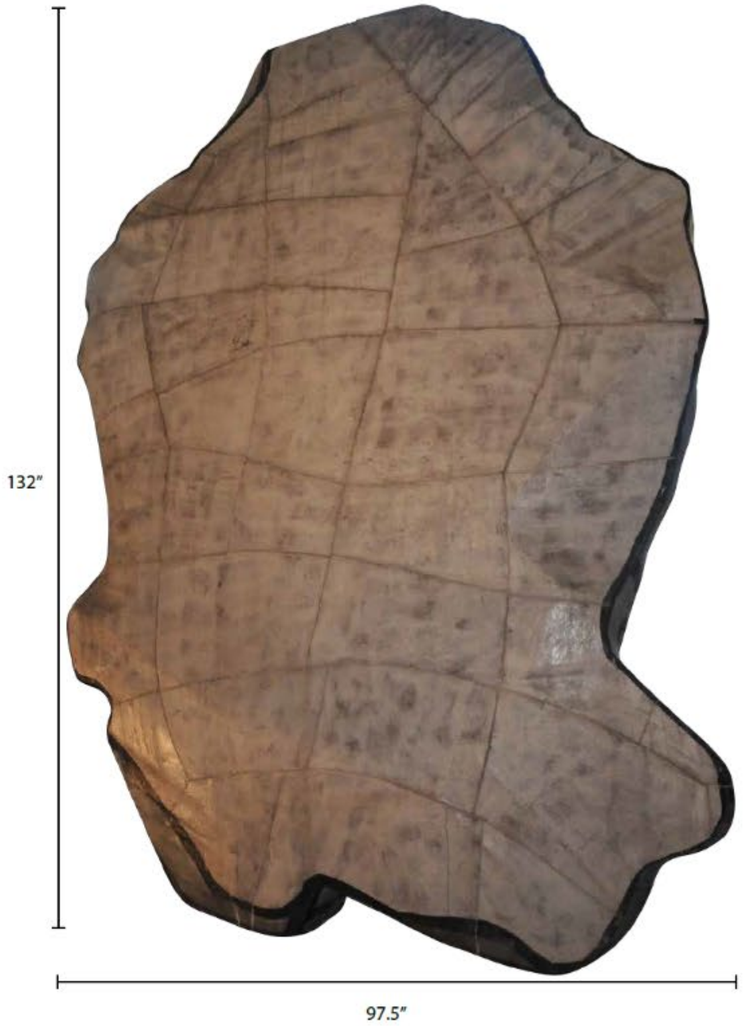
- The concrete area tested is at moderate risk of corrosion activity
- Presence of **Macro-cell**: as half-cell and corrosion rates were detected, it indicates that defects are present in the coating.
- As the test was conducted on a wet structure, it is anticipated that as the structure begins to dry, corrosion might accelerate.

“L’Erection Logologique Bleue Concrete” Sculpture

Tarrytown, New York

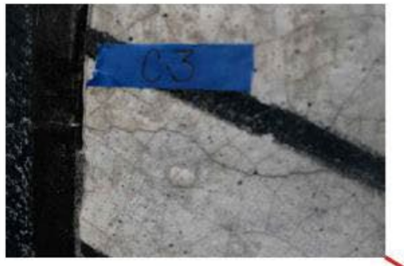
- Jean Dubuffet 1967 - 1969.
- Enameled Concrete
- Enameled Concrete, terra cotta, and steel reinforcing bars

① FRONT ELEVATION



② BACK ELEVATION

③ SIDE ELEVATION



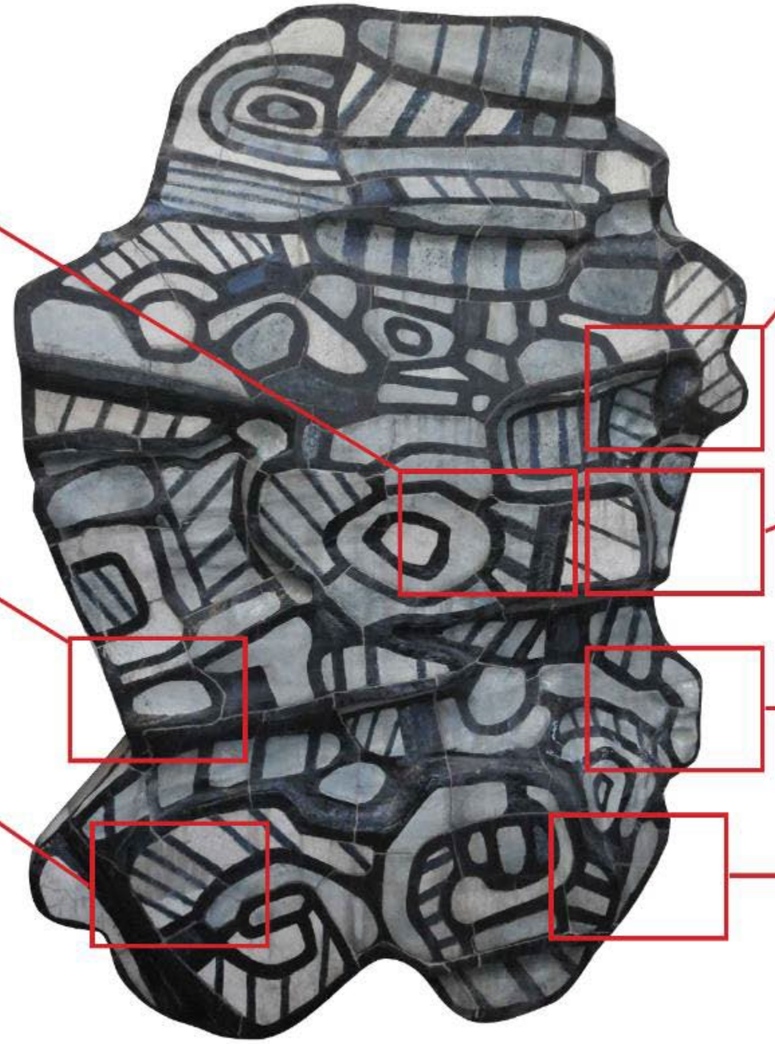
1 CRACK ID - C3 (1 of 2)

2 CRACK ID - C6

3 CRACK ID - C1

CRACK MAPPING		
Crack ID	Width [inches]	Depth [inches]
C1	0.013	2.604
C2	0.011	0.660
C3	0.022	3.600
C3	0.006	0.840
C4	0.022	0.312
C5	0.052	0.432
C6	0.012	0.432

4 CRACK MAPPING TABLE



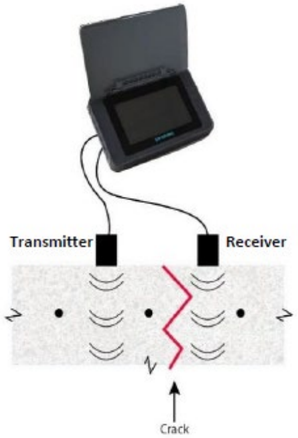
5 CRACK ID - C4

6 CRACK ID - C3 (2 of 2)

7 CRACK ID - C2

8 CRACK ID - C5

Ultrasonic Pulse Velocity Testing



ULTRASONIC PULSE VELOCITY

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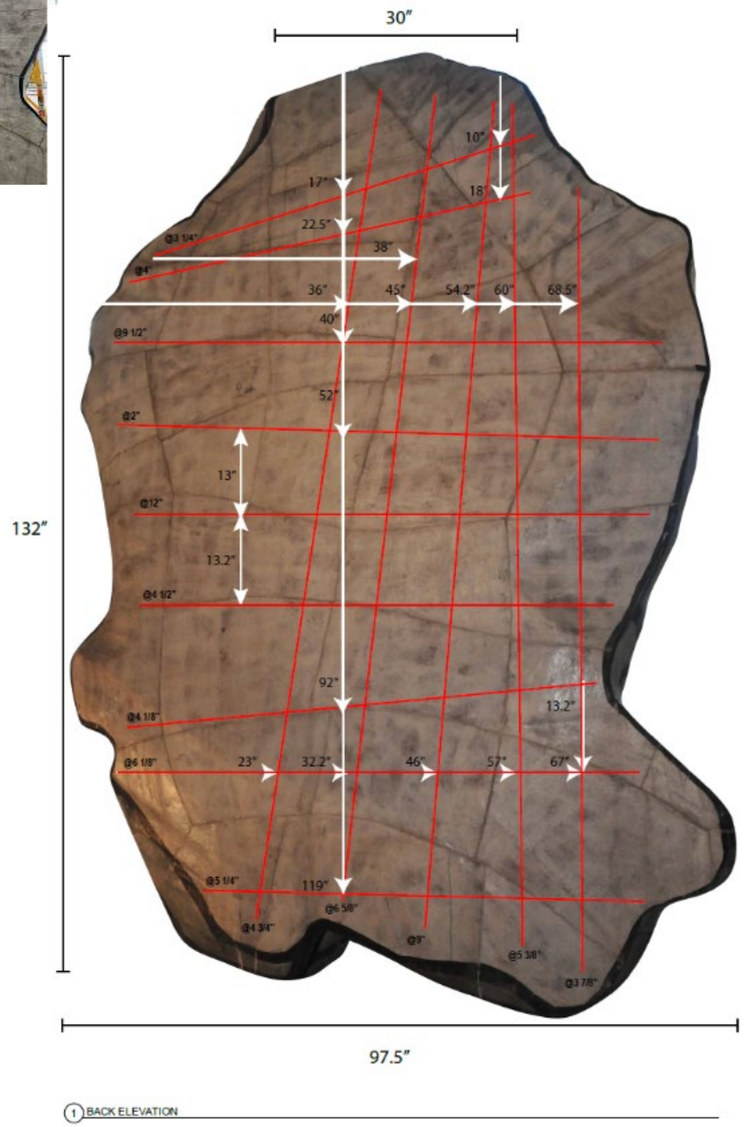
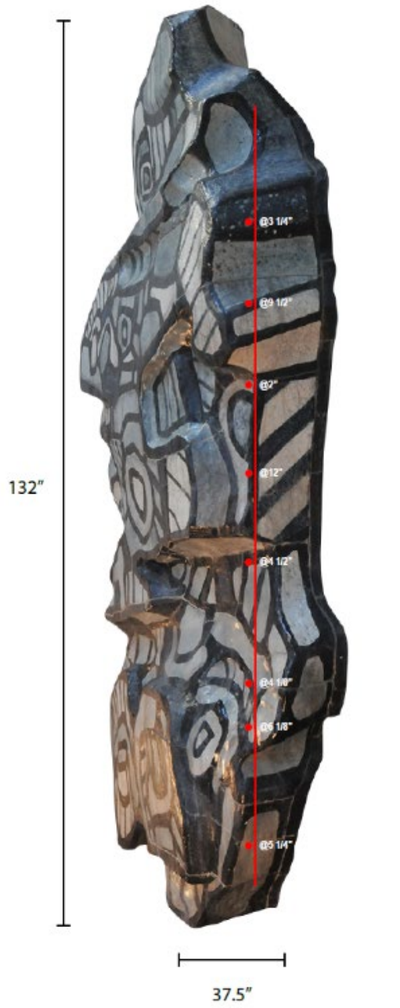


1 BACK ELEVATION



2 SIDE ELEVATION

DUE TO THE TEXTURE AND CONFIGURATION OF THE SCULPTURE, THE FRONT SIDE WAS NOT SCANNED.

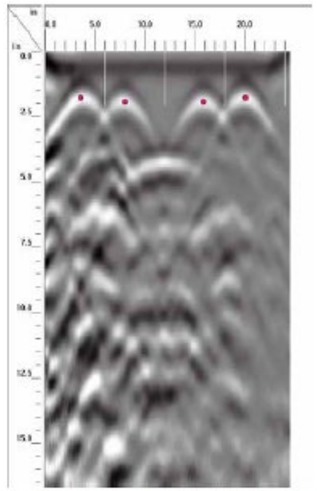


Figure 1 - Example of Rebar Data Collection

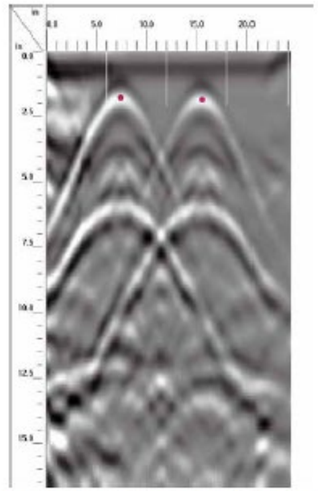


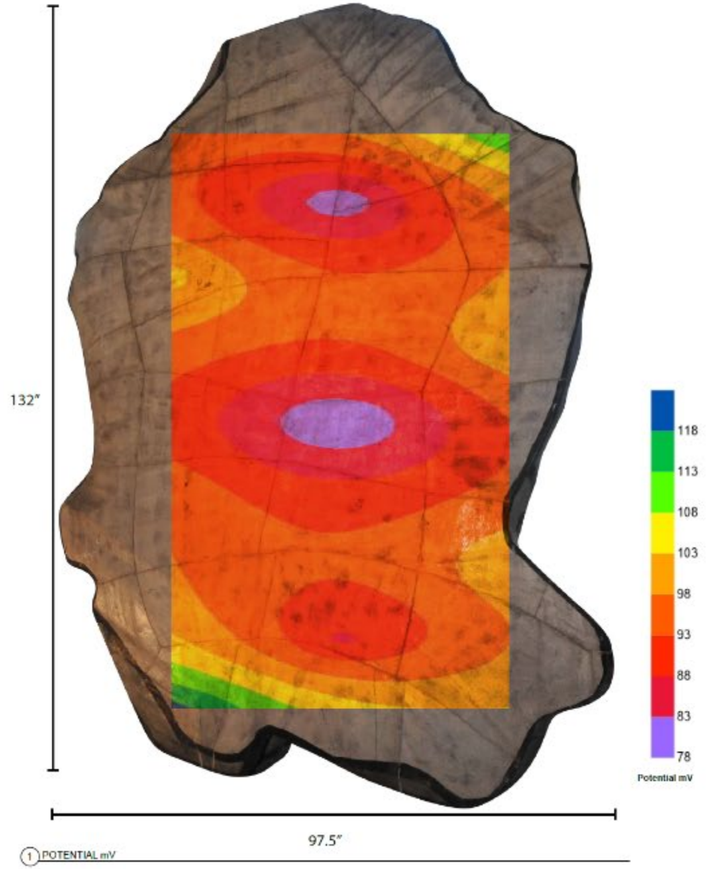
Figure 2 - Example of Rebar Data Collection

THE STEEL REINFORCEMENT WITHIN THE SCULPTURE IS CONTINUOUS AS ILLUSTRATED IN THE TABLE BELOW:

Location*	Ω [Mv]	Passed Y/N
Top Left hook -Top Right Hook	0.72 [0.15]	Yes
Top Left Hook – Base Beam	0.48 [0.10]	Yes

Table 1 Continuity Testing Results

**Drilling was limited to only few areas given the nature of the piece.*



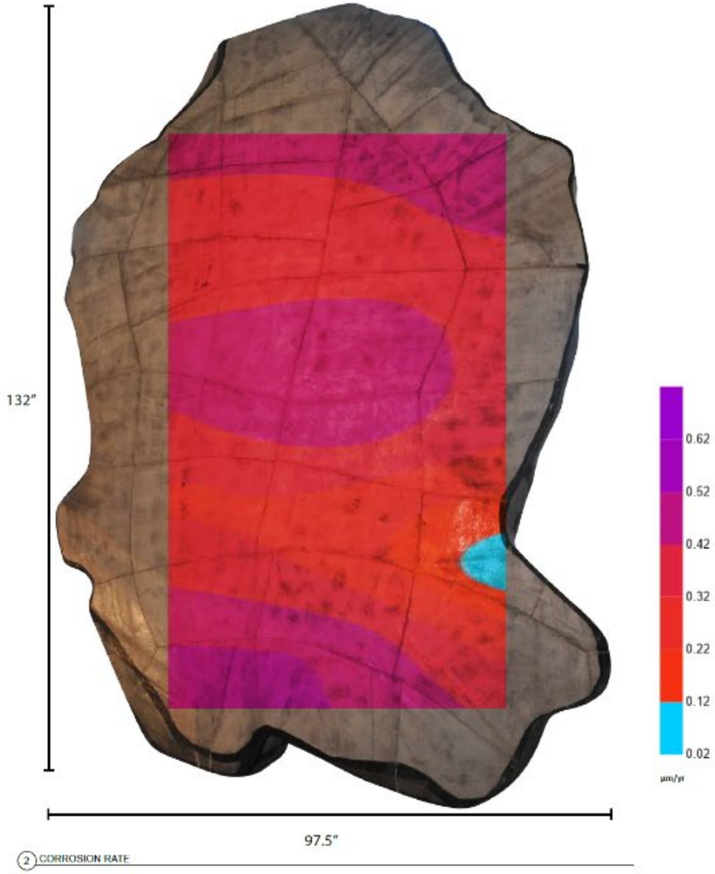
1 POTENTIAL mV

Ecorr [Potential mV] w.r.t to Ag/AgCL			
Average	Min	Max	St. Deviation
75.93	127	-76.9	46.59

Table 2 - Ecorr Statistical Analysis

Min	Max	No. of Readings	%
>	-134	27	100.00%
-134	-284	0	0.00%
<	-284	0	0.00%
		27	

Table 3 - Ecorr Statistical Analysis



2 CORROSION RATE

Icorr [Corrosion Rate µm/yr]			
Average	Min	Max	St. Deviation
0.42	0.03	0.8	0.17
<	-284	0	0.00%
		27	

Table 4 - ICorr Statistical Analysis

Min	Max	No. of Readings	%
<	0.1	1	3.70%
0.1	1.16	26	96.30%
1.16	3.34	0	0.00%
3.34	11.6	0	0.00%
>	11.6	0	0.00%
		27	100.00%

Table 5 - ICorr Statistical Analysis

l r oqapv l b as aoc oaaka] o e fqa_ qr o] i] oqp

“L’Erection Logologique Bleue Concrete”

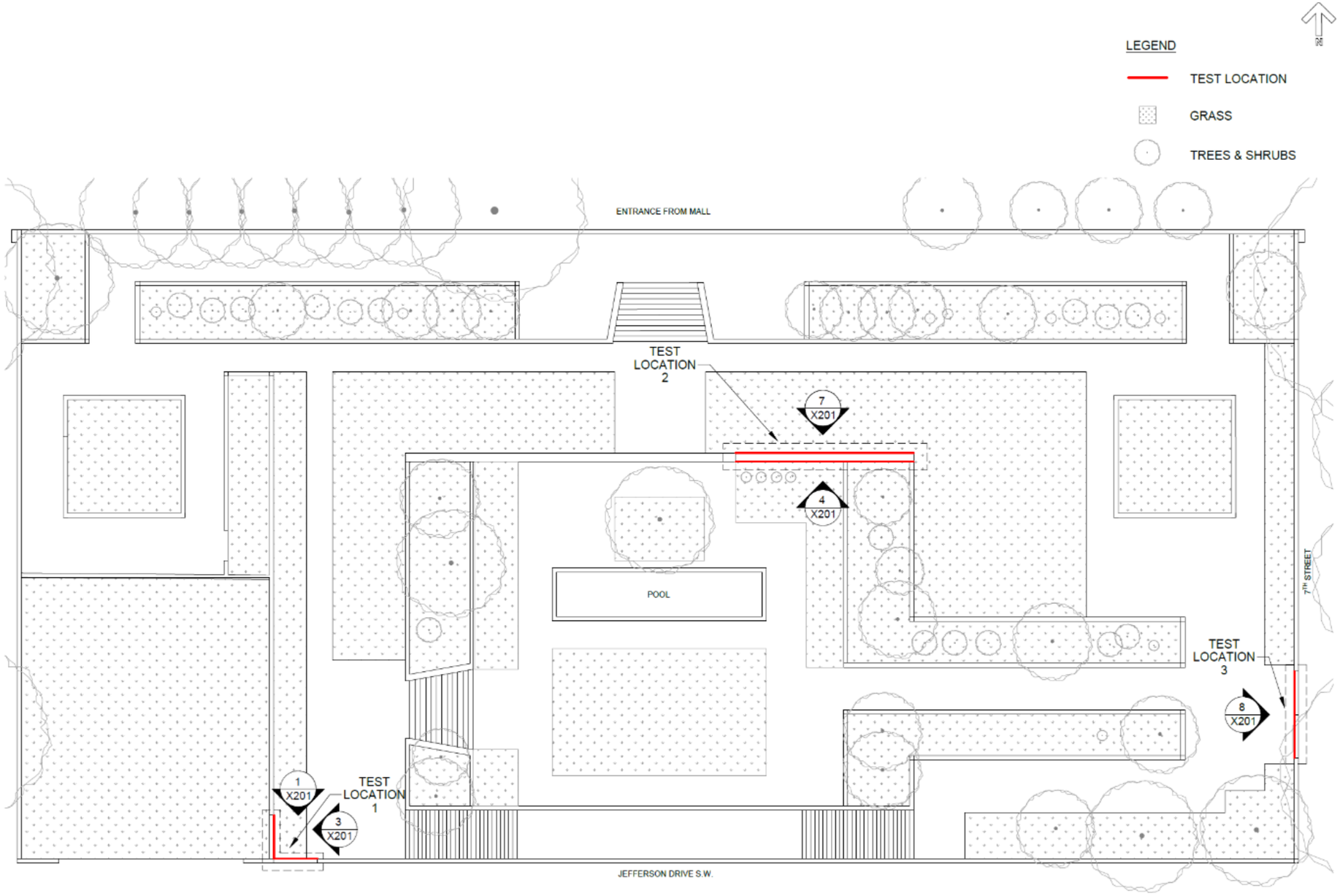
Results

- THE SCULPTURE IS IN GOOD CONDITION.
- ALL REINFORCEMENT APPEARS TO BE CONTINUOUS WITHIN ITSELF.
- DURING THE FIELD WORK, **NO REBAR** WAS EXPOSED DUE TO THE NATURE OF THE OBJECT.
- DRILLING WAS LIMITED TO METAL ELEMENTS ALREADY EXPOSED SUCH AS HOOKS AND THE FOOTINGS.
- FROM THE **STABLE** CORROSION TESTING RE, MORE THAN 90% OF THE POTENTIAL DATA COLLECTED SHOWS NO SIGN OF CORROSION ACTIVITY ACCORDING TO ASTM G876 STANDARD. THE HIGHEST CORROSION RATE DETECTED IS 0.80 µM/YR WITH AN AVERAGE OF 0.42 µM/YR WITHIN THE TWENTY-SEVEN [27] MEASUREMENTS RECORDED.
- THE CONCRETE WAS FOUND TO BE VERY DRY WHICH DIRECTLY INFLUENCED THE POTENTIAL READINGS. AS REPORTED BY THE ROCKEFELLER FOUNDATION STAFF MEMBERS, THE SCULPTURE HAS BEEN STORED IN A WAREHOUSE FOR SEVERAL YEARS WITH LIMITED TO NO EXPOSURE TO ATMOSPHERIC CONDITION.
- AS THE SCULPTURE WAS “LOST AND THEN FOUND” NYTIMES ARTICLE Lost and found: An 11-foot-tall Dubuffet | Rockefeller Brothers Fund IT WAS DETERMINED BY THE POTANTICO CENTER, PART OF THE ROCKERFELLERS ESTATE, TO INCLUDE THE SCUPLTURE IN THE GARDEN, AMONGST THEIR 93 OTHER OUTDOOR SCULPTURES.
- A TREATMENT AND RELOCATION PLAN WAS IMPLEMENTED BY EVERGREENE ARCHITECTURAL ARTS, NOW IN ITS CURRENT LOCATION, HIGH ON HILL AT KYKUIT, ROCKERFELLER’S ESTATE IN TARRYTOWN, NY.

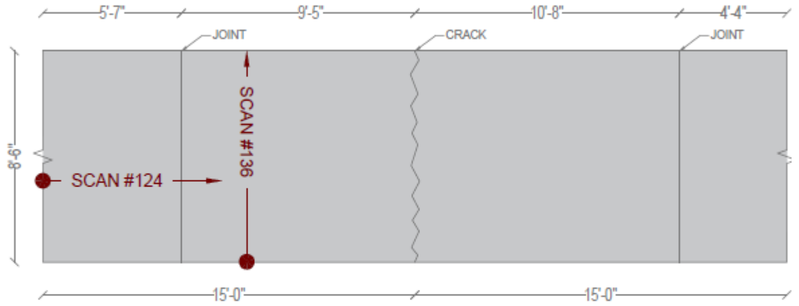
Hirshhorn Sculpture Garden

Washington, DC

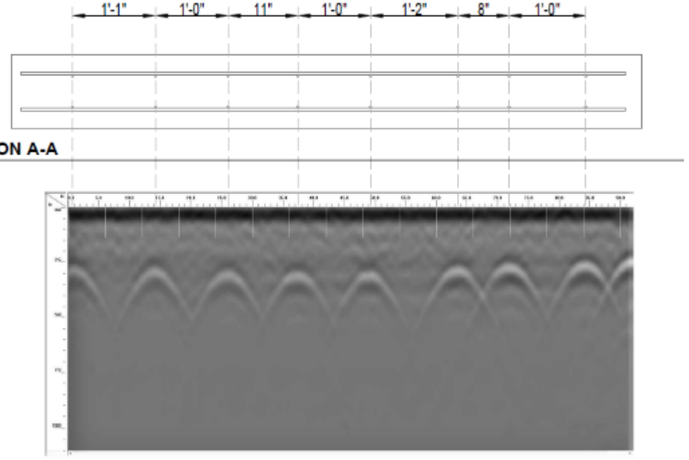
- 1974 Gordon Bundshaft designed as part of a cohesive space for the Hirshhorn Museum
- Placed on a 1.3 acre site, with an inner sunken core with a reflection pool
- Concrete wall panels and planters of varying height and thickness
- All wall panels act as retaining walls



1 **GARDEN SITE PLAN**
1/16" = 1'-0"

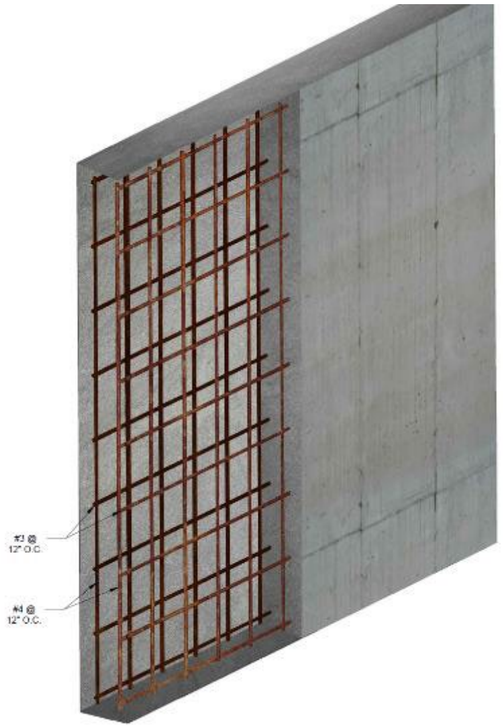


1 **WEST ELEVATION - SPR SCAN LOCATIONS**
NTS

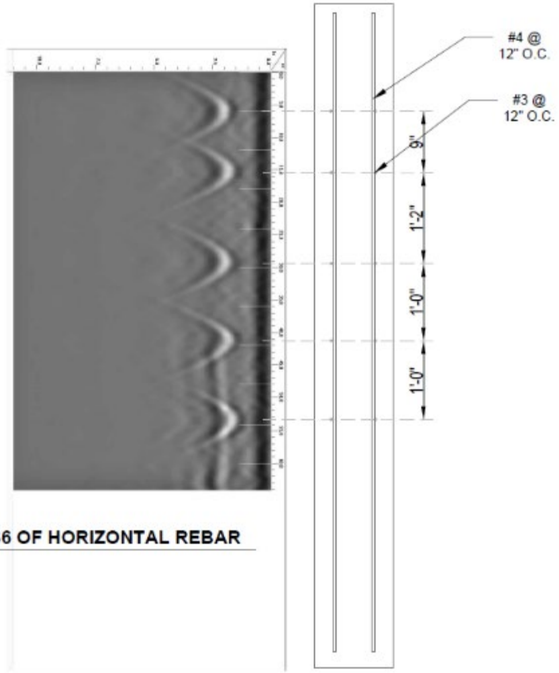


2 **SECTION A-A**
NTS

3 **SPR SCAN #29 OF VERTICAL REBAR**
NTS

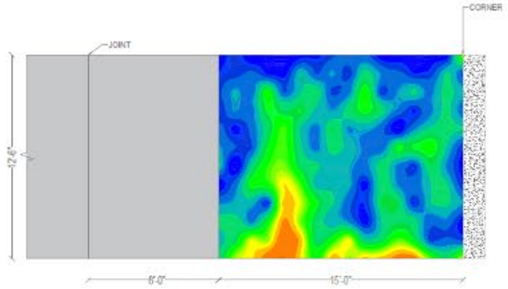


4 **ELEVATION ISOMETRIC VIEW (TYP.)**



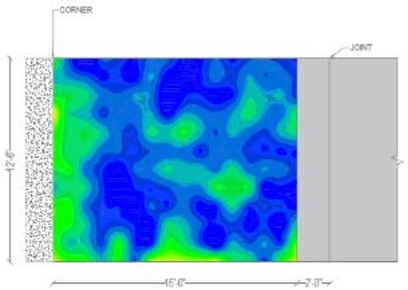
6 **SPR SCAN #36 OF HORIZONTAL REBAR**
NTS

7 **SECTION B-B**
NTS



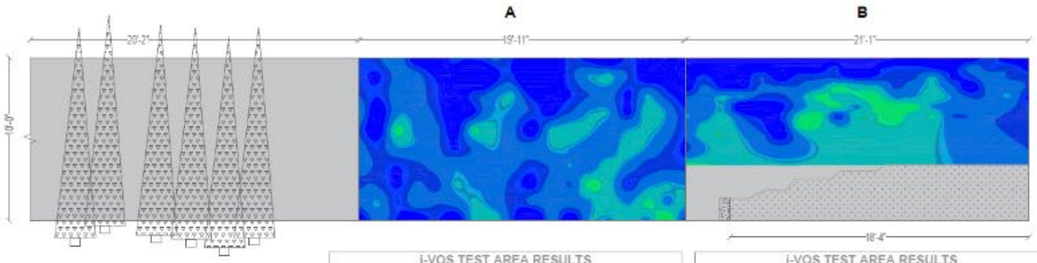
i-VOS TEST AREA RESULTS			
Potential (mV) w.r.t. Cu/CuSo4	Probability of Corrosion	No. of Readings (#)	(%)
> -200	90% Probability of No Corrosion	156	81.25
-200 to -350	Uncertain	31	16.15
< -350	90% Probability of Corrosion	5	2.60

1 NORTH ELEVATION - TEST LOCATION 1
1/4" = 1'-0"



i-VOS TEST AREA RESULTS			
Potential (mV) w.r.t. Cu/CuSo4	Probability of Corrosion	No. of Readings (#)	(%)
> -200	90% Probability of No Corrosion	171	89.06
-200 to -350	Uncertain	21	10.94
< -350	90% Probability of Corrosion	0	0.00

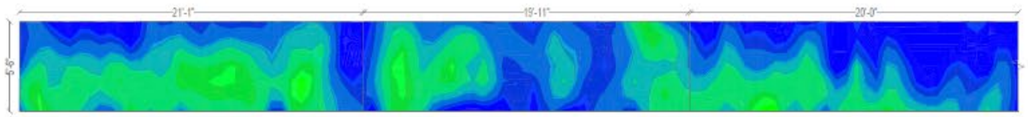
2 EAST ELEVATION - TEST LOCATION 1
1/4" = 1'-0"



i-VOS TEST AREA RESULTS			
Potential (mV) w.r.t. Cu/CuSo4	Probability of Corrosion	No. of Readings (#)	(%)
> -200	90% Probability of No Corrosion	180	100.00
-200 to -350	Uncertain	0	0.00
< -350	90% Probability of Corrosion	0	0.00

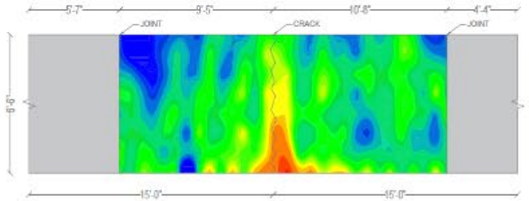
i-VOS TEST AREA RESULTS			
Potential (mV) w.r.t. Cu/CuSo4	Probability of Corrosion	No. of Readings (#)	(%)
> -200	90% Probability of No Corrosion	111	100.00
-200 to -350	Uncertain	0	0.00
< -350	90% Probability of Corrosion	0	0.00

3 SOUTH ELEVATION - TEST LOCATION 2
1/4" = 1'-0"



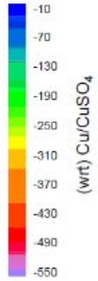
i-VOS TEST AREA RESULTS			
Potential (mV) w.r.t. Cu/CuSo4	Probability of Corrosion	No. of Readings (#)	(%)
> -200	90% Probability of No Corrosion	315	100.00
-200 to -350	Uncertain	0	0.00
< -350	90% Probability of Corrosion	0	0.00

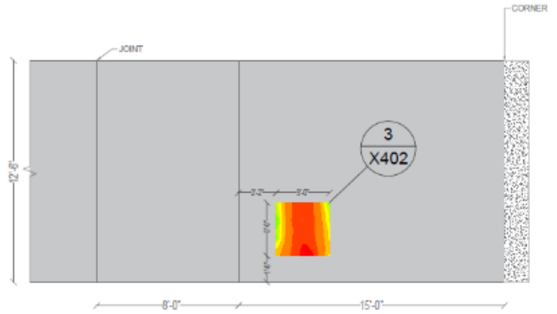
4 NORTH ELEVATION - TEST LOCATION 2
1/4" = 1'-0"



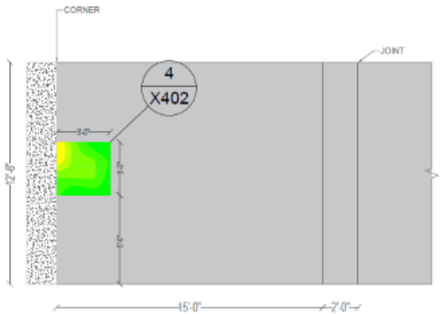
i-VOS TEST AREA RESULTS			
Potential (mV) w.r.t. Cu/CuSo4	Probability of Corrosion	No. of Readings (#)	(%)
> -200	90% Probability of No Corrosion	168	70.00
-200 to -350	Uncertain	65	27.08
< -350	90% Probability of Corrosion	7	2.92

5 WEST ELEVATION - TEST LOCATION 3
1/4" = 1'-0"

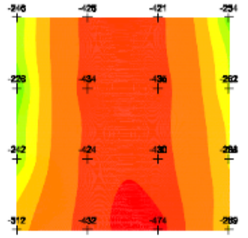




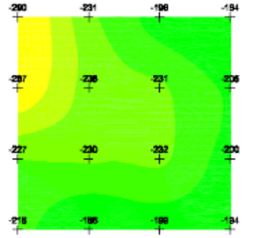
1 NORTH ELEVATION - CORROSION POTENTIALS (i-VOS)
1/4" = 1'-0"



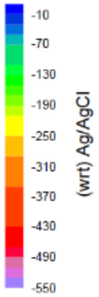
2 EAST ELEVATION - CORROSION POTENTIALS (i-VOS)
1/4" = 1'-0"

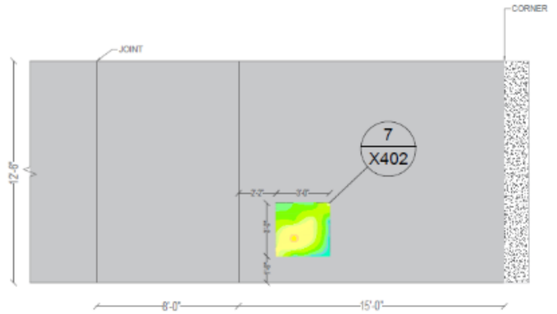


3 CONTOUR MAP
NTS

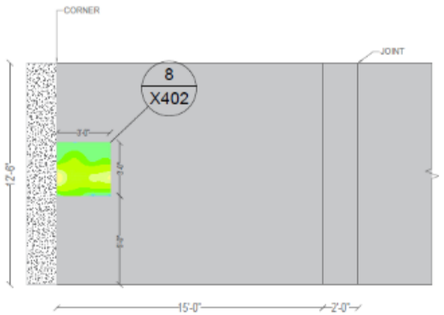


4 CONTOUR MAP
NTS

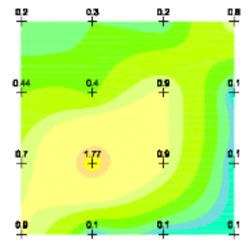




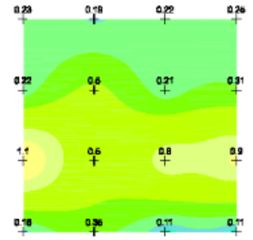
5 NORTH ELEVATION - CORROSION RATES (i-COS)
1/4" = 1'-0"



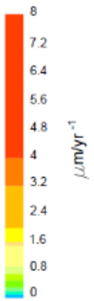
6 EAST ELEVATION - CORROSION RATES (i-COS)
1/4" = 1'-0"

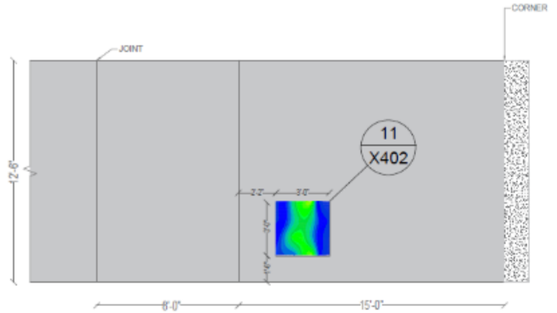


7 CONTOUR MAP
NTS

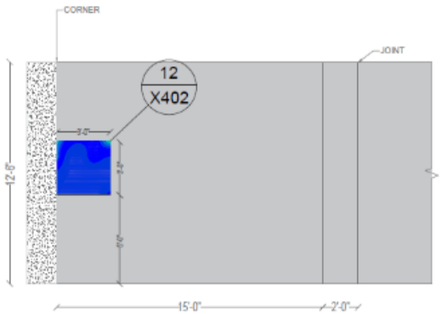


8 CONTOUR MAP
NTS

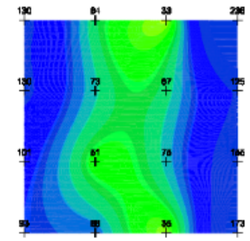




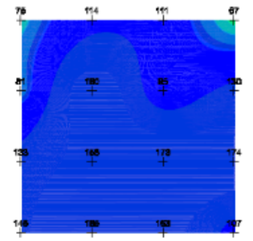
9 NORTH ELEVATION - RESISTIVITY (i-ROM)
1/4" = 1'-0"



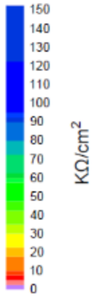
10 EAST ELEVATION - RESISTIVITY (i-ROM)
1/4" = 1'-0"

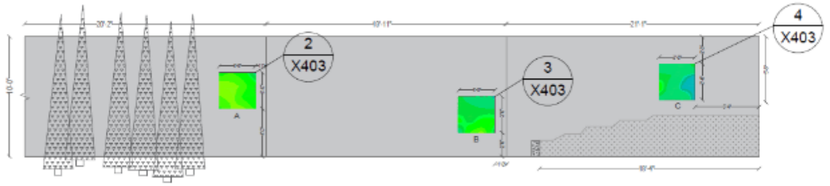


11 CONTOUR MAP
NTS



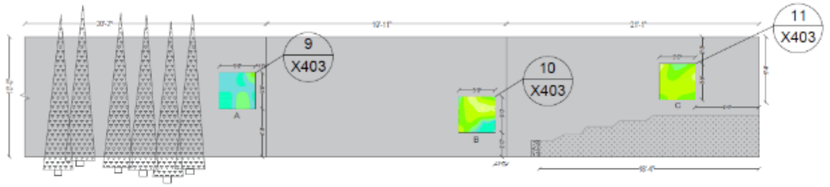
12 CONTOUR MAP
NTS





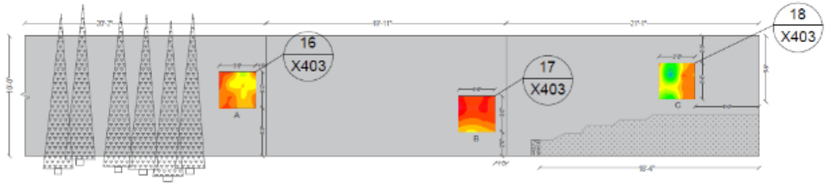
1 SOUTH ELEVATION - CORROSION POTENTIALS (i-VOS)
3/16" = 1'-0"

5 NORTH ELEVATION - CORROSION POTENTIALS (i-VOS)
3/16" = 1'-0"



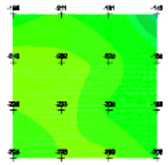
8 SOUTH ELEVATION - CORROSION RATES (i-COS)
3/16" = 1'-0"

12 NORTH ELEVATION - CORROSION RATES (i-COS)
3/16" = 1'-0"

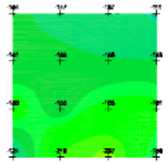


15 SOUTH ELEVATION - RESISTIVITY (i-ROM)
3/16" = 1'-0"

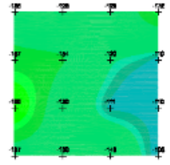
19 NORTH ELEVATION - RESISTIVITY (i-ROM)
3/16" = 1'-0"



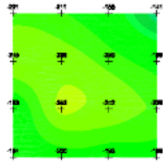
2 CONTOUR MAP
NTS



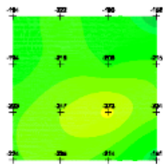
3 CONTOUR MAP
NTS



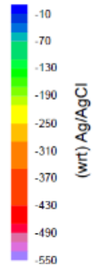
4 CONTOUR MAP
NTS

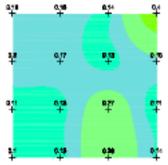


6 CONTOUR MAP
NTS

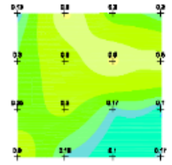


7 CONTOUR MAP
NTS

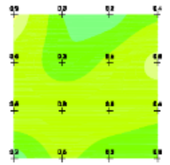




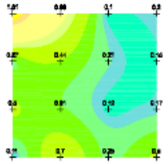
9 CONTOUR MAP
NTS



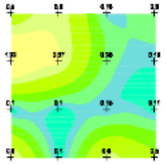
10 CONTOUR MAP
NTS



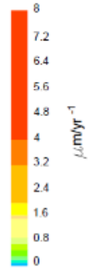
11 CONTOUR MAP
NTS

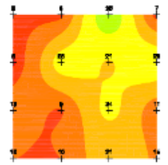


13 CONTOUR MAP
NTS

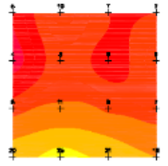


14 CONTOUR MAP
NTS

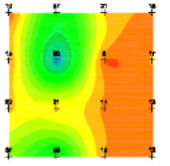




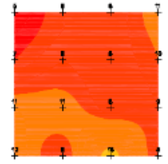
16 CONTOUR MAP
NTS



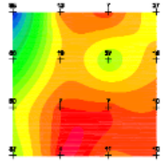
17 CONTOUR MAP
NTS



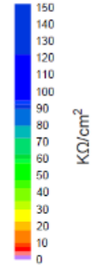
18 CONTOUR MAP
NTS



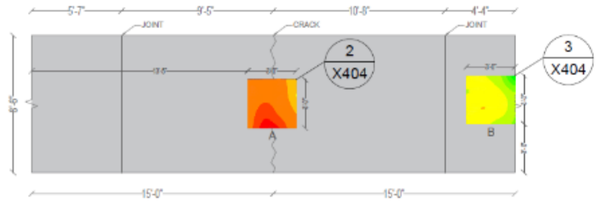
20 CONTOUR MAP
NTS



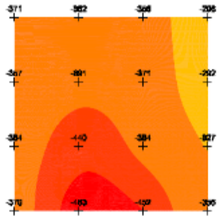
21 CONTOUR MAP
NTS



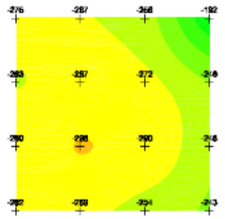
LPR TEST LOCATIONS



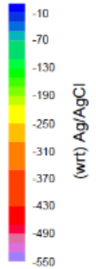
1 **WEST ELEVATION - CORROSION POTENTIALS (i-VOS)**
1/4" = 1'-0"

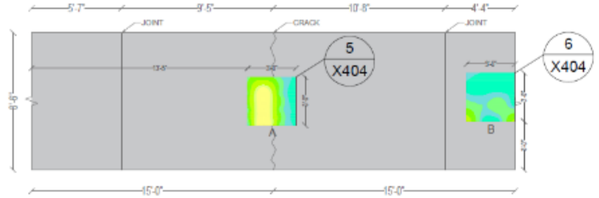


2 **CONTOUR MAP**
NTS

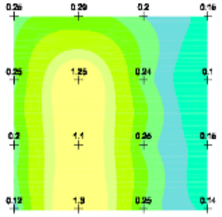


3 **CONTOUR MAP**
NTS

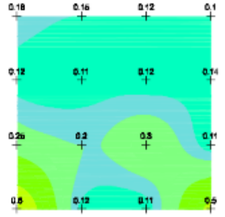




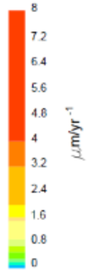
4 **WEST ELEVATION - CORROSION RATES (i-COS)**
1/4" = 1'-0"

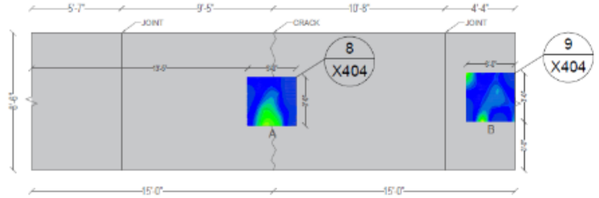


5 **CONTOUR MAP**
NTS

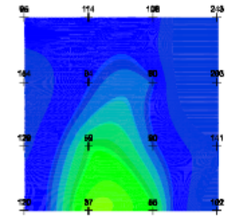


6 **CONTOUR MAP**
NTS

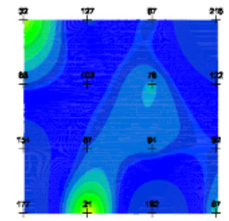




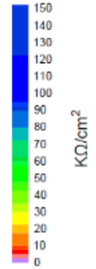
7 **WEST ELEVATION - RESISTIVITY (i-ROM)**
1/4" = 1'-0"



8 **CONTOUR MAP**
NTS



9 **CONTOUR MAP**
NTS



Hirschhorn Sculpture Garden Walls

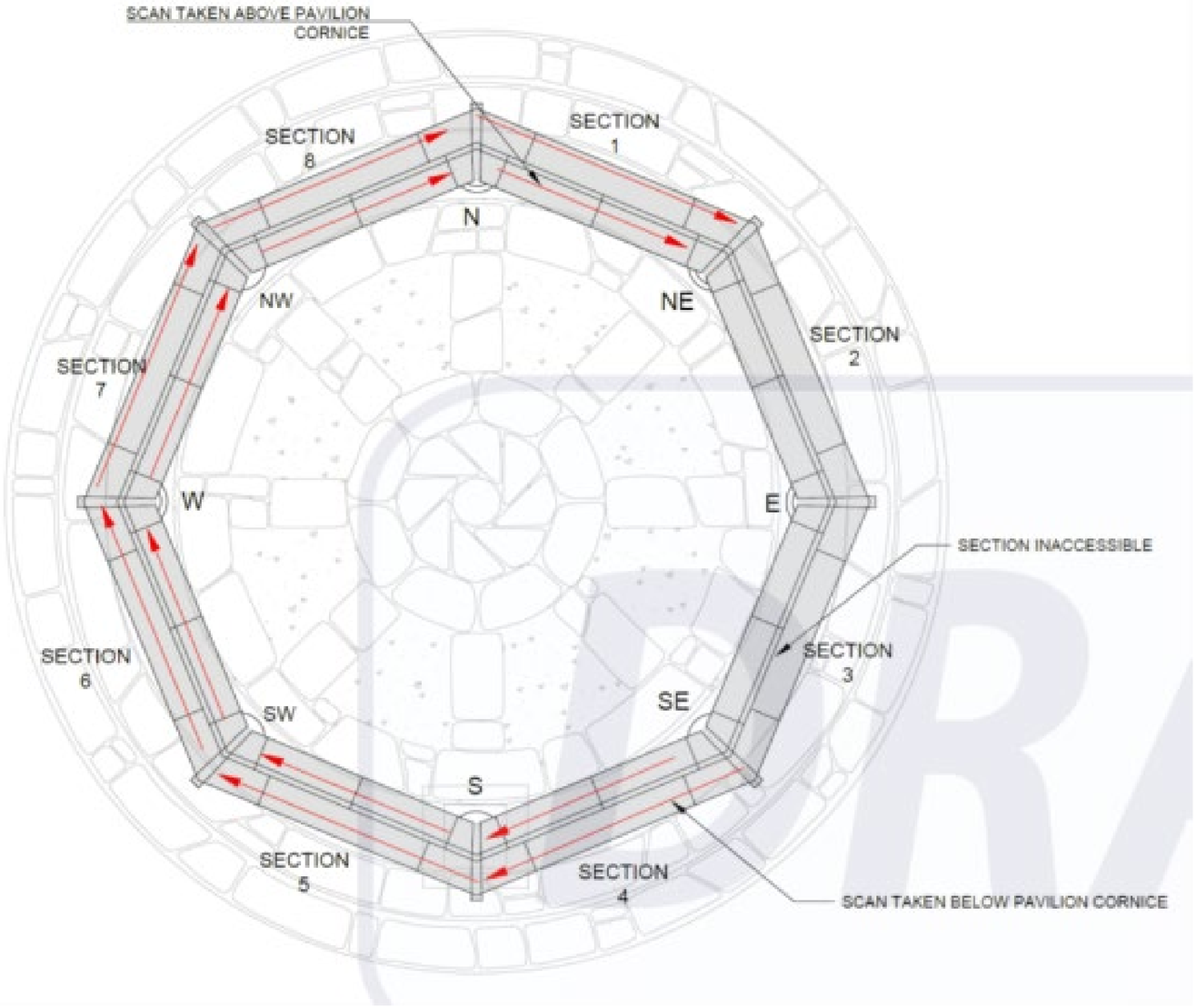
Results

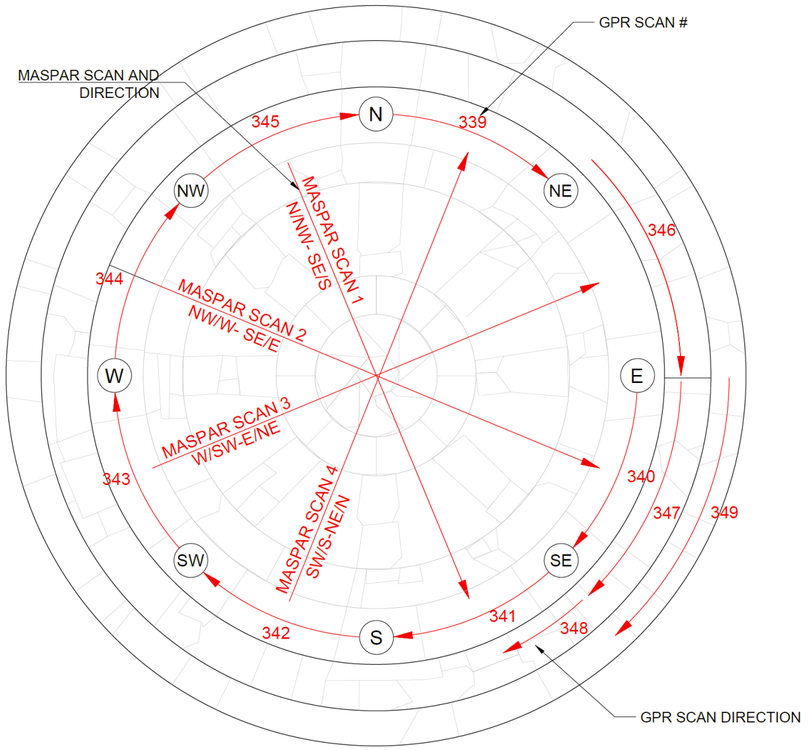
- ASR affected concrete
- High Moisture driving corrosion

Tibbetts Park Pavilion

Yonkers, NY

- 1920s Lakeside Pavilion and Bandstand
- One of the first developed parks in Westchester, NY with 161 acres
- Pavilion / gazebo was constructed for the park opening
- Site was largely abandoned and was in a very deteriorated state
- No existing drawings or construction information was available


SCAN TAKEN ABOVE PAVILION CORNICE
SECTION 1
SECTION 2
SECTION 3
SECTION 4
SECTION 5
SECTION 6
SECTION 7
SECTION 8
N
NE
E
SE
S
SW
W
NW
SECTION INACCESSIBLE
SCAN TAKEN BELOW PAVILION CORNICE


GPR SCAN #
MASPAR SCAN AND DIRECTION
N
NE
E
SE
S
SW
W
NW
345
339
346
344
340
347
349
343
341
342
348
MASPAR SCAN 1 N/NW- SE/S
MASPAR SCAN 2 NW/W- SE/E
MASPAR SCAN 3 W/SW-E/NE
MASPAR SCAN 4 SW/S-NE/N
GPR SCAN DIRECTION

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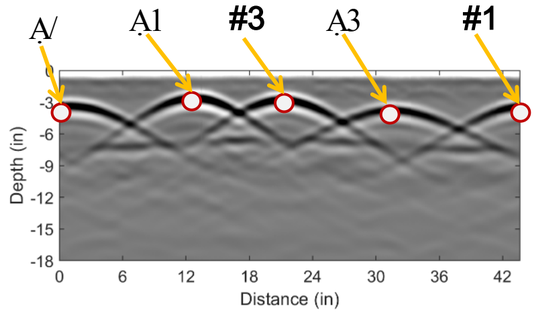
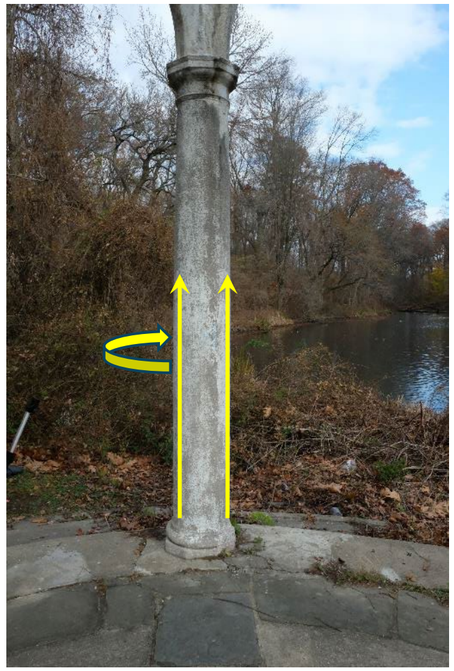
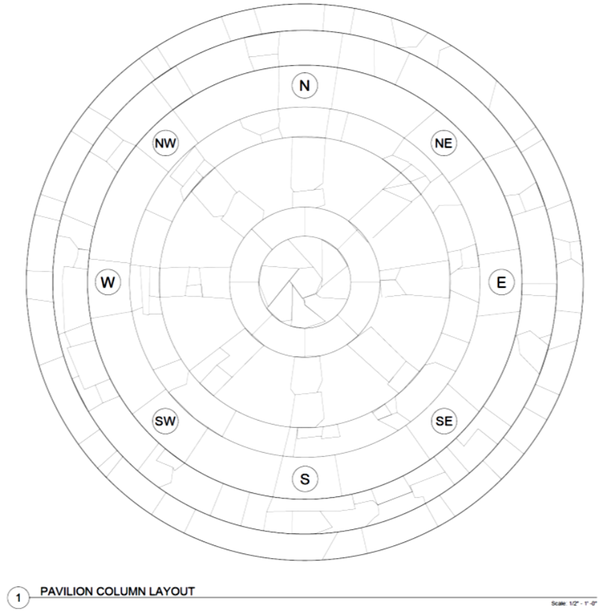
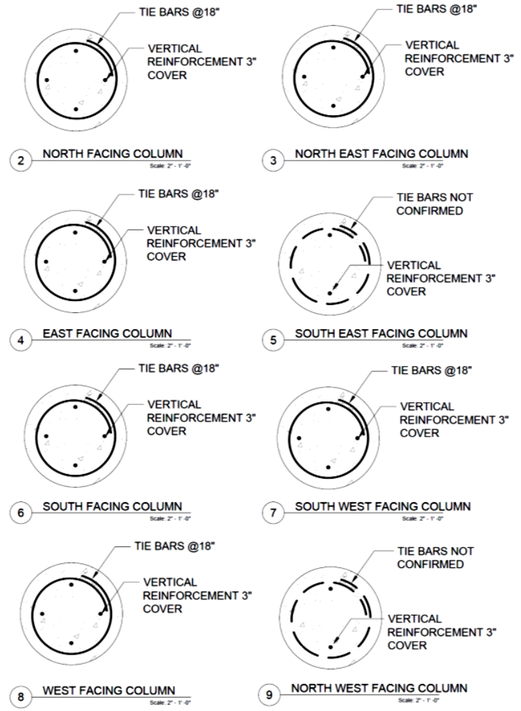




NORTH COLUMN



1 PAVILION COLUMN LAYOUT



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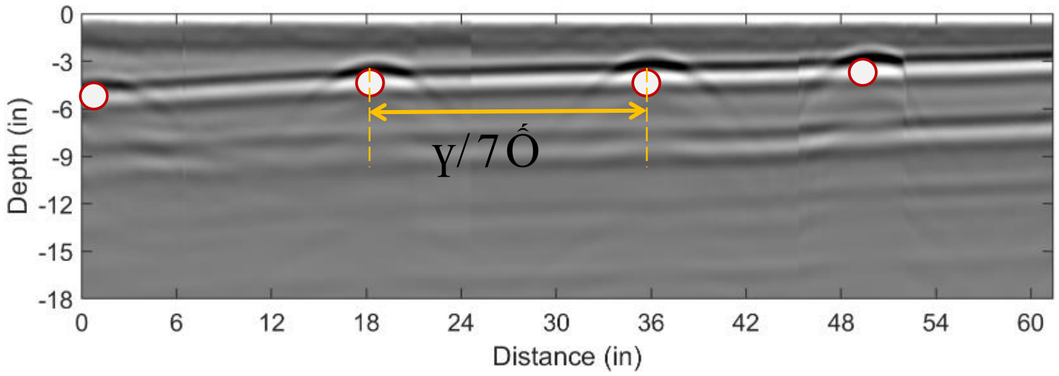

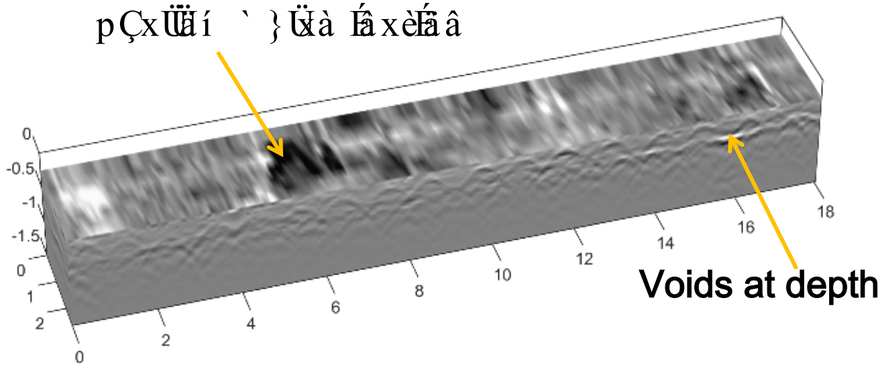
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-0.5
-1
-1.5
0
1
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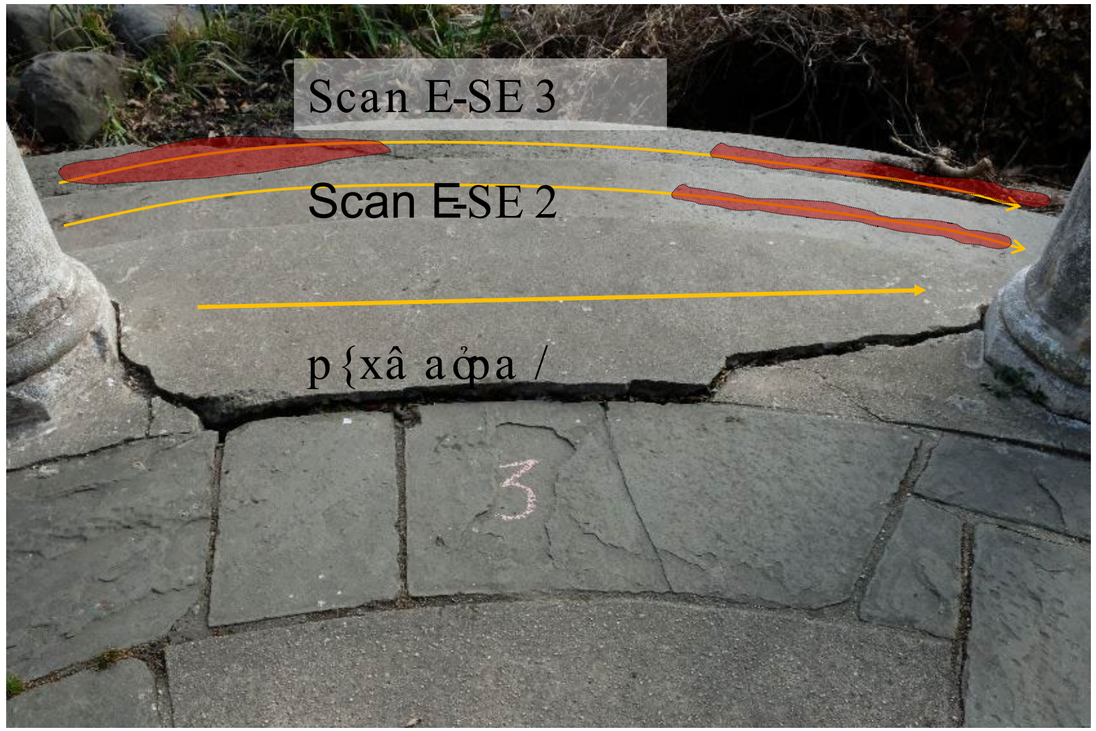
0
2
4
6
8
10
12
14
16
18
Voids at depth



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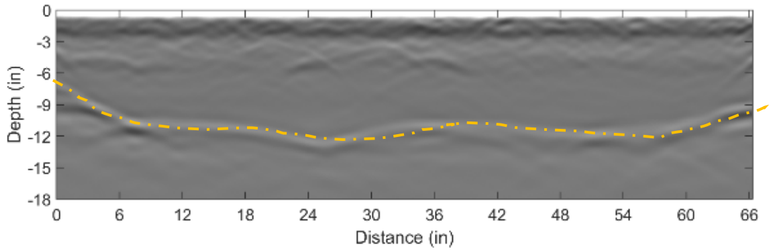

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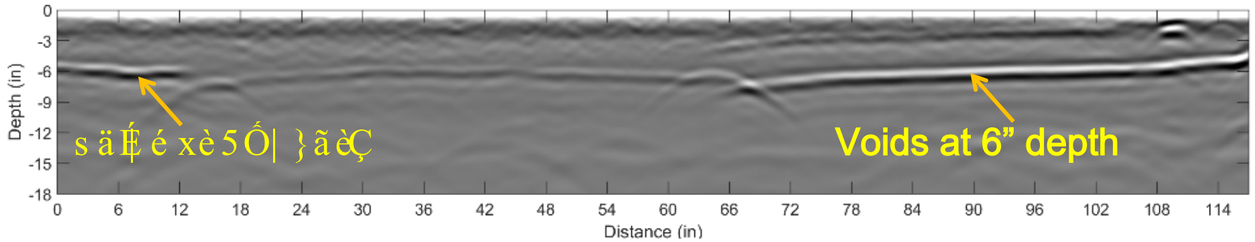

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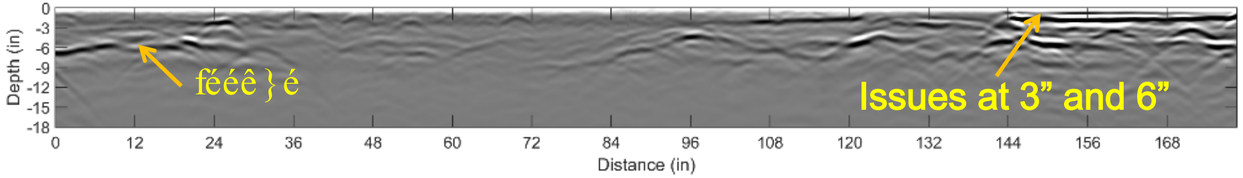
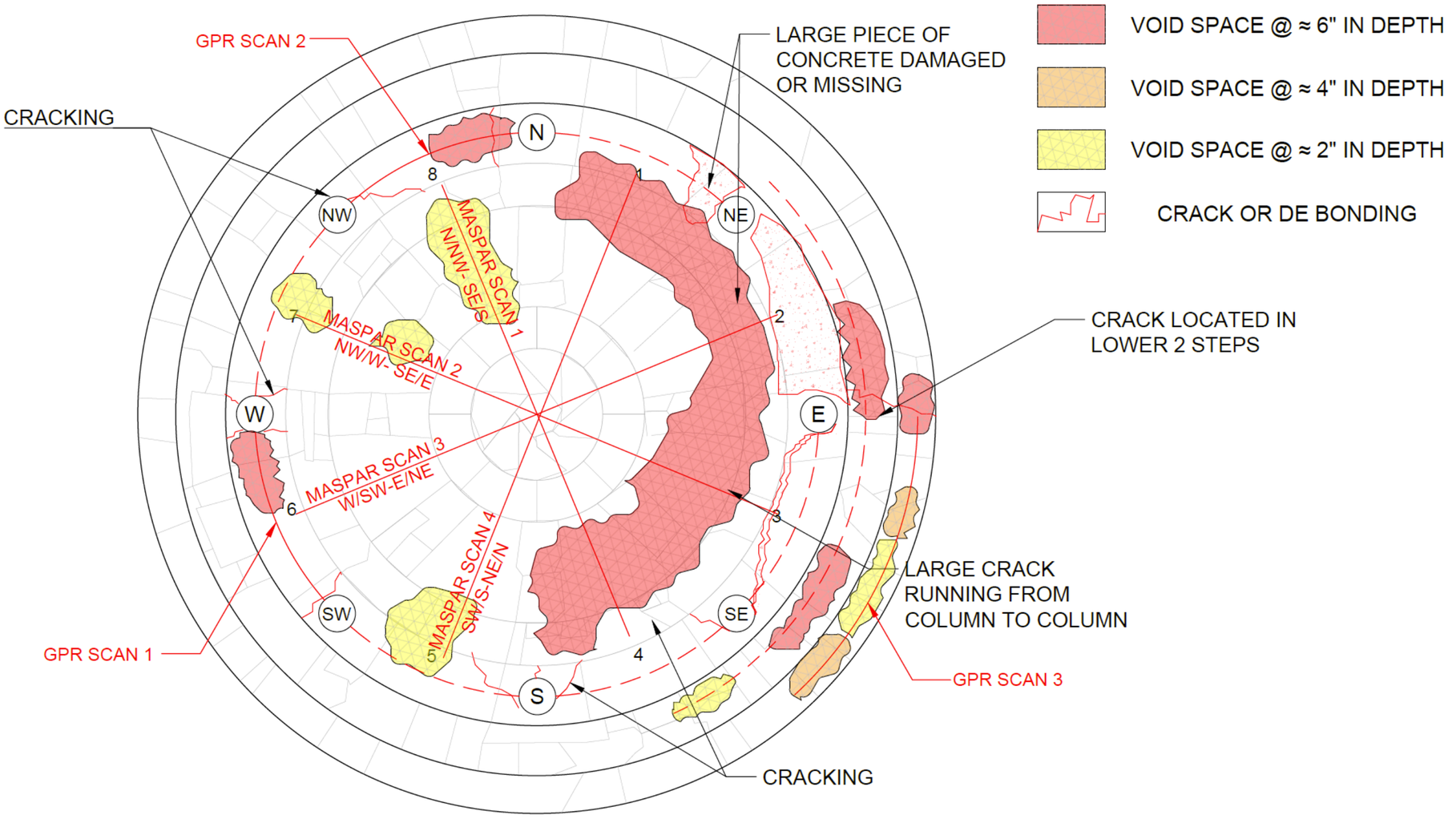
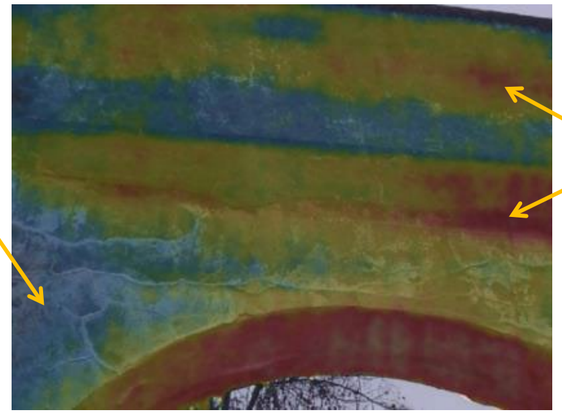
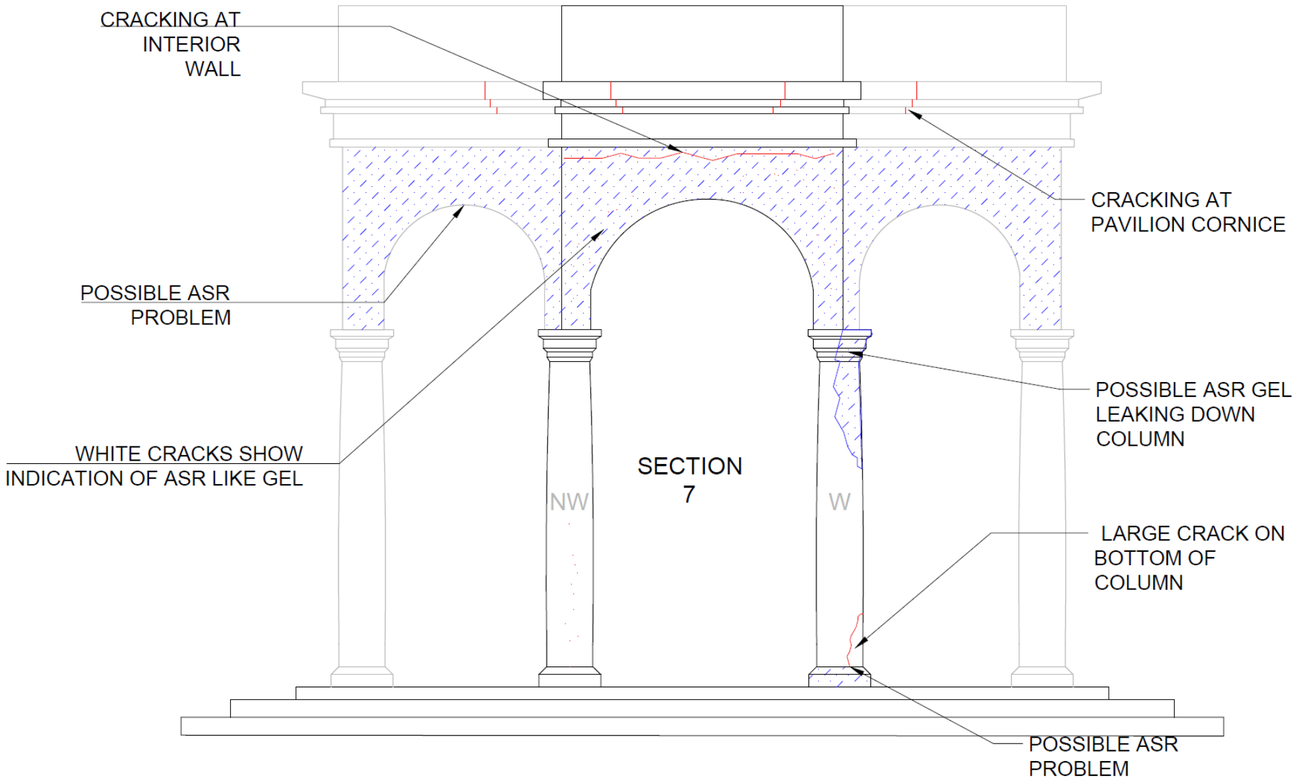


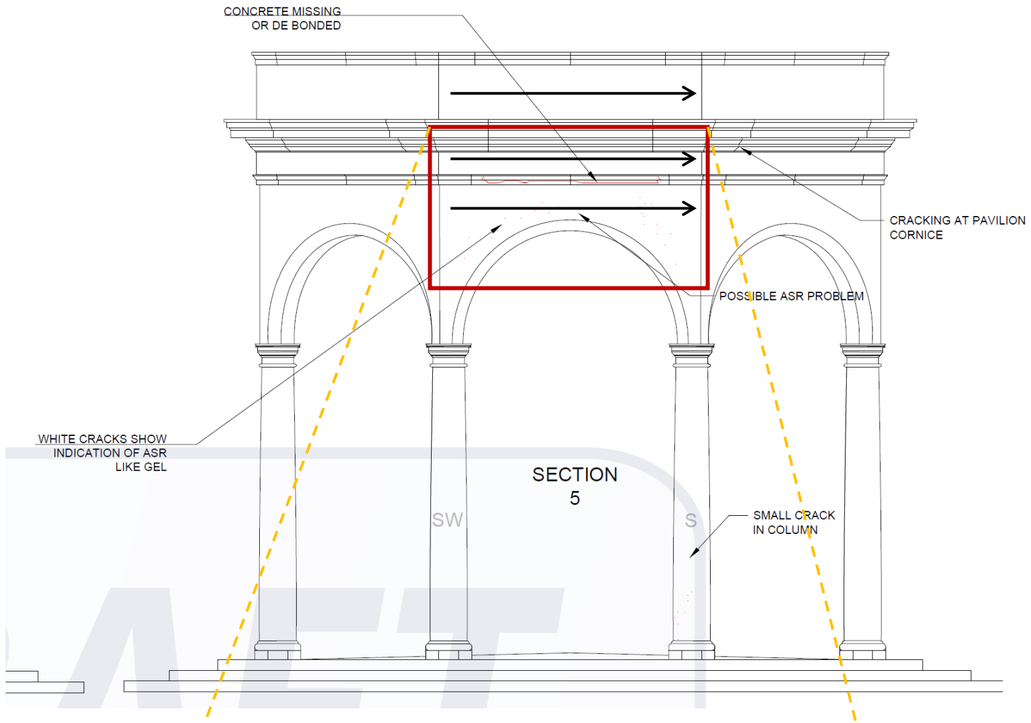

GPR SCAN 2
CRACKING
LARGE PIECE OF CONCRETE DAMAGED OR MISSING
VOID SPACE @ ≈ 6" IN DEPTH
VOID SPACE @ ≈ 4" IN DEPTH
VOID SPACE @ ≈ 2" IN DEPTH
CRACK OR DE BONDING
CRACK LOCATED IN LOWER 2 STEPS
LARGE CRACK RUNNING FROM COLUMN TO COLUMN
GPR SCAN 3
GPR SCAN 1
CRACKING
N
NE
E
SE
S
SW
W
NW
1
2
3
4
5
6
7
8
MASPAR SCAN 1 NNW-SE/S
MASPAR SCAN 2 NW/W-SE/E
MASPAR SCAN 3 W/SW-E/NE
MASPAR SCAN 4 SW/S-NE/N

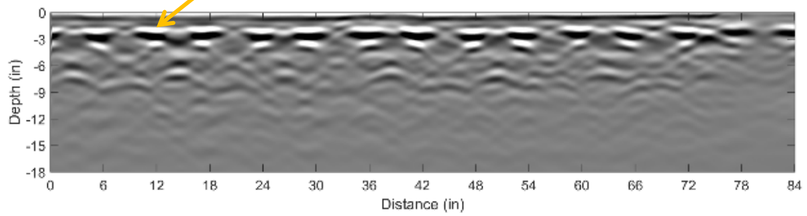


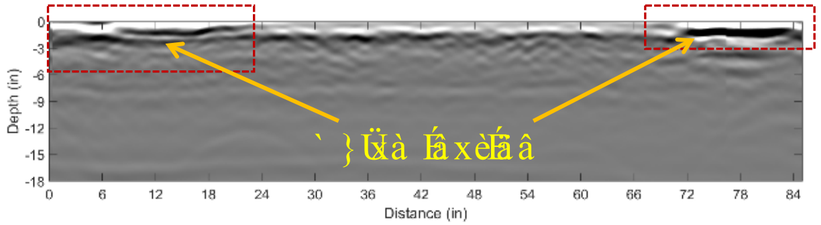
Likely ASR related issues

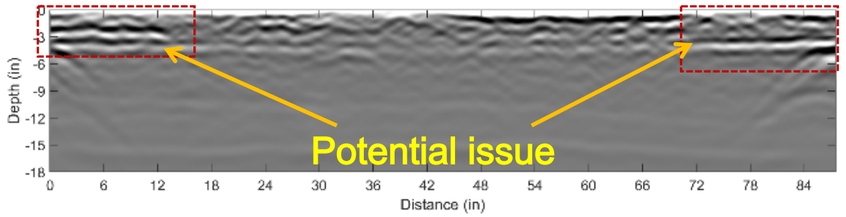
Delamination spalling issues




CONCRETE MISSING
OR DE BONDED
CRACKING AT PAVILION
CORNICE
POSSIBLE ASR PROBLEM
WHITE CRACKS SHOW
INDICATION OF ASR
LIKE GEL
SECTION
5
SW
S
SMALL CRACK
IN COLUMN


Depth (in)
Distance (in)


Depth (in)
Distance (in)


Depth (in)
Potential issue
Distance (in)

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- **Comprise of historic Portland cement and translucent white dolomitic marble with ratio of 1:3.25**
- **NO evidence of ASR**
- **Cracking occurred most likely due to freeze and thawing cycles.**

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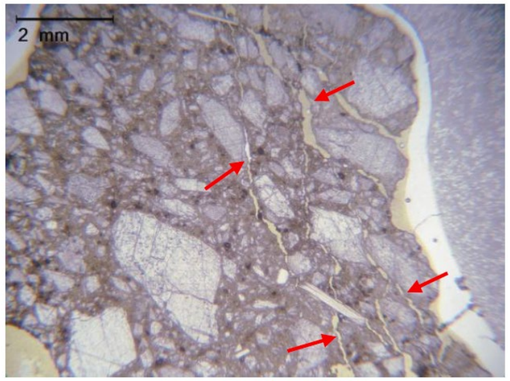
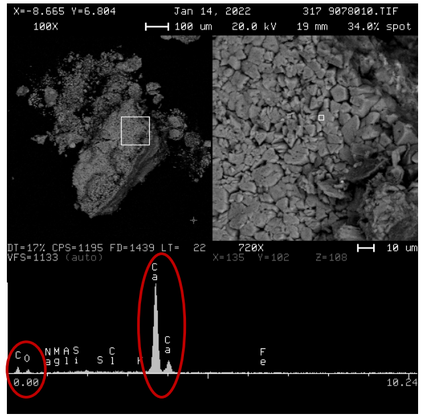


Plane Polarized Light



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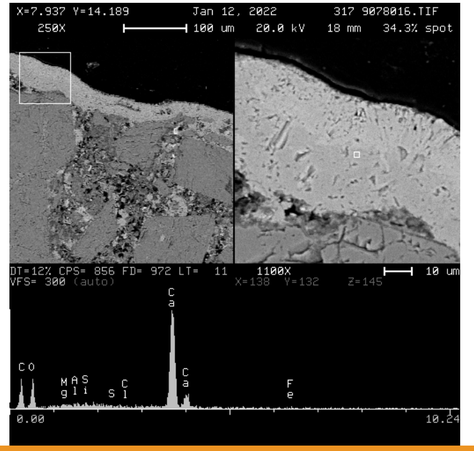

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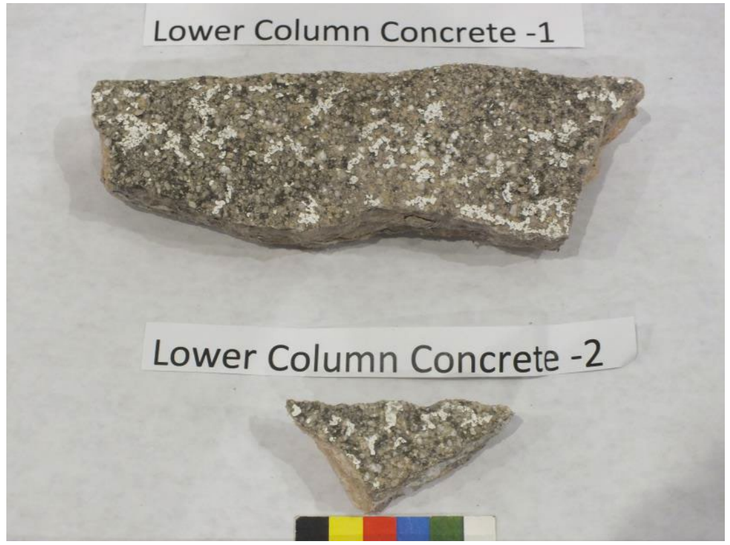

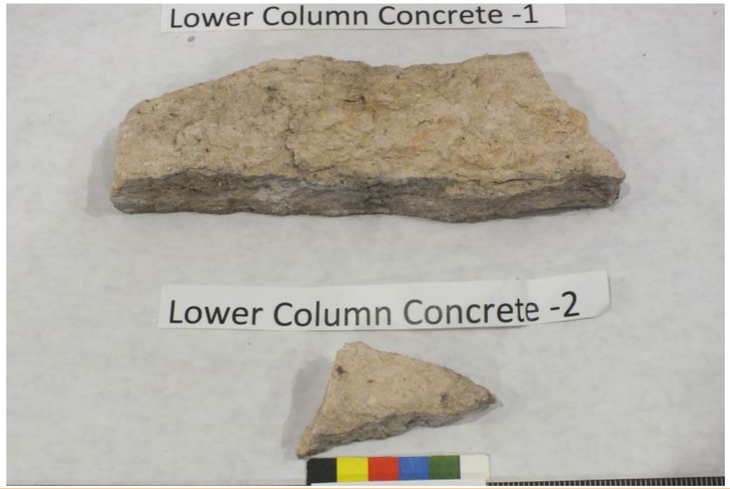

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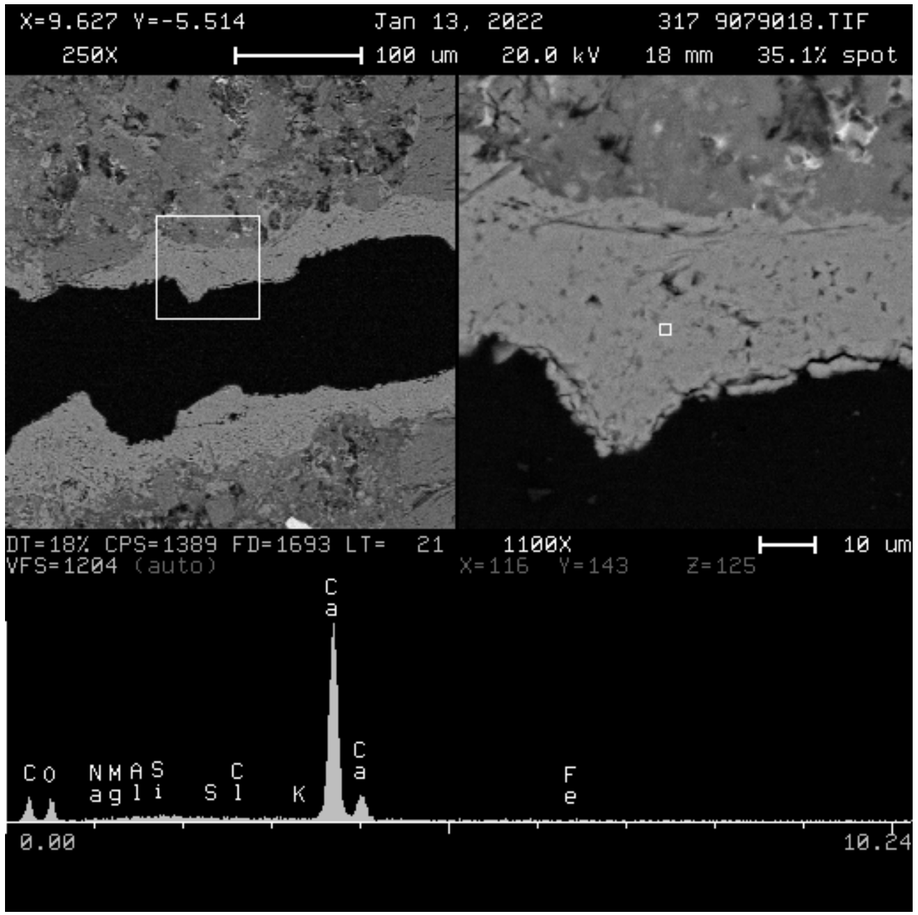

TIBBETTS PARK PAVLION

Results

- Freeze Thaw affected concrete
- High Moisture
- Significant Delaminations

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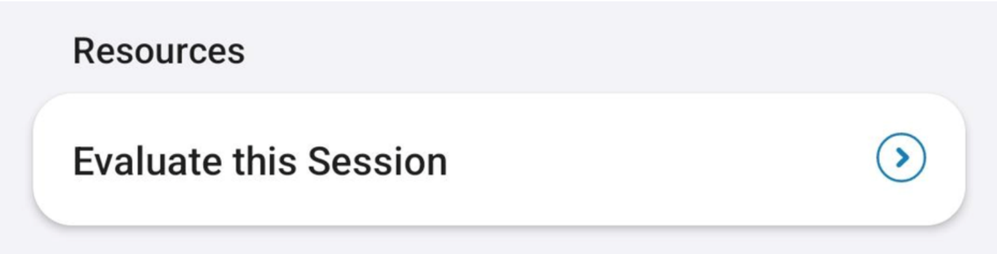

To complete the session evaluation, open the ICRI Convention App.

Under **Plan Your Event,** select Schedule, and then the Technical Session you are attending. Select the sub-session you are attending, scroll down to Resources, and select Evaluate this Session.

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