How to Build a Perfect Marsh

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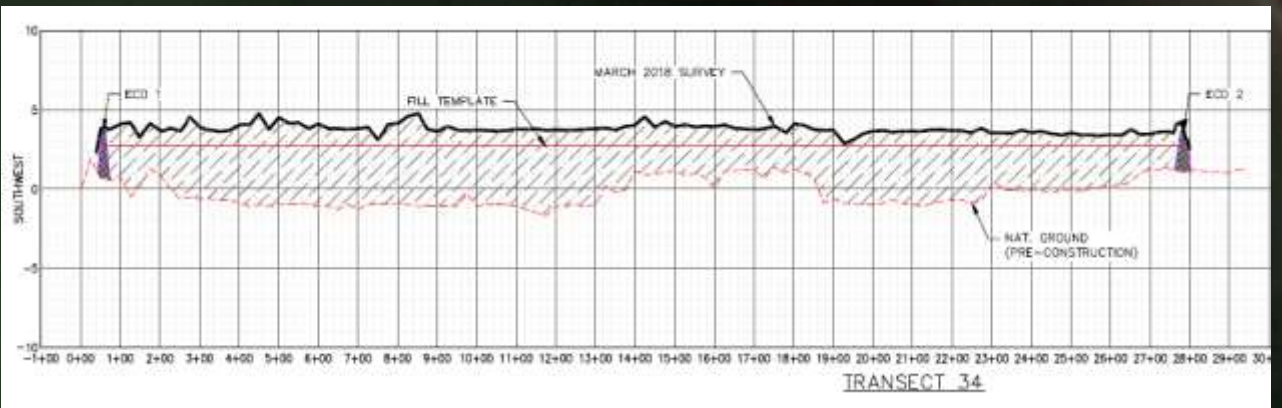
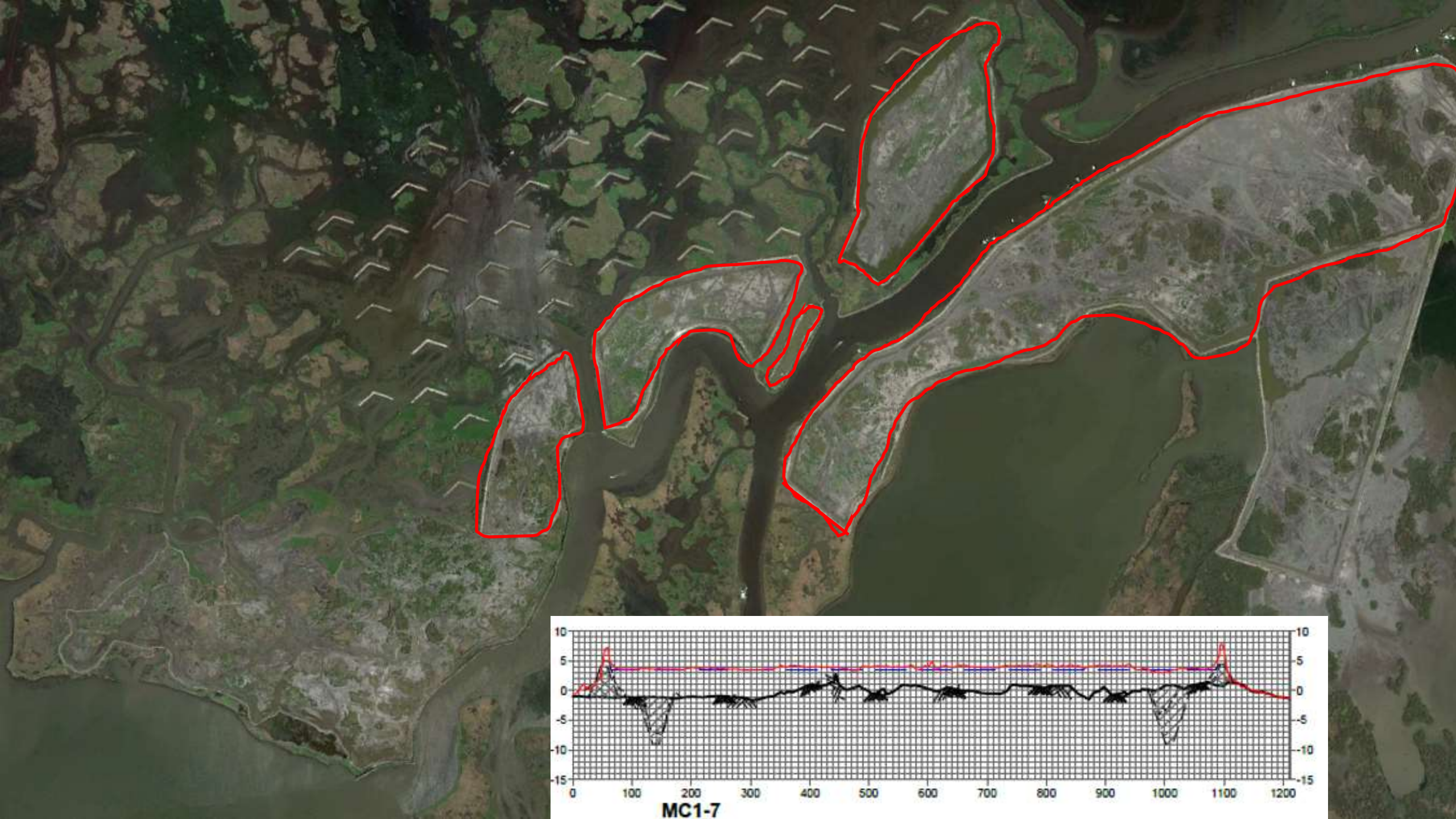
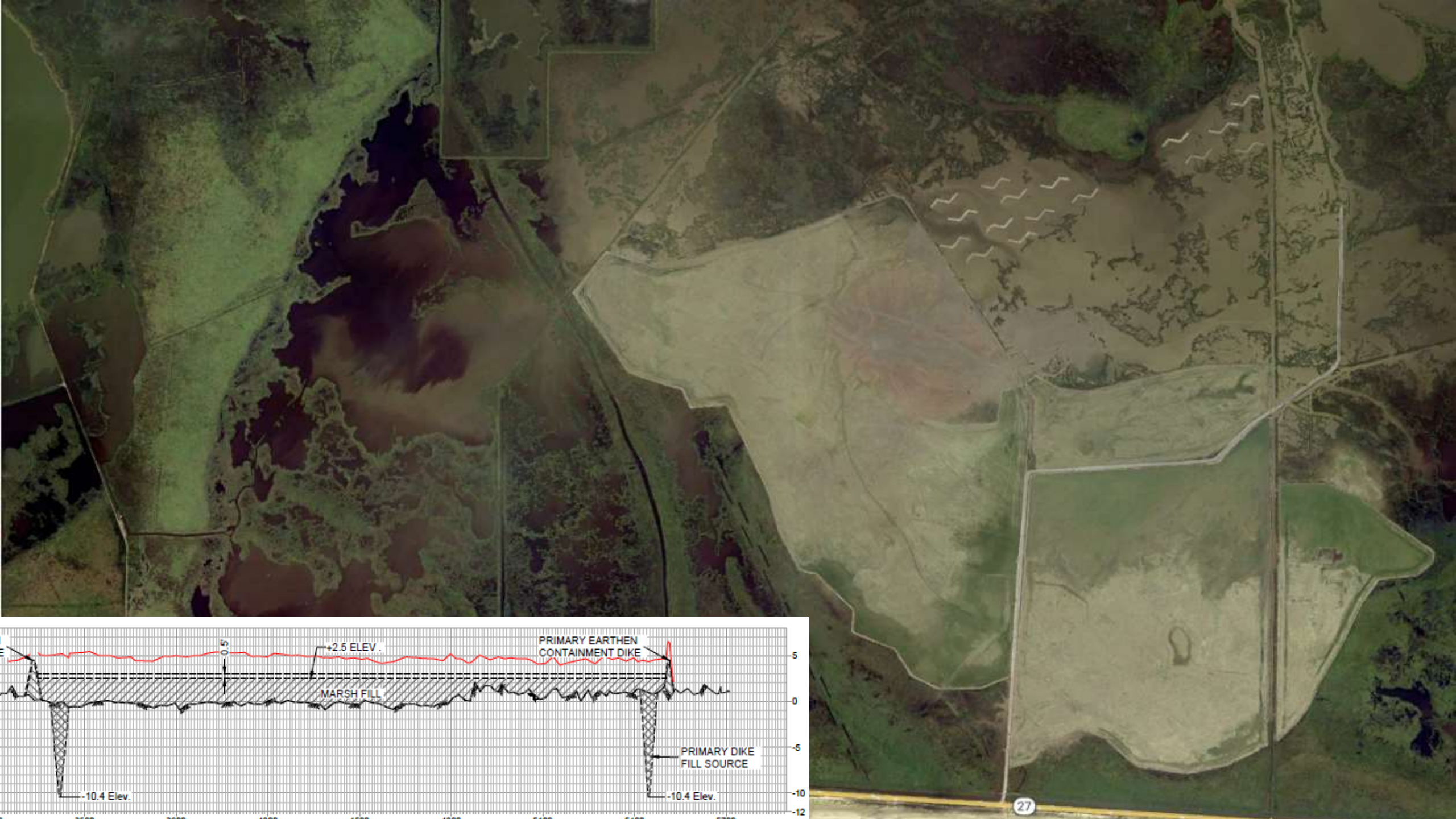
CPRA
Coastal Protection and Restoration Authority of Louisiana

ADAPTIVE
MANAGEMENT AND ENGINEERING

1/2018


ECO 1
FILL TEMPLATE
MARCH 2018 SURVEY
ECO 2
NAT. GROUND
(PRE-CONSTRUCTION)
SOUTHWEST
TRANSECT 34


10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
MC1-7


0.5
+2.5 ELEV .
PRIMARY EARTHEN
CONTAINMENT DIKE
MARSH FILL
PRIMARY DIKE
FILL SOURCE
-10.4 Elev.
-10.4 Elev.
5
0
-5
-10
-12
27

EM_1110-2-5025 Dredging and Dredge Material Management (CDF Design)

- Geometry of CDF is designed using the (1) dredge production (CY/HR), (2) required volume of material to be dredged (CY), and (3) average design concentration from settling column testing.

- The calculations can be reversed to determine the flow rate/dredge size.

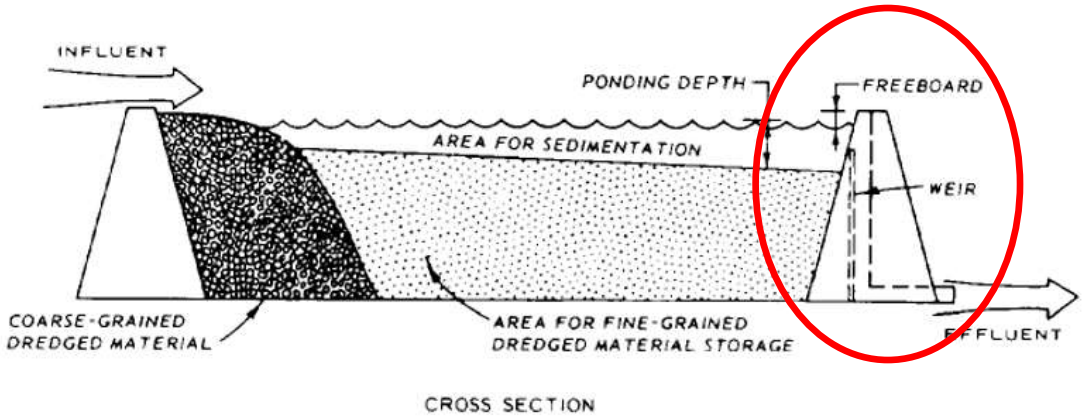
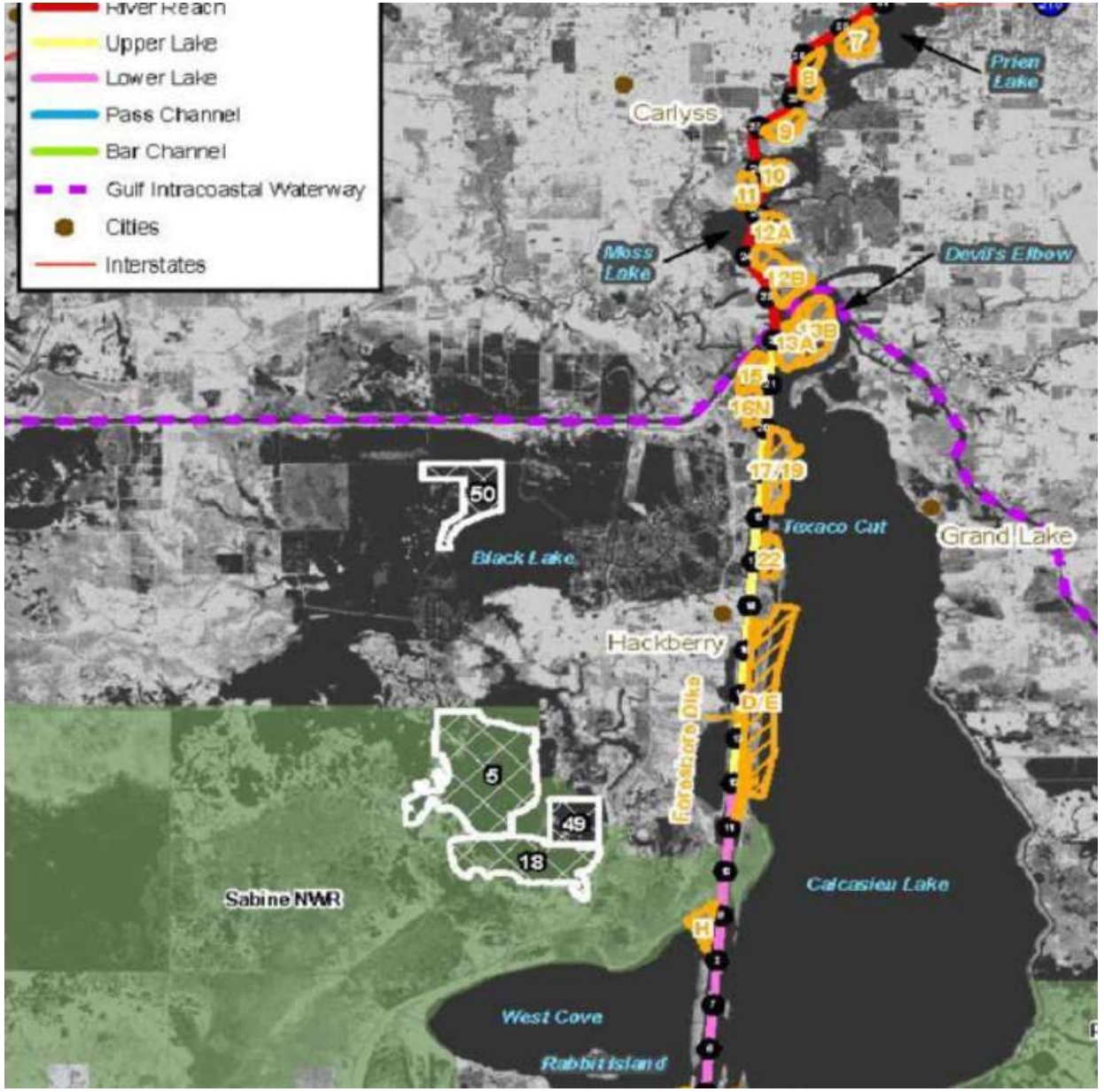


Figure 1-1. Conceptual diagram of a dredged material containment area



Marsh Creation Design Guidelines

Coastal Protection and Restoration Authority
150 Terrace Avenue, Baton Rouge, LA 70802 | coastal@la.gov | www.coastal.la.gov

Marsh Creation Design Guidelines

Marsh Creation Projects

Report Version: MCDG1.0

Date: November 15, 2017

Coastal Protection and Restoration Authority
450 Laurel Street, Baton Rouge, LA 70804 | coastal@la.gov | www.coastal.la.gov

Geotechnical Standards

Marsh Creation and Coastal Restoration Projects

Report: Version 1.0

Date: December 21, 2017

EARTHEN CONTAINMENT DIKE (ECD) AND BORROW AREA GEOMETRIES TABLE												
			ECD				ECD BORROW			ECD DESIGN		
ECD #	MC AREA #	CMF EL. (FT.)	CREST WIDTH W (FT.) (5 ft. min.)	CREST EL. H (FT.) (1 ft. to 2 ft. min. freeboard above Max CMF EL.)	SIDE SLOPES 1:X_1 (X_1 = 4 to 6)	BENCH OFFSET B (FT.) (20 ft. min.)	BOTTOM WIDTH (FT.) (varies)	MAX. CUT EL. C (FT.) (Typ. -8.0 to -10.0 ft.)	SIDE SLOPES 1:X_2 (X_2 = 2 to 4)	CASE NO.	Stability Analyses FOS (FOS min=1.20)	

Table B-5: ECD and borrow area geometries table for stability analyses. Typical and minimums values are shown in parentheses (This is a typical summary table for the GER)

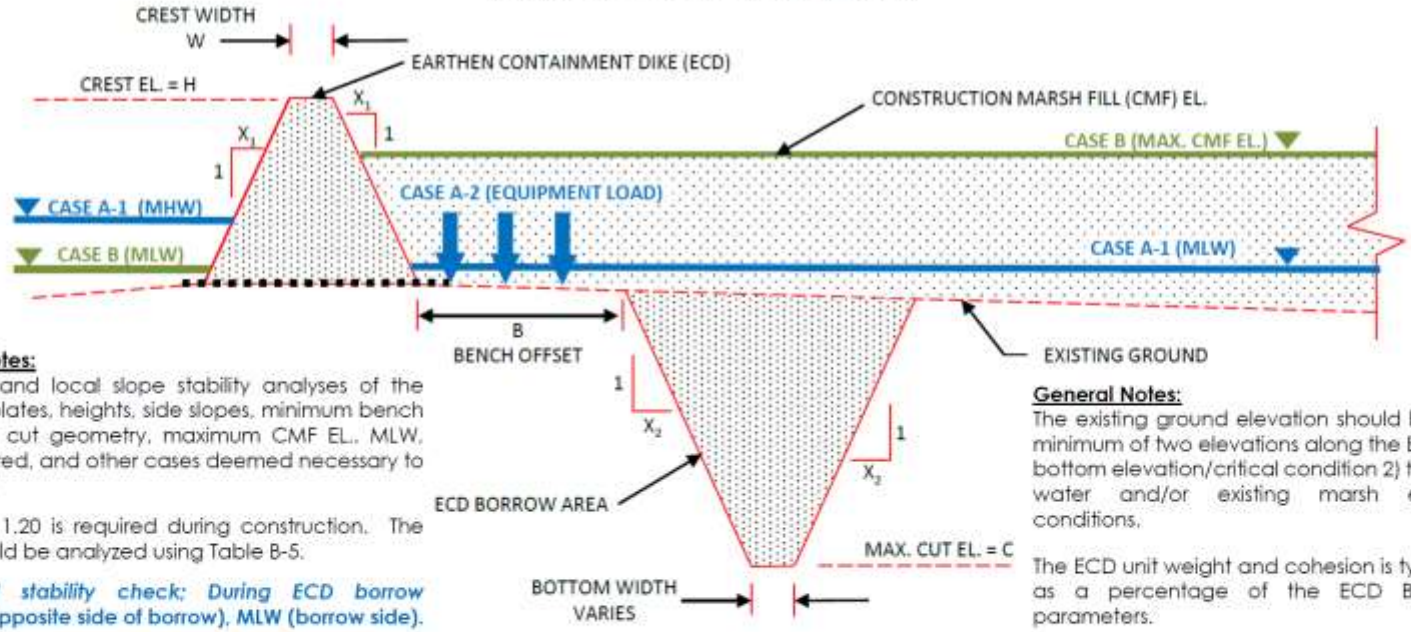


Figure B-5: Typical ECD Template.

Stability Analyses Notes:

Conduct a global and local slope stability analyses of the proposed ECD templates, heights, side slopes, minimum bench offset, borrow area cut geometry, maximum CMF EL., MLW, multi-lift CMF if required, and other cases deemed necessary to ensure ECD stability.

A minimum FOS of 1.20 is required during construction. The following cases should be analyzed using Table B-5.

***CASE A-1: Global stability check; During ECD borrow excavation;* MHW (opposite side of borrow), MLW (borrow side).**

***CASE A-2: Local stability check; During ECD borrow excavation; Distributed load from excavation equipment*, MLW (borrow side).**

***CASE B: Dredged Material placed to CMF EL.*; CMF (max. elevation), MLW (opposite side of borrow).**

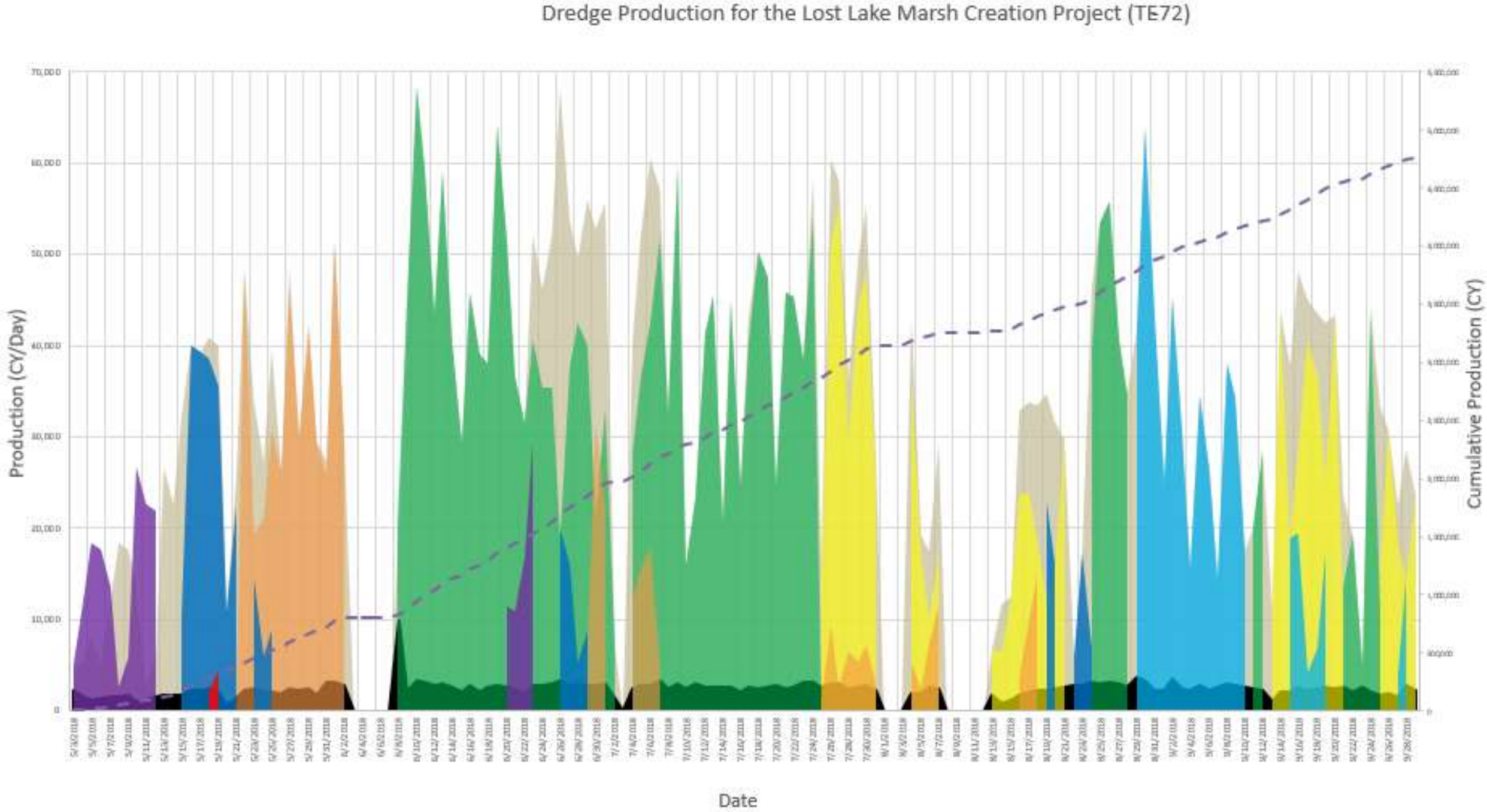
General Notes:

The existing ground elevation should be analyzed at a minimum of two elevations along the ECD: 1) the lowest bottom elevation/critical condition 2) the average open water and/or existing marsh elevation/general conditions.

The ECD unit weight and cohesion is typically expressed as a percentage of the ECD Borrow Area soil parameters.

A distributed load of 260 psf is typically used based on large marsh hoe/marsh buggy equipment. The ECD is constructed in several lifts.

A geosynthetic reinforcement fabric may be utilized to achieve the minimum FOS.


Dredge Production for the Lost Lake Marsh Creation Project (TE72)
Production (CY/Day)
Cumulative Production (CY)
Date

Variations in Concentrations in Fill Slurry

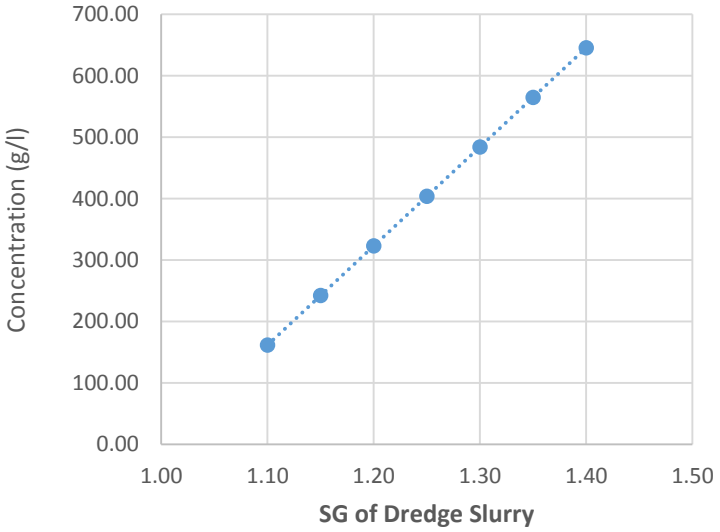
Date Sample was Taken	Marsh Creation Area	Sample Location	Sample Size (milliliters)	Tare Number	Tare Weight (grams)	Tare Weight + Wet Weight (grams)	Tare Weight + Dry Weight (grams)	Water Weight (grams)	Dry Weight (grams)	Water Volume (milliliters)	Weight of Salt (grams)	Weight of Solids (grams)	Concentration (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

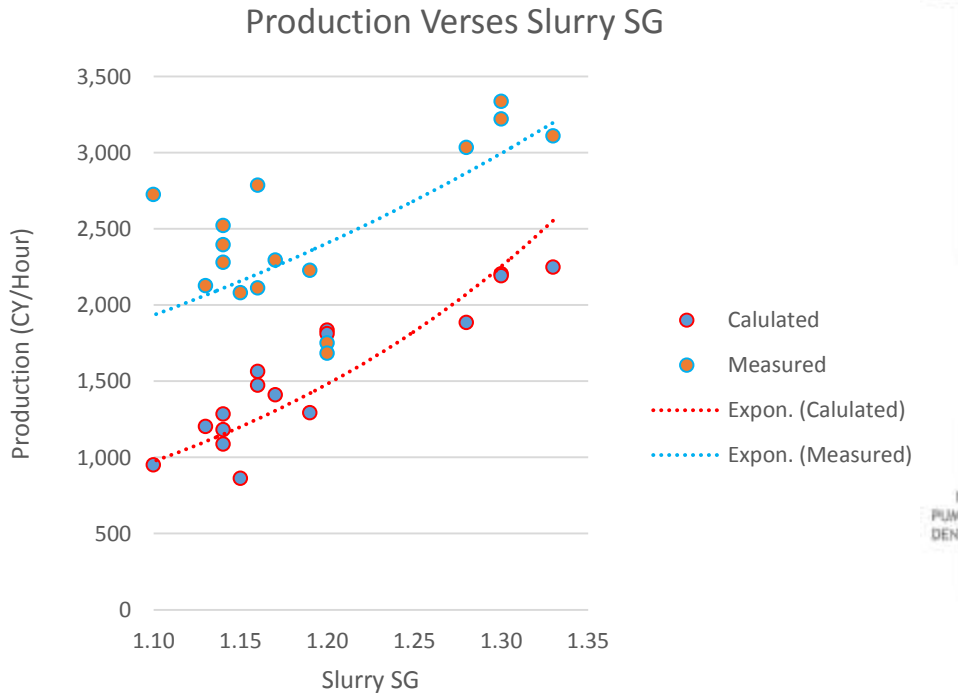
Dredge Slurry Density Limits

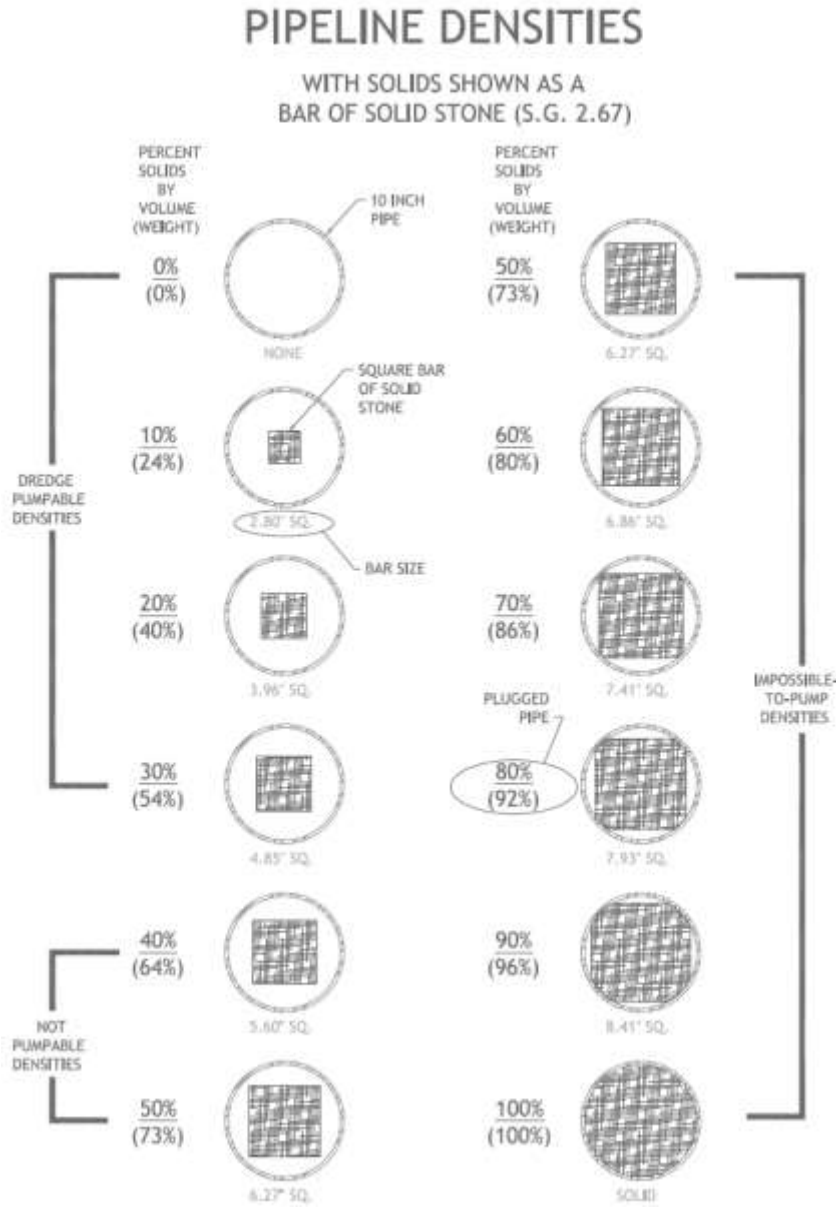
Specific Gravity of Slurry [SG_{SL}]	Specific Gravity of Solids [SG_S]	Concentration of Solids [C_s]	Concentration of Slurry (grams per liter) [C_{SL}]	Void Ratio
1.093	2.72	0.135	150.01	18.13
1.10	2.72	0.144	161.30	16.86
1.15	**2.72**	**0.206**	**241.95**	**11.24**
1.20	**2.72**	**0.264**	**322.60**	**8.43**
1.25	**2.72**	**0.316**	**403.26**	**6.75**
1.30	**2.72**	**0.365**	**483.91**	**5.62**
1.35	**2.72**	**0.410**	**564.56**	**4.82**
1.40	2.72	0.452	645.21	4.22

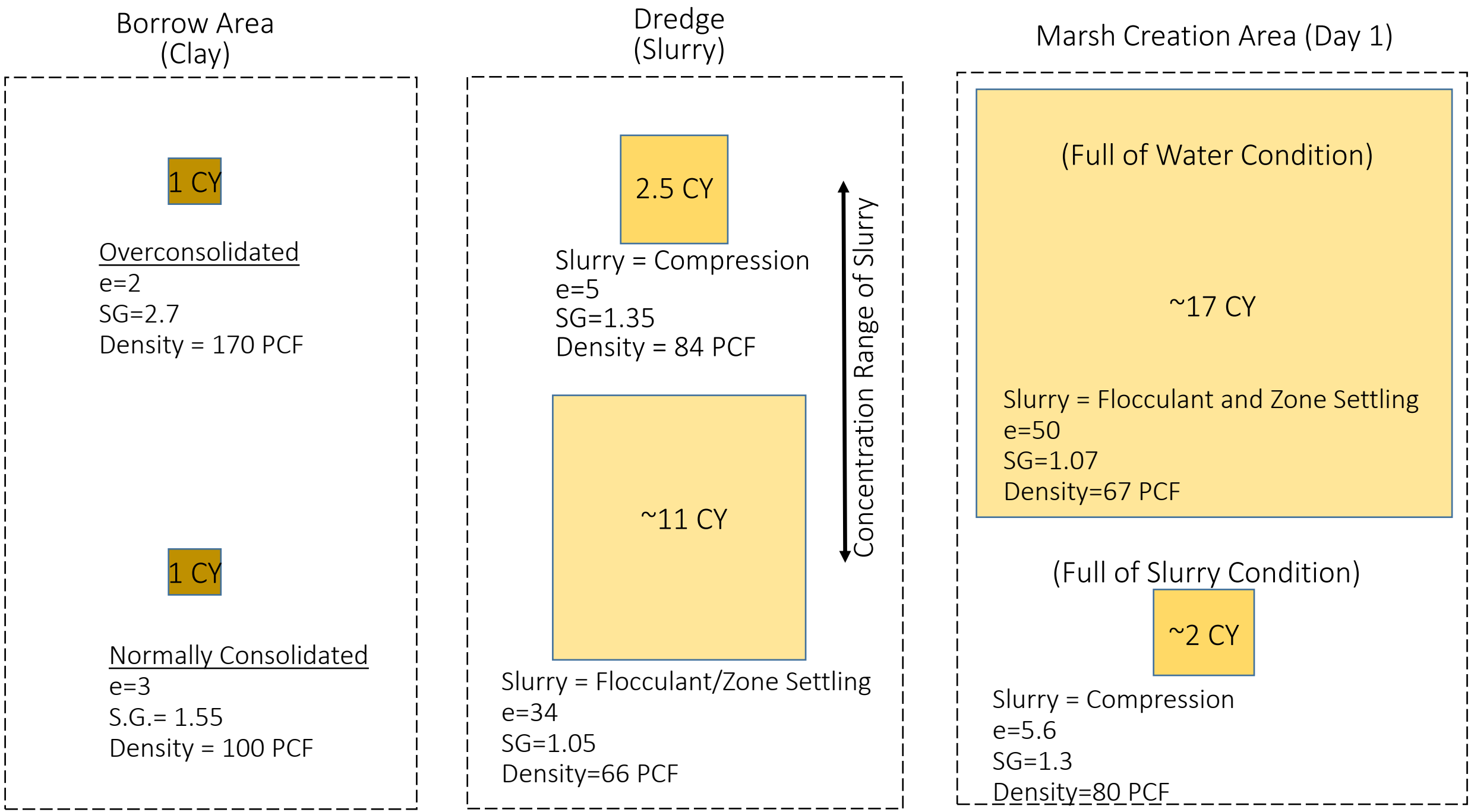
Zone settling

Range of dredge slurry in pipe (In compression)



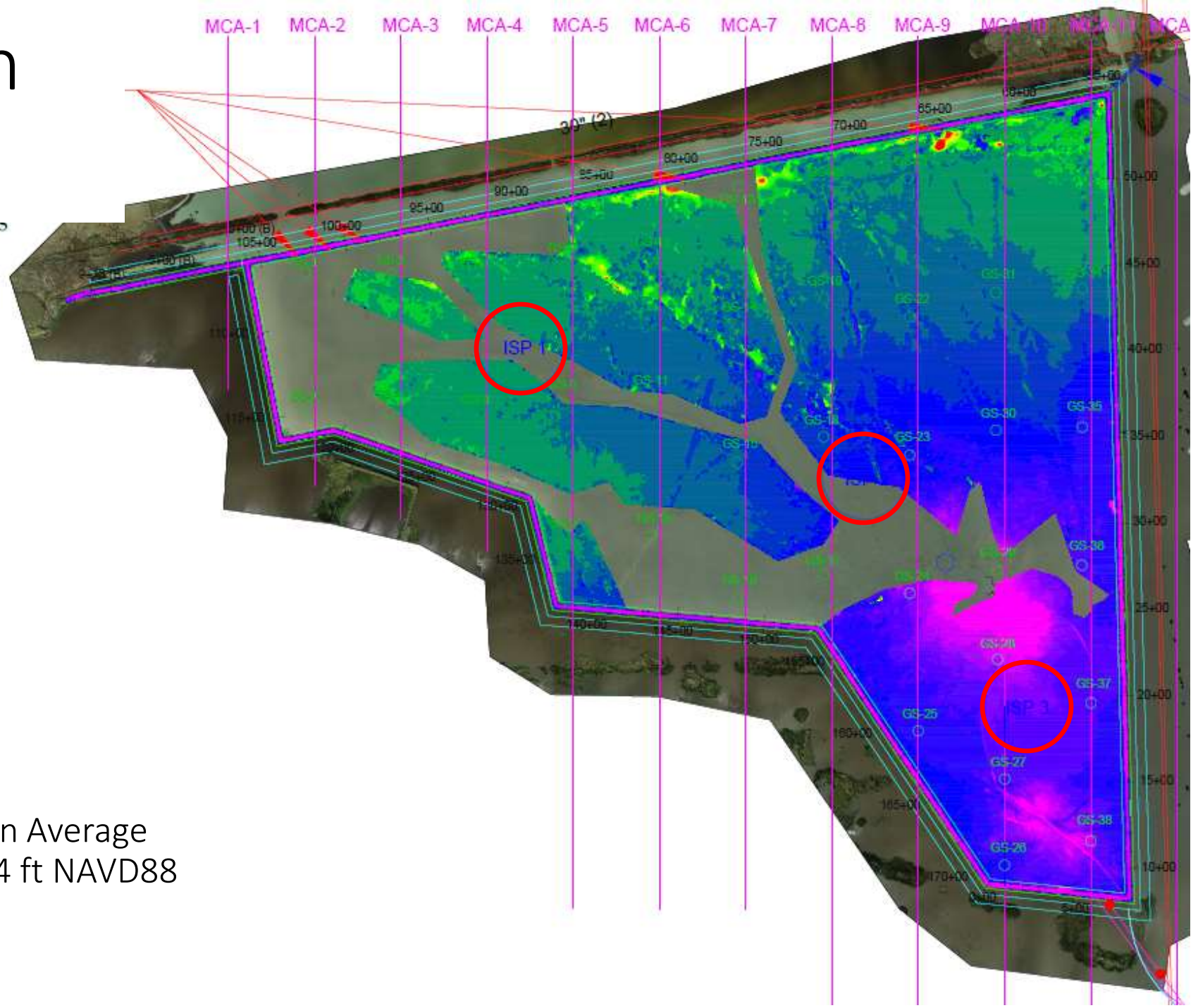





Borrow Area
(Clay)
1 CY
Overconsolidated
e=2
SG=2.7
Density = 170 PCF
1 CY
Normally Consolidated
e=3
S.G.= 1.55
Density = 100 PCF
Dredge
(Slurry)
2.5 CY
Slurry = Compression
e=5
SG=1.35
Density = 84 PCF
~11 CY
Slurry = Flocculant/Zone Settling
e=34
SG=1.05
Density=66 PCF
Concentration Range of Slurry
Marsh Creation Area (Day 1)
(Full of Water Condition)
~17 CY
Slurry = Flocculant and Zone Settling
e=50
SG=1.07
Density=67 PCF
(Full of Slurry Condition)
~2 CY
Slurry = Compression
e=5.6
SG=1.3
Density=80 PCF

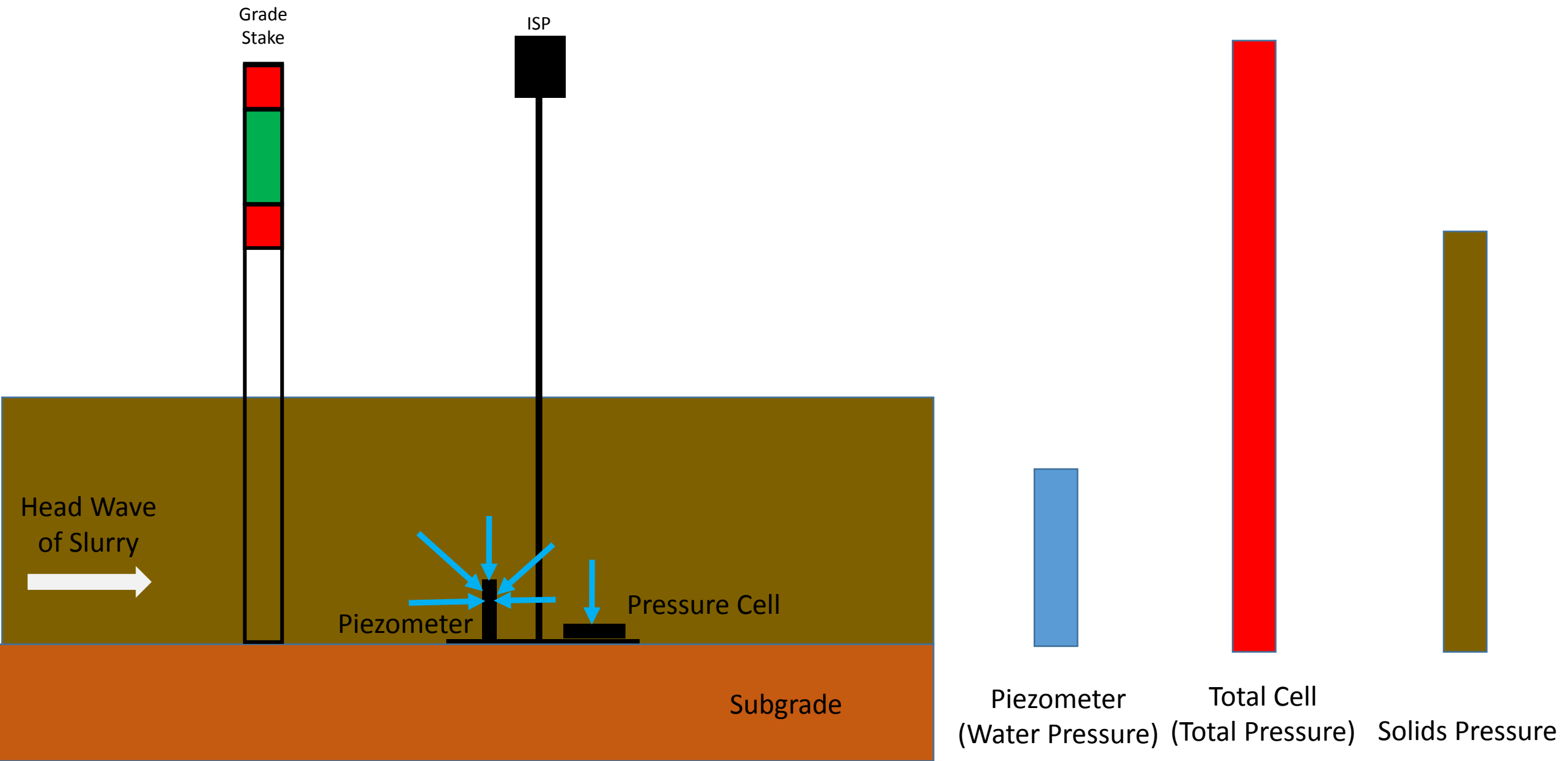
Marsh Creation Project

Range	Color
< - -1	
-1 - -0.75	
-0.75 - -0.5	
-0.5 - -0.25	
-0.25 - 0	
0 - 0.25	
0.25 - 0.5	
0.5 - 0.75	
0.75 - 1	
1 - 1.25	
1.25 - 1.5	
1.5 - 1.75	
1.75 - 2	
2 - 2.25	
2.25 - 2.5	
2.5 - 2.75	
2.75 - 3	
3 - 3.25	
3.25 - 3.5	
3.5 - 3.75	
3.75 - 4	
>= 4	

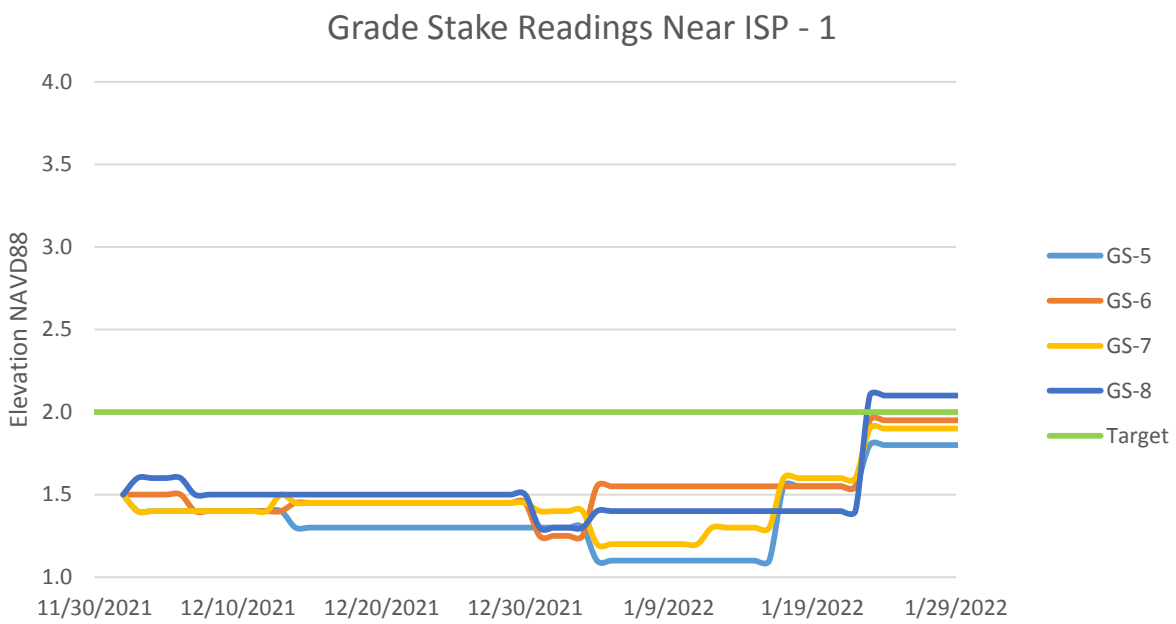


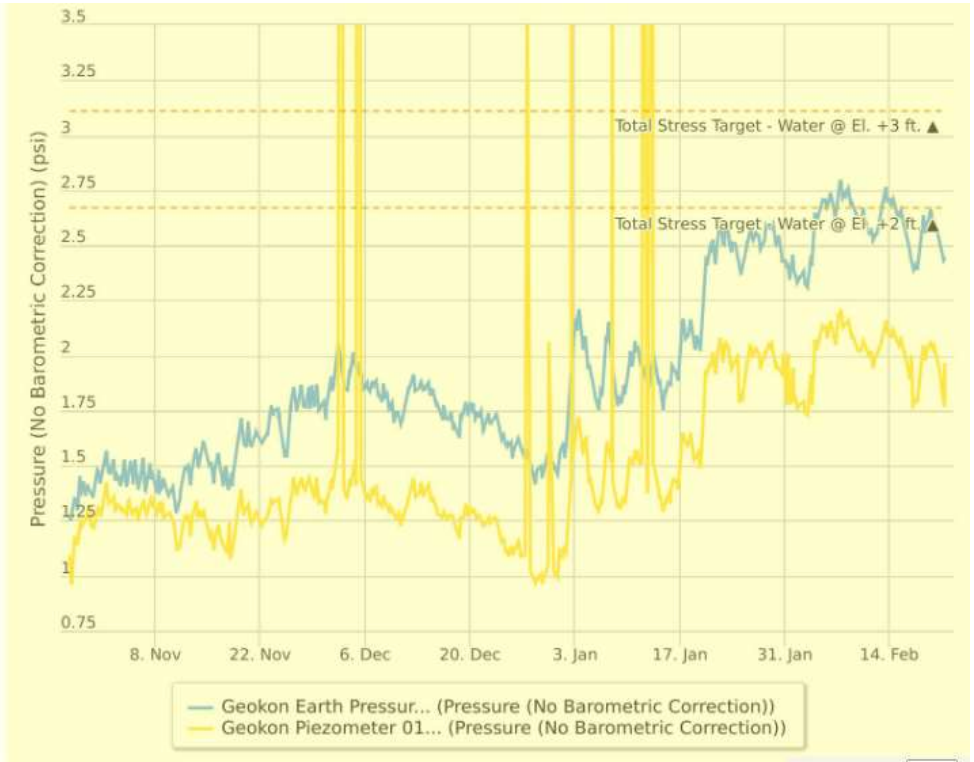
Preconstruction Average Elevation = -1.4 ft NAVD88

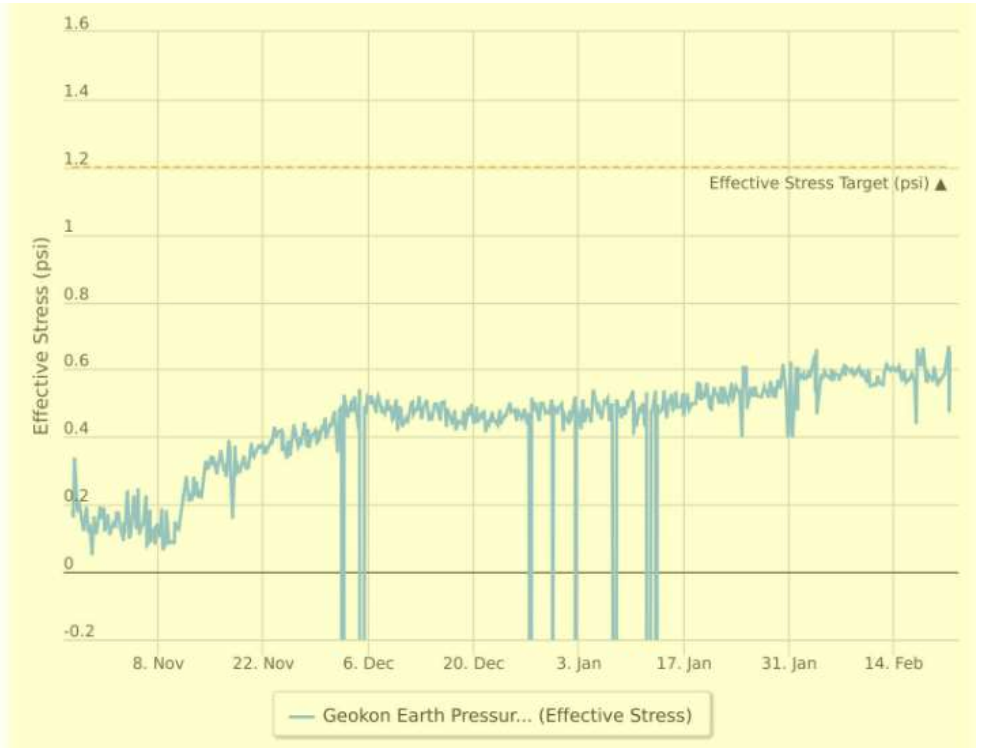
Post Construction(Slurry Consolidates and Elevation Decreases)

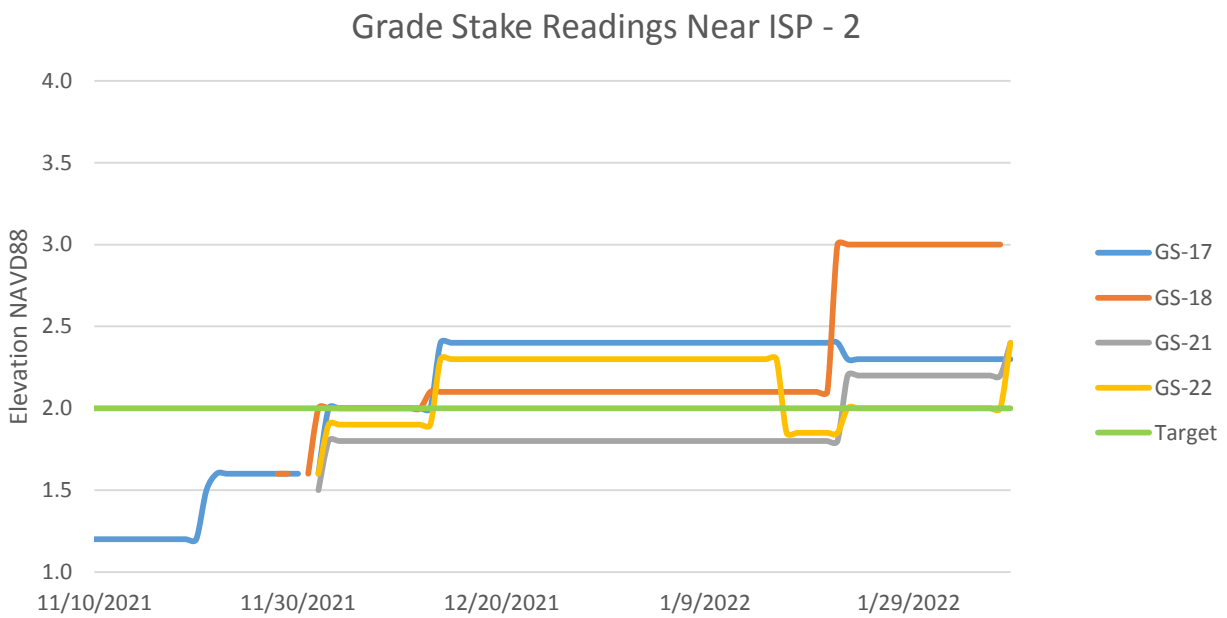


Instrumented Settlement Plates (ISPs)

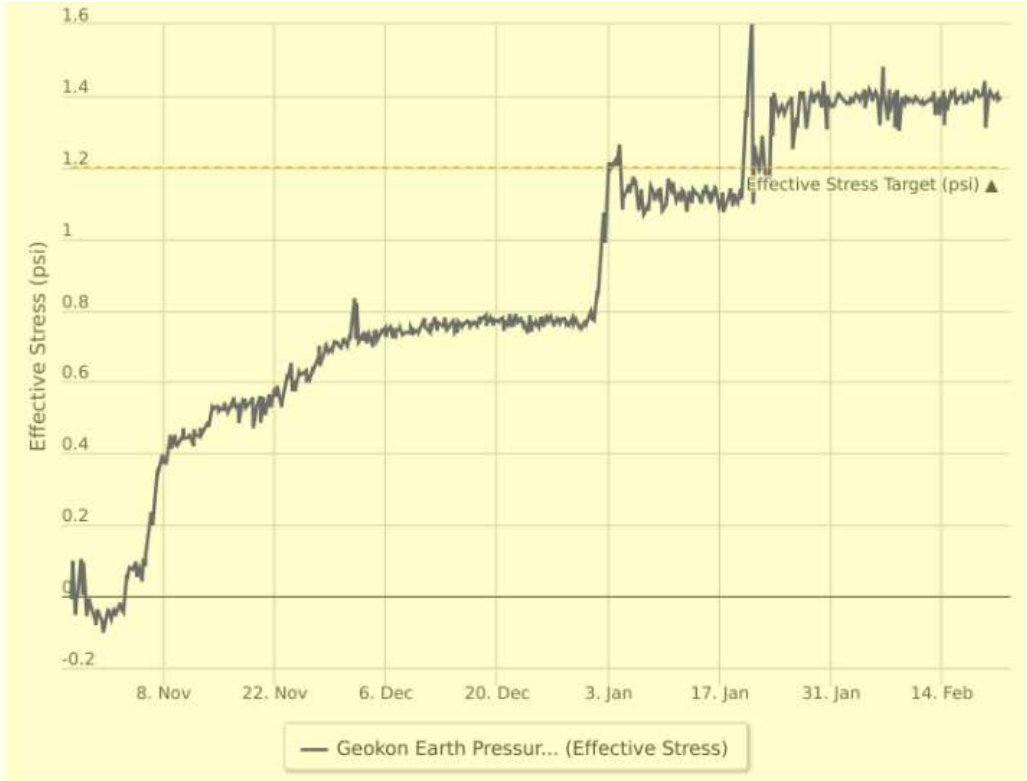

Grade Stake Readings Near ISP - 1
Elevation NAVD88
4.0
3.5
3.0
2.5
2.0
1.5
1.0
11/30/2021
12/10/2021
12/20/2021
12/30/2021
1/9/2022
1/19/2022
1/29/2022
GS-5
GS-6
GS-7
GS-8
Target

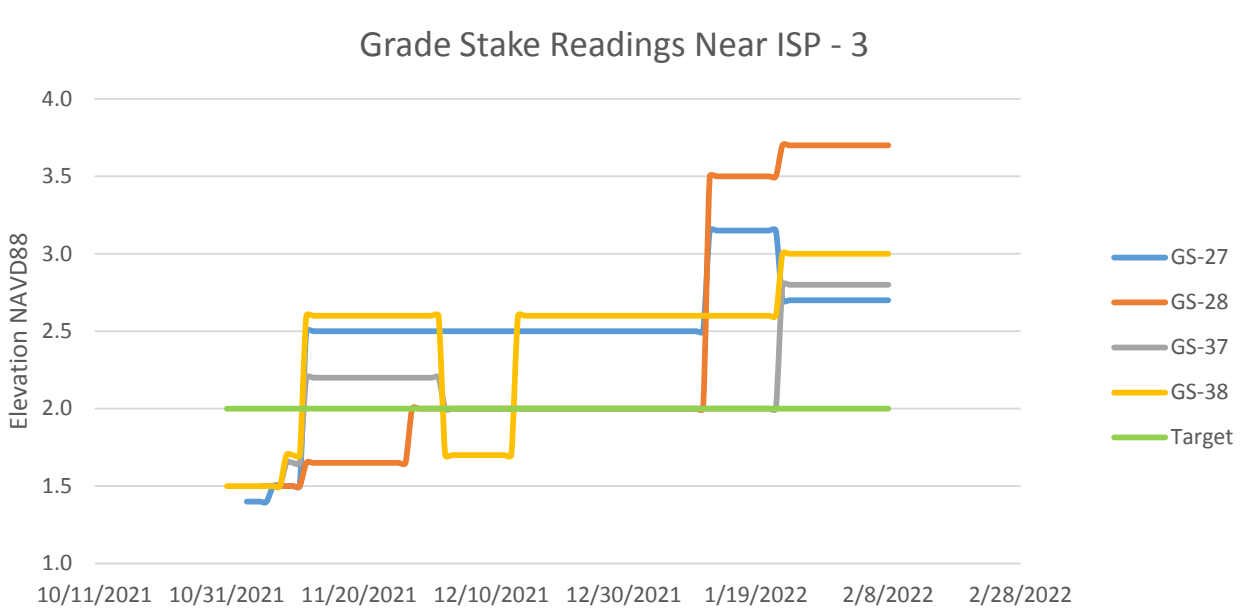

Pressure (No Barometric Correction) (psi)
Total Stress Target - Water @ El. +3 ft.
Total Stress Target - Water @ El. +2 ft.
8. Nov
22. Nov
6. Dec
20. Dec
3. Jan
17. Jan
31. Jan
14. Feb
Geokon Earth Pressur... (Pressure (No Barometric Correction))
Geokon Piezometer 01... (Pressure (No Barometric Correction))

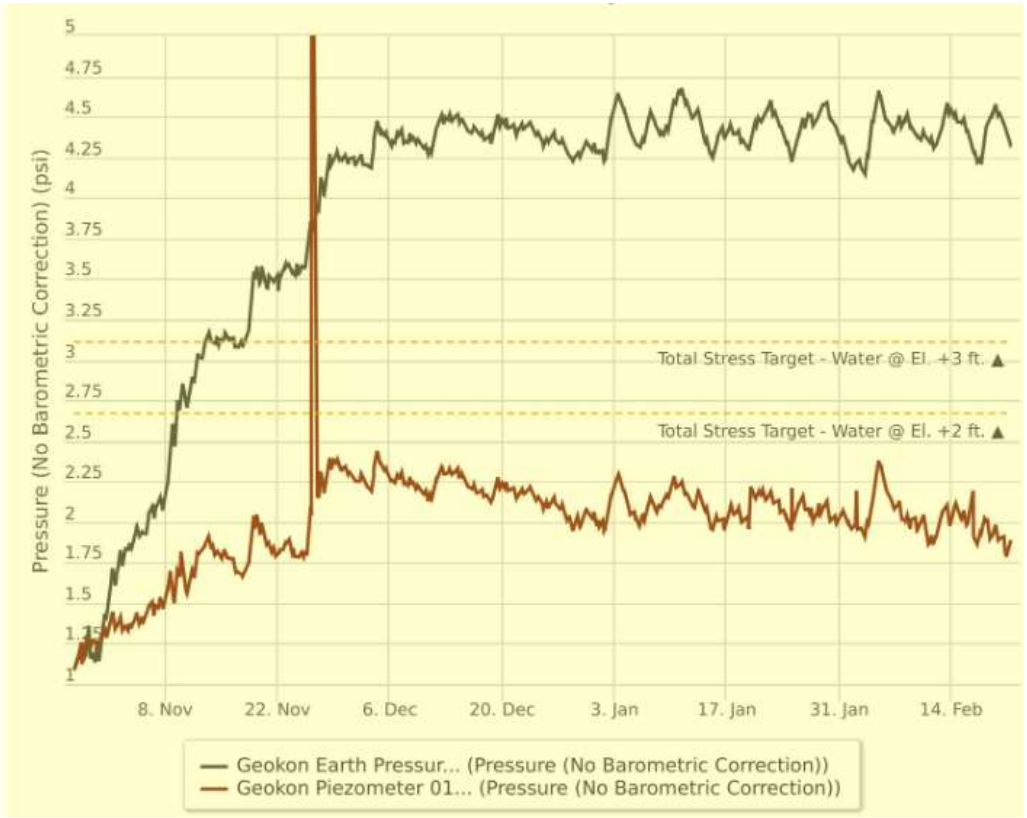

Effective Stress (psi)
Effective Stress Target (psi)
8. Nov
22. Nov
6. Dec
20. Dec
3. Jan
17. Jan
31. Jan
14. Feb
Geokon Earth Pressur... (Effective Stress)

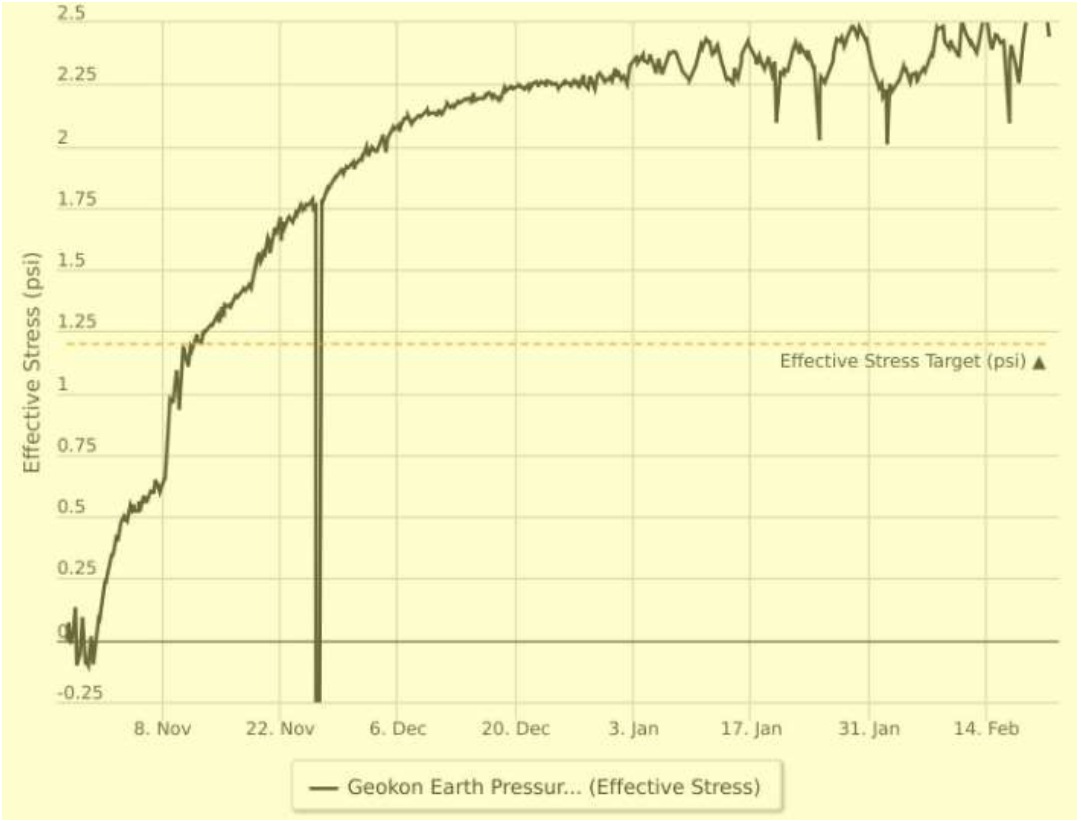

Grade Stake Readings Near ISP - 2
Elevation NAVD88
4.0
3.5
3.0
2.5
2.0
1.5
1.0
11/10/2021
11/30/2021
12/20/2021
1/9/2022
1/29/2022
GS-17
GS-18
GS-21
GS-22
Target


Pressure (No Barometric Correction) (psi)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
Total Stress Target - Water @ El. +3 ft.
Total Stress Target - Water @ El. +2 ft.
8. Nov
22. Nov
6. Dec
20. Dec
3. Jan
17. Jan
31. Jan
14. Feb
Geokon Earth Pressur... (Pressure (No Barometric Correction))
Geokon Piezometer 01... (Pressure (No Barometric Correction))


Effective Stress (psi)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
Effective Stress Target (psi)
8. Nov
22. Nov
6. Dec
20. Dec
3. Jan
17. Jan
31. Jan
14. Feb
Geokon Earth Pressur... (Effective Stress)

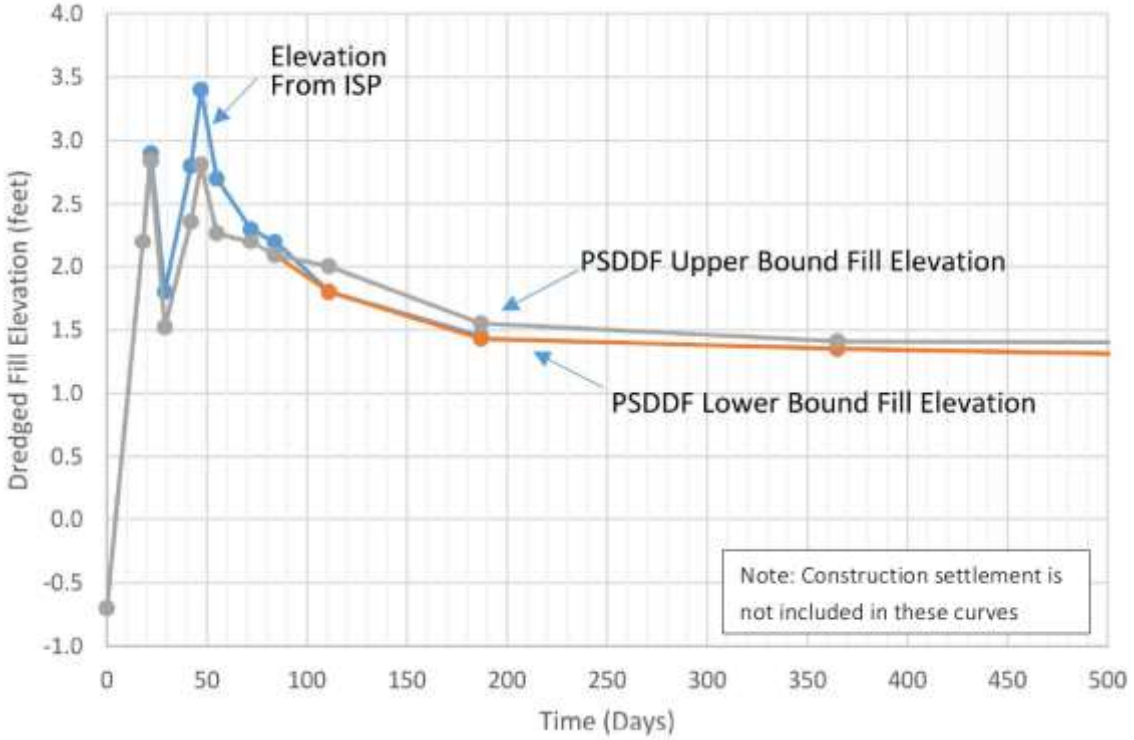

Grade Stake Readings Near ISP - 3
Elevation NAVD88
4.0
3.5
3.0
2.5
2.0
1.5
1.0
10/11/2021
10/31/2021
11/20/2021
12/10/2021
12/30/2021
1/19/2022
2/8/2022
2/28/2022
GS-27
GS-28
GS-37
GS-38
Target


Pressure (No Barometric Correction) (psi)
Total Stress Target - Water @ El. +3 ft.
Total Stress Target - Water @ El. +2 ft.
8. Nov
22. Nov
6. Dec
20. Dec
3. Jan
17. Jan
31. Jan
14. Feb
Geokon Earth Pressur... (Pressure (No Barometric Correction))
Geokon Piezometer 01... (Pressure (No Barometric Correction))


Effective Stress (psi)
Effective Stress Target (psi)
8. Nov
22. Nov
6. Dec
20. Dec
3. Jan
17. Jan
31. Jan
14. Feb
Geokon Earth Pressur... (Effective Stress)

Marsh Creation Project

Coles Bayou Project – Projected Marsh Elevation Based on ISP Construction Data



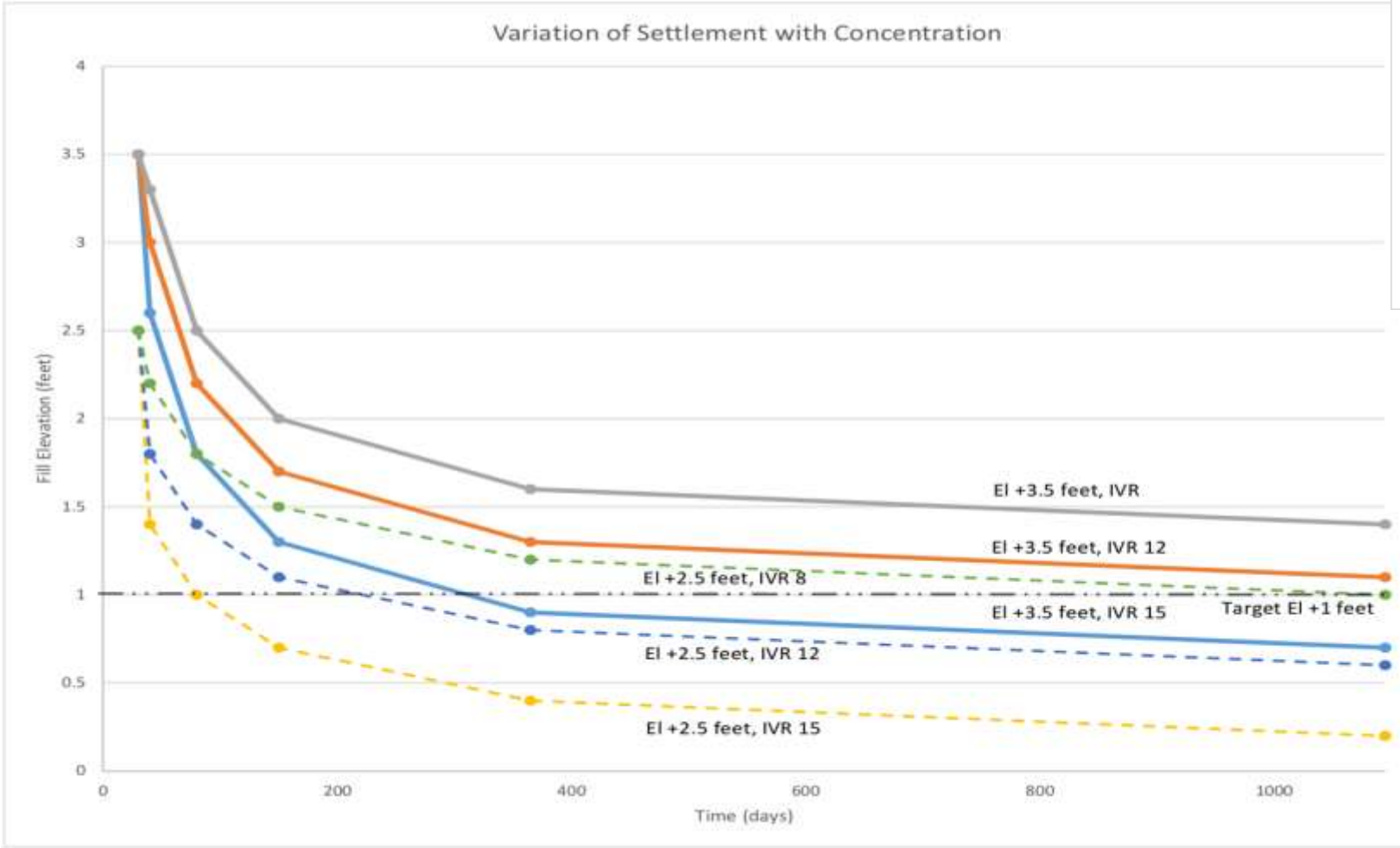
Fill Elevation at End of Dredged Fill Placement at ISP-3 (feet, NAVD 88)	Approximate Construction Settlement (feet)	Fill Elevation (feet, NAVD 88)							
		84 Days	111 Days	187 Days	365 Days	730 Days	1095 Days	3650 Days	7300 Days
+2.7 (Lower Bound Settlement)	0.4	+2.09	+1.8	+1.43	+1.35	+1.25	+1.2	+1	+0.95
+2.7 (Upper Bound Settlement)	0.4	+2.1	+2.0	+1.55	+1.41	+1.39	+1.38	+1.36	+1.35

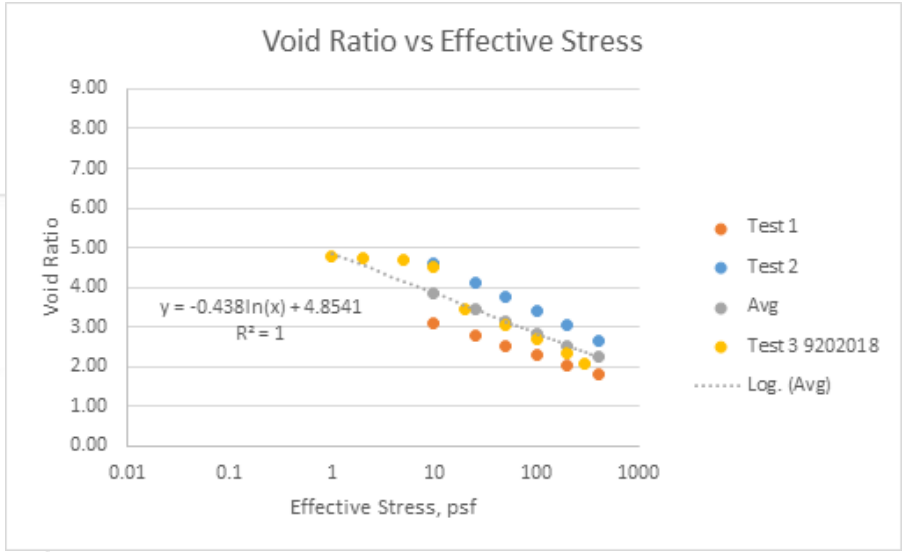
*Based on information provided by CPRA, construction duration was approximately 55 days.

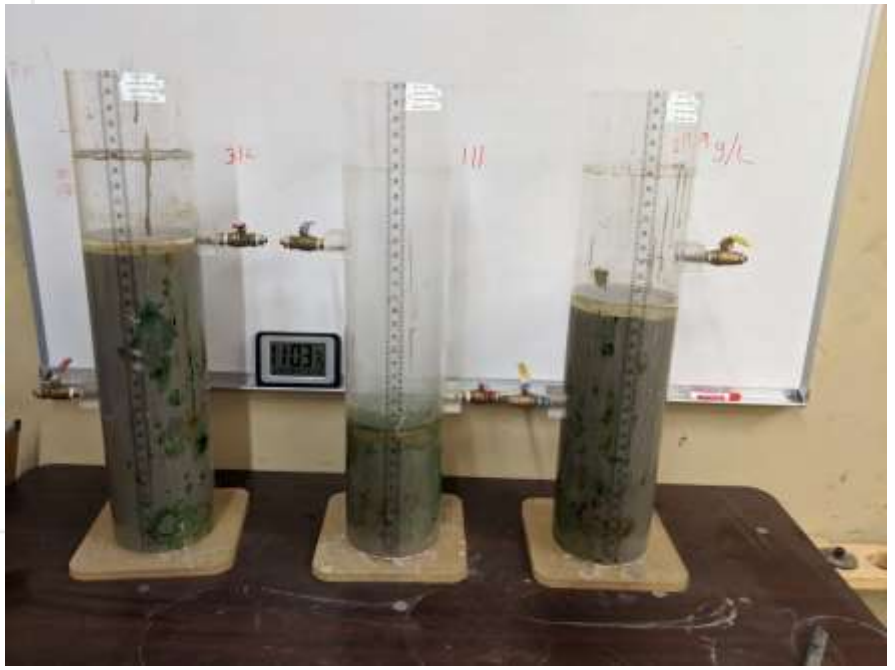
The Perfect Marsh

- The project is bid and awarded and the Engineer has designed the perfect marsh and made all the correct assumptions:
  - Dredge size
  - Sequencing
  - Material Type
  - Discharge, weir box, and pipeline locations
- The dredge completes the project in the exact time estimated and no break downs occur, no storm events occur, no borrow area inconsistencies…

Settlement Curves







Geotechnical Construction Monitoring

- Observational Method
  - DOTD bridge monitoring
  - Pile Load test
  - Nuclear density tests of placed fill
- CPRA has developed a program for marsh creation projects
- This program continues to evolve with each project

Geotechnical Construction Monitoring

- **Customizable** Program designed to verify, calibrate, and/or adjust geotechnical design
  - Settlement estimates, target fill heights

1. Physical samples collected during construction or post-construction

2. ISP = Instrumented Settlement Plates – record slurry elevation and density*

3. ECD Monitoring – strength gain beneath ECD*

4. Camera System*

*Real Time Option Available

Monitoring Tools

Construction Sampling

Post-Construction Sampling

Instrumentation

Camera and Solar Panel

Physical Sampling

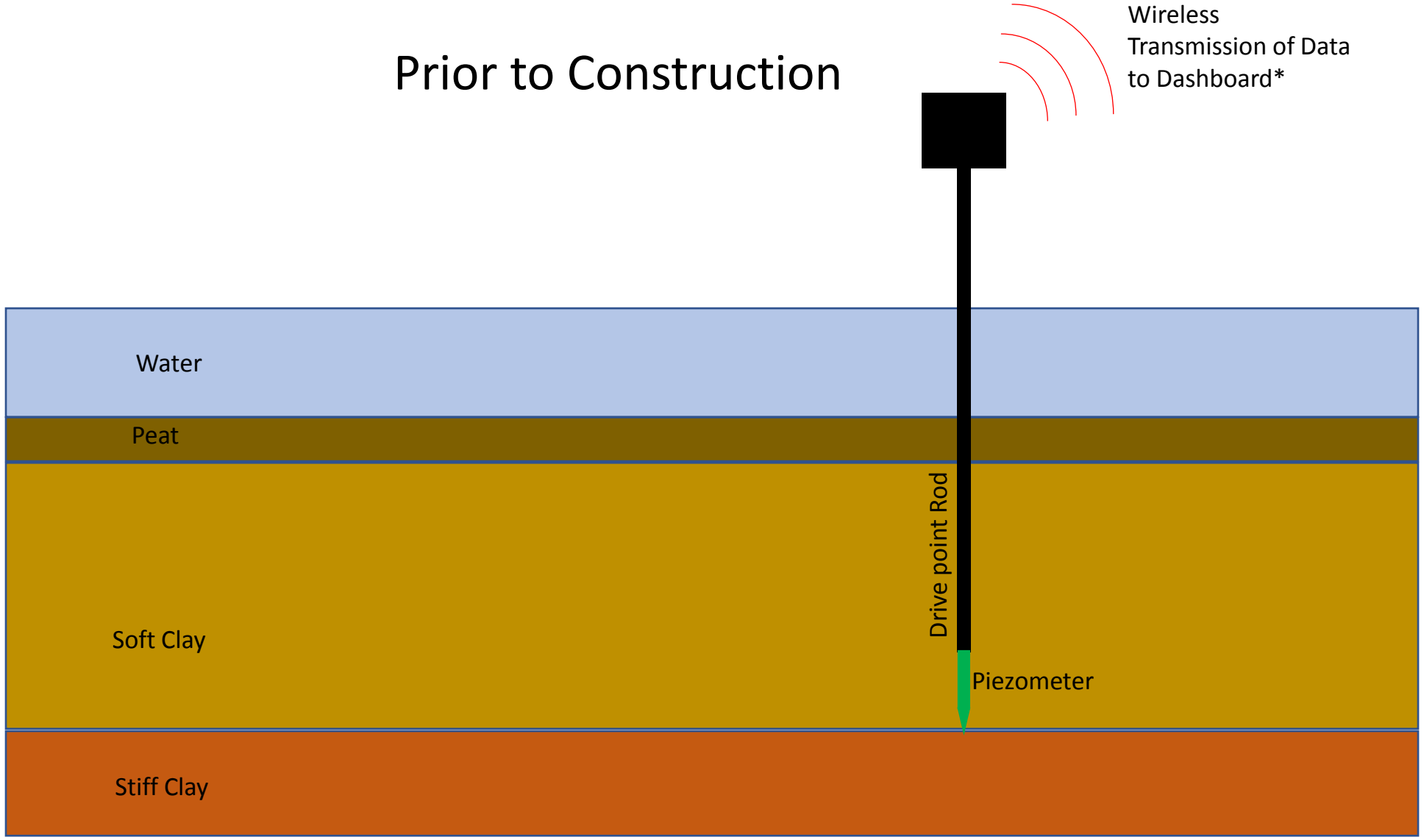
Physical Sampling

Physical Sampling

ECD Monitoring

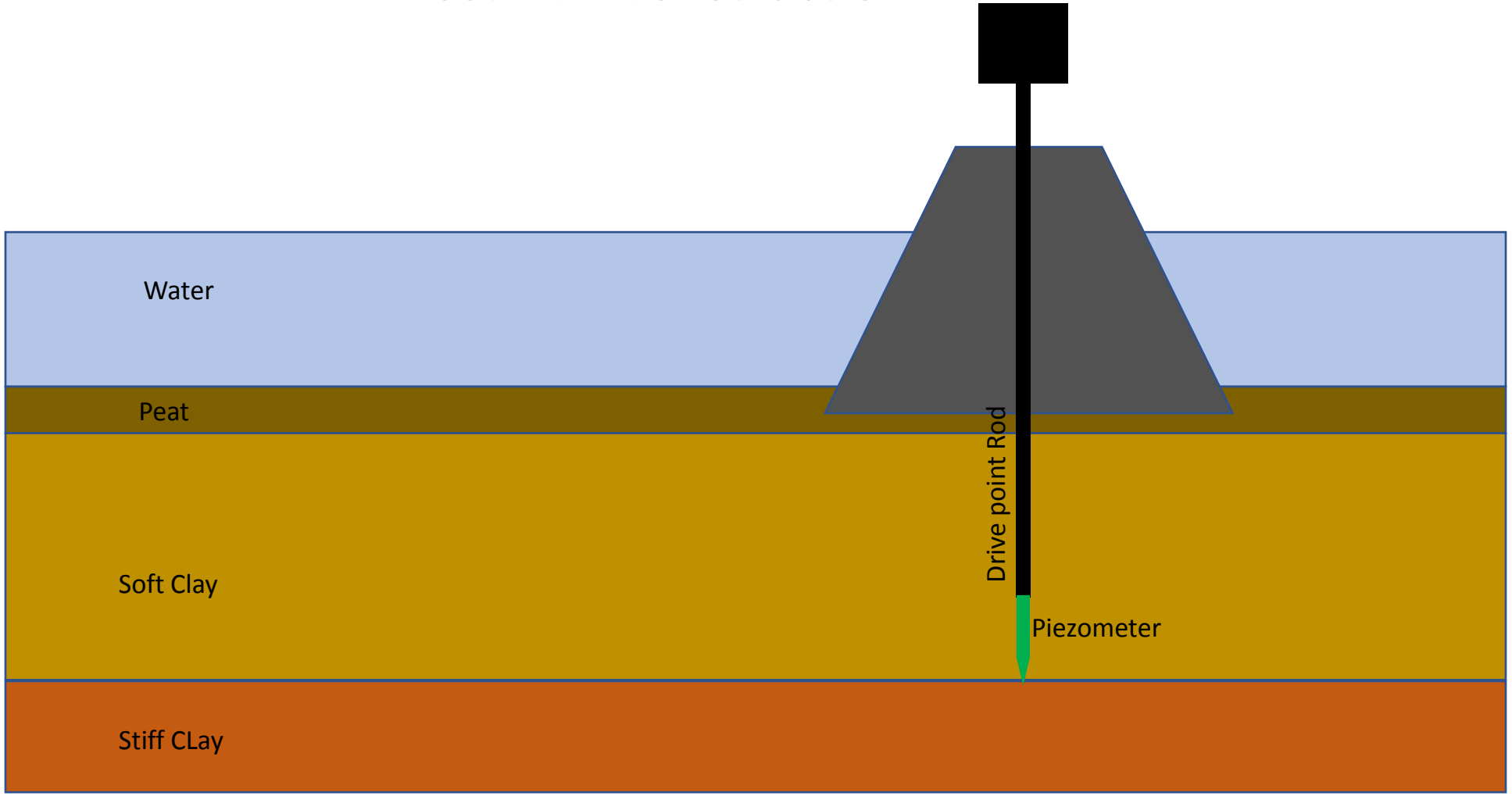
ECD Monitoring

Prior to Construction



ECD Monitoring

Post ECD Construction



Reduction in Wait Time

ECD Monitoring

Camera System

Camera System

Hurricane Ida