CUY-IR480-1842, VALLEY VIEW BRIDGE

SEPTEMBER 25, 2018

odot

CUY-IR480-1842

MEASUREMENT AND USE OF SET-UP IN PILE DESIGN

Christopher Merklin, P.E.

Administrator

Ohio DOT Office of Geotechnical Engineering

*Thank-you to Alex Dettoff - ODOT and Chuck Winters – Jacobs, for many of the slides

CUY-IR480-1842, VALLEY VIEW BRIDGE

CUY-IR480-1842, VALLEY VIEW BRIDGE

CUY-IR480-1842, VALLEY VIEW BRIDGE

- Design Build
  - Deck replacement on the existing twin four lane structures
  - Construction of a new four lane structure in the median.
  - Rehab and repair of existing bridge structures
  - Approach roadway construction to connect to new bridge

CUY-IR480-1842, VALLEY VIEW BRIDGE

CUY-IR480-1842, VALLEY VIEW BRIDGE

CUY-IR480-1842, VALLEY VIEW BRIDGE

- SOME STATISTICS:
  - Existing bridges Built from 1970 to 1975
  - Bridges are 4157’ long, up to 190’ tall
  - Bridges used 277,652’ of driven piling
    - Design assumed 14” CIP Pipe Piles
    - Construction used Step-Tapered Piles
  - R.A. and P1 through P12 on Friction Piles
  - P13 and P14 on Spread Footings on rock
  - F.A. on HP 12x53 Piles driven to rock

CUY-IR480-1842, VALLEY VIEW BRIDGE

- Existing Bridge Piles:
  - Existing twin bridges typically have:
    118 piles per each pier,
    each about 92 feet long.
  - This is 10,856 feet of pile per pier (x2).

CUY-IR480-1842, VALLEY VIEW BRIDGE

- 3 DB Teams
- 2 Foundation ATC concepts
  - Inclusion of Pile Set-up and Modification of Pile Driving Requirements (Marquette)
  - CFA piles
- Walsh/CH2M (Jacobs) selected
  - $228M ($11M<2nd bidder)
  - Inclusion of Pile Set-up and Modification of Pile Driving Requirements

CUY-IR480-1842, VALLEY VIEW BRIDGE

- The Walsh/CH2M plan
  - Drive fewer, larger piles per pier, and **make use of pile setup** in design
  - About 45 piles per pier, each around 120 feet long on average.
  - This is 5,400 feet of pile per pier.
  - About **half** the amount of pile per pier!

CUY-IR480-1842, VALLEY VIEW BRIDGE

- ODOT Standard Requirements for CIP Piles
  - Establish driving criteria by dynamic testing (PDA with signal matching) on first 2 production piles at EOID
  - Use production hammer for all dynamic testing
  - Verify UBV at EOID
  - Perform 1 static load test per 10,000 feet of the same size pile and UBV

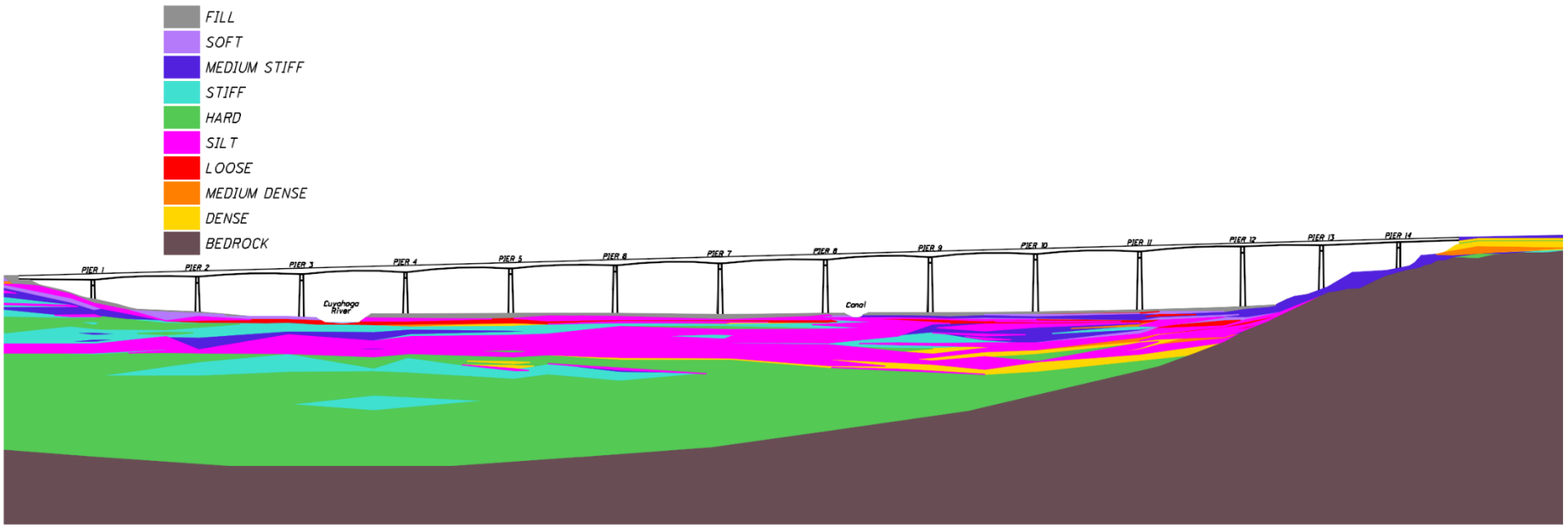
CUY-IR480-1842, VALLEY VIEW BRIDGE

- The Walsh/CH2M plan
  - 18-inch CIP, 1/2-inch thick wall, closed end at 11/14 Piers
  - Test pile program to determine set-up
  - 6 indicator test piles with long term restrikes
  - Use Apple for long term restrikes
  - 2 static load tests
  - EOID and 1-day restrike on 2 production piles

CUY-IR480-1842, VALLEY VIEW BRIDGE

- ODOT Counter
  - Indicator test pile at all piers (11)
  - Production dynamic testing at EOID, 3-day+ restrike
  - If indicator pile is within footprint, only dynamically test 1 production pile
  - Use production hammer up to 7-day restrike, larger hammer beyond that
  - 3 Static load tests with internal strain gages

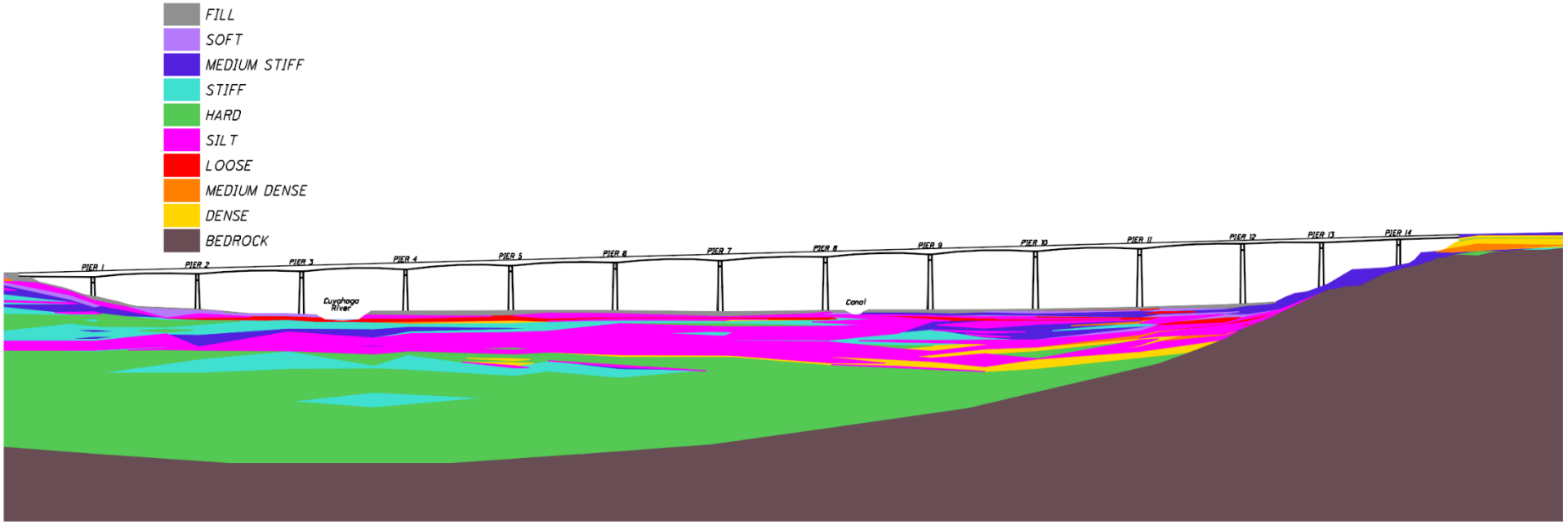
CROSS SECTION OF THE VALLEY



- **“Green”** soil is the 30+ bpf that we typically look for

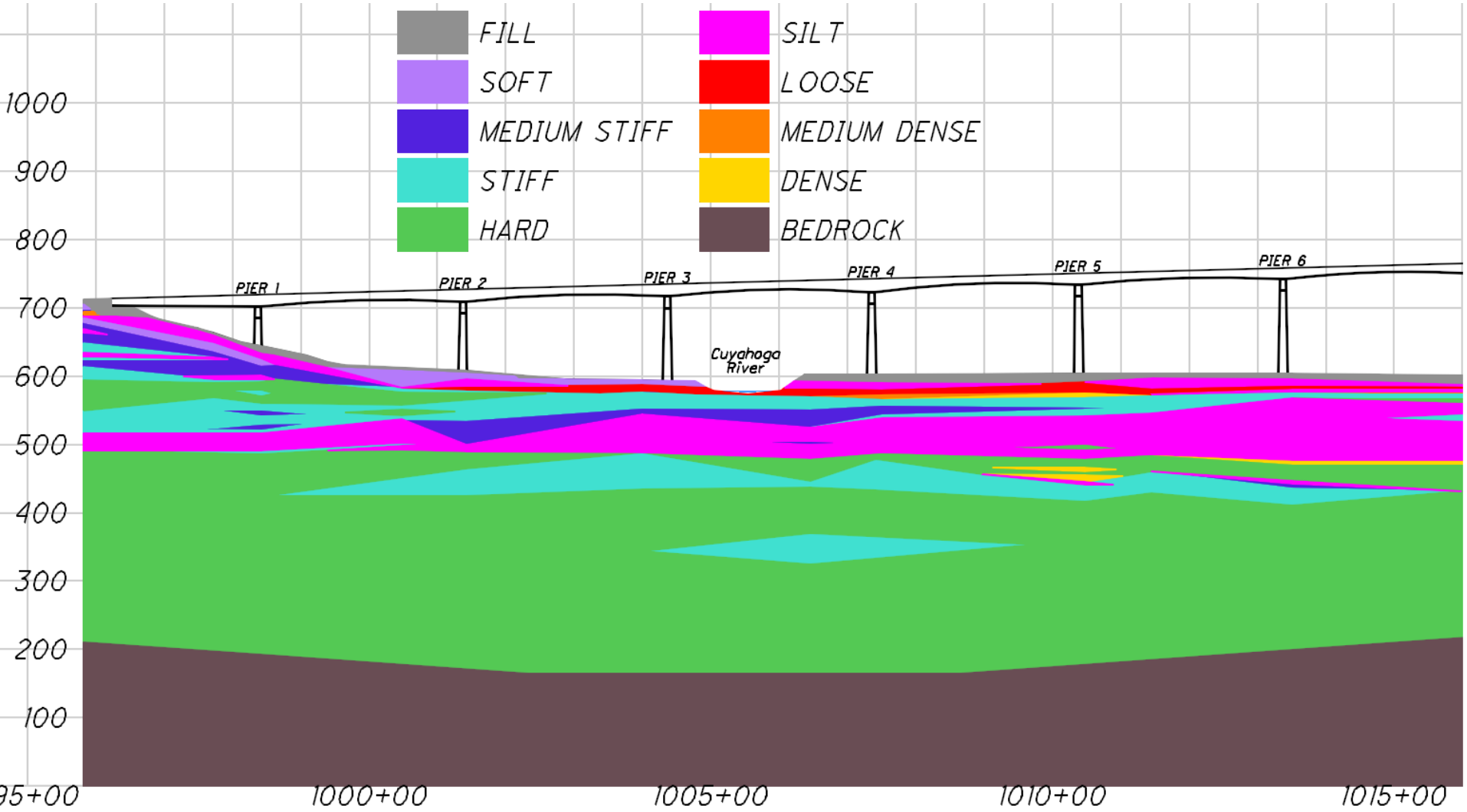
CROSS SECTION OF THE VALLEY

- Just get to the **“Green”**…

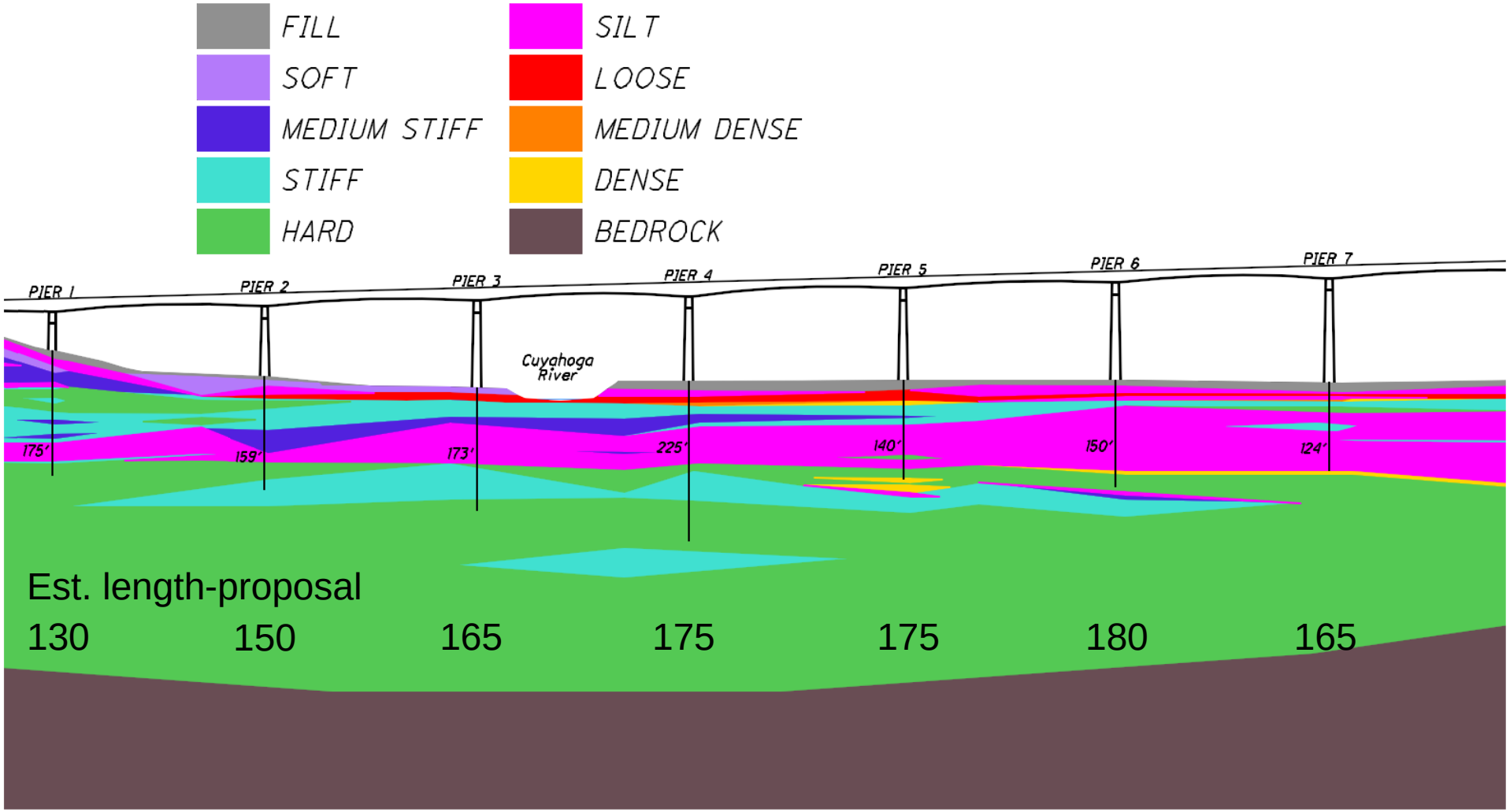


- Looks easy, right?

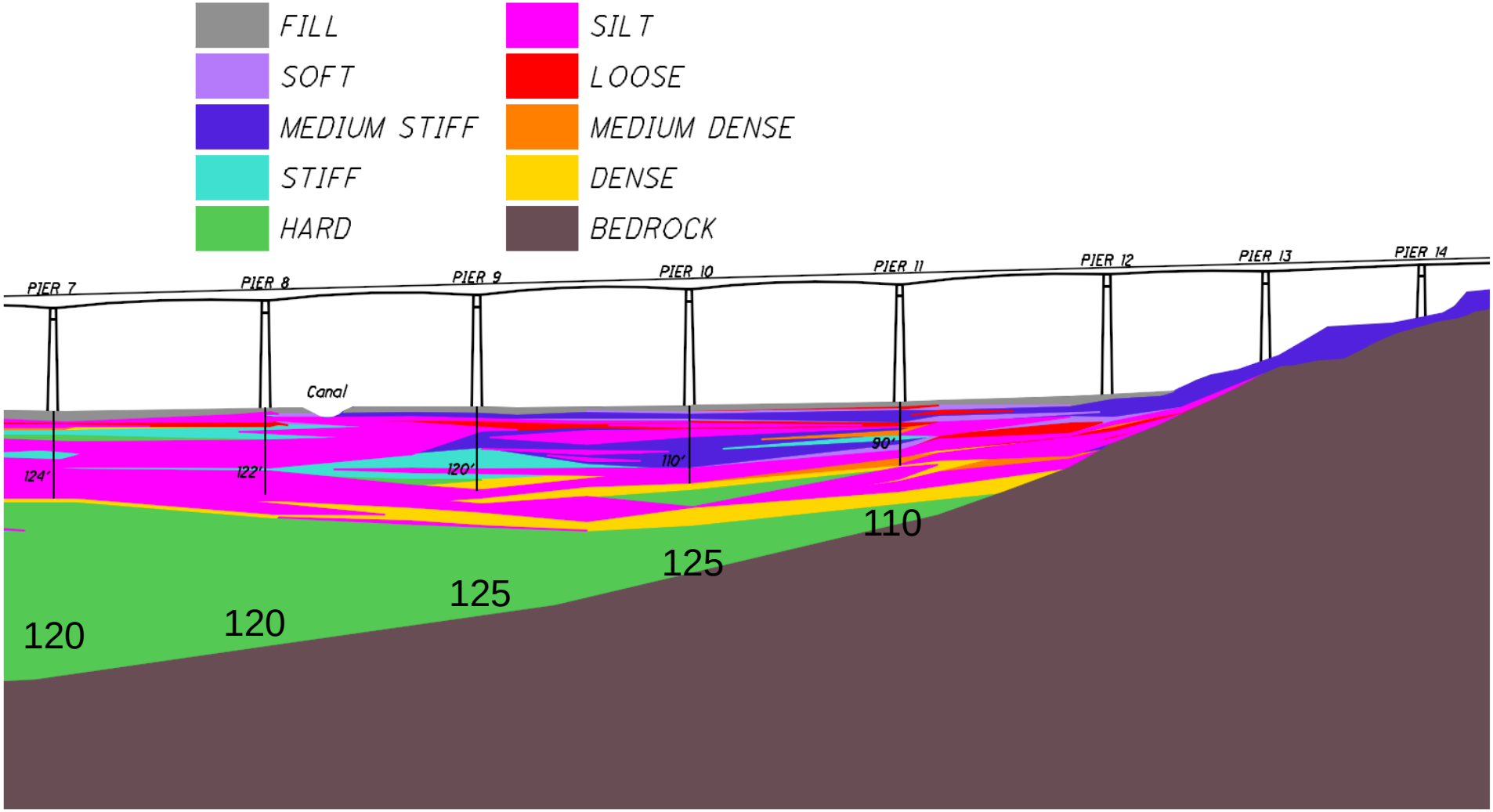
CROSS SECTION OF THE VALLEY



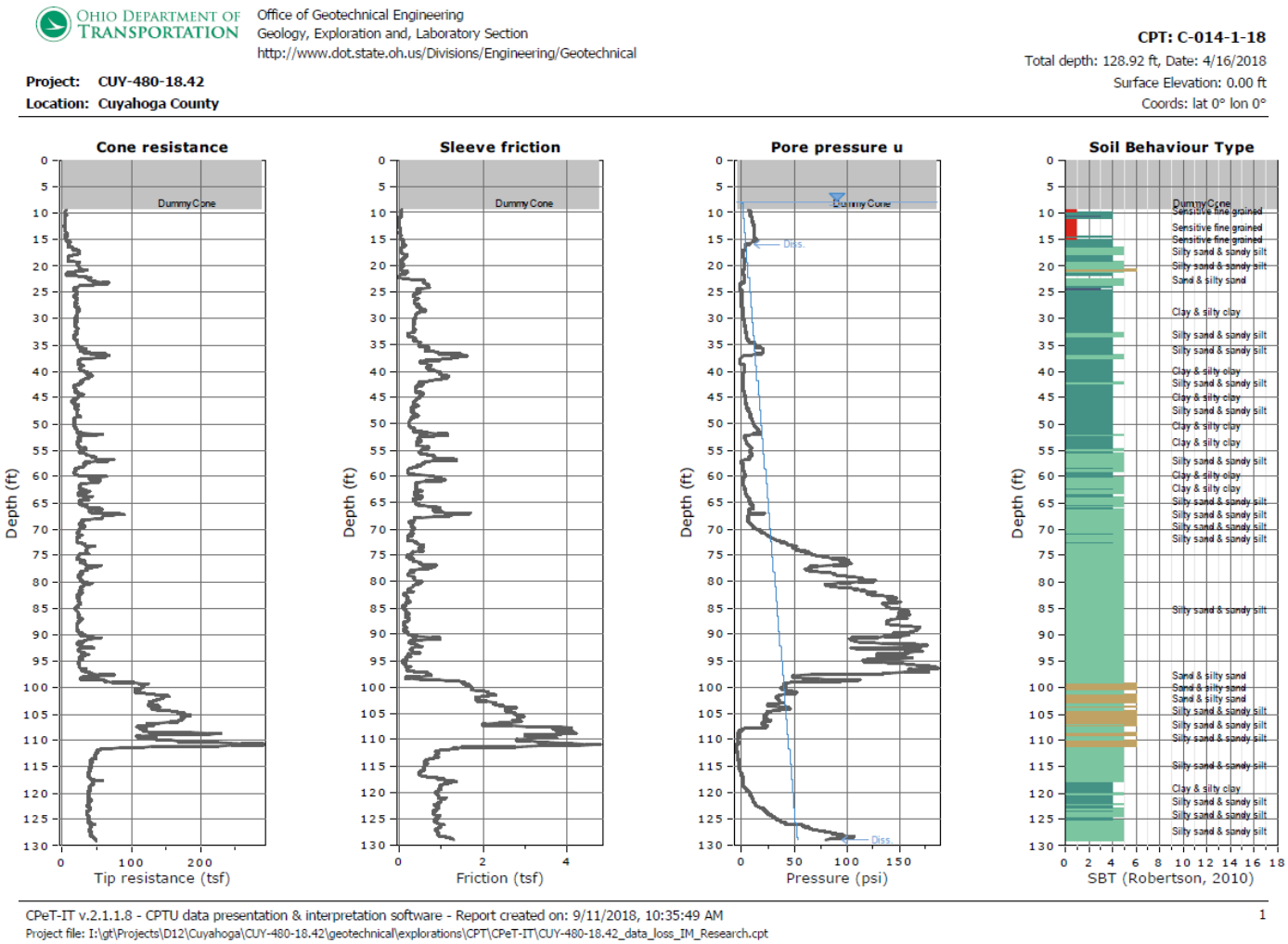
CROSS SECTION OF THE VALLEY



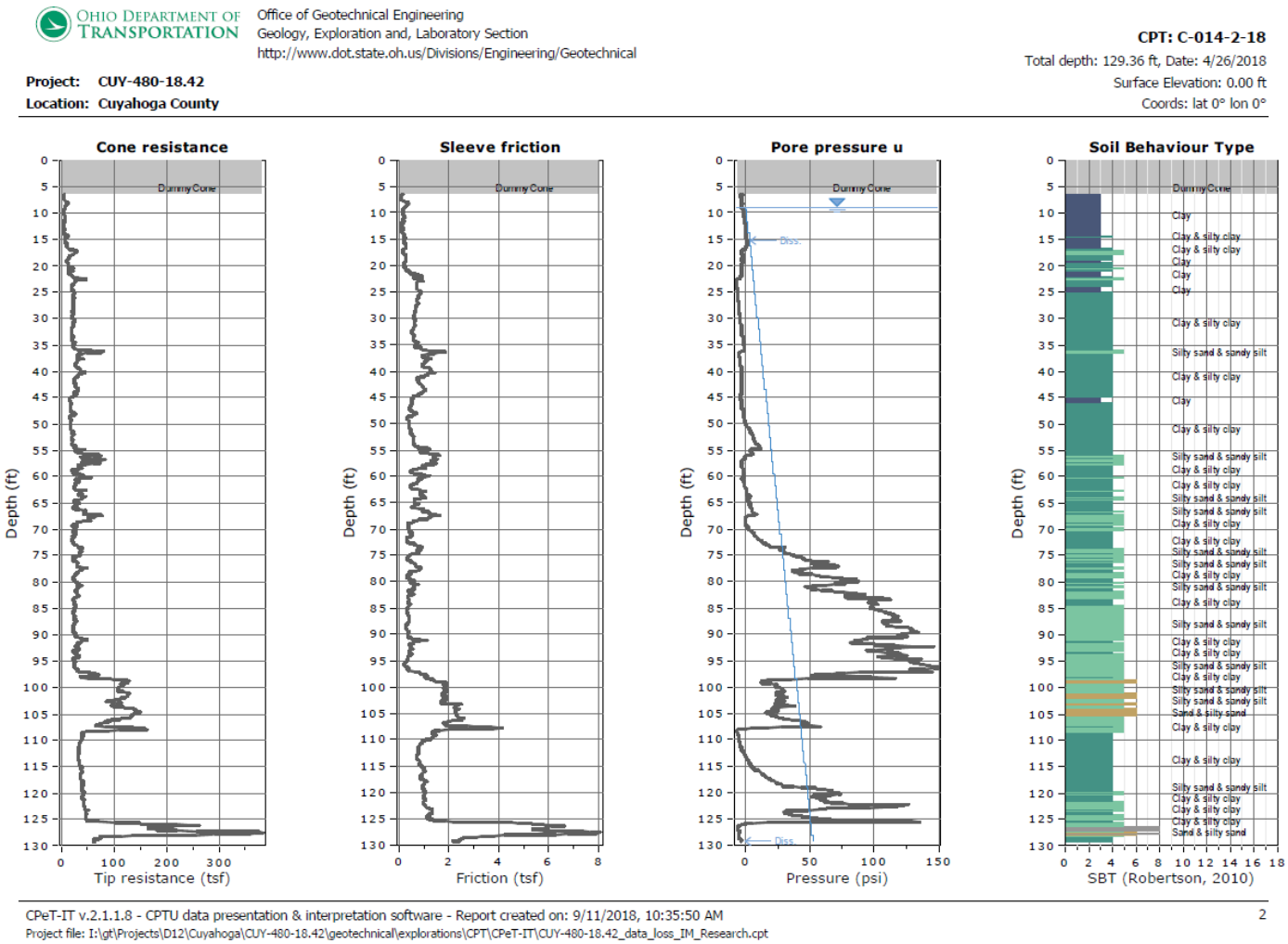
CROSS SECTION OF THE VALLEY



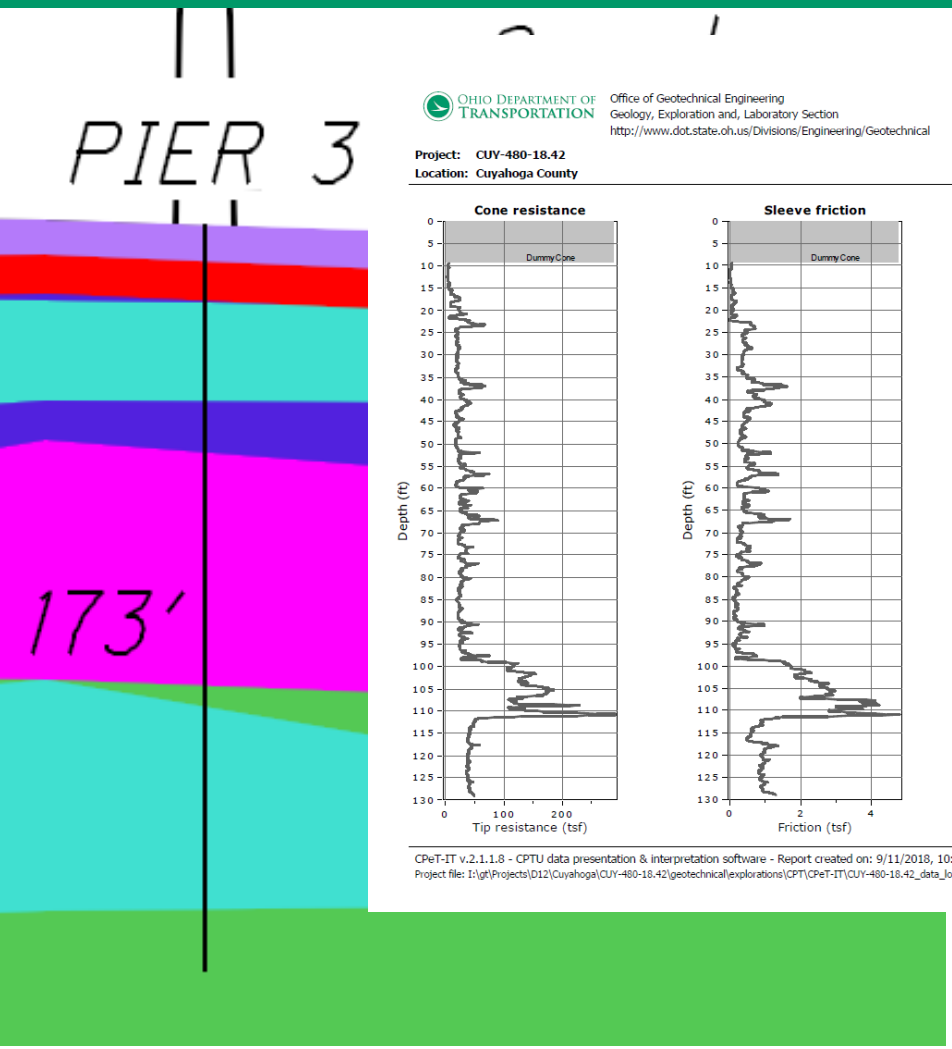
CROSS SECTION OF THE VALLEY

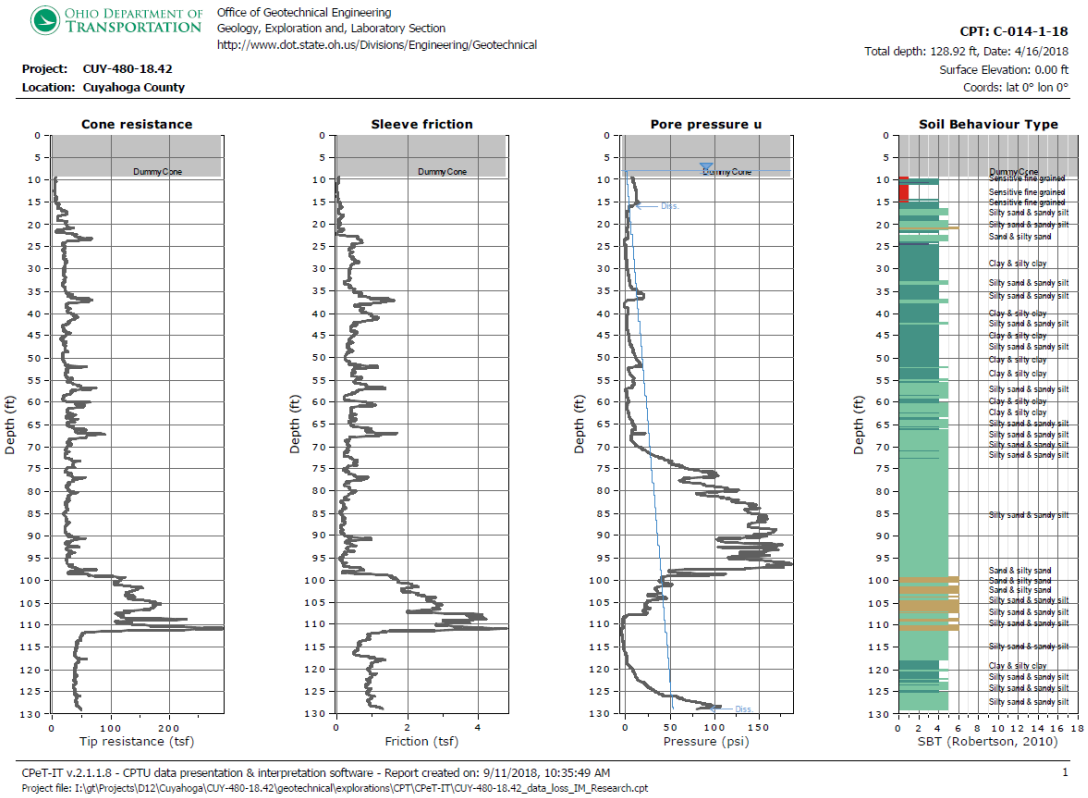


CROSS SECTION OF THE VALLEY

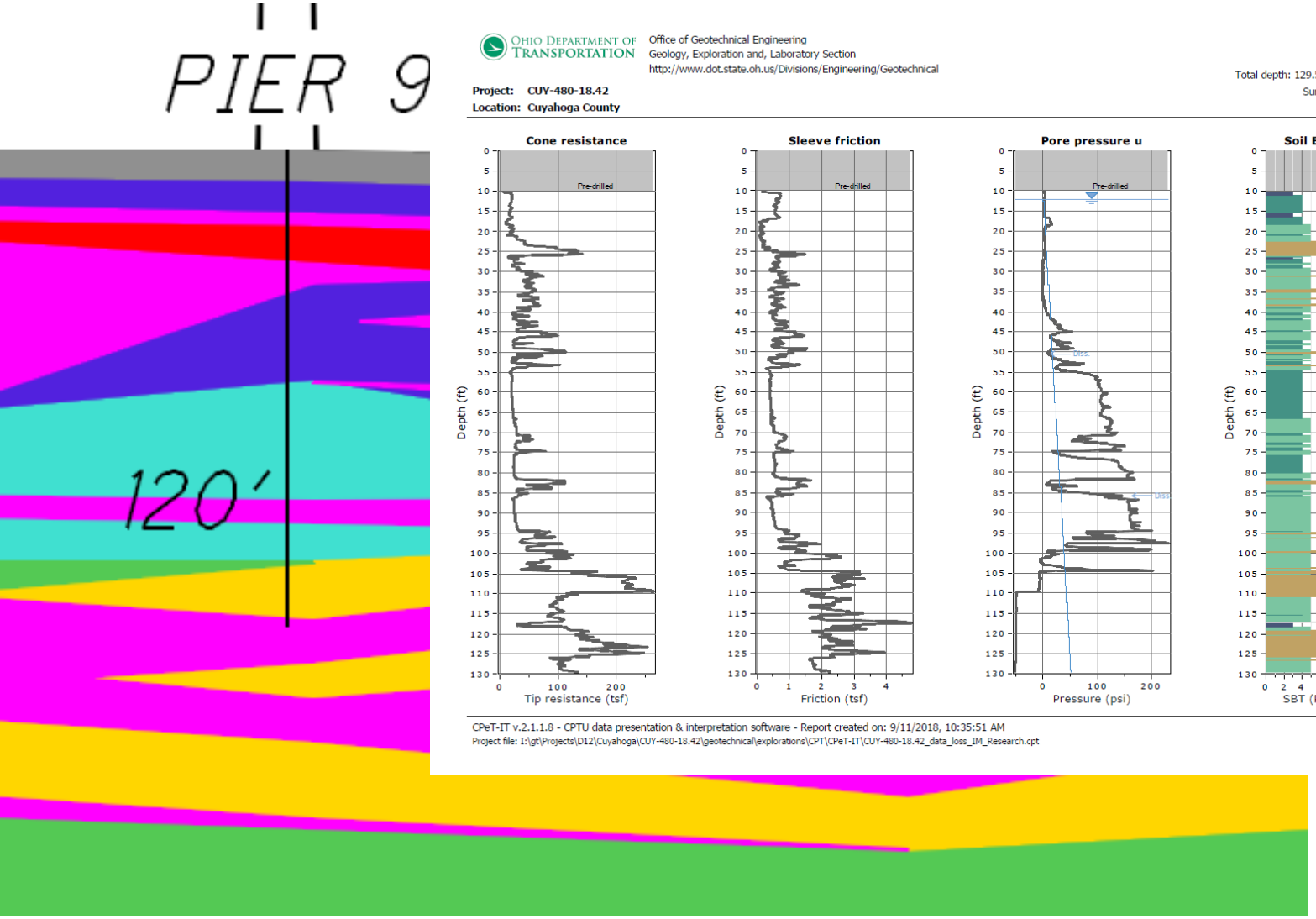


CROSS SECTION OF THE VALLEY

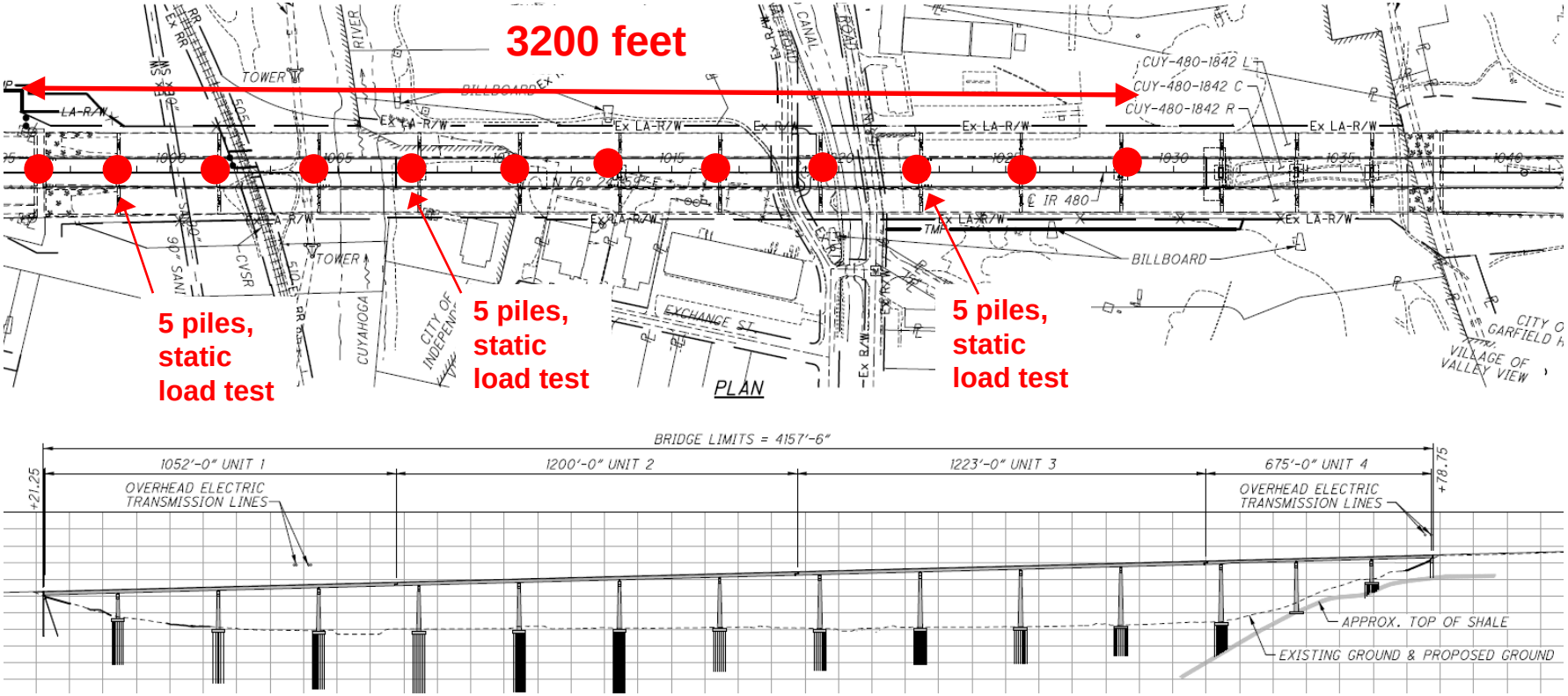




CROSS SECTION OF THE VALLEY



TEST PILE PROGRAM

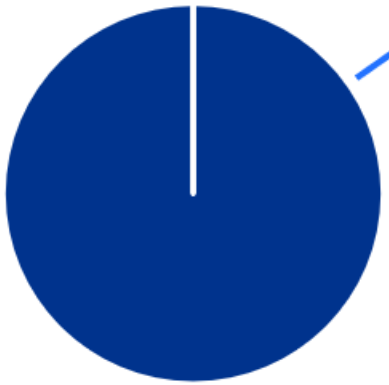


TEST PILE PROGRAM

TEST PILE PROGRAM

TEST PILE PROGRAM

End-of-Initial Drive (423 kips)



Typically,

Factored resistance = φ_{dyn} * driven resistance

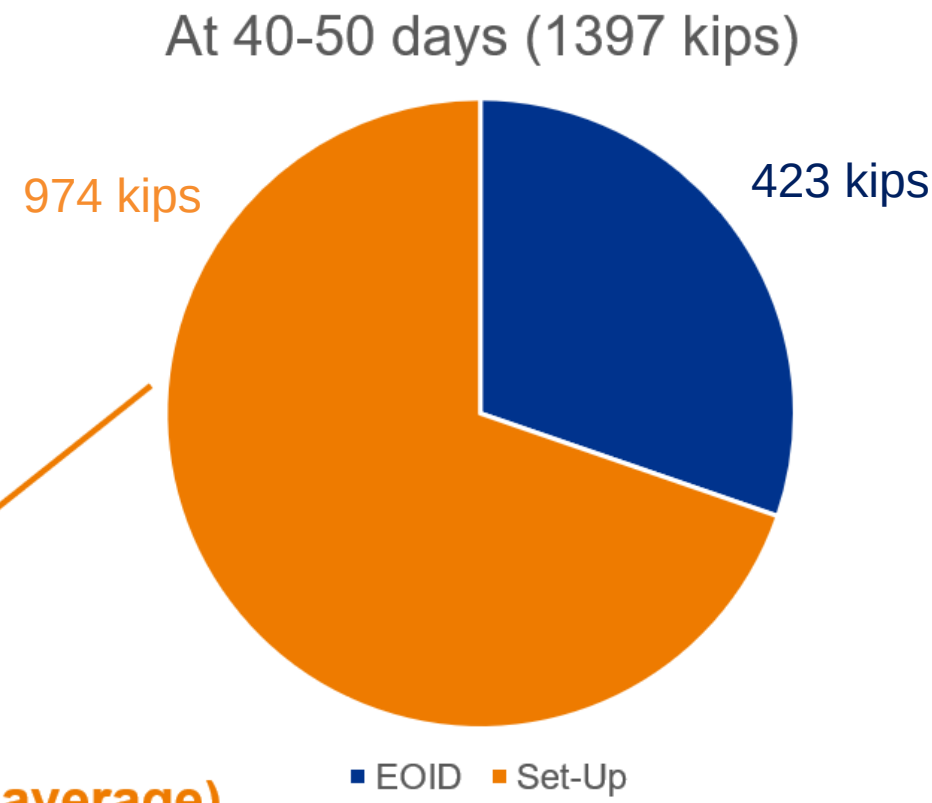
for φ_{dyn} = 0.8 (static testing, PDA),

Factored resistance = **338 kips (average)**

JACOBS

dot

TEST PILE PROGRAM



for φ_{dyn} = 0.6 to 0.7 (range)

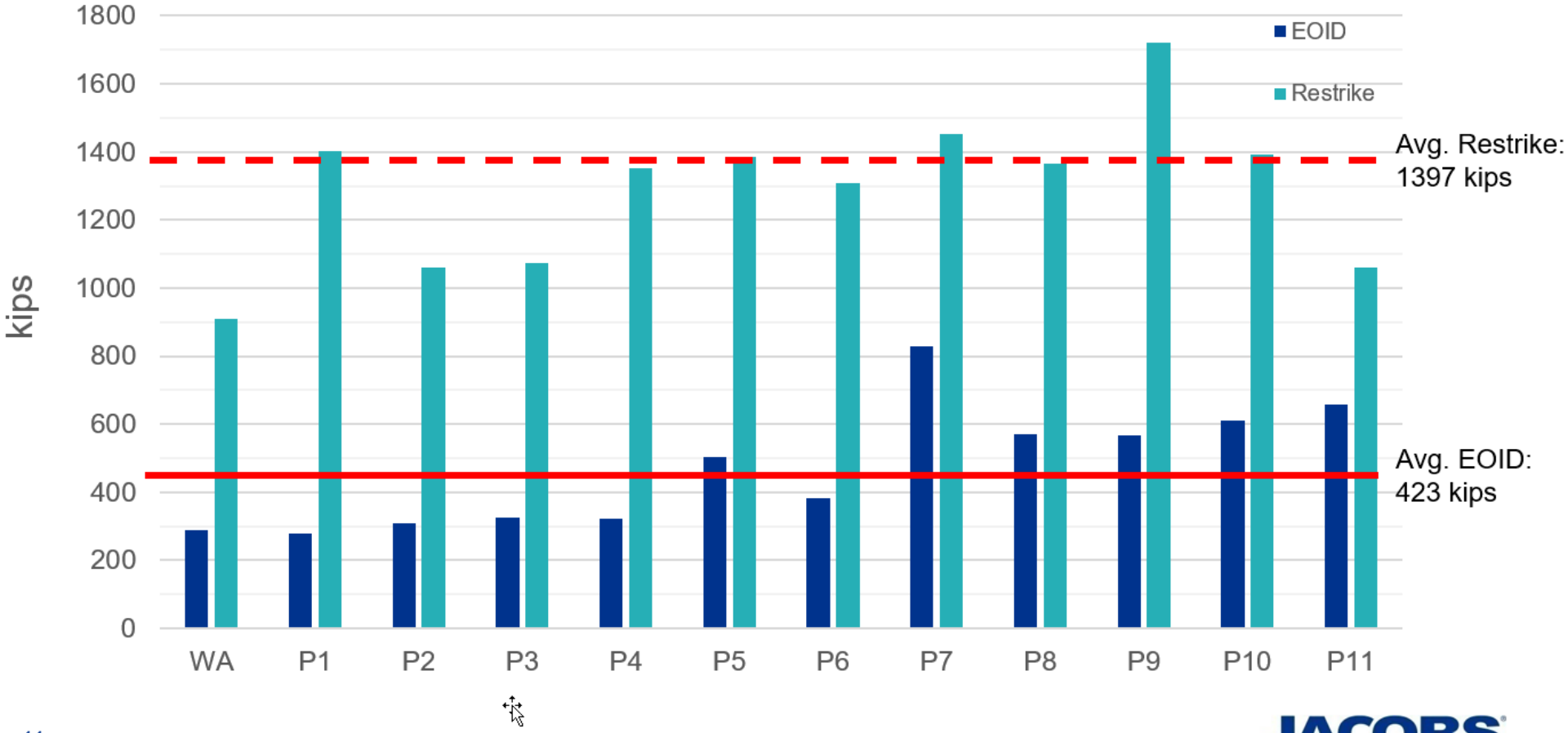
Factored resist = **838 to 978 kips (average)**

JACOBS

dot

TEST PILE PROGRAM

EOID & Restrike Capacities



11

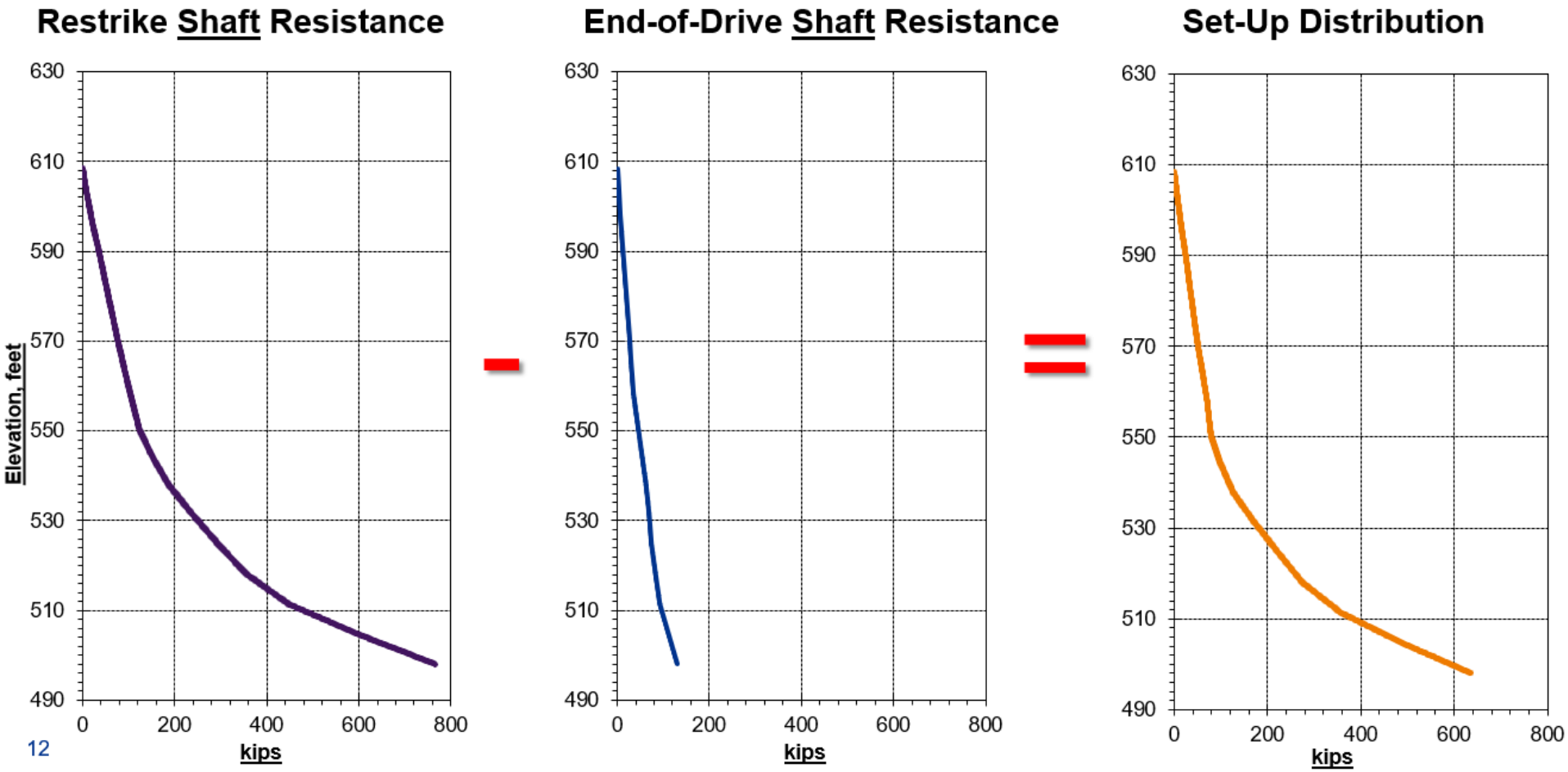
JACOBS

dot

TEST PILE PROGRAM

Unit	Pier	Pile no.	Installation			Short term restrikes (kips)					Static load test			APPLE		
			Date	Depth (ft)	Initial capacity (kips)	1-day restrike	2-day restrike	3/4-day restrike	5-day restrike	6/7-day restrike	Capacity (kips)	Date	Age (days)	Capacity (kips)	Date	Age (days)
1	RA	RA-TP	25-May	160	290	--	--	455	--	--	--	--	--	910	18-Jul	54
	1	P1-A	30-Mar	140	250	--	--	445	--	--	--	--	--	1171	18-May	49
		P1-B	30-Mar	140	280	--	--	491	--	--	--	--	--	--	--	--
		P1-C	28-Mar	175	285	--	343	--	580	--	--	--	--	1543	17-May	50
		P1-D	26-Mar	140	304	--	438	590	--	750	--	--	--	--	--	--
		P1-1	2-Apr	175	279	--	--	--	--	--	1450	15-May	43	1495	17-May	45
	2	P2-1	9-Apr	159	309	--	--	--	--	539	--	--	--	1060	18-May	39
	3	P3-1	12-Apr	173	325	--	--	--	--	493	--	--	--	1074	21-May	39
2	4	P4-A	13-Feb	179	293	--	--	--	--	1030	--	--	--	1449	5-Apr	51
		P4-B	9-Feb	225	401	--	--	594	--	--	--	--	--	1292	5-Apr	55
		P4-C	12-Feb	179	312	--	--	--	--	975	--	--	--	1405	5-Apr	52
		P4-D	7-Feb	190	234	350	--	--	634	824	--	--	--	1672	5-Apr	57
		P4-1	16-Feb	180	365	--	--	--	--	--	950	30-Mar	42	945	5-Apr	48
	5	P5-1	13-Feb	140	502	778	--	--	--	--	--	--	--	1386	4-Apr	50
	6	P6-1	14-Feb	150	381	--	764	--	--	--	--	--	--	1307	4-Apr	49
	7	P7-1	15-Feb	124	830	1051	--	--	--	--	--	--	--	1451	13-Mar	26
3	8	P8-1	6-Feb	122	570	811	--	--	--	--	--	--	--	1364	14-Mar	36
	9	P9-A	23-Jan	120	722	940	--	--	--	--	--	--	--	--	--	--
		P9-B	24-Jan	117	520	847	--	--	--	--	--	--	--	1707	9-Mar	44
		P9-C	25-Jan	112	460	--	--	--	--	--	--	--	--	1376	9-Mar	43
		P9-D	24-Jan	116	420	840	--	--	--	--	--	--	--	1716	9-Mar	44
		P9-1	25-Jan	120	710	--	--	--	--	--	1800	5-Mar	39	2081	9-Mar	43
	10	P10-1	26-Jan	110	610	--	--	851	--	--	--	--	--	1393	7-Mar	40
	11	P11-1	29-Jan	90	657	725	744	745	--	--	--	--	--	1059	7-Mar	37

Set-Up Calculation



TEST PILE PROGRAM

- ODOT Misconception
  - Test pile program would create a family of curves
  - Production EOID and restrike results would be compared to family of curves
  - Pick a matching curve
- The indicator test pile at each pier is the curve

TEST PILE PROGRAM

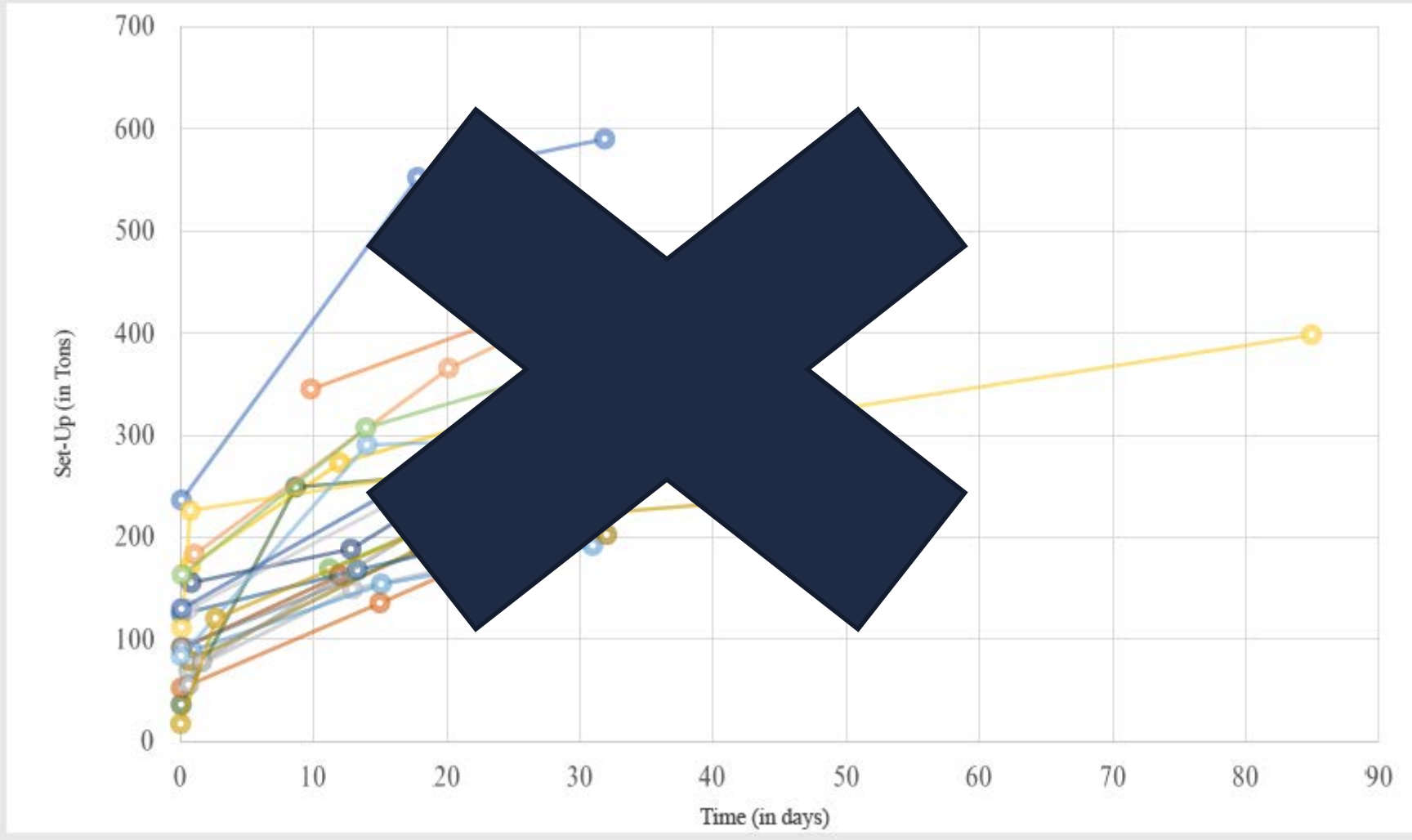
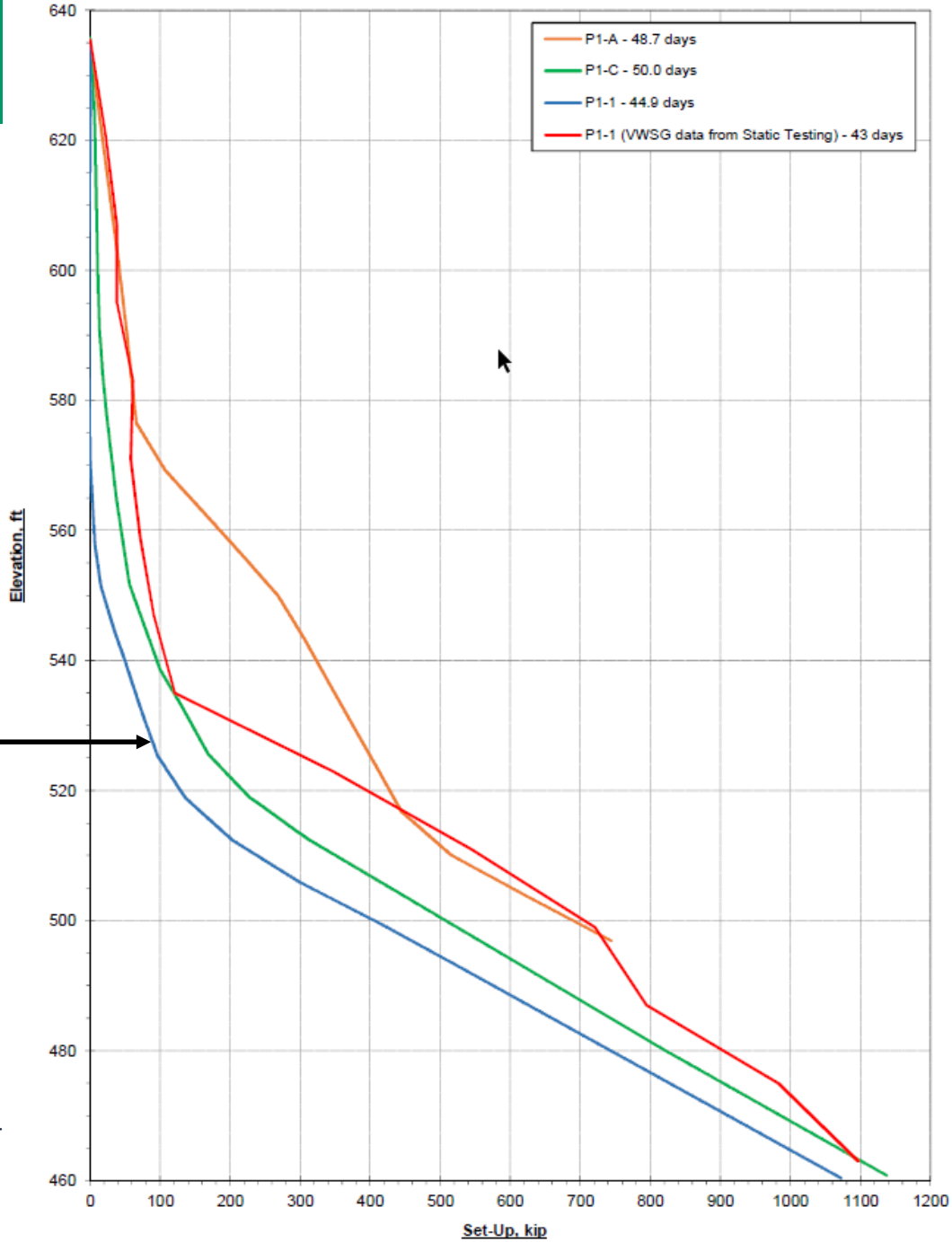


Figure 2- Cumulative Set-Up vs. Elevation - Pier 1

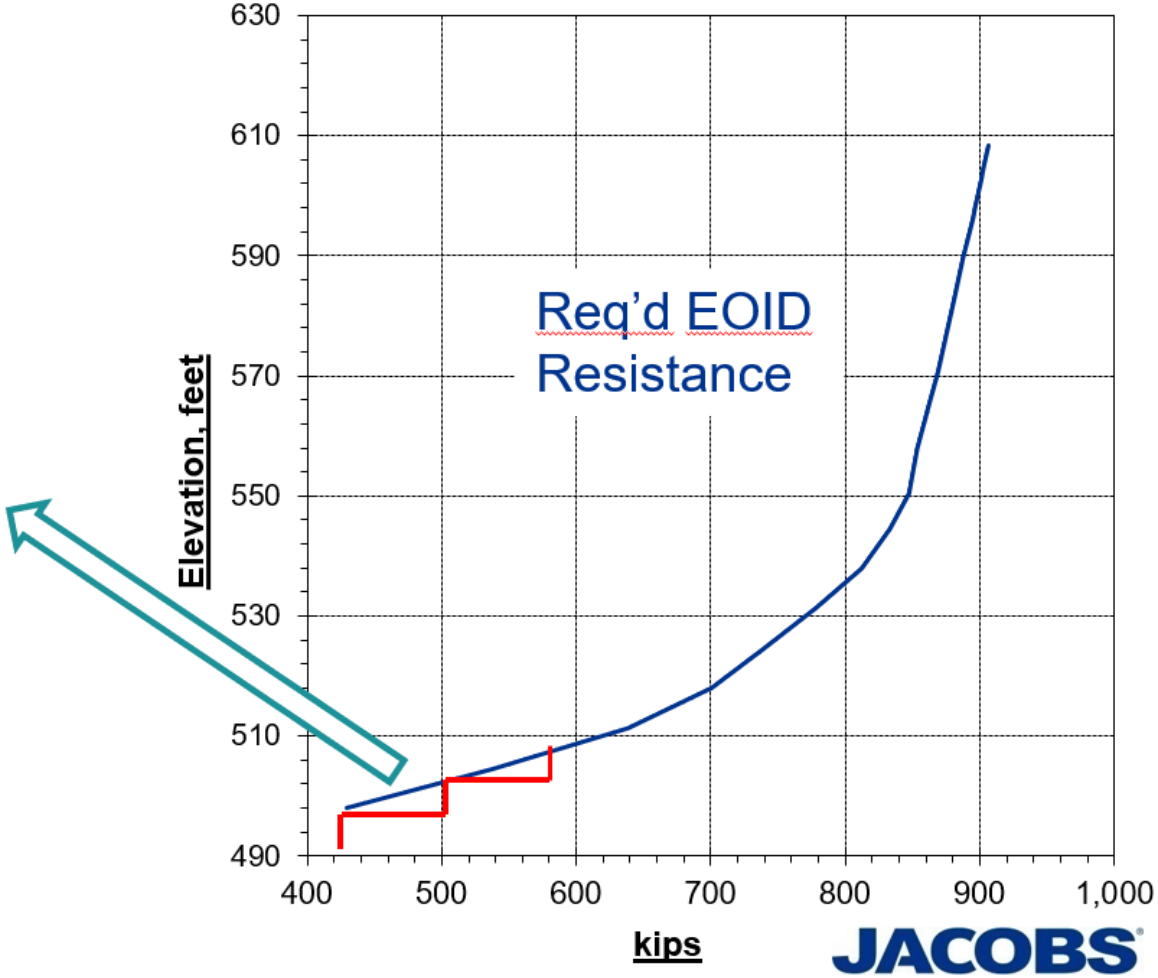


Pick the lowest

TEST PILE PROGRAM

Depth-Variable Penetration Resistance Criteria

Pile Toe Depth, feet		Average Hammer Stroke, feet				
from	*to*	**9.0**	**9.5**	**10.0**	**10.5**	**11.0**
102	*105*	82	62	48	39	33
105	*108*	43	35	29	25	22
108	--	25	21	18	16	15



16

TEST PILE PROGRAM

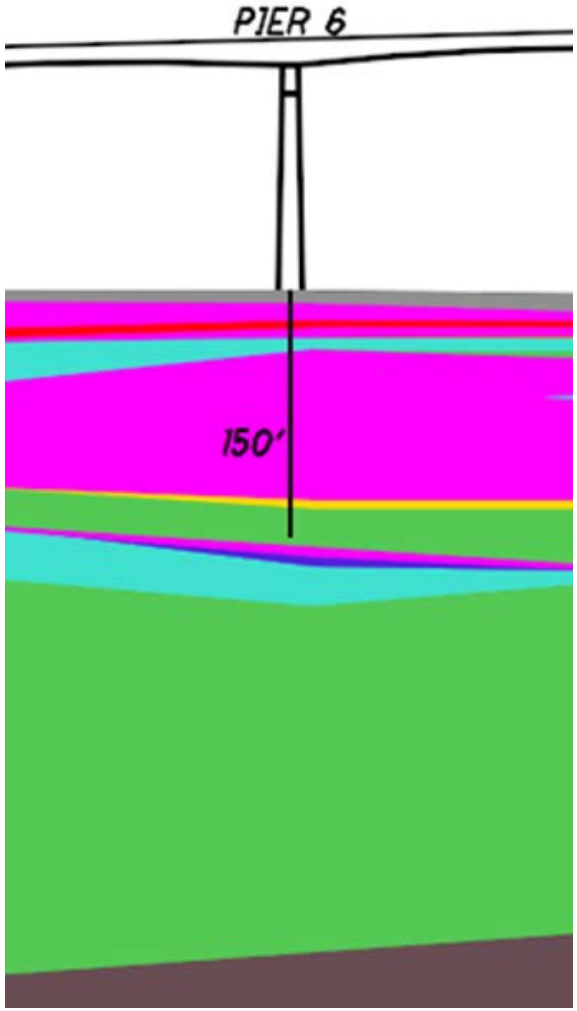
- Resistance factor for set-up
  - 0.45 mentioned in proposal
  - 0.65 proposed in test program
  - 0.55 proposed by ODOT
  - Settled on 0.6
- Factored resistance between 700-800 kips

CUY-IR480-1842 – PILE SET-UP

CUY-IR480-1842 - PILE SET-UP

CUY-IR480-1842 – PILE SET-UP

- Recent challenge – refusing above high set-up layer



PILE SET-UP RESEARCH

- Prediction methodology for the magnitude of setup/driving loss
  - Literature search
  - Collect historic restrike data
  - Identify different geologic conditions
  - Interim Report
  - Collect active pile load test data
  - Correlate setup behavior to soil properties
  - Develop formulae to predict pile setup.

PILE SET-UP RESEARCH

PILE SET-UP RESEARCH

CUY-IR480-1842 - PILE SET-UP