Difference between Design of Upland Disposal Sites and Marsh Creation Sites

Upland Disposal Sites

- US Army Corps of Engineers is responsible for the dredging and disposal of large volumes of dredged material each year.
- Dredging of sediments from streams, rivers, lakes and coastal waters
- Published data readily available
- Engineering Manuals
  - Dredging and Dredge Material Management EM 1110-2-5025
  - Confined Disposal for Dredged Material EM 1110-2-5027
  - Technical Report GL-86-13

Upland Disposal Sites

Purpose	Predominantly for disposal of material from maintenance dredging
Location	Typically along a river, streams, lakes and coastal waters
Requirements	Engineered structures designed to provide required storage volume and have stringent regulations on effluent during and after construction
Planning and Design	Account for containment dikes for long-term storage of material
	Account for material sedimentation and consolidation/dewatering behavior and potential consolidation of foundation soils.
	Weir design and location, effects of area size and shape, and use of interior spur dikes; Effluent flow rate is typically equal to influent flow rate to maintain a continuously operating disposal area. 1 to 2 grams per liter.

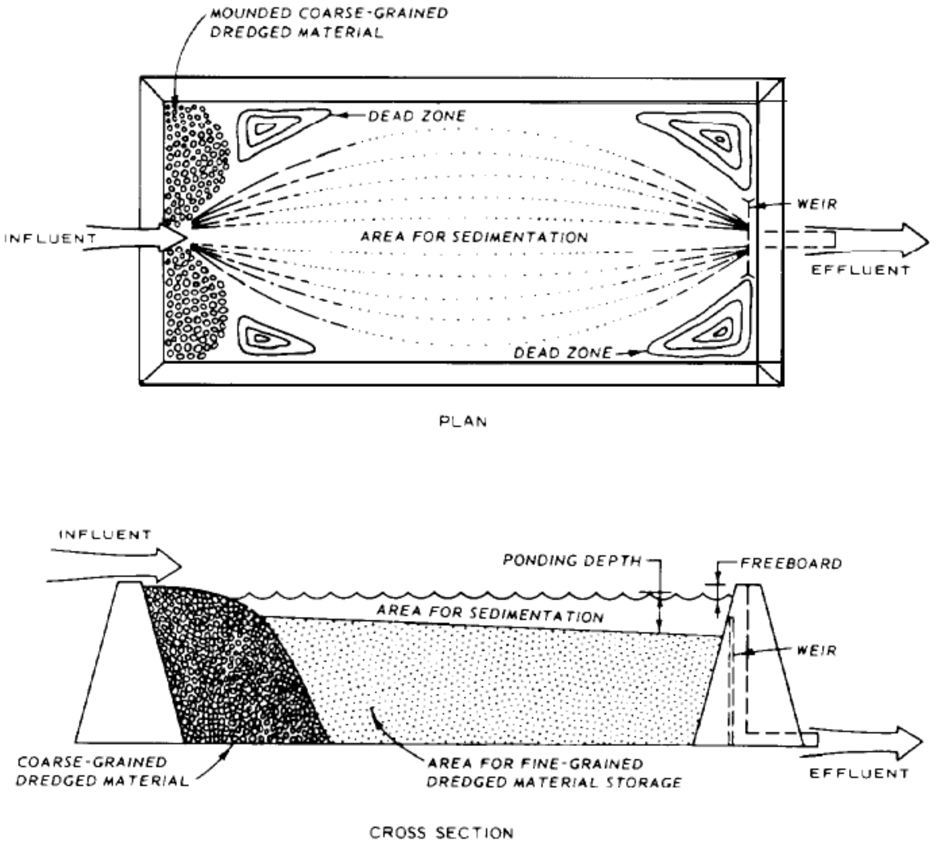


Figure 1-1. Conceptual diagram of a dredged material containment area

Settling Stages:

Discrete settling - Particle maintains individuality and does not change in size, shape or density during the settling process

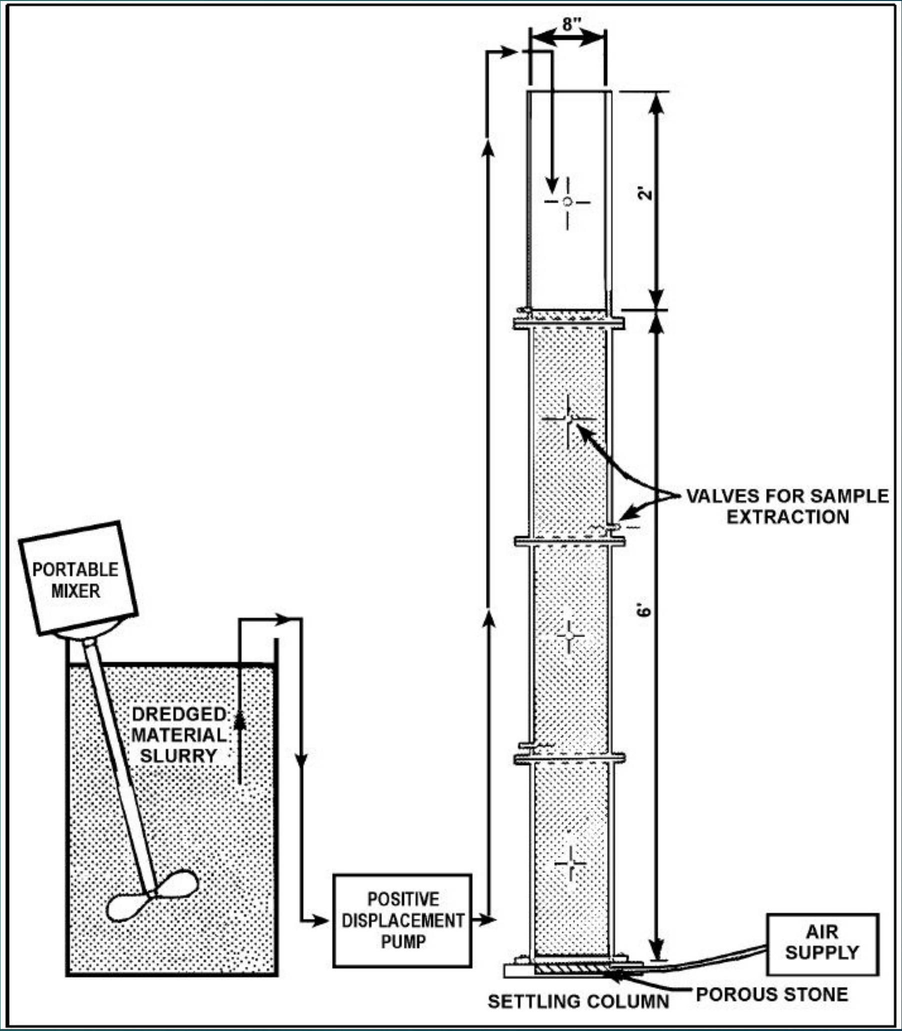
Flocculent settling - Particles agglomerate during the settling period with change in physical properties and settling rate

Zone settling - Flocculent suspension forms a lattice structure and settles as a mass. The high solids concentration partially blocks the release of water and hinders settling of neighboring particles. A distinct interface between the slurry and the supernatant water is exhibited during the settling process

Compression settling - Settling occurs by compression of the lattice structure – Density increase occurs

Settling Column Test (EM 1110-2-5027)

- Summary:
- Equipment
  - 8-inch diameter Plexiglas tubing
  - Sectioned with ports for extraction (0.5 ft)
  - Airstone for agitation
- Sample
  - Fine grained material
  - Approximately 15 gallons of sediment
  - Water in-situ
- Pilot Test
  - Graduated cylinder (4 liter capacity)
  - 150 grams/liter concentration
  - Interface within first few hours to a day – Zone settling
  - No interface within first day – Flocculent settling



Settling column test contd.

- Testing Procedure:
  - Mix slurry and pour/pumping
  - Agitate while pouring
  - Interface not formed first day – perform flocculent settling test
    - Withdraw samples at regular time intervals and determine suspended solids concentrations.
    - 1, 2, 4, 6, 12, 24, 48 hrs, etc. until an interface forms and fluid above interface has solids concentration of 1 gram per liter.
    - 50-milliliter sample from each port.
  - Zone settling test
    - Fall of liquid-solid interface with time
    - Plot depth to interface vs time
    - Slope of constant velocity settling zone is zone settling velocity (function of initial slurry concentration)

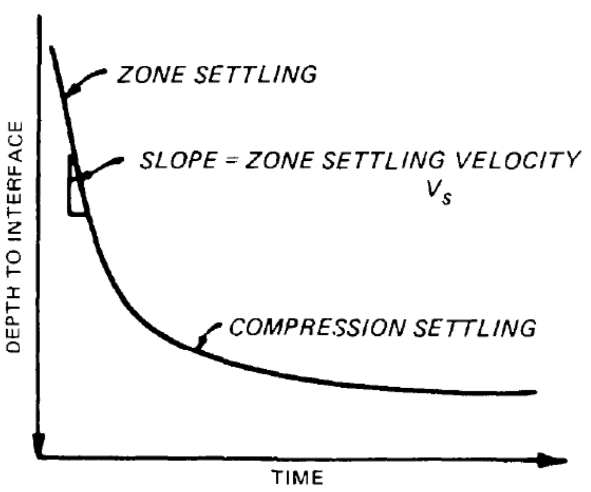


Figure 3-4. Conceptual plot of interface height versus time

SETTLING COLUMN TEST CONTD.

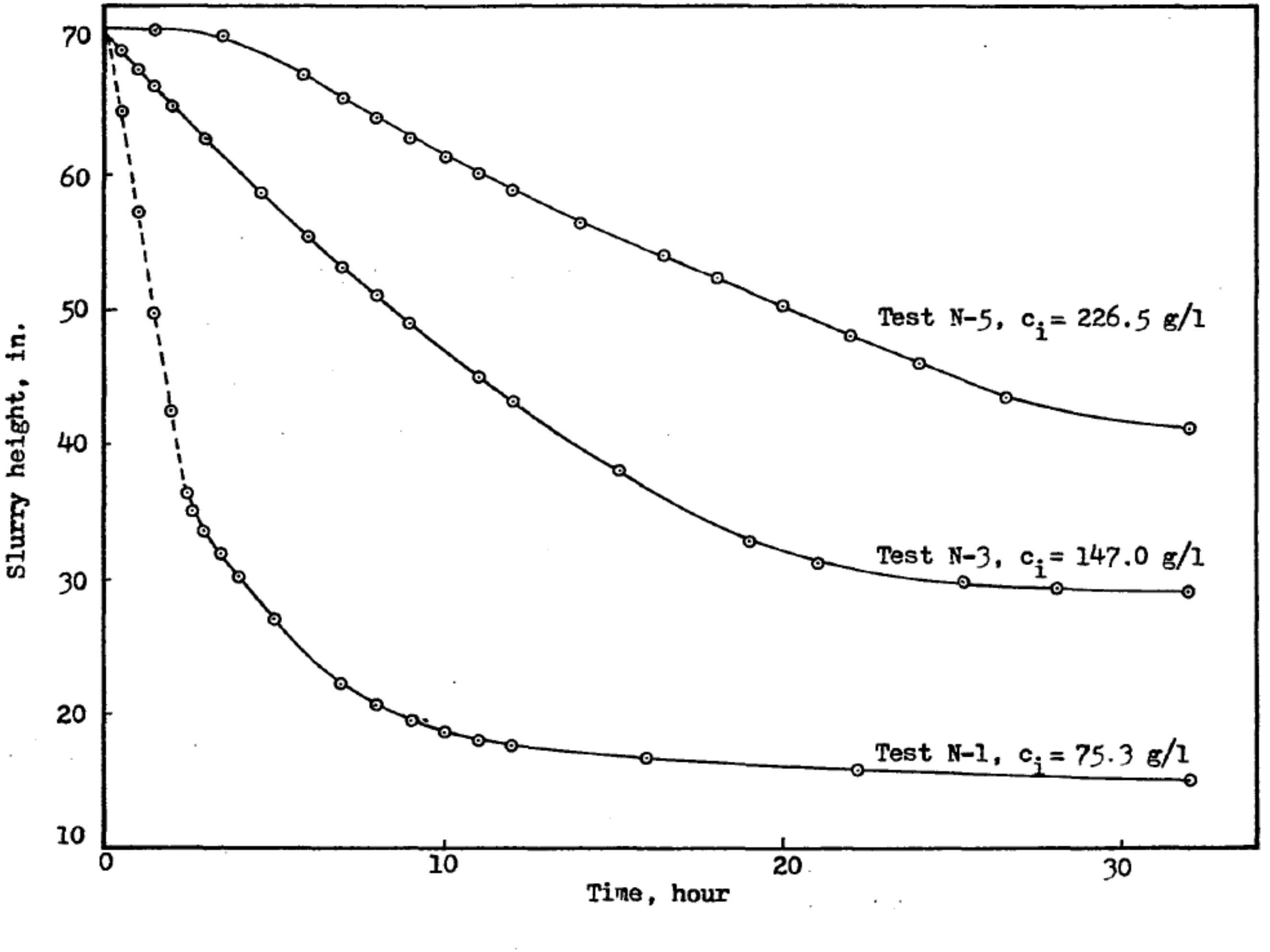
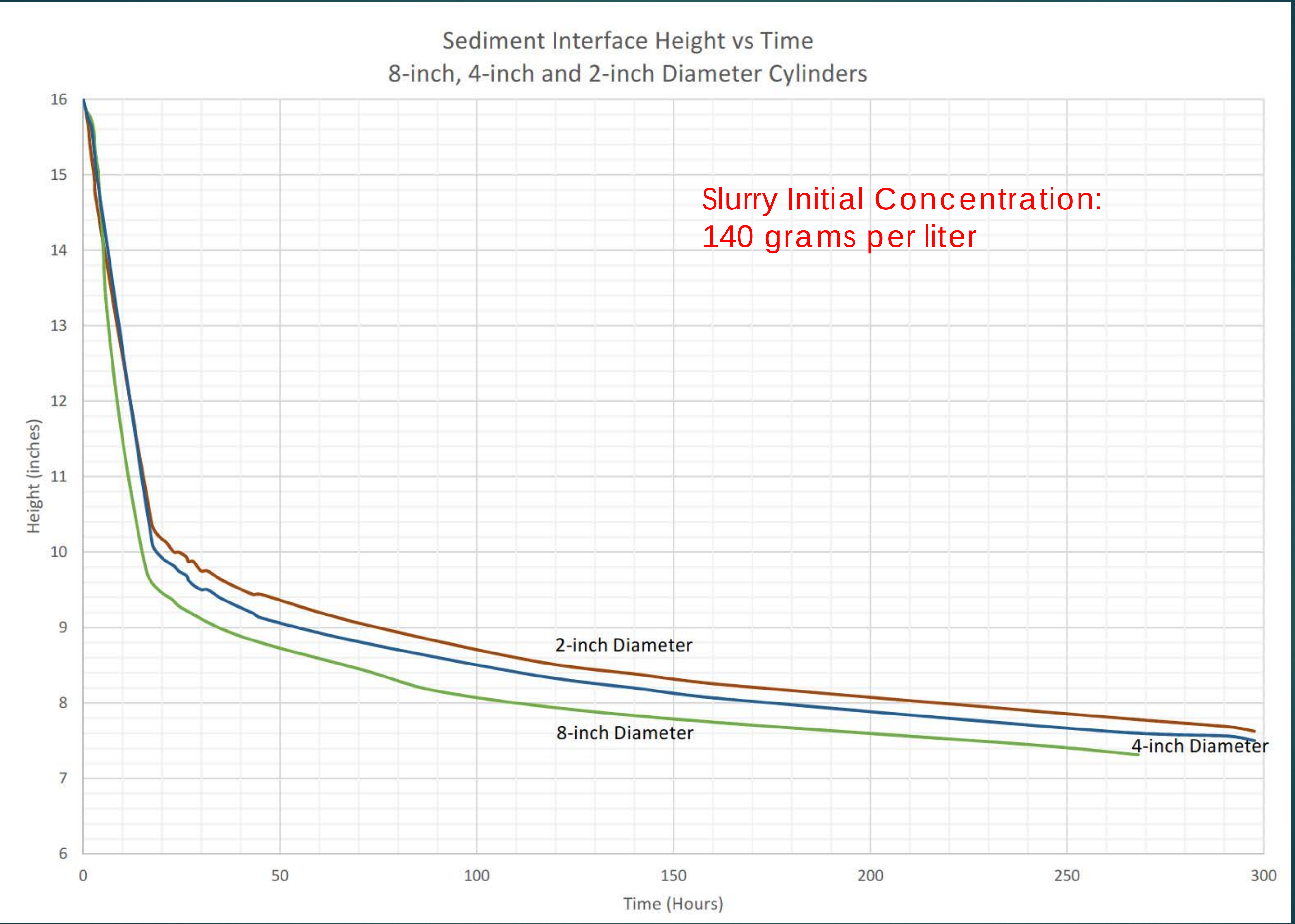
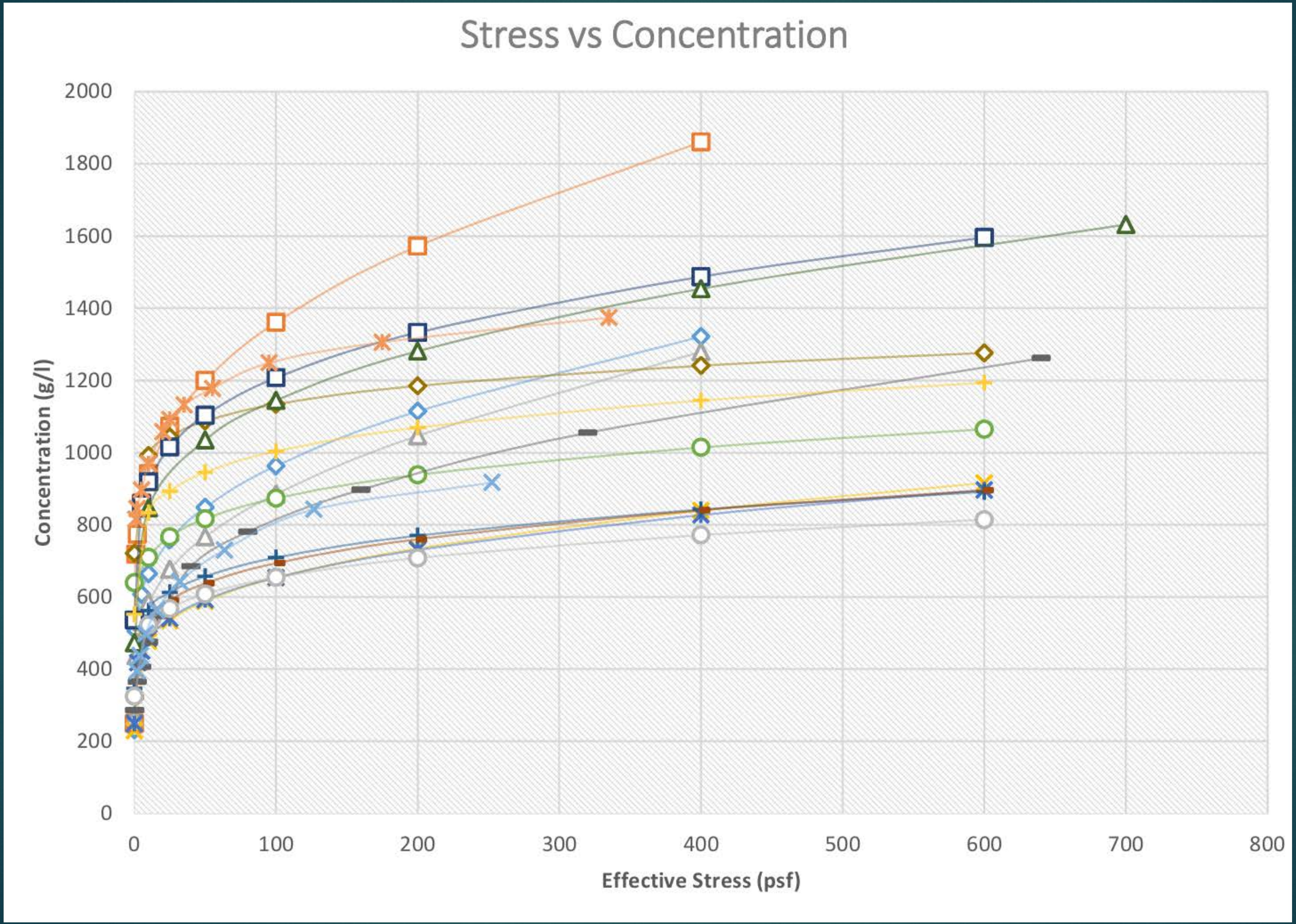


Figure 3.4. Comparison of settling behaviors of slurry at different initial concentrations

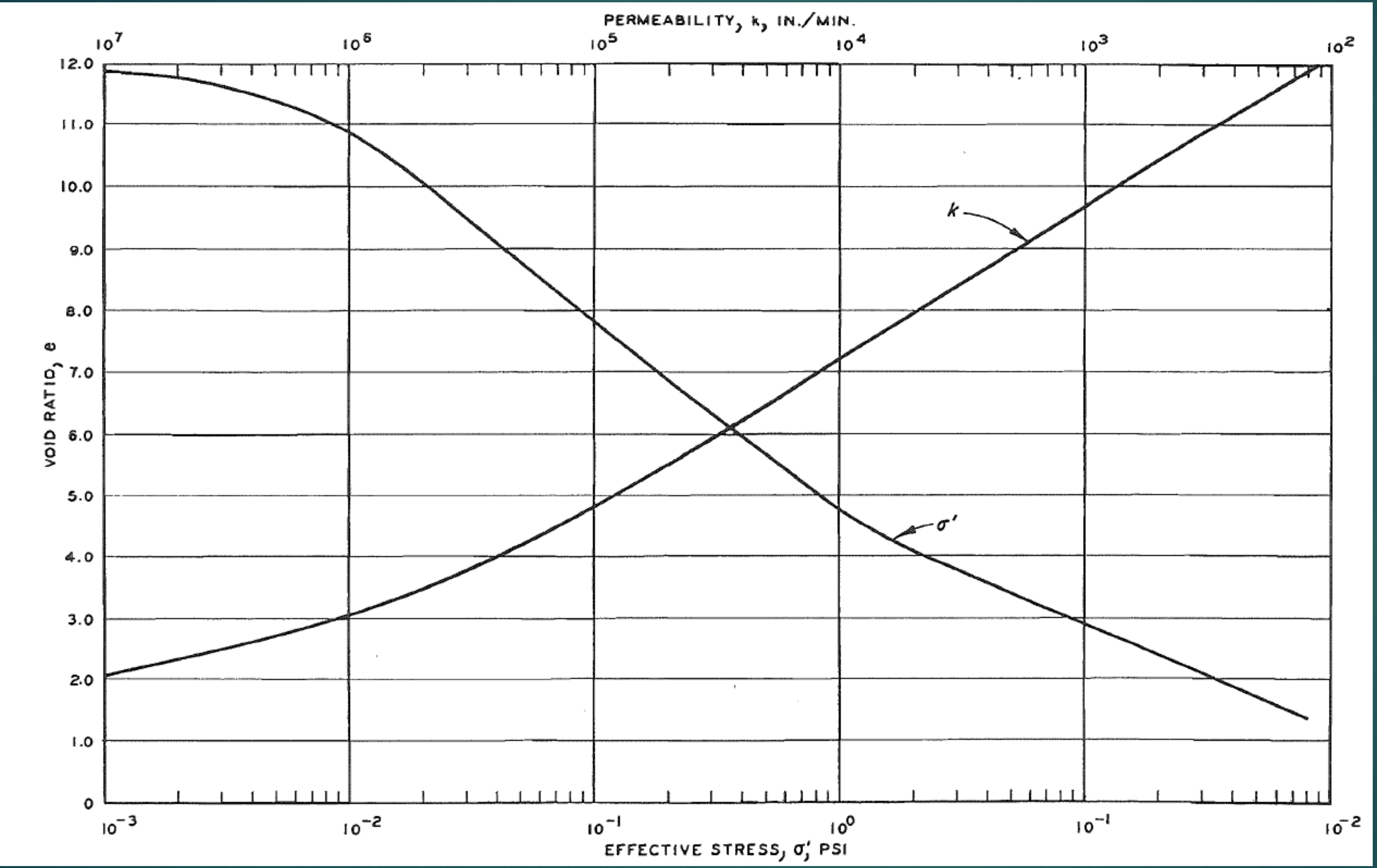
Reference: Lin, Tso-Wang, "Sedimentation and self weight consolidation of dredge spoil" (1983). Retrospective Theses and Dissertations. Paper 7643.



Sediment Interface Height vs Time
8-inch, 4-inch and 2-inch Diameter Cylinders
Slurry Initial Concentration:
140 grams per liter
2-inch Diameter
8-inch Diameter
4-inch Diameter
Height (inches)
Time (Hours)
16
15
14
13
12
11
10
9
8
7
6
0
50
100
150
200
250
300


Stress vs Concentration
Concentration (g/l)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
600
700
800
Effective Stress (psf)

Permeability, Void Ratio and Stress



Reference: USACE Technical Report GL-86-13

Marsh Creation Sites

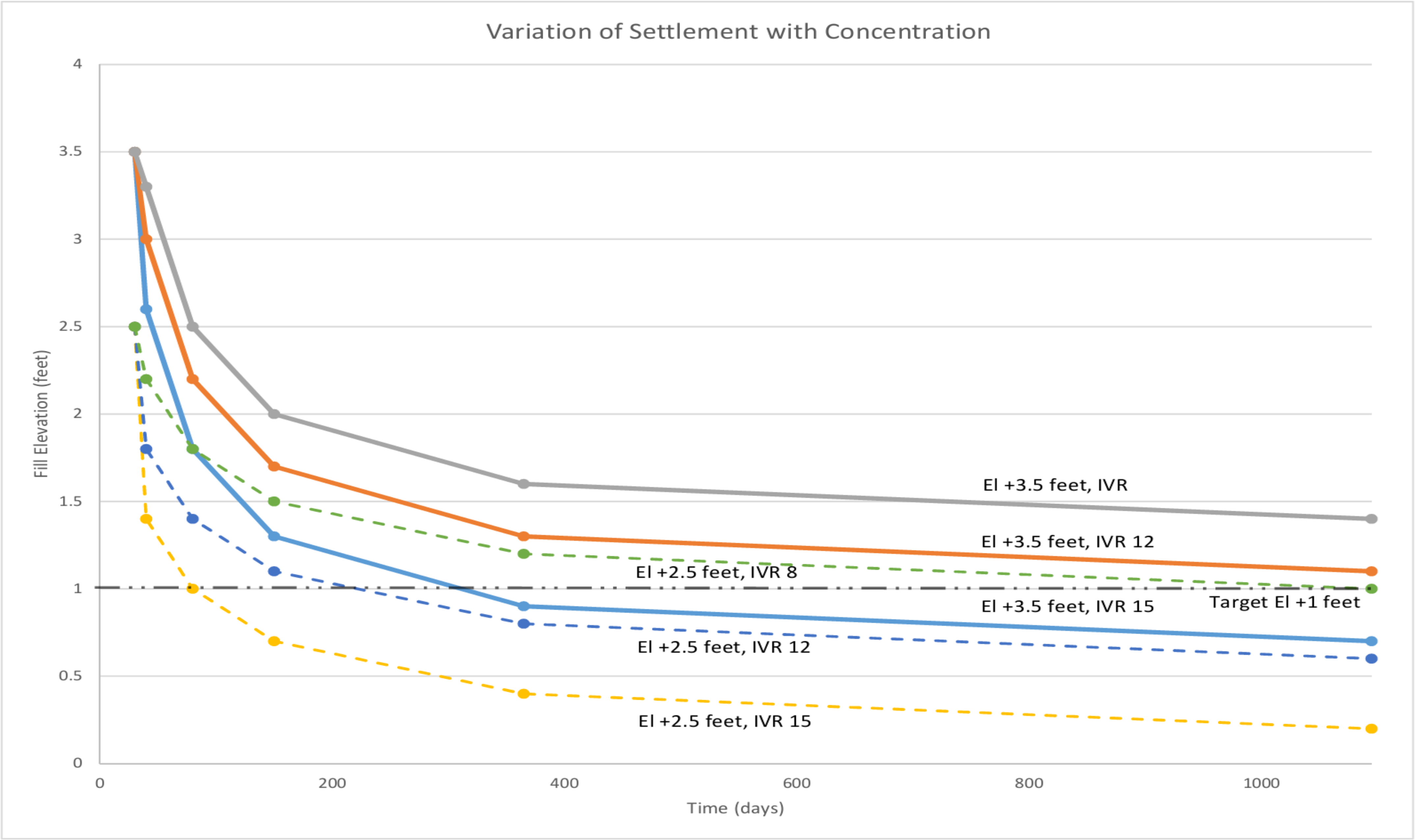
Purpose	Predominantly involves re-building subsided/eroded marsh areas
Location	Coastal areas
Requirements	Engineered areas designed to re-build habitat and sustain growth; Over flow of material is planned to provide nourishment to surrounding areas.
Planning and Design	Account for containment dikes (if any) for short-term retention of material; Limitations to the height to which dikes are constructed.
	Account for dredged material flocculation and consolidation/dewatering behavior and potential consolidation of foundation soils
	Weir design completed by contractor, shape, size and interior dikes based on contractors experience and design

Are we on the right track?

- Based on marsh creation projects constructed to date, there appears to be a gap between the design and the performance of the marsh
- Fill quantity estimates during design and construction are some times varying by an order of magnitude
- Often times the fill is at higher elevation than what it was designed
- There appears to be more area nourished than initially planned for during design

Why the Discrepancy???

Multiple Ways to Skin a Cat:



Factors Influencing Behavior of Fill

- There are numerous factors that influence the behavior of fill including, but not limited to:
  - Borrow material type (sand, silt, clay, organics, shell etc.)
  - Grain size distribution
  - Material properties
  - Horsepower of dredge and boosters
  - Duration of construction
  - Production rate and pipe diameter
  - Concentration of fill
  - Mudline elevation

- Given the current contracting methods, the best that can be provided during the design stage is a range for settlement during and after construction.

CPRA - Marsh Creation Design Guidelines

- Based on numerous marsh creation projects completed by CPRA, we have estimated a slurry concentration that takes in to account the efficiency of the dredge

Concentration of Slurry Based on Specific Gravity of Slurry

SLURRY CONCENTRATION BY VOLUME (PHASE DIAGRAM)

Specific Gravity of Slurry [SG_{SL}]	Specific Gravity of Solids [SG_S]	Concentration of Solids [C_S]	Volume of Solids (liter) [V_S]	Volume of Water (liter) [V_W]	Density of Saltwater (grams per liter) [ρ_W]	Weight of Water (grams) [W_W]	Weight of Solids (grams) [W_S]	Concentration of Slurry (grams per liter) [C_{SL}]
1.10	2.72	0.058	0.058	0.942	1020	960.70	161.30	**161**
1.15	2.72	0.087	0.087	0.913	1020	931.05	241.95	**241**
1.23	2.72	0.134	0.134	0.866	1020	883.60	371.00	**371**
1.25	2.72	0.145	0.145	0.855	1020	871.74	403.26	**403**
1.30	2.72	0.174	0.174	0.826	1020	842.09	483.91	**483**
1.35	2.72	0.203	0.203	0.797	1020	812.44	564.56	**564**
1.40	2.72	0.233	0.233	0.767	1020	782.79	645.21	**645**

SLURRY CONCENTRATION BY WEIGHT (PHASE DIAGRAM)

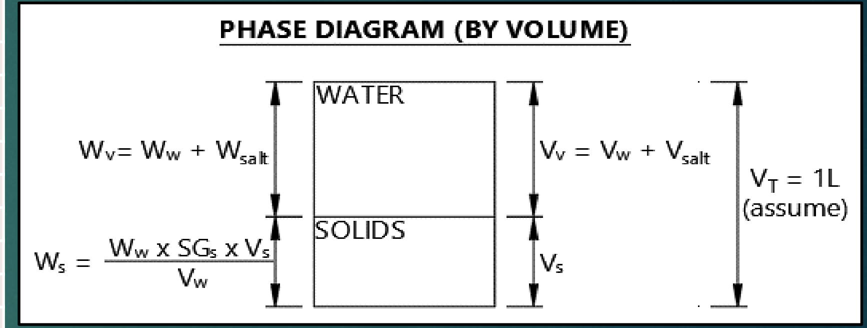
Specific Gravity of Slurry [SG_{SL}]	Specific Gravity of Solids [SG_S]	Concentration of Solids [C_S]	Weight of Solids (grams) [W_S]	Weight of Water (grams) [W_W]	Density of Saltwater (grams per liter) [ρ_W]	Volume of Water (liter) [V_W]	Volume of Solids (liter) [V_S]	Concentration of Slurry (grams per liter) [C_{SL}]
1.10	2.72	0.144	143.76	856.24	1020	0.839	0.052	**161**
1.15	2.72	0.206	206.27	793.73	1020	0.778	0.074	**241**
1.20	2.72	0.264	263.57	736.43	1020	0.722	0.095	**371**
1.25	2.72	0.316	316.28	683.72	1020	0.670	0.114	**403**
1.30	2.72	0.365	364.94	635.06	1020	0.623	0.132	**483**
1.35	2.72	0.410	409.99	590.01	1020	0.578	0.148	**564**
1.40	2.72	0.452	451.83	548.17	1020	0.537	0.163	**645**

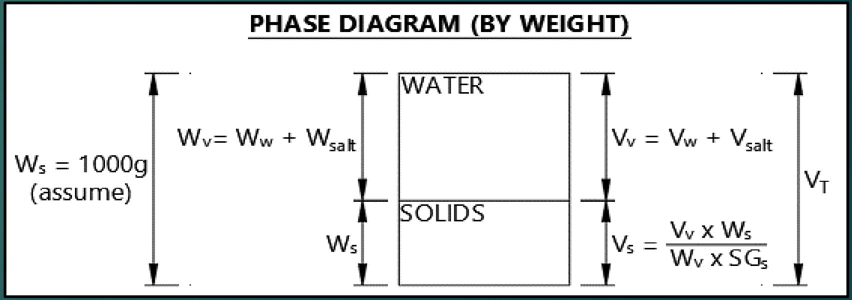
REFERENCES:

1 Confined Disposal of Dredged Material. Corps of Engineers Washington Dc, 1987.

2 Slurry Handbook. Flygt, www.hidrotecaguas.com/catalogos/Bombas_para_liquidos_abrasivos.pdf

3 The Discharge Pipeline - Slurry Density. Willard Says......, 2010, www.willardsays.com/dredge_discharge_density.pdf.

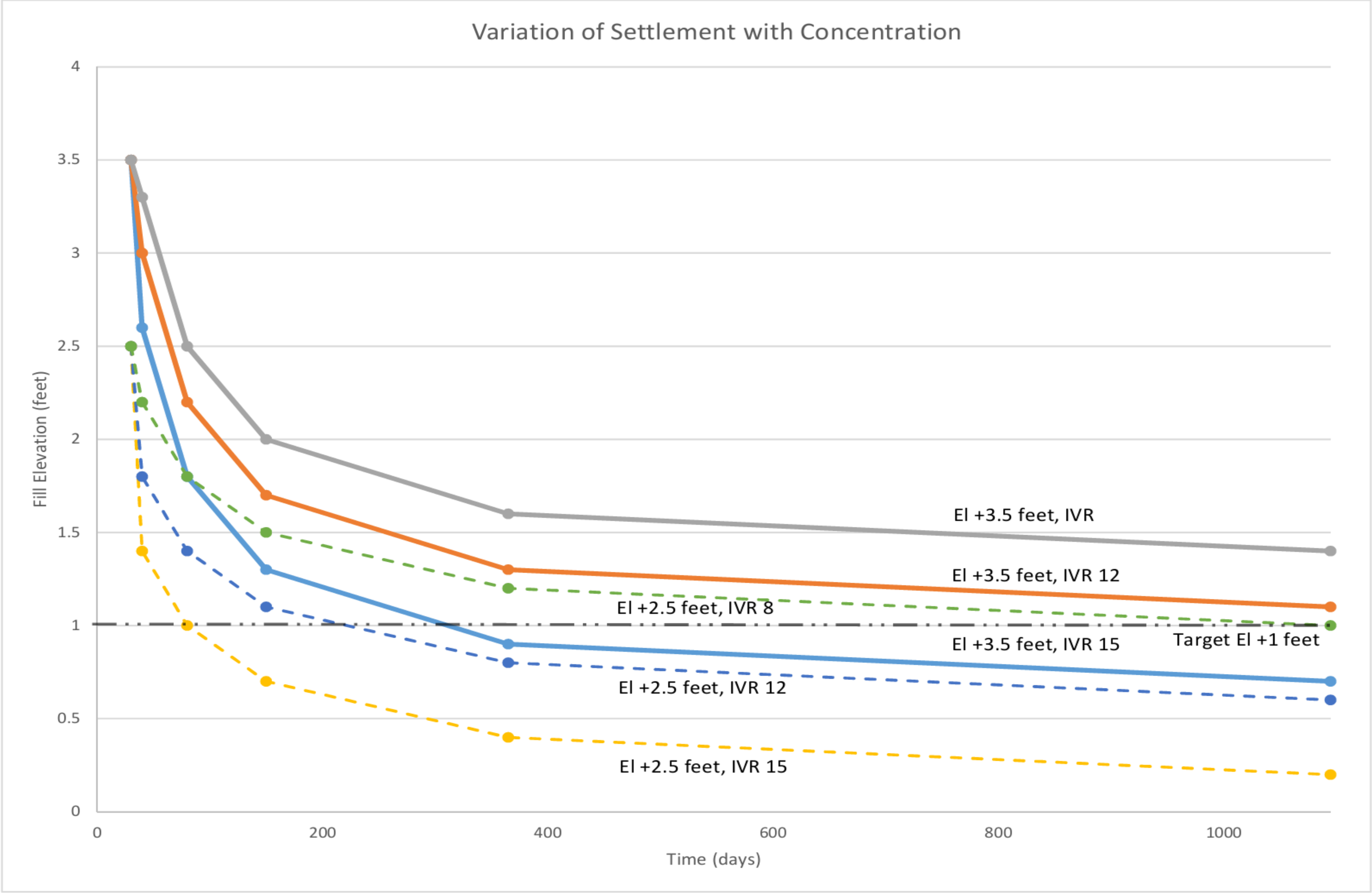




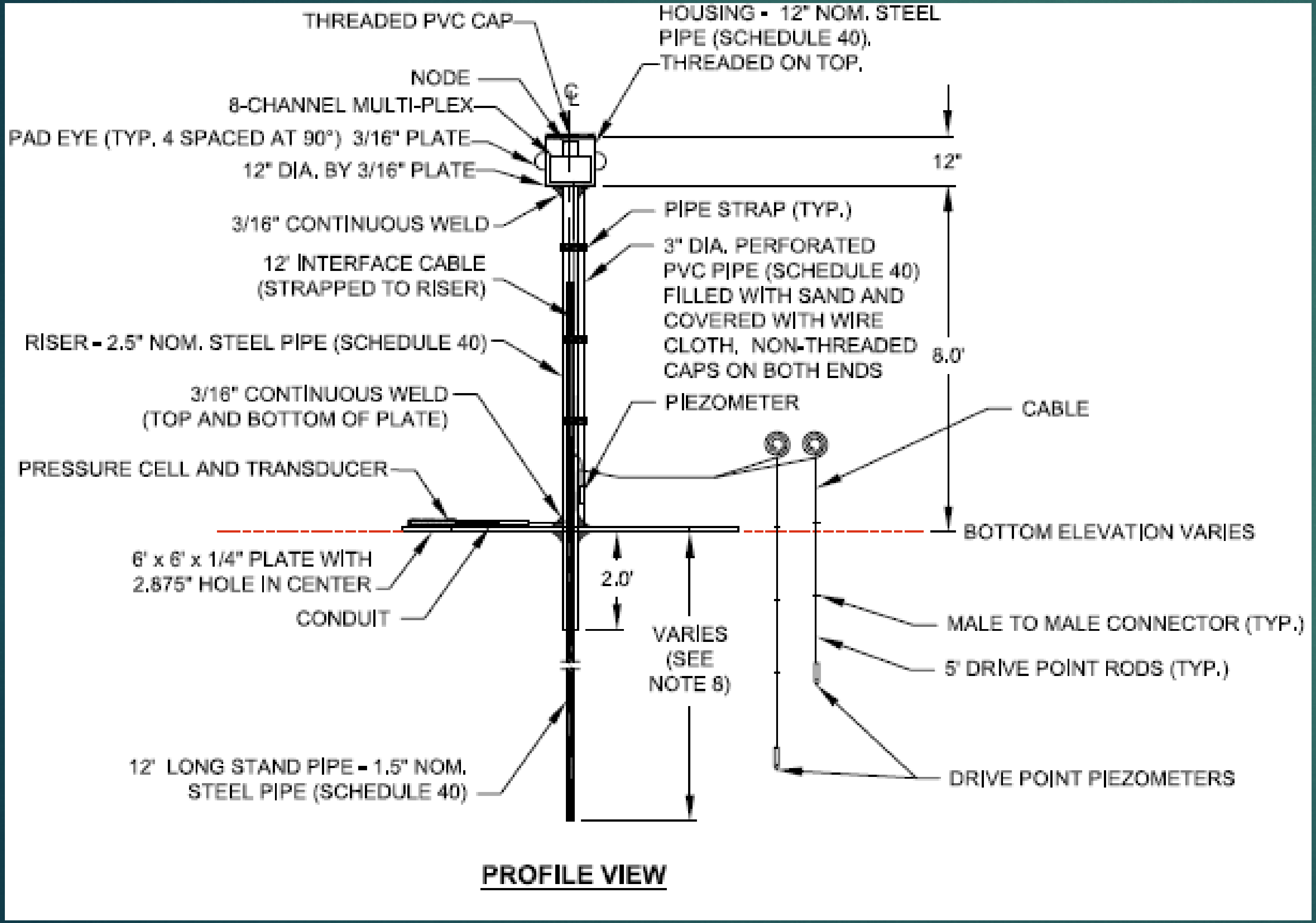
SG_{sl} = Specific gravity of the slurry
SG_s = Specific gravity of the solids
C_v = Concentration of solids by volume
C_m = Concentration of solids by weight

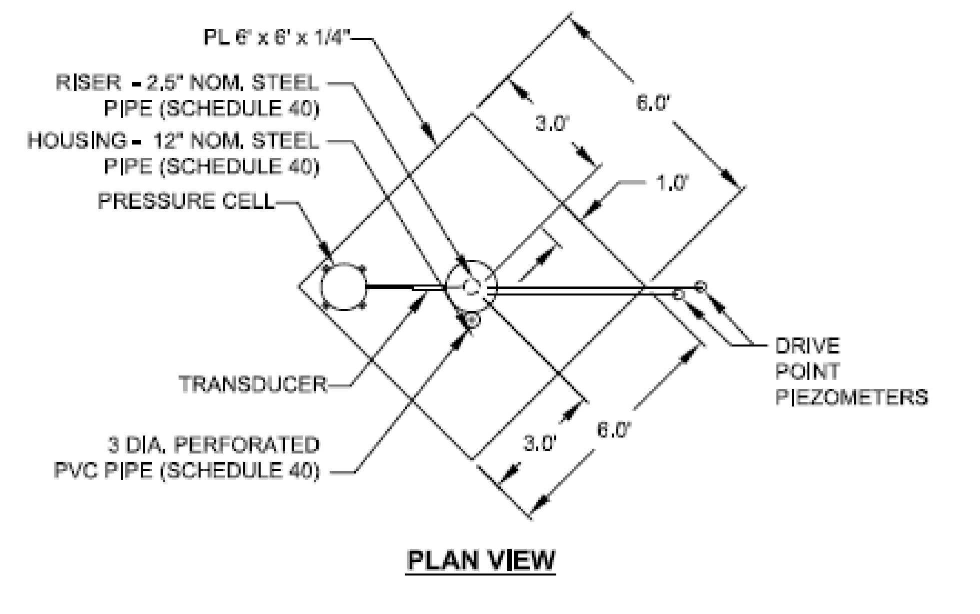
Marsh Fill Testing

Date Sample was Taken	Marsh Creation Area	Sample Location	Sample Size (milliliters)	Tare Number	Tare Weight (grams)	Tare Weight + Wet Weight (grams)	Tare Weight + Dry Weight (grams)	Water Weight (grams)	Dry Weight (grams)	Water Volume (milliliters)	Weight of Salt (grams)	Weight of Solids (grams)	Concentration (grams per liter)	Concentration using volume (grams per liter)	Concentration of Solids by Weight (percent)	Specific Gravity of Solids	Back Calculated Slurry Specific Gravity From Weight Concentration
6/6/2018	2A/2D	MCA	120	506	40.8	177.4	70.0	107.4	29.2	107.4	0.1794	29.02	245.79	241.84	21.376	2.72	1.156
6/6/2018	2A/2D	MCA	120	511	40.0	179.4	69.9	109.5	29.9	109.5	0.1829	29.72	246.77	247.64	21.449	2.72	1.157
6/11/2018	1/1A	MCA	120	513	40.3	167.1	73.9	93.2	33.6	93.2	0.1556	33.44	317.02	278.70	26.498	2.72	1.201
6/11/2018	1/1A	MCA	120	510	41.1	191.9	80.9	111.0	39.8	111.0	0.1854	39.61	315.49	330.12	26.393	2.72	1.200
6/11/2018	2C	MCA	120	512	40.1	168.9	67.3	101.6	27.2	101.6	0.1697	27.03	242.34	225.25	21.118	2.72	1.154
6/11/2018	2C	MCA	120	509	39.7	179.3	69.1	110.2	29.4	110.2	0.1840	29.22	241.57	243.47	21.060	2.72	1.154
6/11/2018	2B WEST	MCA	120	505	39.5	185.2	82.7	102.5	43.2	102.5	0.1712	43.03	363.67	358.57	29.650	2.72	1.231
6/11/2018	2B WEST	MCA	120	503	40.1	188.9	86.4	102.5	46.3	102.5	0.1712	46.13	386.15	384.41	31.116	2.72	1.245
6/11/2018	2A/2D	MCA	120	501	39.7	179.8	73.1	106.7	33.4	106.7	0.1782	33.22	279.38	276.85	23.840	2.72	1.178
6/11/2018	2A/2D	MCA	120	507	39.6	180.7	73.3	107.4	33.7	107.4	0.1794	33.52	279.98	279.34	23.884	2.72	1.178
6/11/2018	2B EAST	MCA	120	502	40.2	187.0	78.4	108.6	38.2	108.6	0.1814	38.02	310.16	316.82	26.022	2.72	1.197
6/11/2018	2B EAST	MCA	120	500	40.4	183.0	77.5	105.5	37.1	105.5	0.1762	36.92	310.09	307.70	26.017	2.72	1.197
5/31/2018	2A/2D	MCA	120	508	40.0	163.7	48.6	115.1	8.6	115.1	0.1922	8.41	71.14	70.06	6.952	2.72	1.046
5/31/2018	2A/2D	MCA	120	504	40.3	168.3	49.0	119.3	8.7	119.3	0.1992	8.50	69.44	70.84	6.797	2.72	1.045
6/20/2018	1/1A	Pipe	120	510	41.1	175.0	64.0	111.1	22.9	111.1	0.1855	22.69	190.08	189.12	17.084	2.72	1.121
6/20/2018	1/1A	WB	120	512	40.1	154.4	41.2	113.2	1.1	113.2	0.1890	0.93	8.20	7.76	0.980	2.72	1.006
6/20/2018	1/1A	Pipe	120	508	39.9	171.1	62.3	108.8	22.3	108.8	0.1817	22.15	189.39	184.57	17.029	2.72	1.121


Variation of Settlement with Concentration
Fill Elevation (feet)
Time (days)
4
3.5
3
2.5
2
1.5
1
0.5
0
0
200
400
600
800
1000
El +3.5 feet, IVR
El +3.5 feet, IVR 12
El +2.5 feet, IVR 8
Target El +1 feet
El +3.5 feet, IVR 15
El +2.5 feet, IVR 12
El +2.5 feet, IVR 15

Instrumented Settlement Plates (ISPs)





Project Deployments

Assembly

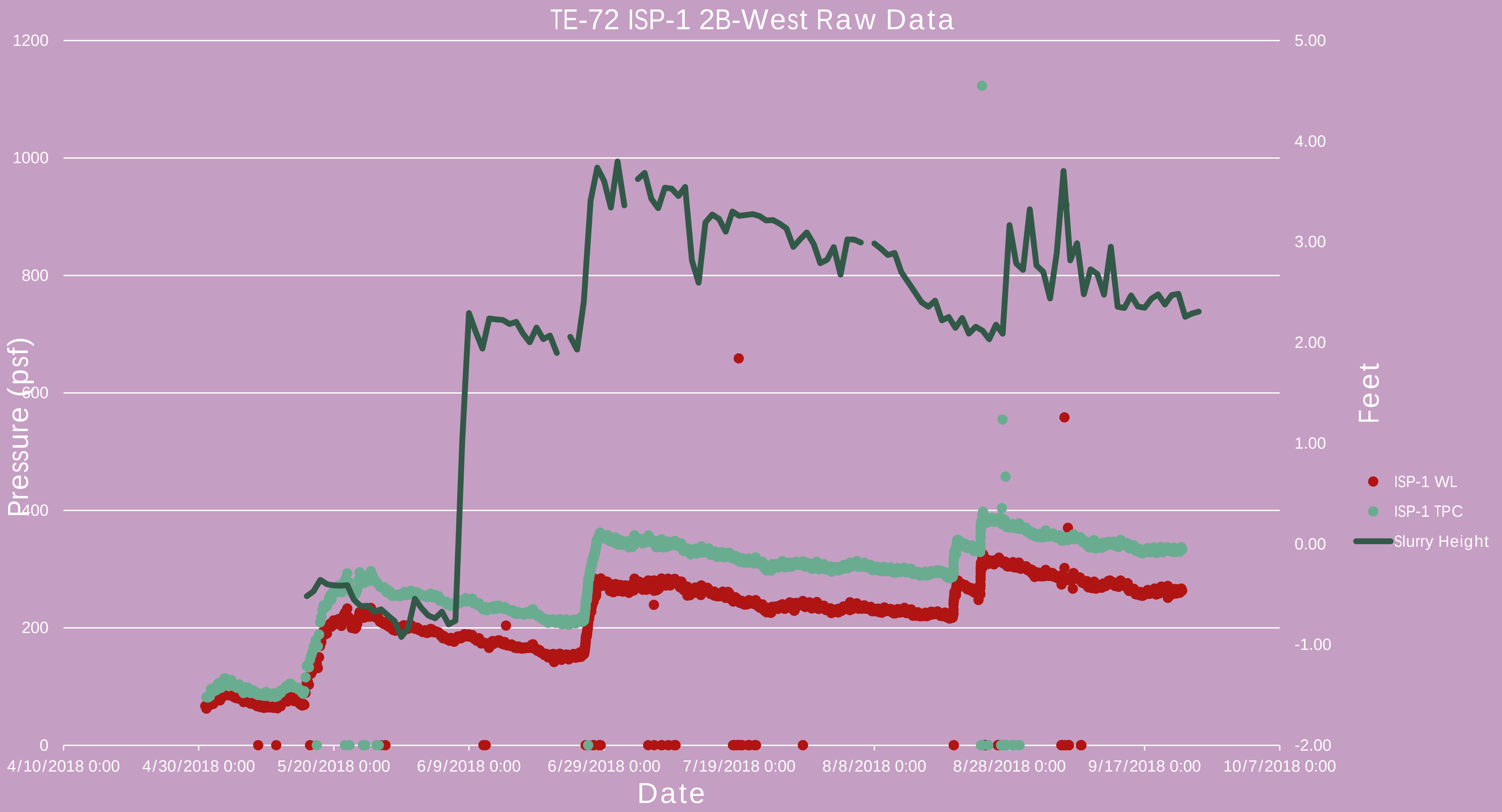




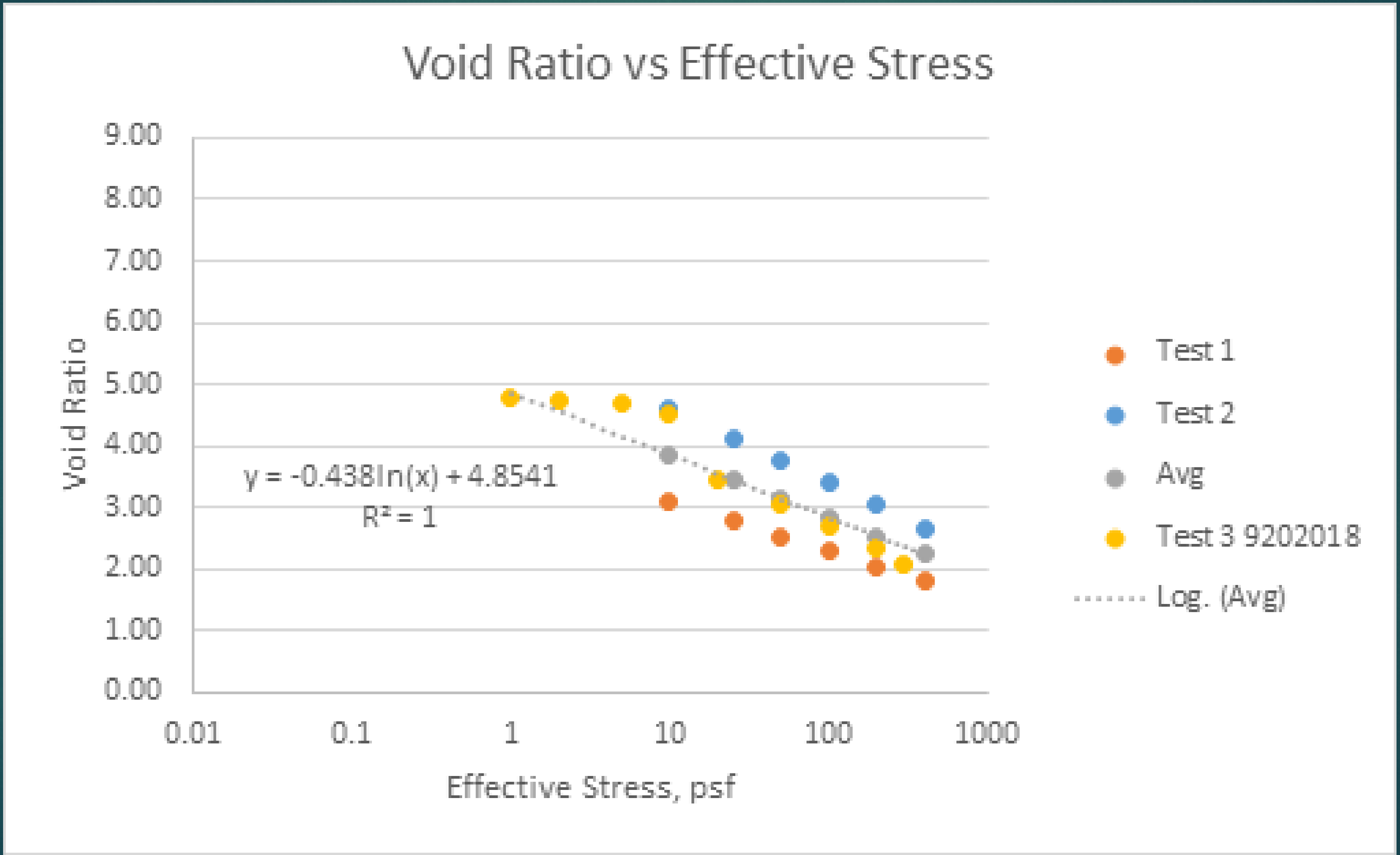
Installation



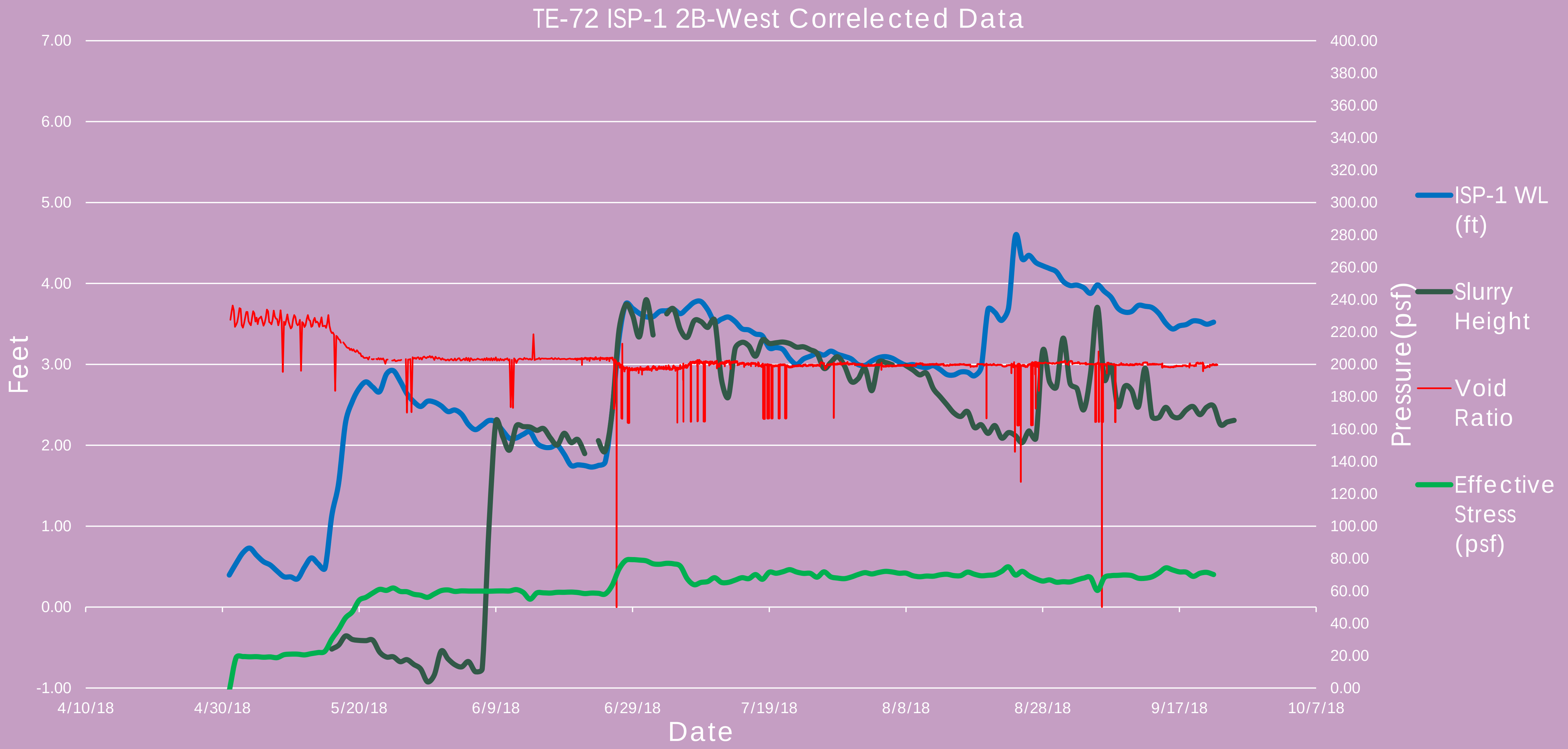

ISP Raw Data


TE-72 ISP-1 2B-West Raw Data
Pressure (psf)
1200
1000
800
600
400
200
0
Feet
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
4/10/2018 0:00
4/30/2018 0:00
5/20/2018 0:00
6/9/2018 0:00
6/29/2018 0:00
7/19/2018 0:00
8/8/2018 0:00
8/28/2018 0:00
9/17/2018 0:00
10/7/2018 0:00
Date
ISP-1 WL
ISP-1 TPC
Slurry Height

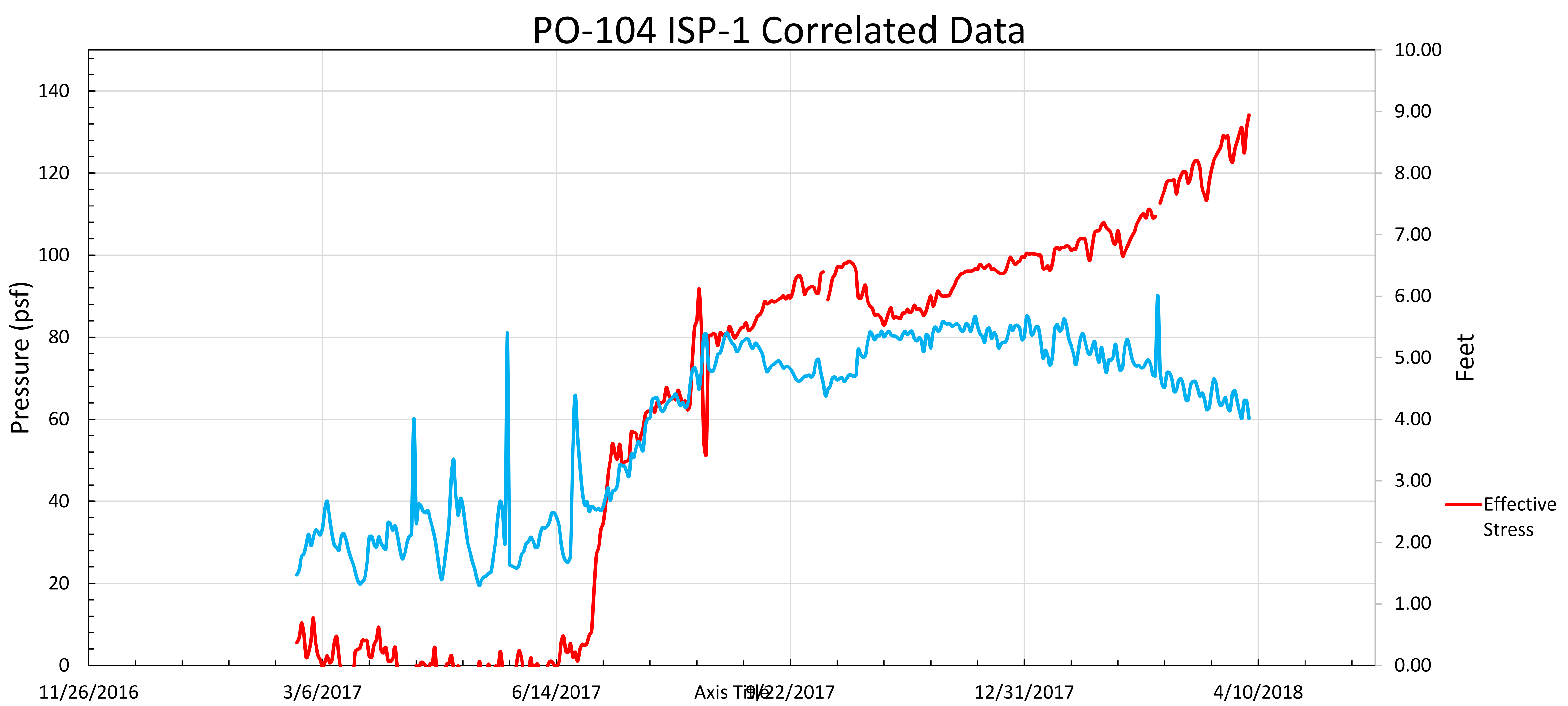
Effective Stress/Void Ratio



ISP Correlated Data



ISP Correlated Data



Thank you. Any Questions?