THERMAL INTEGRITY PROFILING FOR AUGERED CAST-IN-PLACE PILES - *IMPLEMENTATION PLAN*

BDV25 977-34

GRIP 2017

Presented by Kevin Johnson, PhD

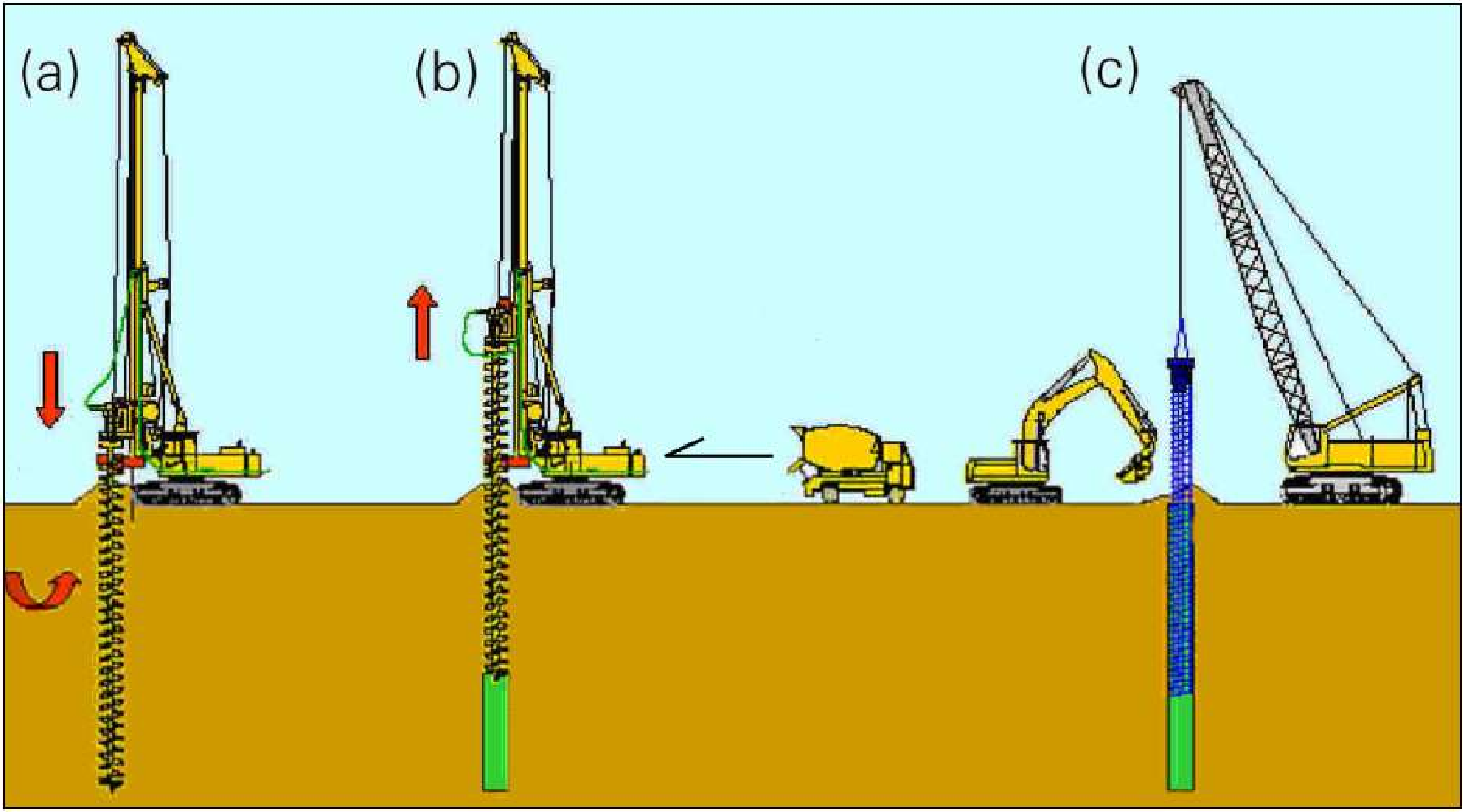
USF UNIVERSITY OF SOUTH FLORIDA

Civil & Environmental Engineering

Overview

- Background ACIP Piles
- Problem Statement
- Research Approach
- Field Work
- Analysis
- Conclusions
- Open Discussion

ACIP Piles
Construction



Source: Dan Brown et al., FHWA-HIF-07-03

ACIP Piles
Construction

ACIP Piles
Quality Control

Problem Statement

- Thermal Integrity Profiling (TIP) has proven to be an effective method for evaluating the as-built integrity of drilled shafts.
- However, TIP is rarely used for evaluating auger-cast-in-place (ACIP) piles, as current practices do not require installation of standard integrity access tubes.
- Current integrity methods for ACIP piles is limited, thus their FDOT use has been limited to foundations for sound walls.
- GOAL: **Translate the use of thermal integrity technology to an effective method for evaluating ACIP piles**.

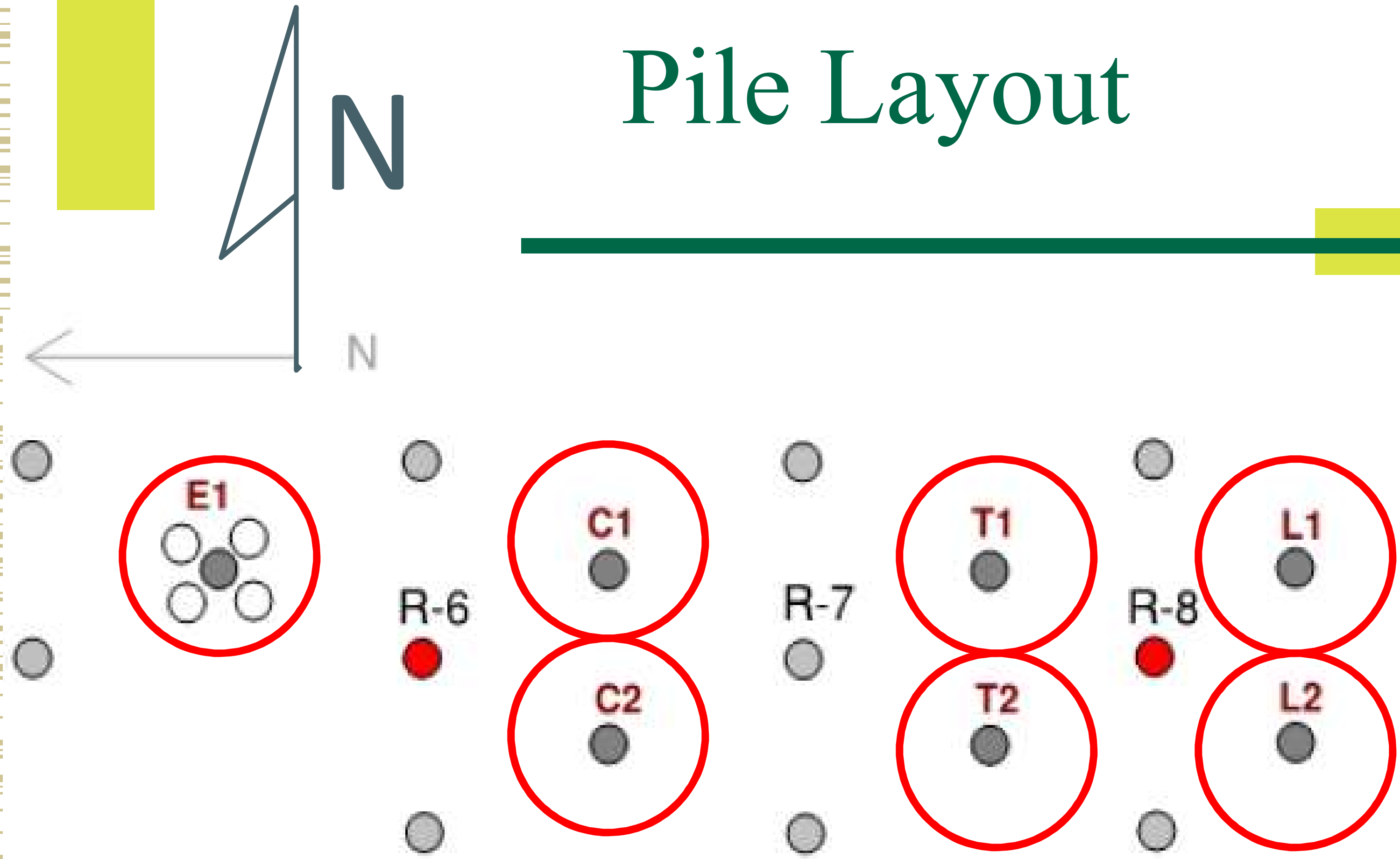
Research Approach

- Phase I Basis for Present Project
  - Literature Review
  - Numerical Modeling
  - Field Testing and Analysis
- **Phase II Implementation**
  - **On-site instrumentation and data collection**
  - **Analysis of data**
  - **Reporting / Conclusions / Recommendations**

Site Details

- DFI Demonstration Study
- 18 ACIP Piles; 7 with TIP instrumentation
  - Tied Thermal Wires
  - Access Tubes (probe)
- Location: Okahumpka, FL (Berkel's Yard)
- Sizes: 18 and 24 inch diameter
- Lengths: 40 – 60ft
- Reinforcement: Single bar, cage or both

Pile Layout



Original Proposed Pile Layout

LEGEND
C1 / C2 : 18-in / 24-in compression pile
T1 / T2 : 18-in / 24-in tension pile
L1 / L2 : 18-in / 24-in lateral pile
E1 : 18-in Extraction pile
○ : 18-in relief holes

DFI internal communique 2016

Pile Details

Pile	Diameter (in)	Length (ft)	Cage Length (ft)	Full Length Center Bar	Access Tubes	TIP Wires		TIP Probe
						Partial Length	Full Length	
E1	18	40	40	3" threaded	--	4	1	No
T1	18	60	--	3" threaded	--	--	1	No
C1	18	60	35	#11	--	4	1	No
L1	18	40	35	#11	--	4	1	No
T2	24	60	--	3" threaded	--	--	1	No
C2	24	60	35	#11	4 (Steel)	4	1	Partial Length
L2	24	40	35	#11	4 (PVC)	4	1	Partial Length

Tube and Wire Combined
C-2 24in (left) L-2 24in (right)

Wire Only Instrumentation

C-1 18in (left) L-1 18in (right)

Wire Only Instrumentation
E-1 18in cage (left) 3in center bar (rt.)

Center Bar Instrumentation

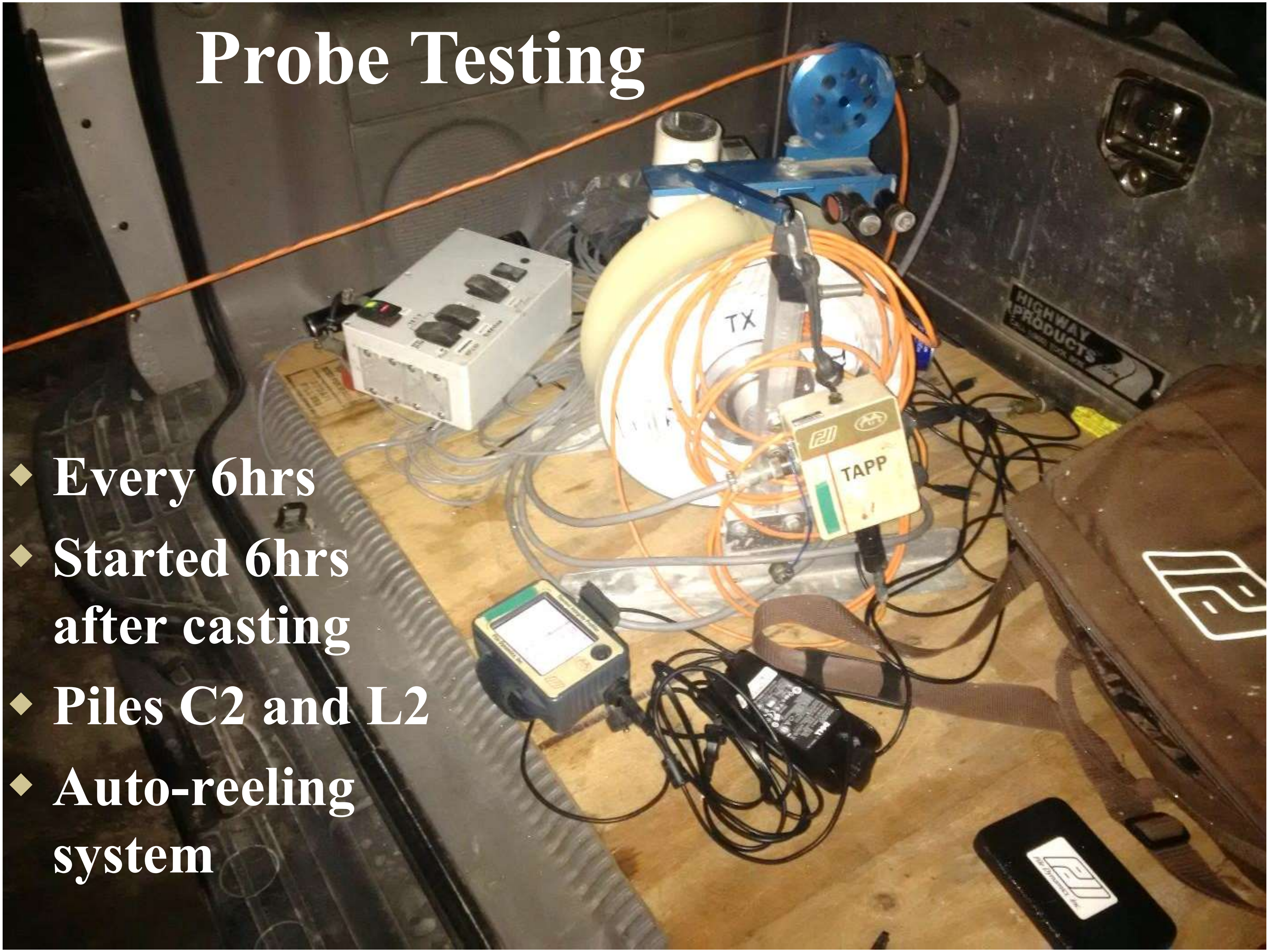
#11bars (left) 3in threaded bars (rt.)

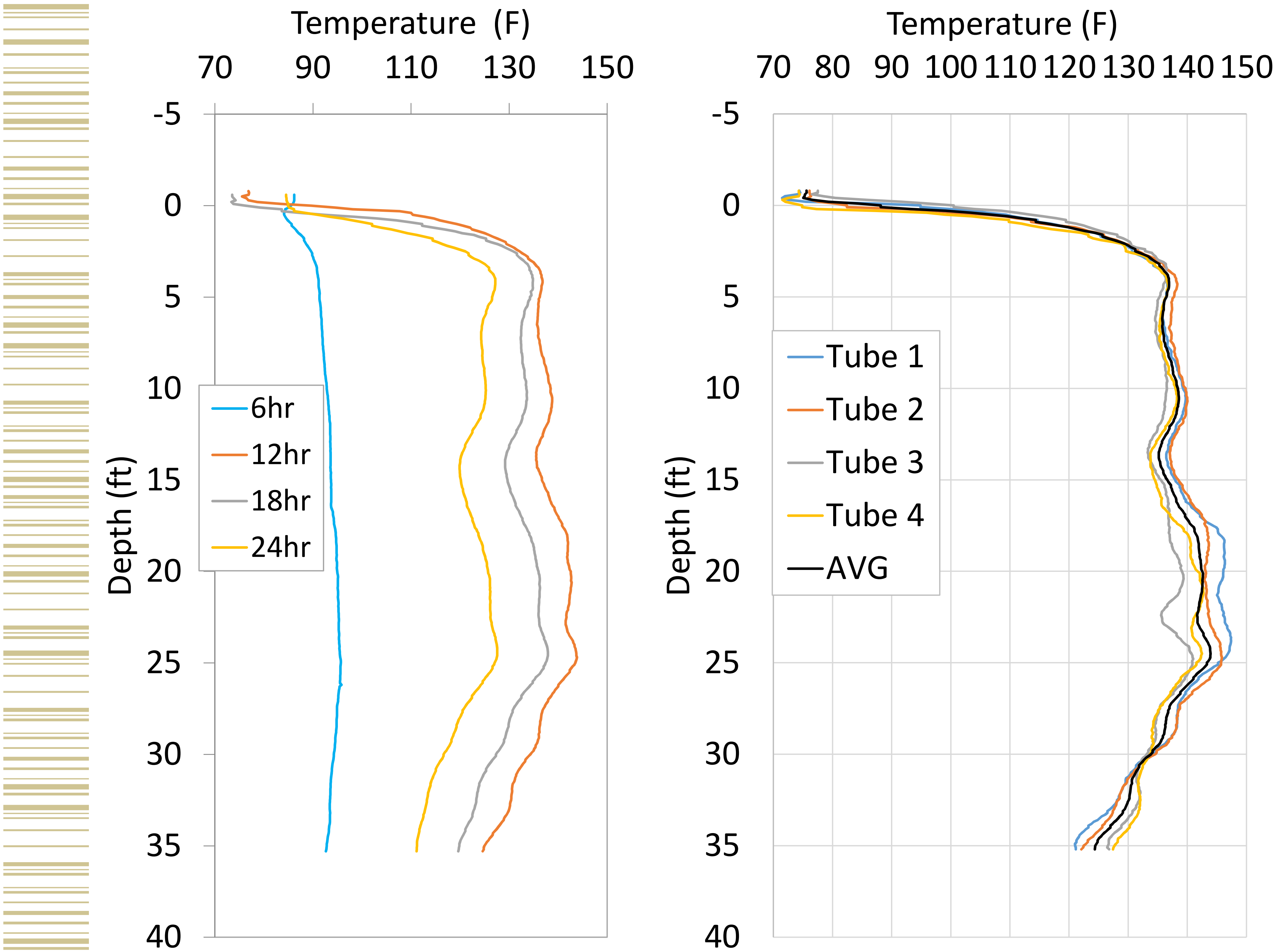

BERKEL

BERKEL

Probe Testing

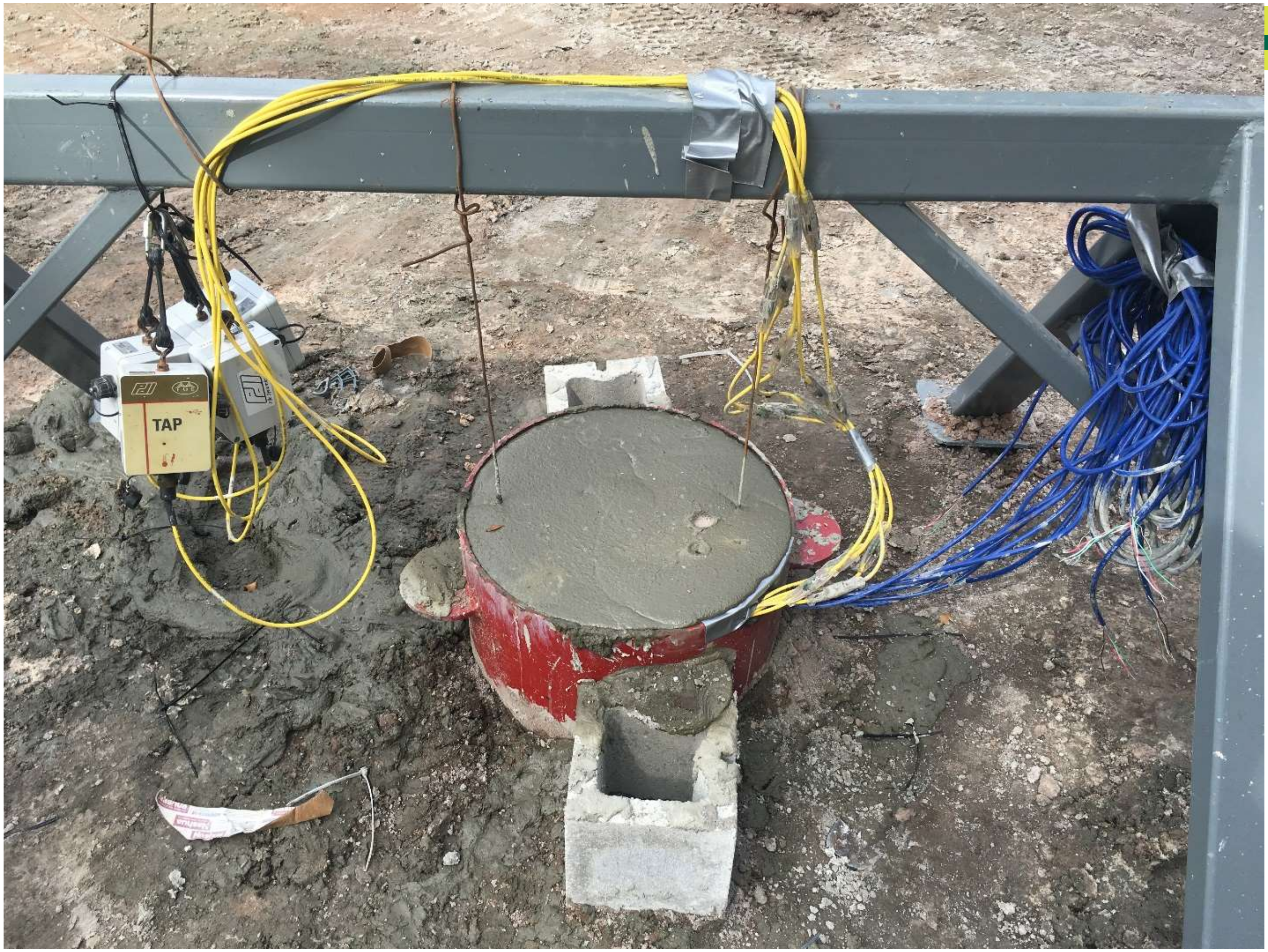
- Every 6hrs
- Started 6hrs after casting
- Piles C2 and L2
- Auto-reeling system





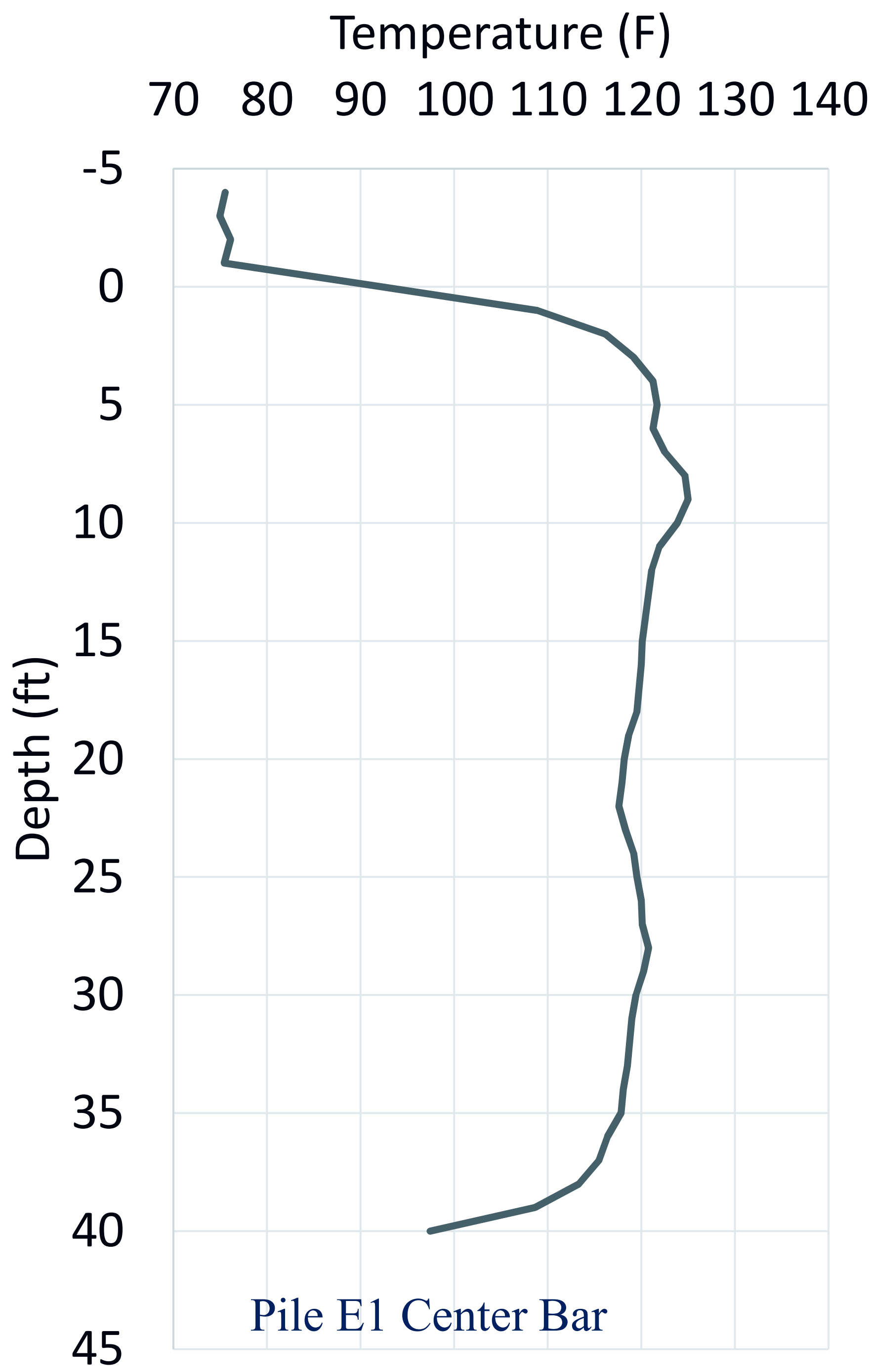
Temperature (F)
70
90
110
130
150
-5
0
5
10
15
20
25
30
35
40
Depth (ft)
6hr
12hr
18hr
24hr
Temperature (F)
70
80
90
100
110
120
130
140
150
-5
0
5
10
15
20
25
30
35
40
Depth (ft)
Tube 1
Tube 2
Tube 3
Tube 4
AVG

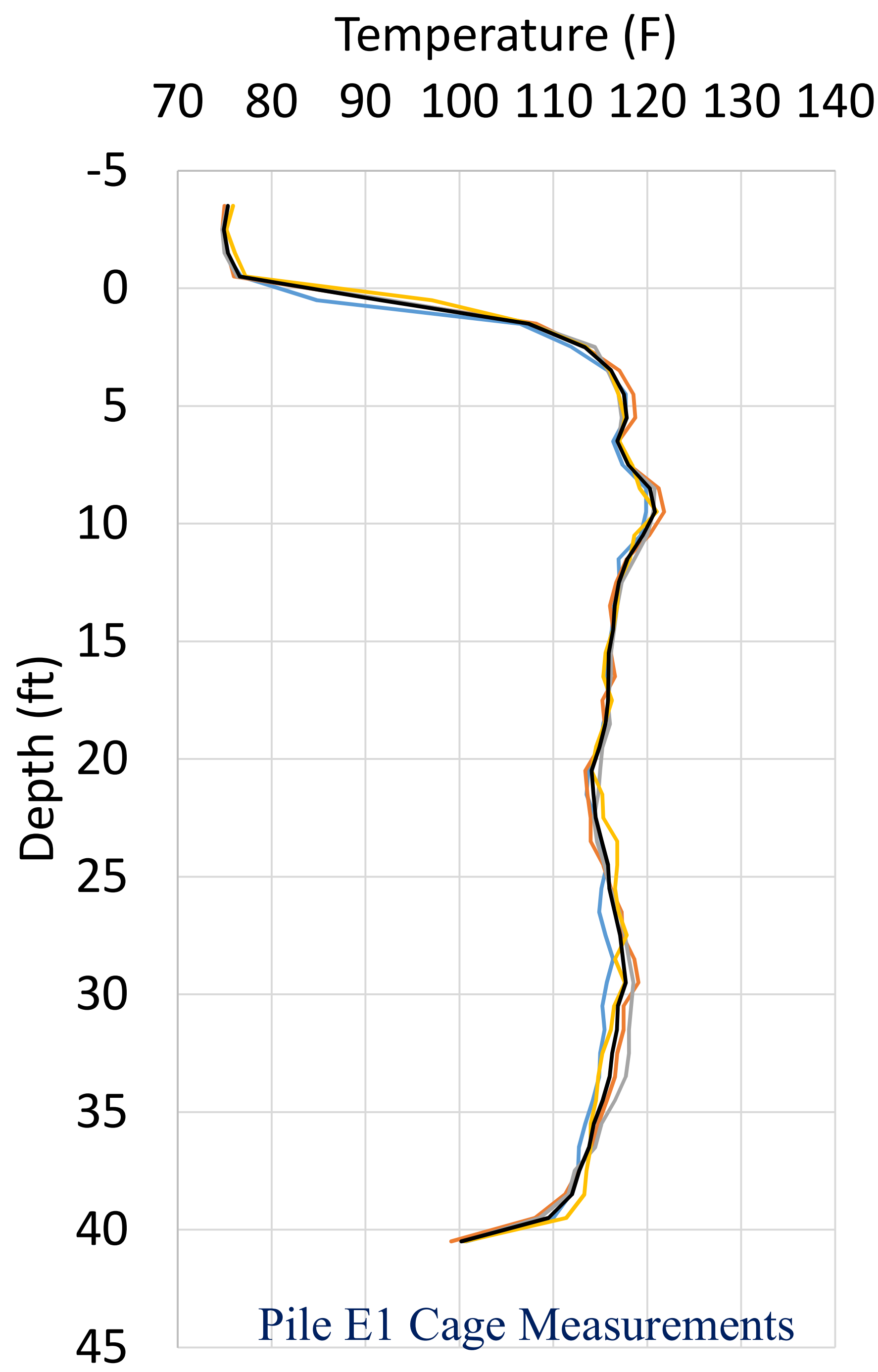
Wire System (C2)



Wire System
T1 (left) and T2 (right)

Wire System
E1 (left) and L1 (right)

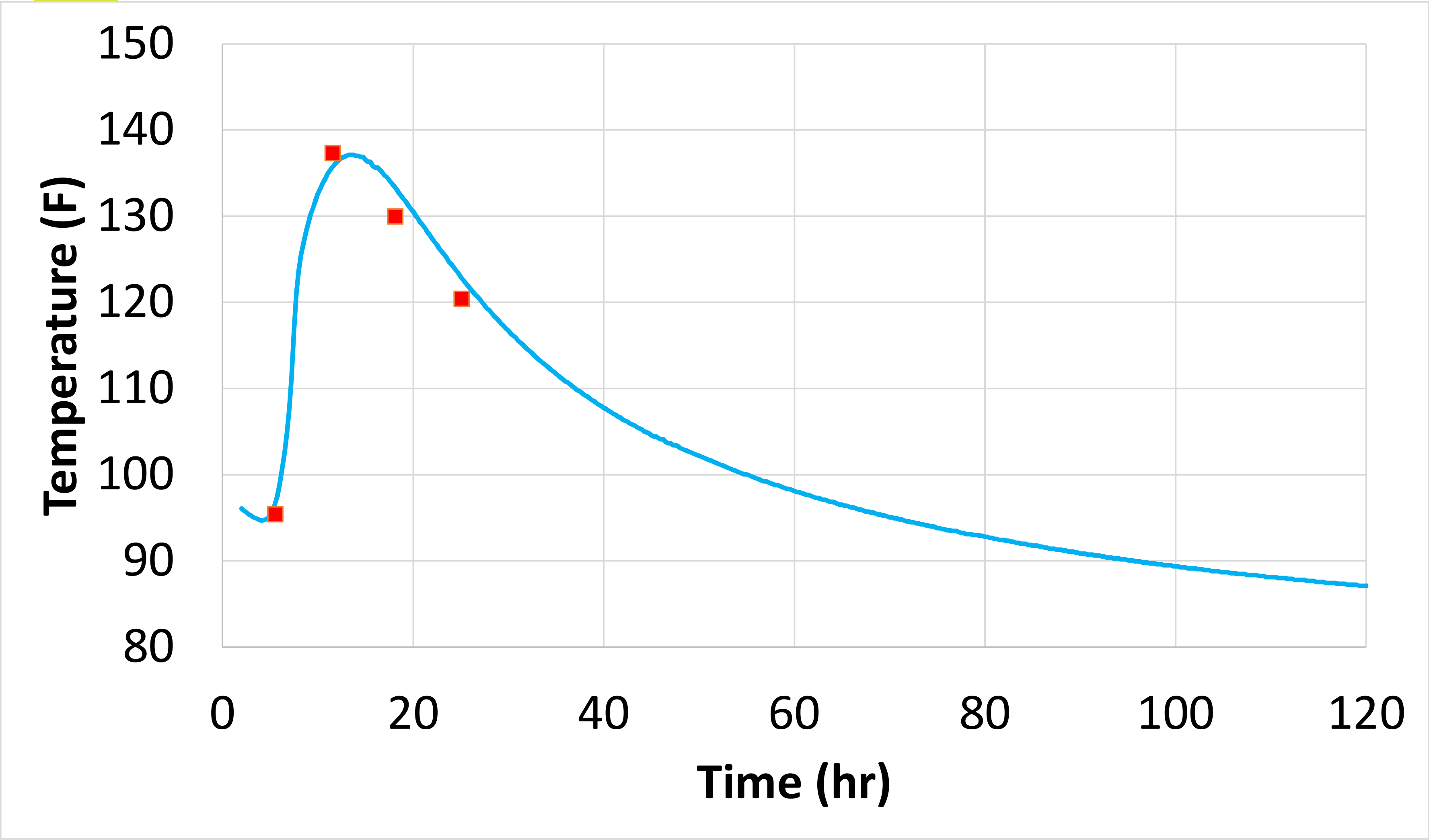

Temperature (F)
70 80 90 100 110 120 130 140
-5
0
5
10
15
20
25
30
35
40
45
Depth (ft)
Pile E1 Center Bar

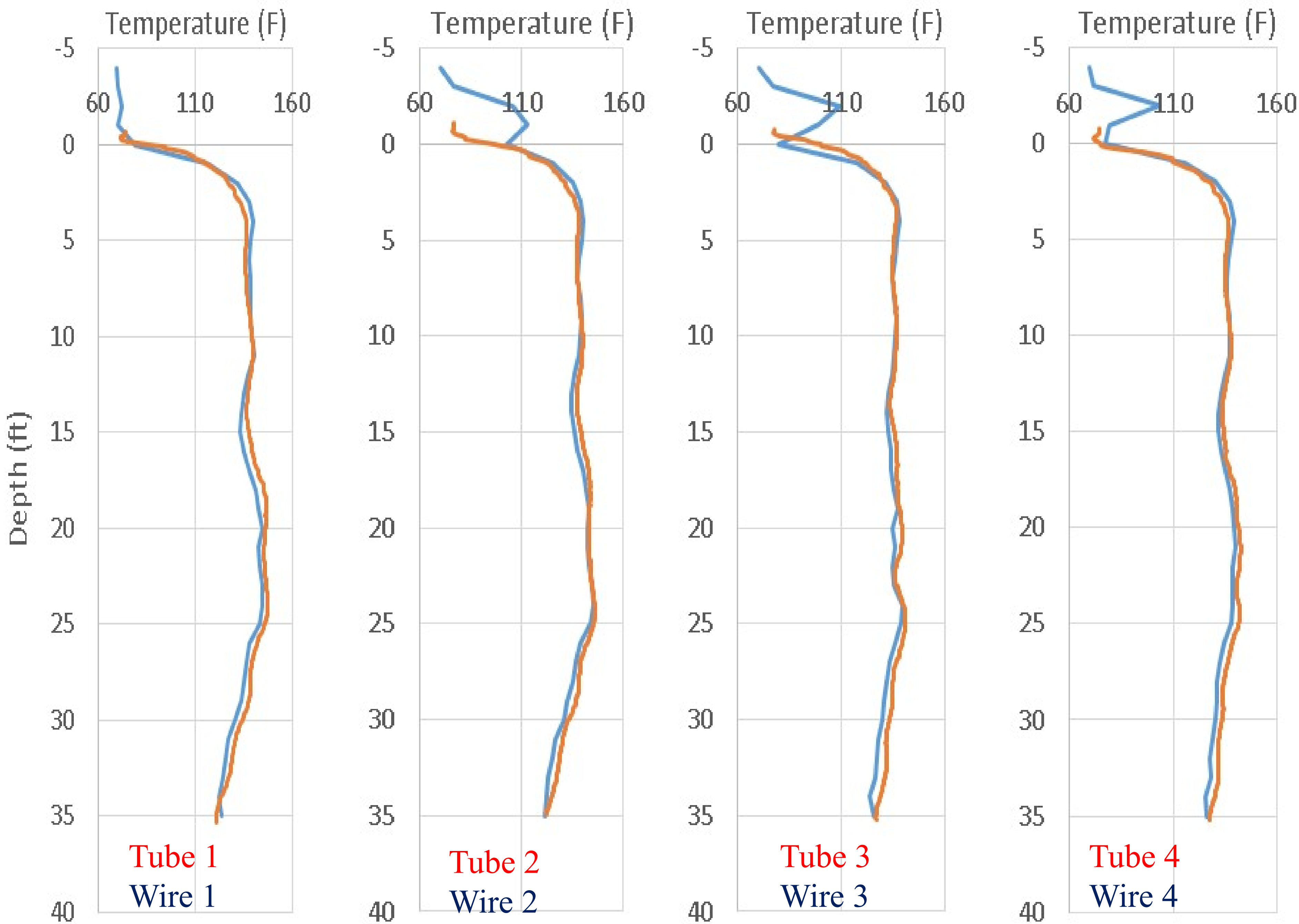

Temperature (F)
70 80 90 100 110 120 130 140
-5
0
5
10
15
20
25
30
35
40
45
Depth (ft)
Pile E1 Cage Measurements

Data Analysis

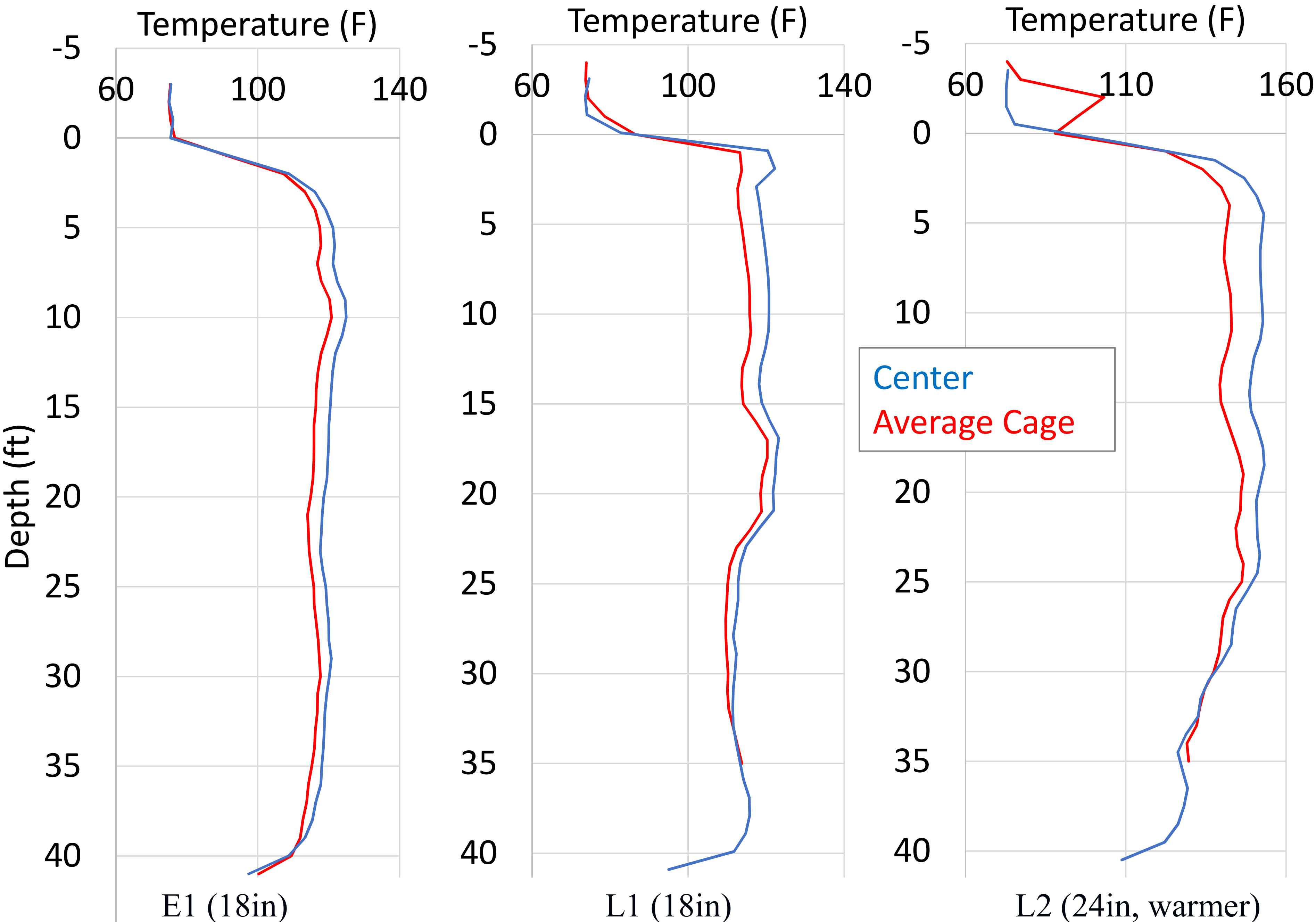
- Comparison of Wire vs Probe
- Center Bar vs Cage Measurements
- Comparison of AME and manual grout volume records
- Tsoil vs Tzero temperature to radius predictions

Probe and Wire Data

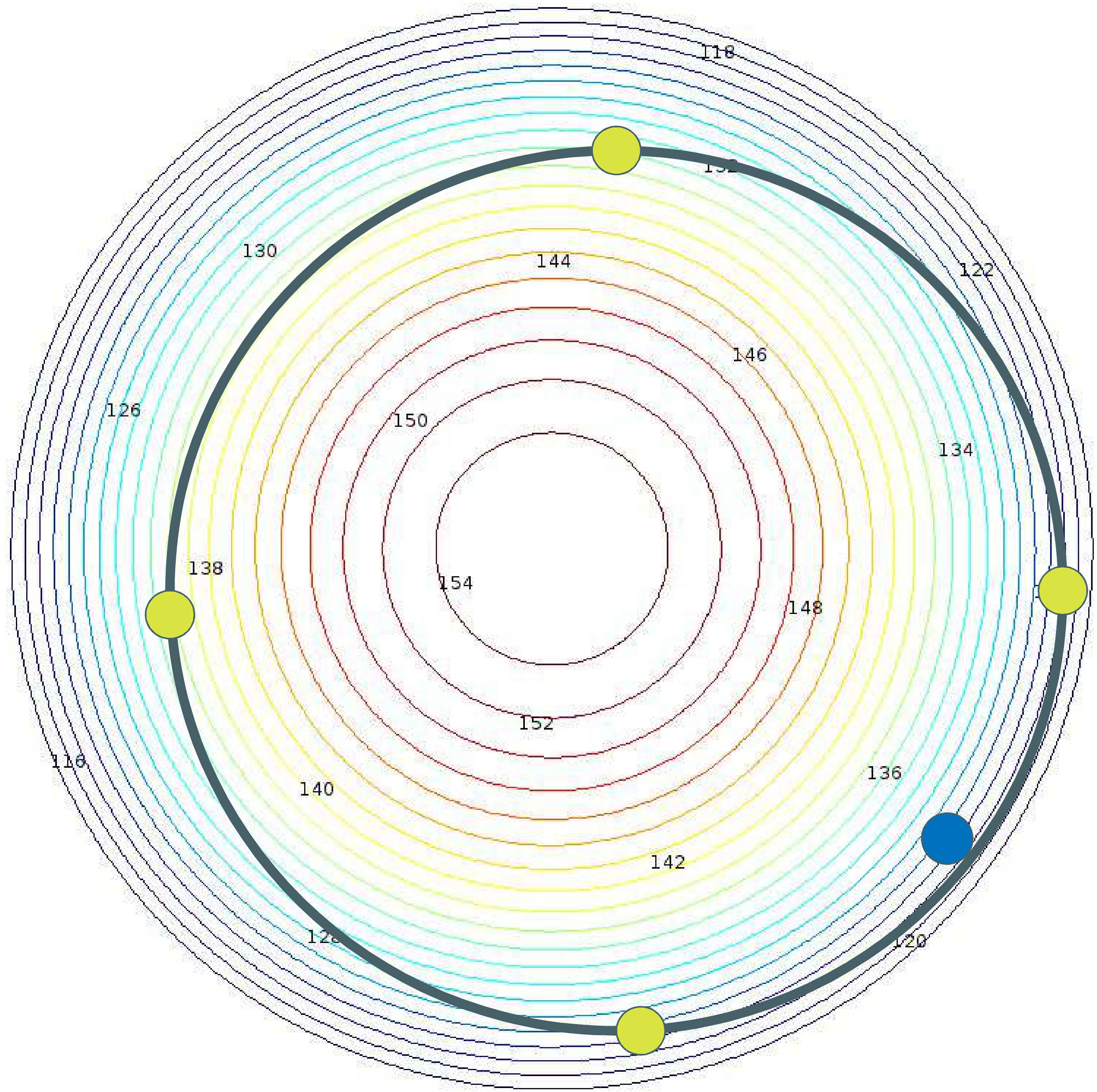


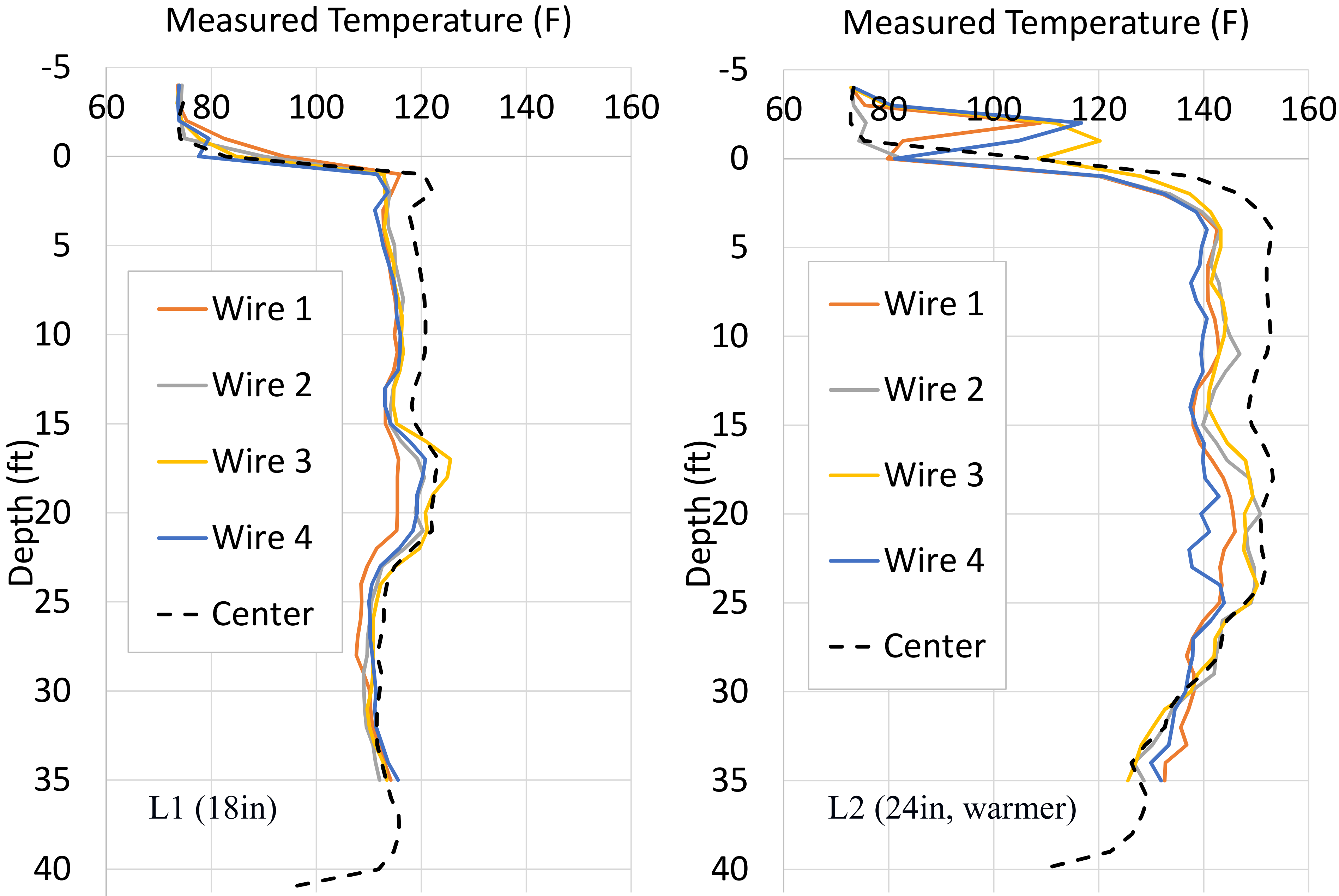


Temperature (F)
Temperature (F)
Temperature (F)
Temperature (F)
Depth (ft)
60
110
160
-5
0
5
10
15
20
25
30
35
40
Tube 1
Wire 1
Tube 2
Wire 2
Tube 3
Wire 3
Tube 4
Wire 4



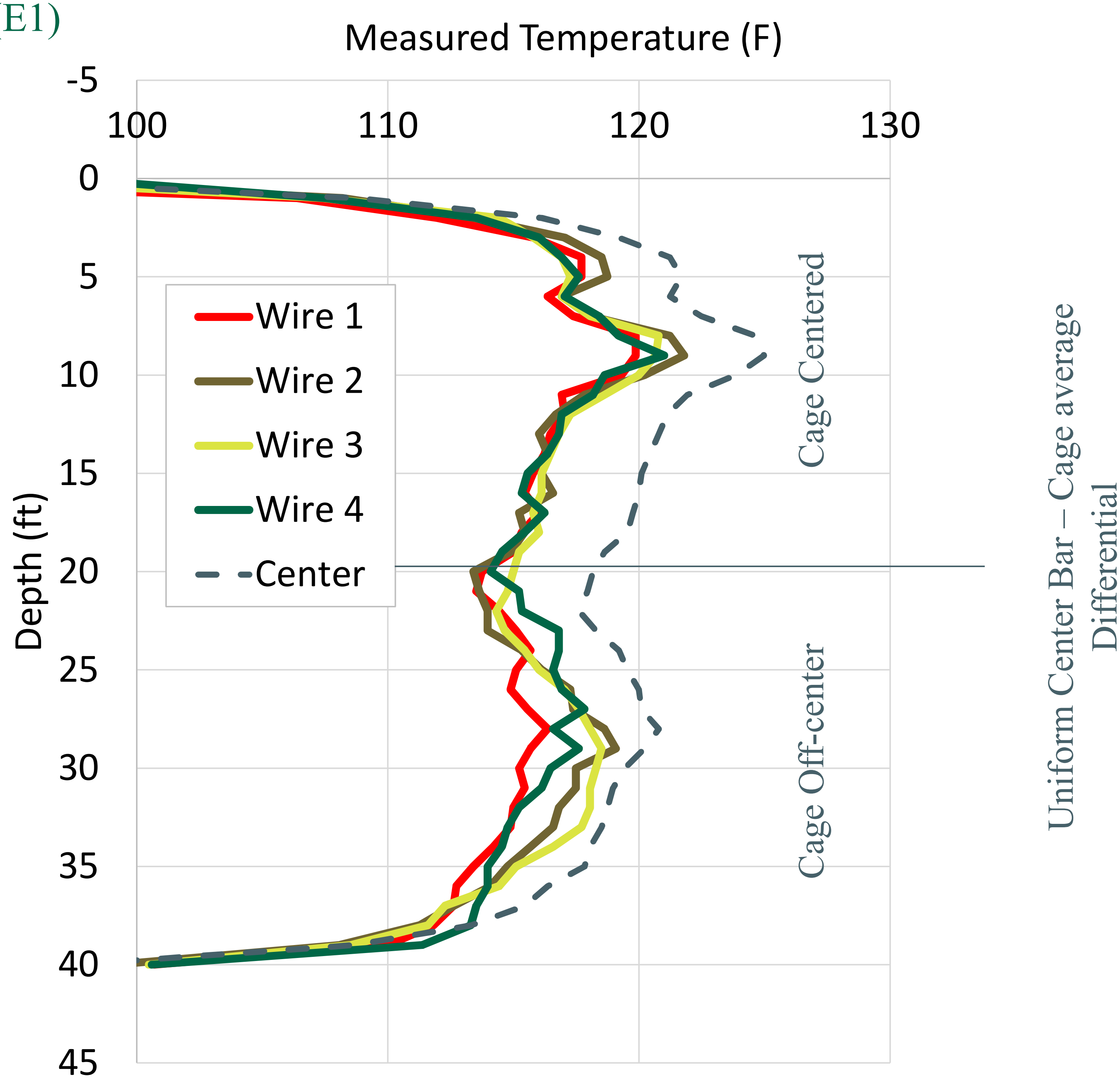
Center bar should always be warmer than the average cage measurement


118
132
130
144
122
146
126
150
134
138
154
148
152
116
136
140
142
128
120



Center bar temperature same as cage from 20ft down

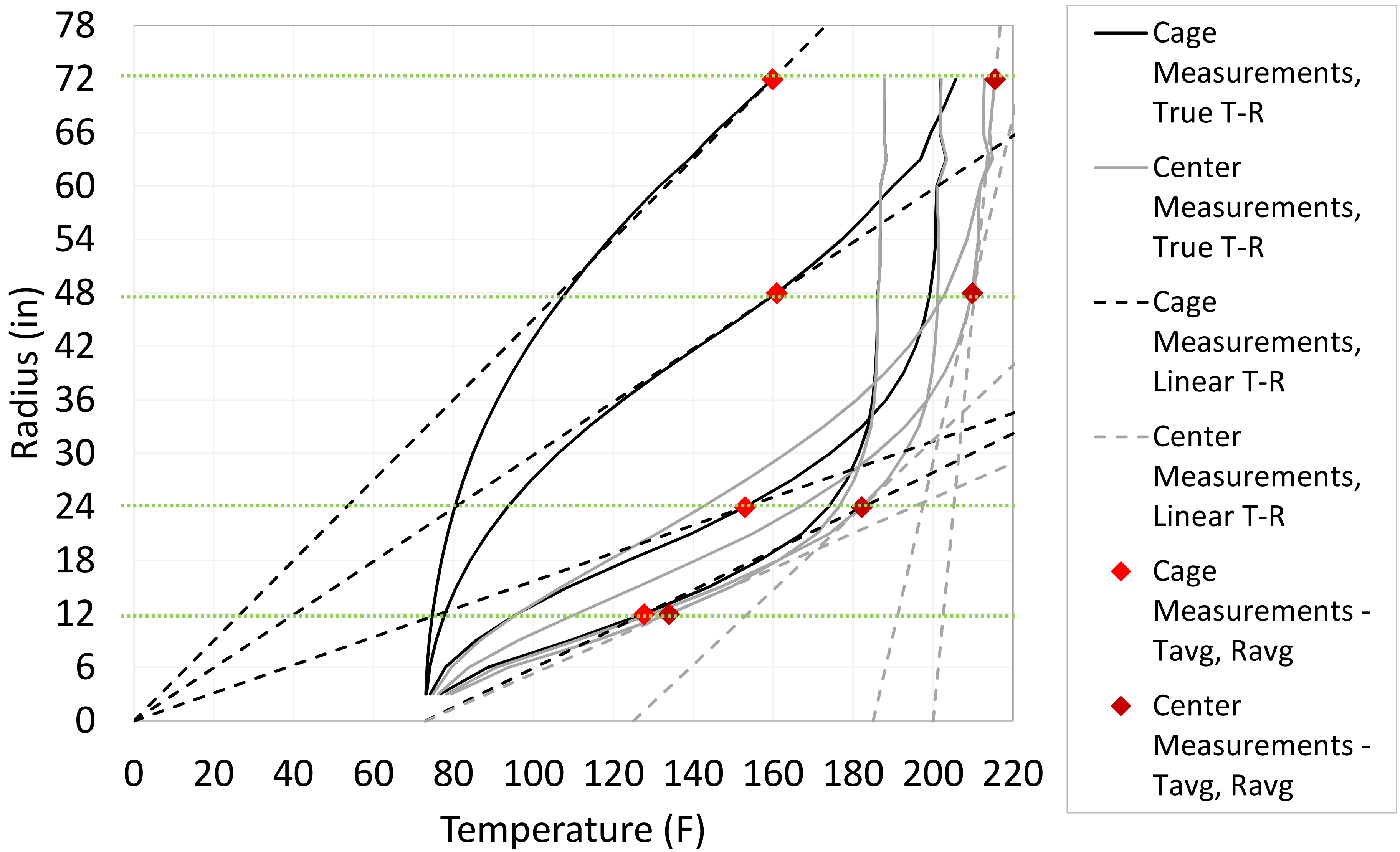
Extraction Pile (E1)

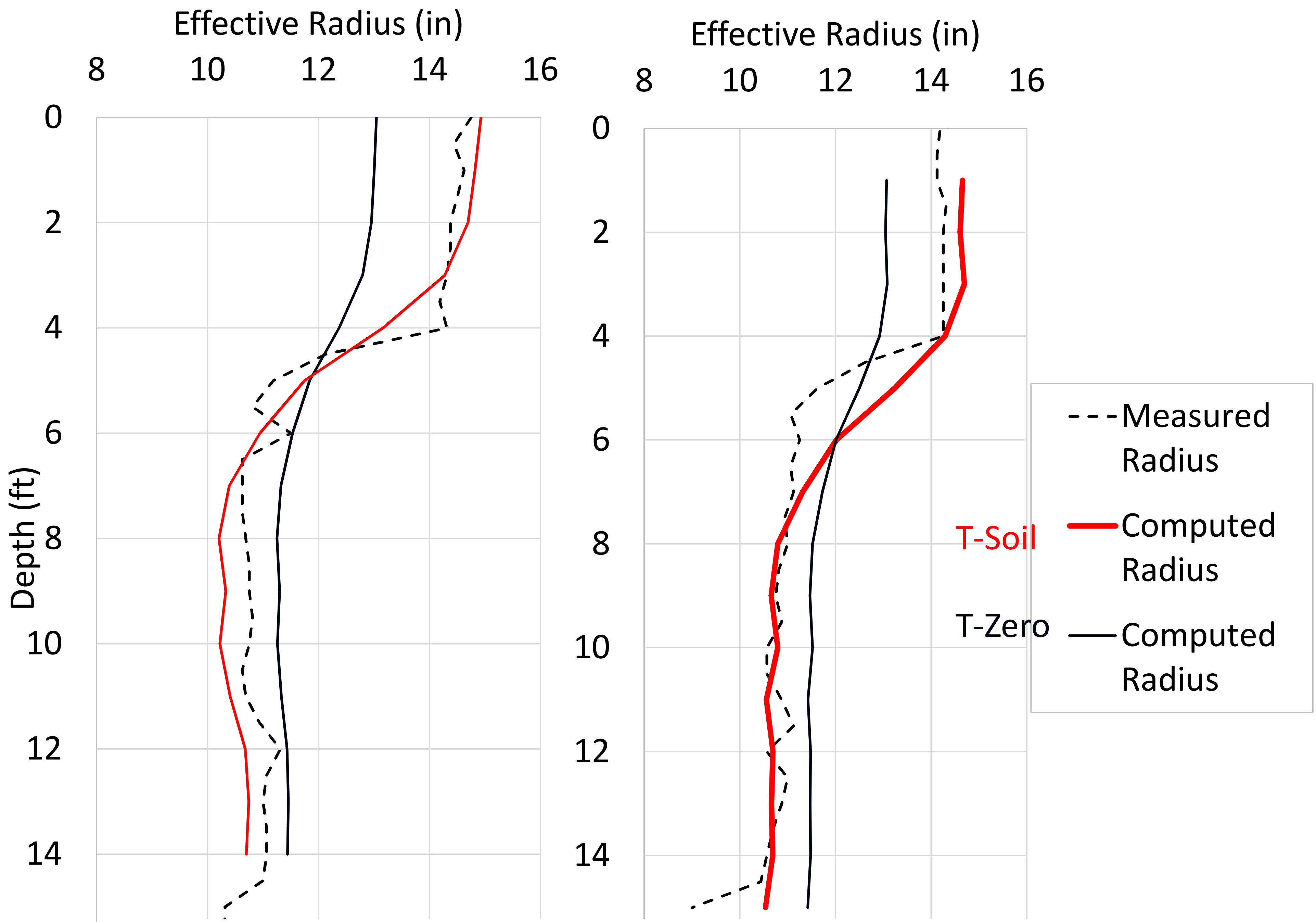


Radius Evaluations

- Hyperbolic Temperature to Radius Relationship
- Simplified Linear Approximation
- Input Parameters
  - Placed Volume
  - Local Soil Temperature
  - Time of Evaluation
- Actual Field Measurement Comparison

Temperature to Radius Relationships

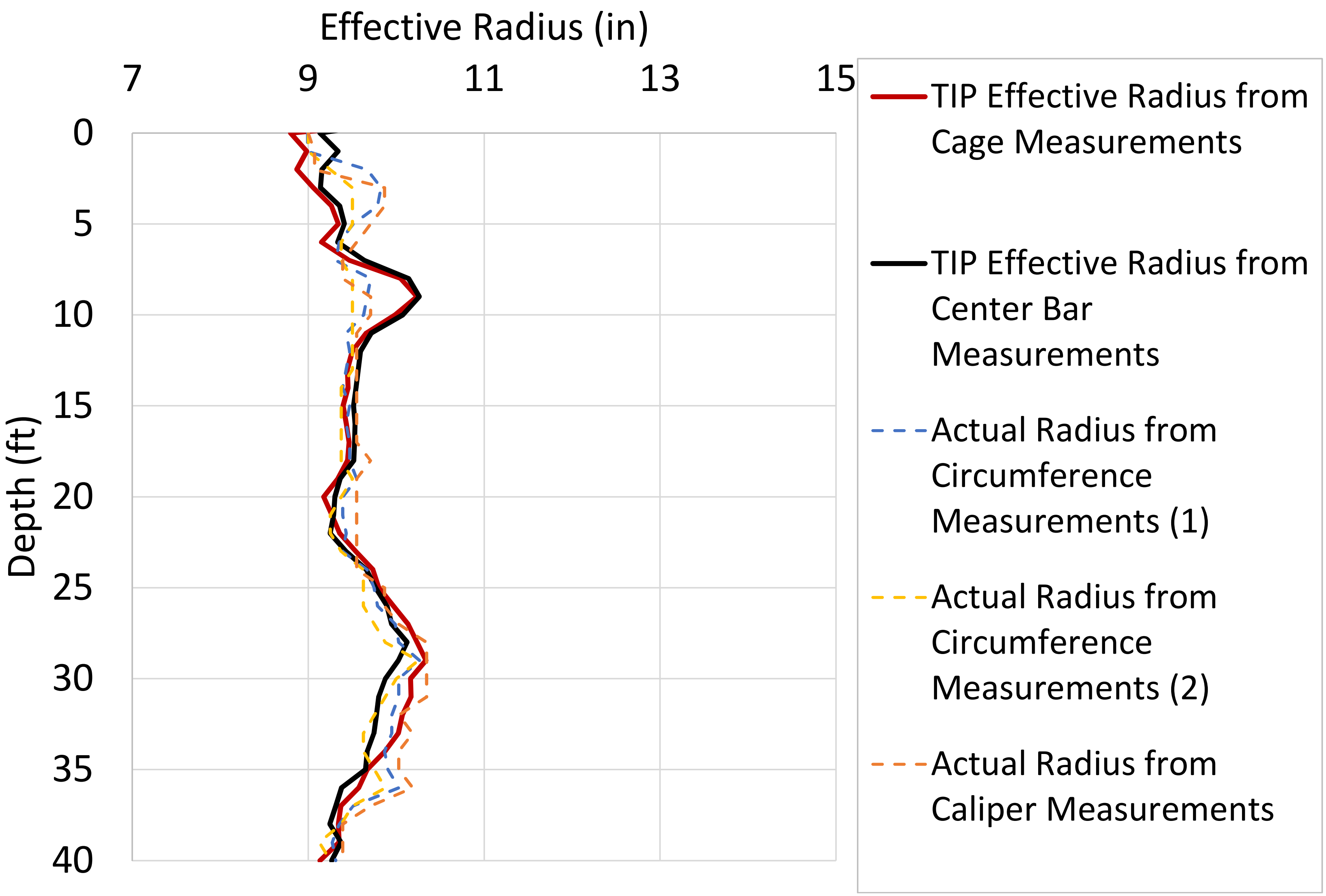


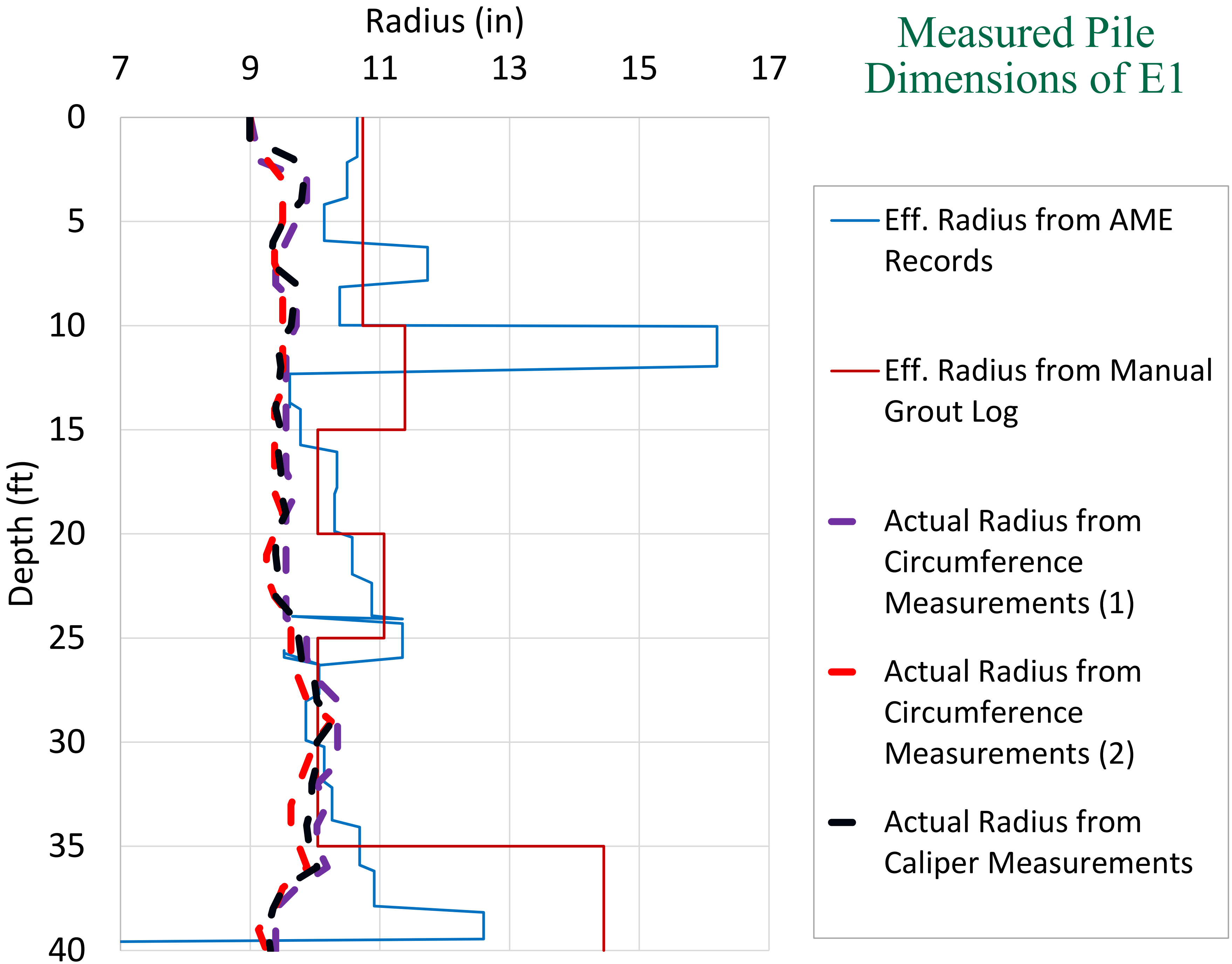


Phase I: 24in shaft center-bar measurements

Extracted Pile (E-1)

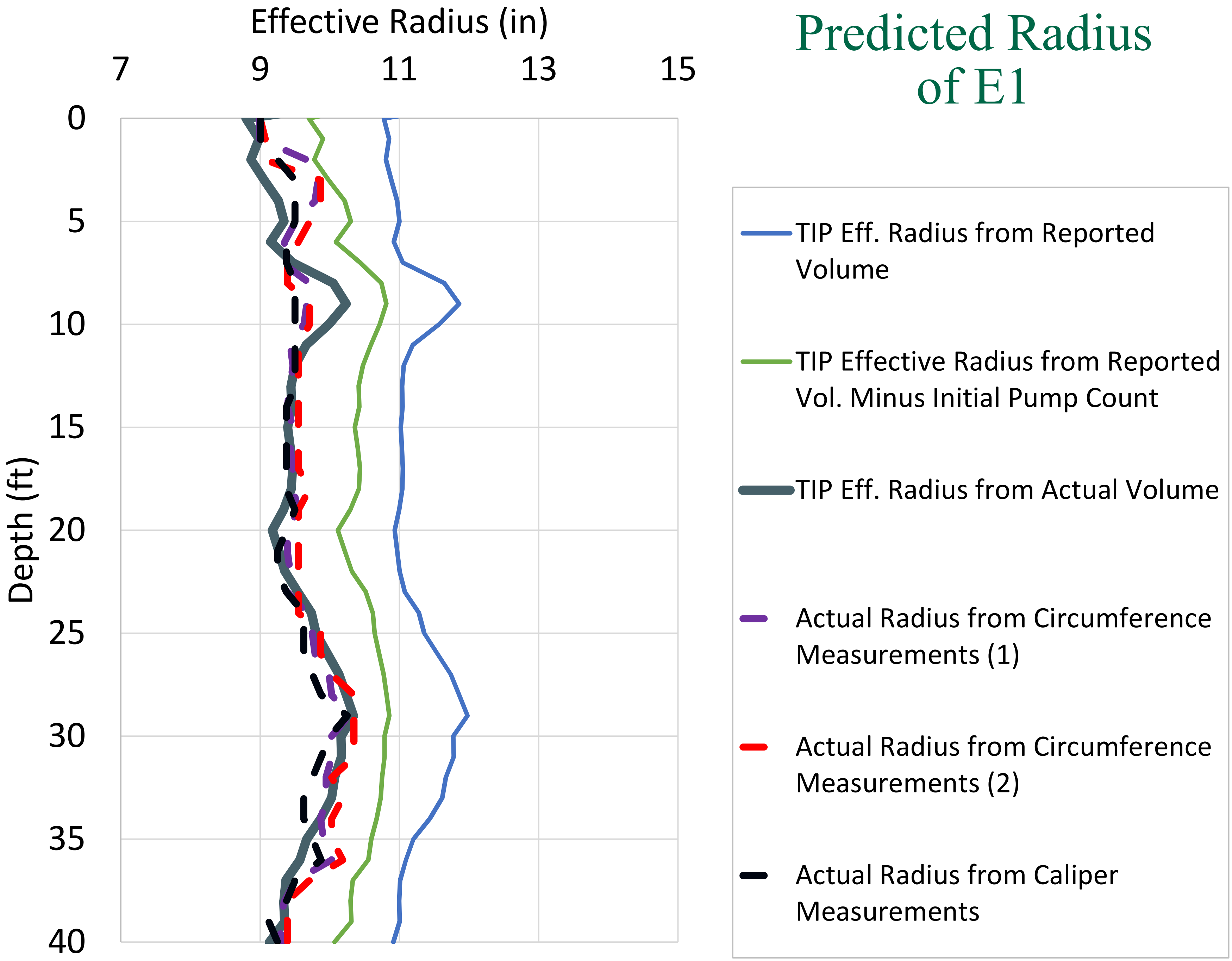
Center Bar vs Cage Radius Predictions

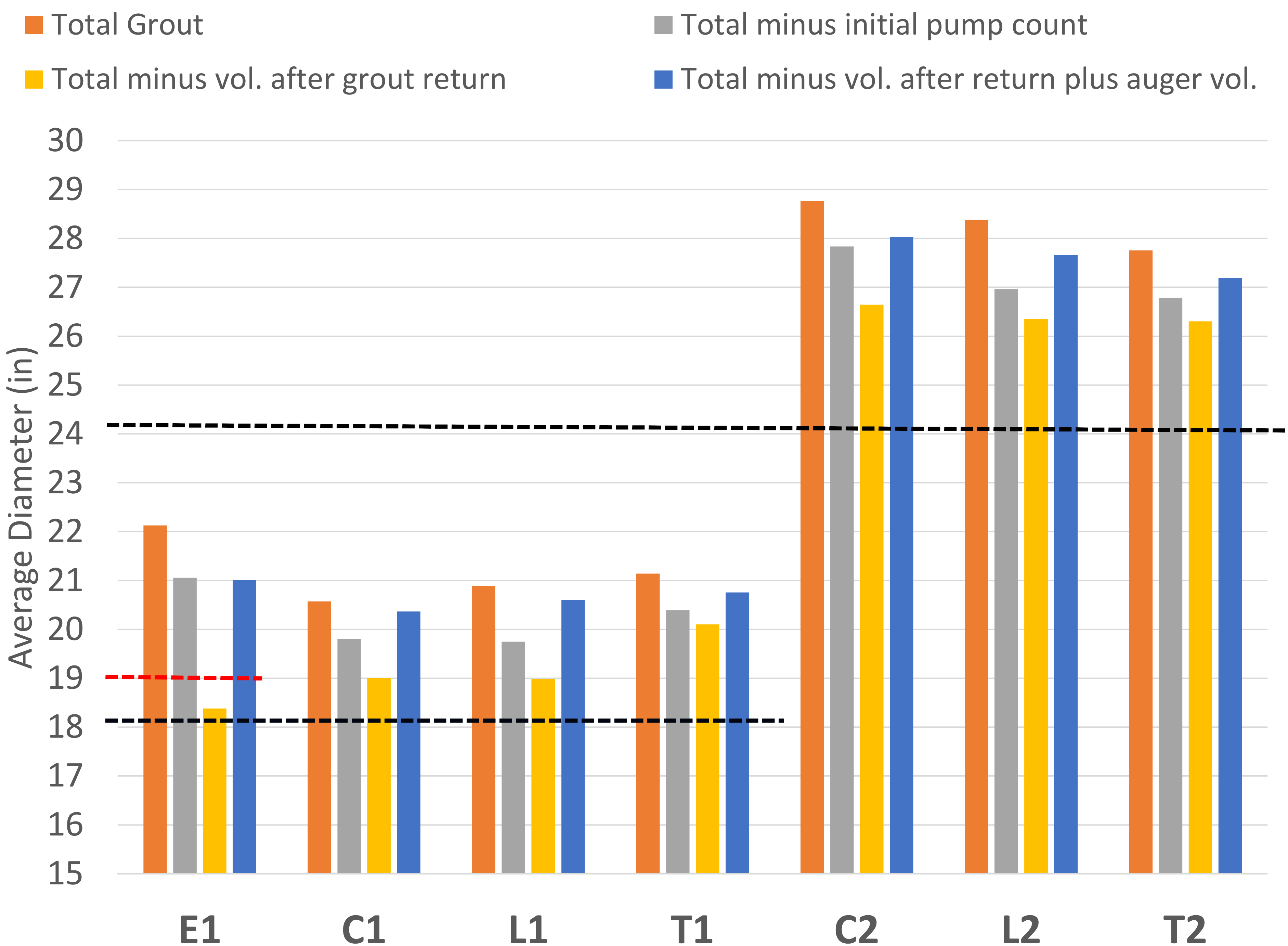




Measured Pile Dimensions of E1
Radius (in)
7
9
11
13
15
17
Depth (ft)
0
5
10
15
20
25
30
35
40
Eff. Radius from AME Records
Eff. Radius from Manual Grout Log
Actual Radius from Circumference Measurements (1)
Actual Radius from Circumference Measurements (2)
Actual Radius from Caliper Measurements

Predicted Radius of E1





Total Grout
Total minus initial pump count
Total minus vol. after grout return
Total minus vol. after return plus auger vol.
Average Diameter (in)
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
E1
C1
L1
T1
C2
L2
T2

Summary

- Probe and wire measurements agreed
- Center bar and cage measurements showed similar features.
- Center bars were off center below 20ft (not detected with cage measurements)
- Temperature to Radius Predictions from center bar and cage worked equally well (if centered)
- Tsoil method was shown to be best suited for small shafts or piles (e.g. diameter < 36in)

Conclusions

- While center bar measurements have the potential to accurately predict the as-built radius profile, centering devices should be more robust and spacing should be smaller
- Cage measurements are not affected in the same way
- Volume of grout is essential for QA as well as the T-R predictions; present methods to measure pumped grout are accurate, but the amount of wasted grout is not accurately recorded.

Acknowledgments

- FDOT Project Manager
  - Dr. David Horhota
- FDOT Review Committee:
  - Juan Castellanos,
  - Larry Jones,
  - Rodrigo Herrera, and
  - Jose Hernando
- DFI Augered Cast-In-Place Pile Committee
- Berkel and Company Contractors
  - Morgan NeSmith

Questions

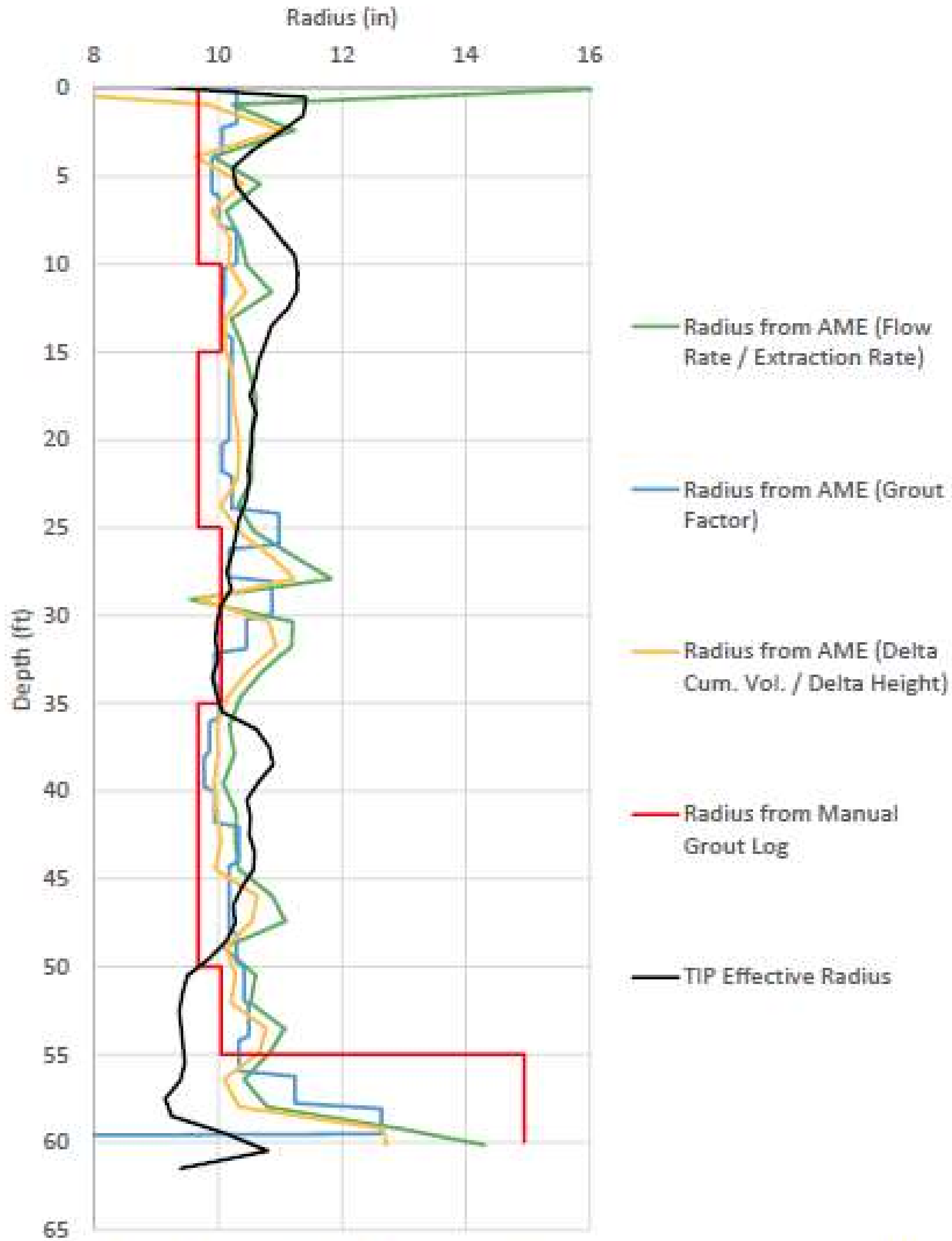


Figure F.1 Pile C1 Computed Radius from AME Data, Manual Grout Log, and TIP Data.

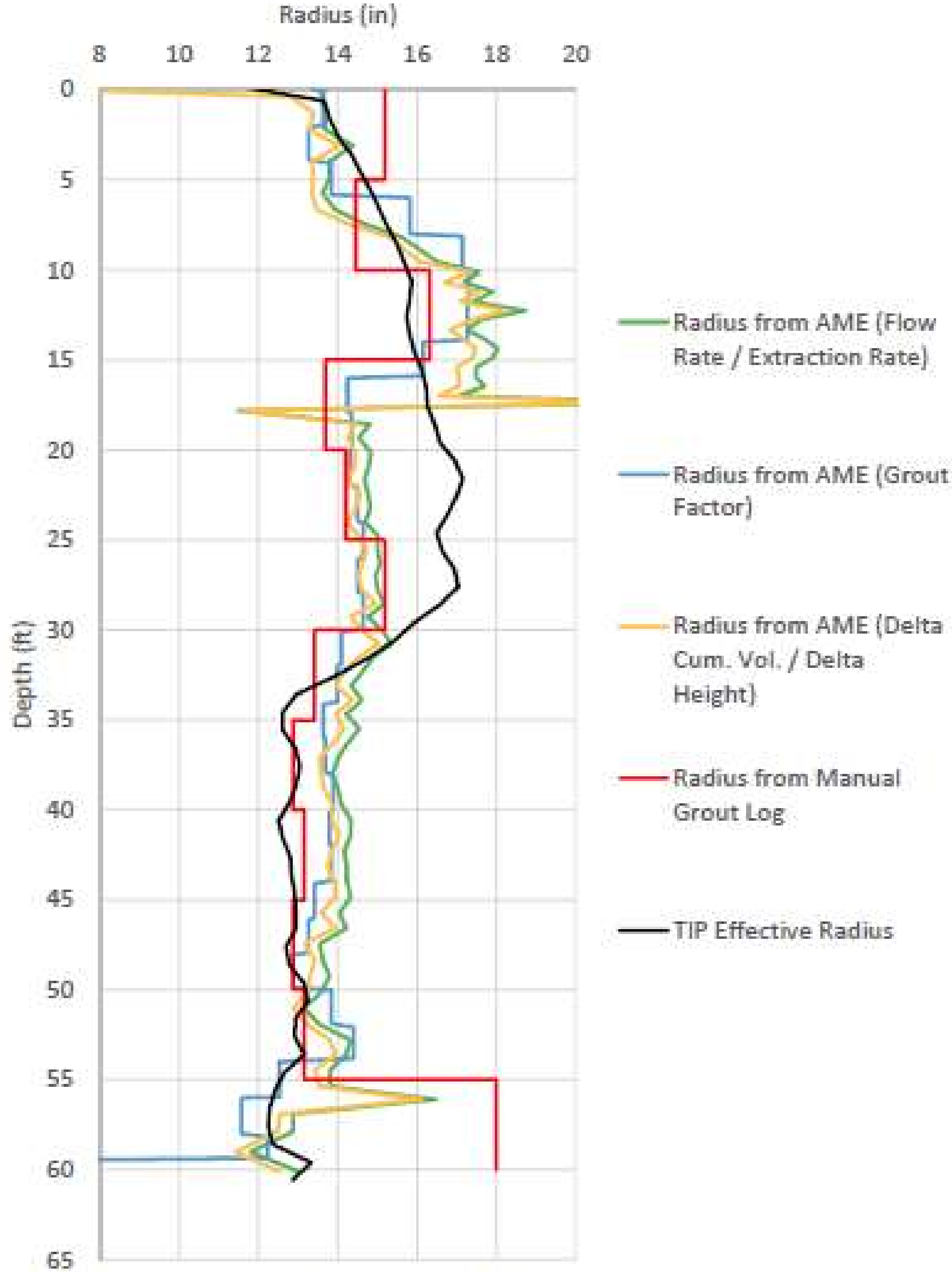


Figure F.2 Pile C2 Computed Radius from AME Data, Manual Grout Log, and TIP Data.

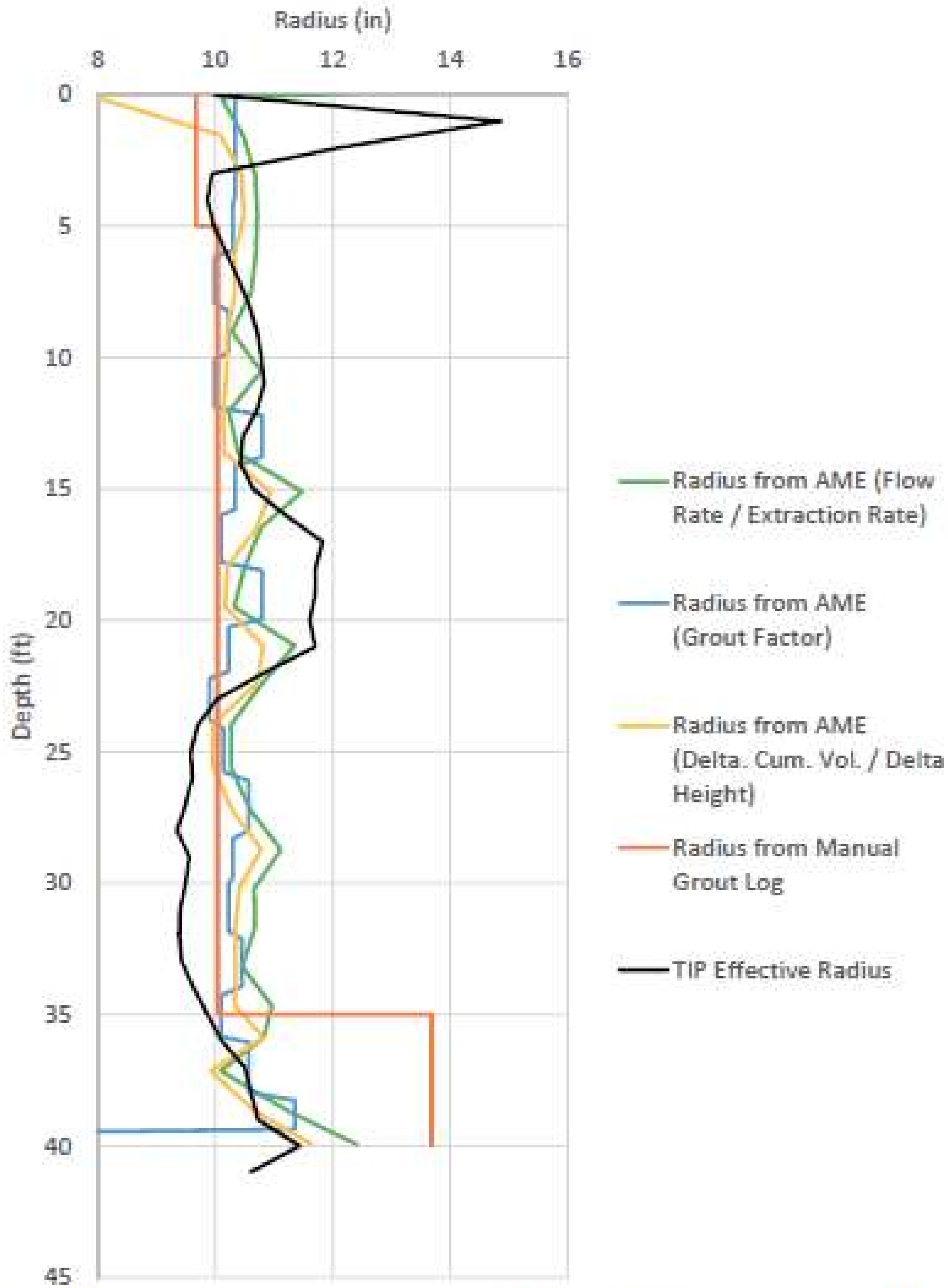


Figure F.3 Pile L1 Computed Radius from AME Data, Manual Grout Log, and TIP Data.

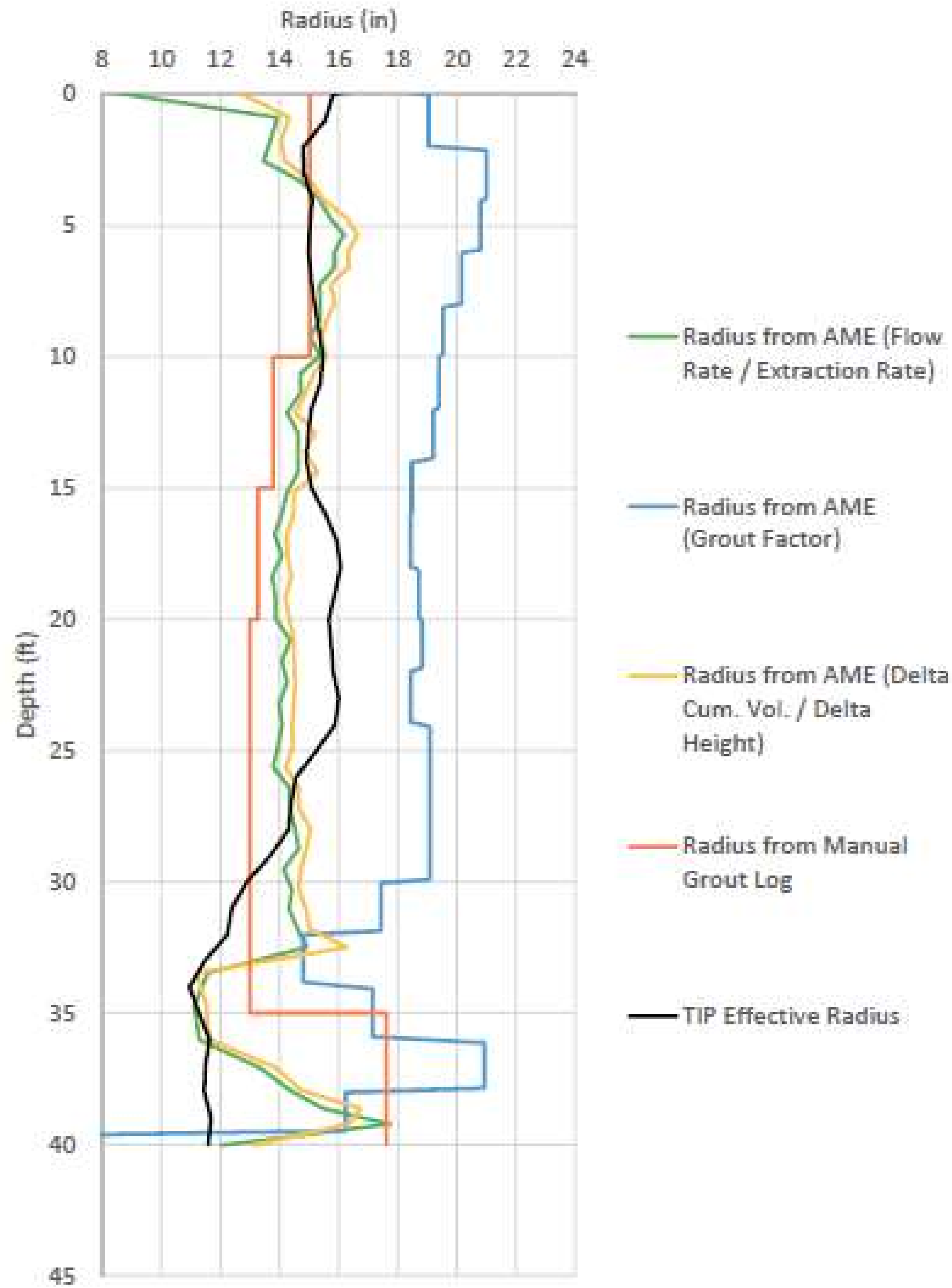


Figure F.4 Pile L2 Computed Radius from AME Data, Manual Grout Log, and TIP Data.

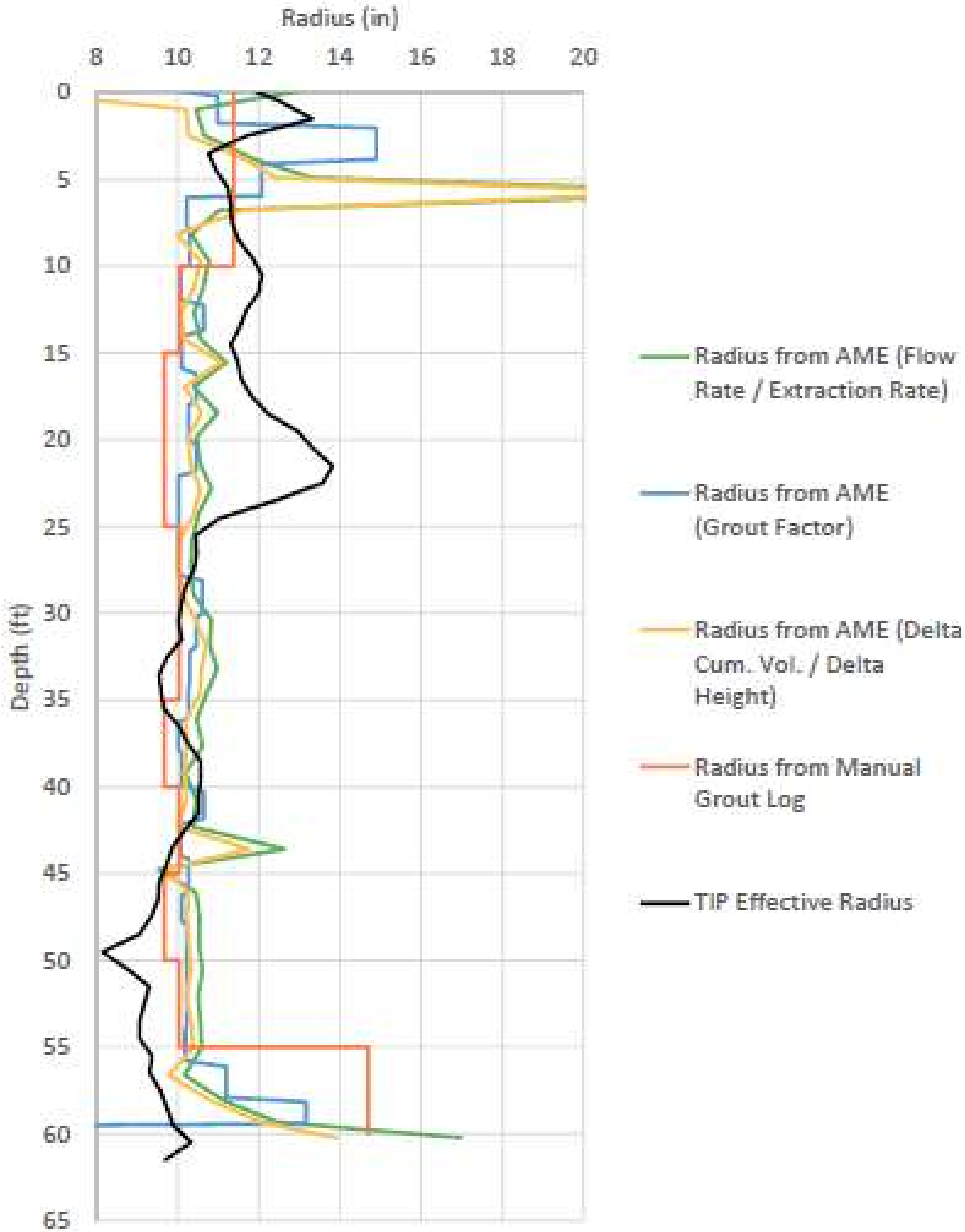


Figure F.5 Pile T1 Computed Radius from AME Data, Manual Grout Log, and TIP Data.

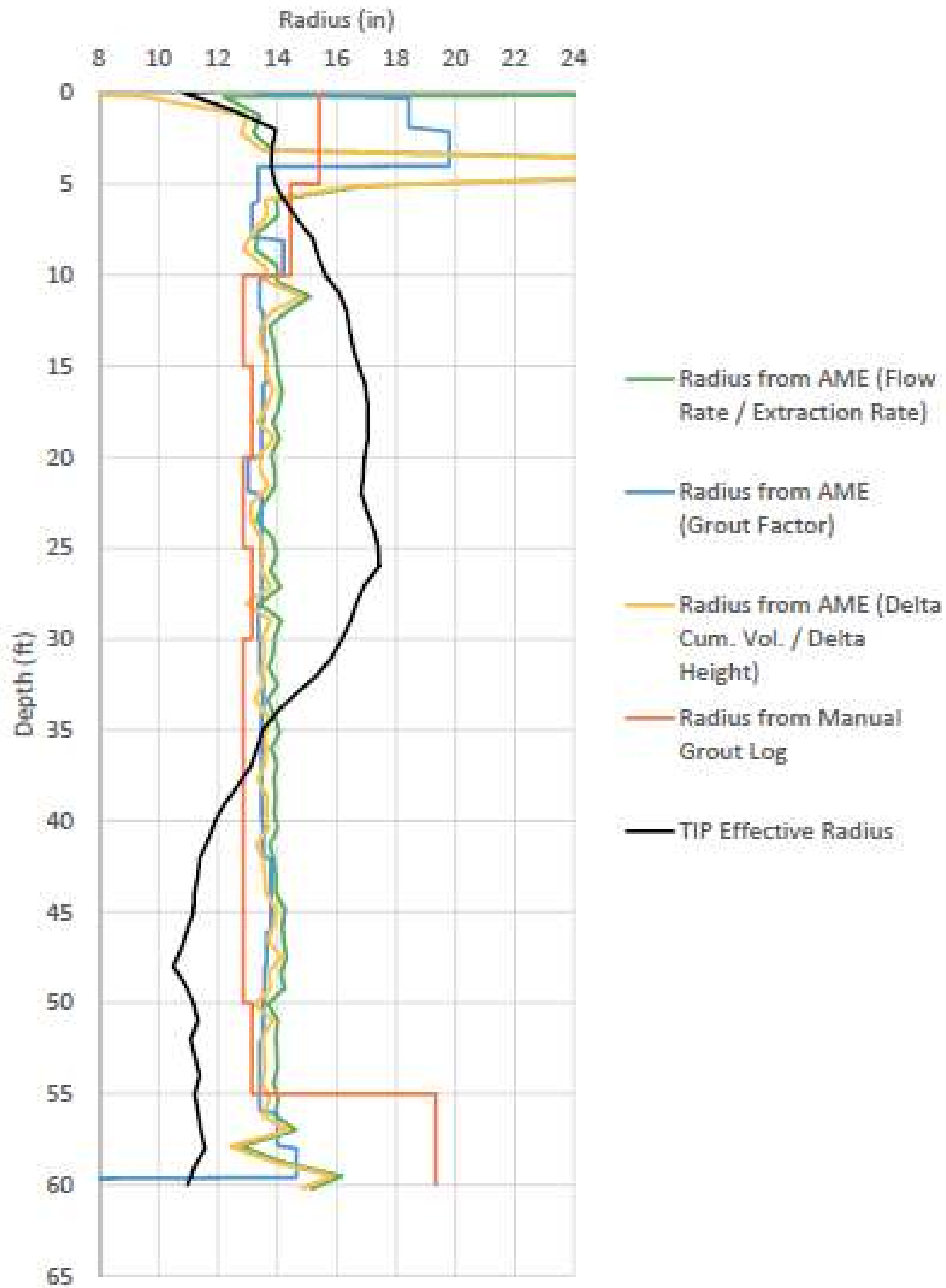


Figure F.6 Pile T2 Computed Radius from AME Data, Manual Grout Log, and TIP Data.

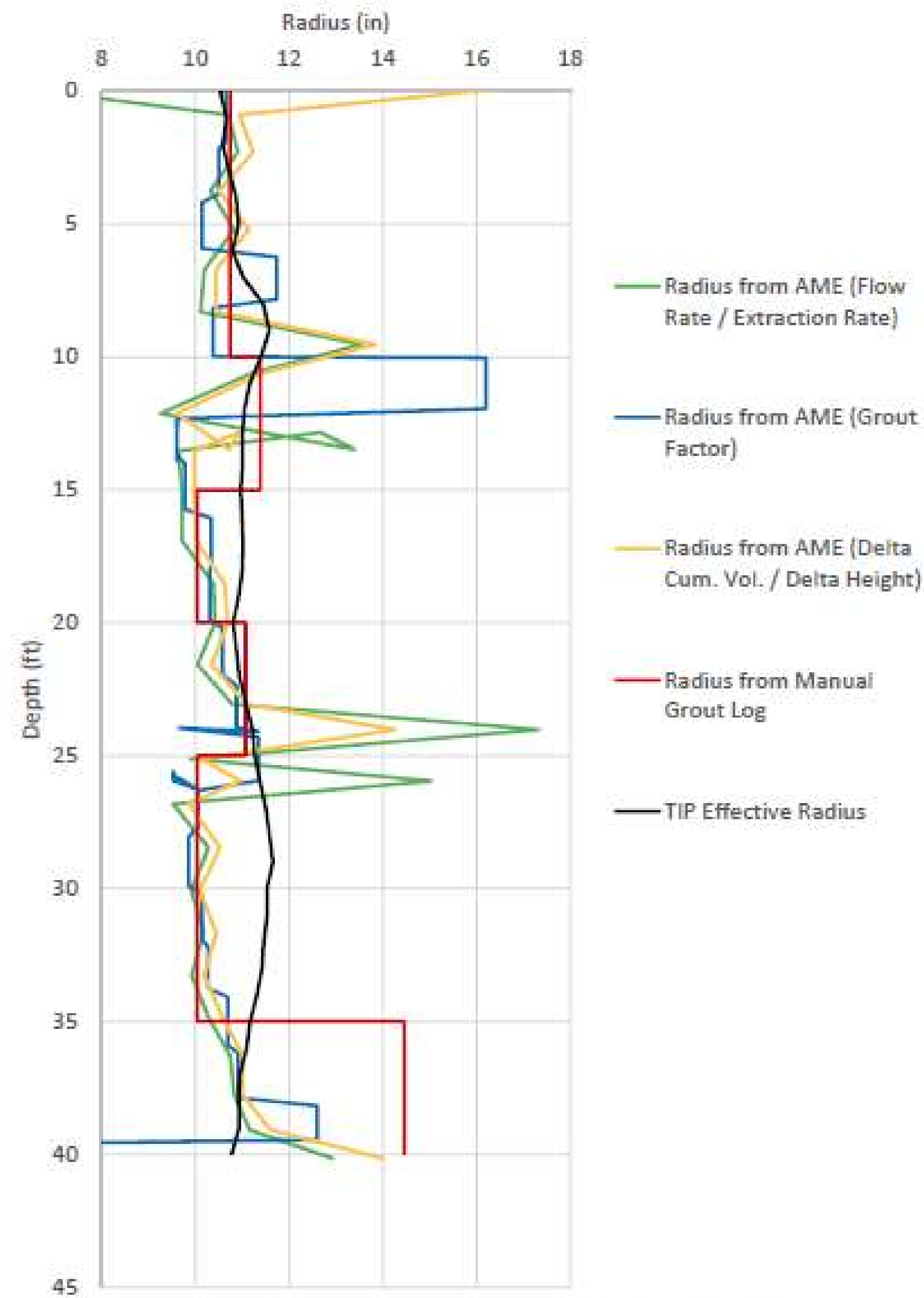


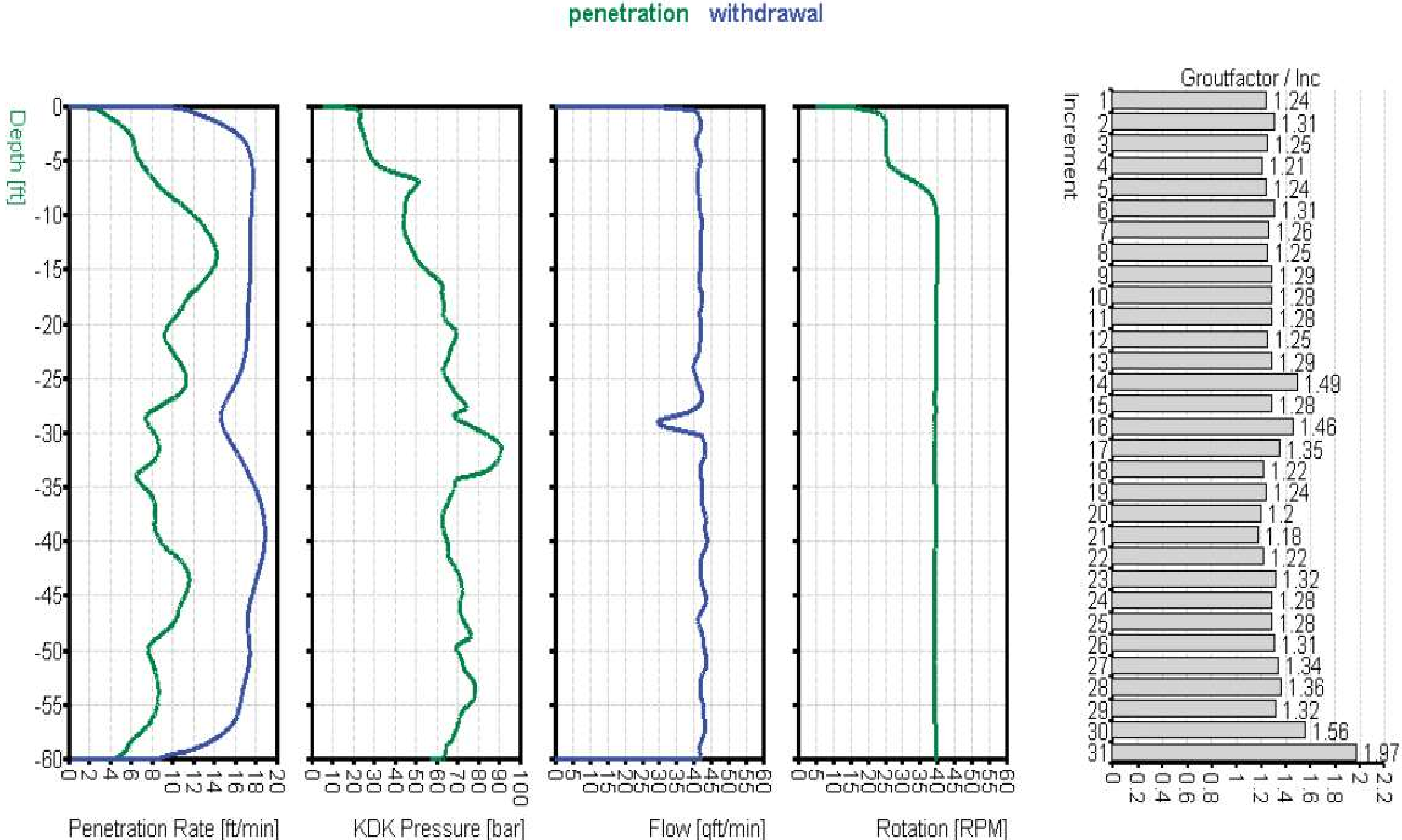
Figure F.7 Pile E1 Computed Radius from AME Data, Manual Grout Log, and TIP Dat

Type of PUMP COUNT input = 'INCREMENTAL' : I

DRILLING & GROUTING TABLE

DEPTH (ft) Below Top	- Top of Segment	SEGMENT EL (ft, NGVD)	SOIL Cond. S, M, or H	GROUT Pressure (psi)	PUMP COUNT INCR. (Per 5 ft)	PUMP COUNT ACCRUED (SUM)	GROUT VOLUMES INCREMENTAL Theor. (cu ft)	INCREMENTAL Actual (cu ft)	INCREMENTAL Actual % Theor.	ACCRUED Actual (cu ft)
0	(Pile TOP)	141.00	Soil Cond.: Start input at Pile TOP, Grout Pump Count: start input at Pile BOTTOM.							
5	- 0	136.00		185	13	178	8.84	10.21	116 %	139.86
10	- 5	131.00		185	13	165	8.84	10.21	116 %	129.64
15	- 10	126.00		185	14	152	8.84	11.00	124 %	119.43
20	- 15	121.00		185	13	138	8.84	10.21	116 %	108.43
25	- 20	116.00		185	13	125	8.84	10.21	116 %	98.21
30	- 25	111.00		185	14	112	8.84	11.00	124 %	88.00
35	- 30	106.00		185	14	98	8.84	11.00	124 %	77.00
40	- 35	101.00		185	13	84	8.84	10.21	116 %	66.00
45	- 40	96.00		185	13	71	8.84	10.21	116 %	55.79
50	- 45	91.00		185	13	58	8.84	10.21	116 %	45.57
55	- 50	86.00		185	14	45	8.84	11.00	124 %	35.36
60	- 55	81.00		185	31	31	8.84	24.36	276 %	24.36
	-									
	-									
	-									
	-									
	-									
	-									
	-									
	-									
Pile BOTTOM @ depth = 60 ft					178		106.03		132 %	139.86
					Total Pump Strokes		Total Theor. Vol. (cf)		Actual/Theor. (%)	Actual (cf)

Parameter vs. Depth



INC 31 = 1 ft INC 30 = 1.6 ft
INC 29 - 1 = 2 ft