Volume Based Acceptance for Mixed Sediment Marsh Creation Projects

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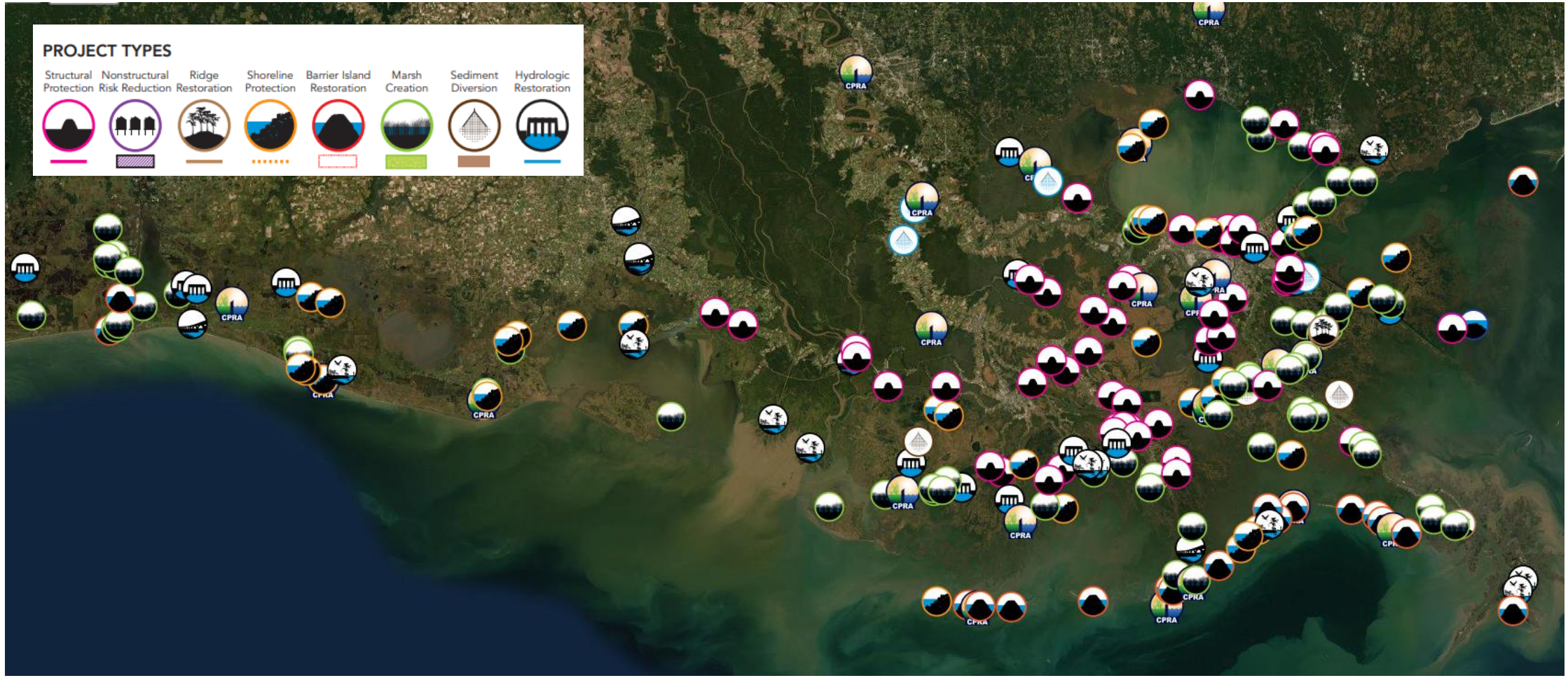
Presentation Outline

- Introduction and Background
- Marsh Creation Design
- Constructed Marsh Fill Elevation Based Acceptance
- Volume Calculations
- Volume Based Acceptance

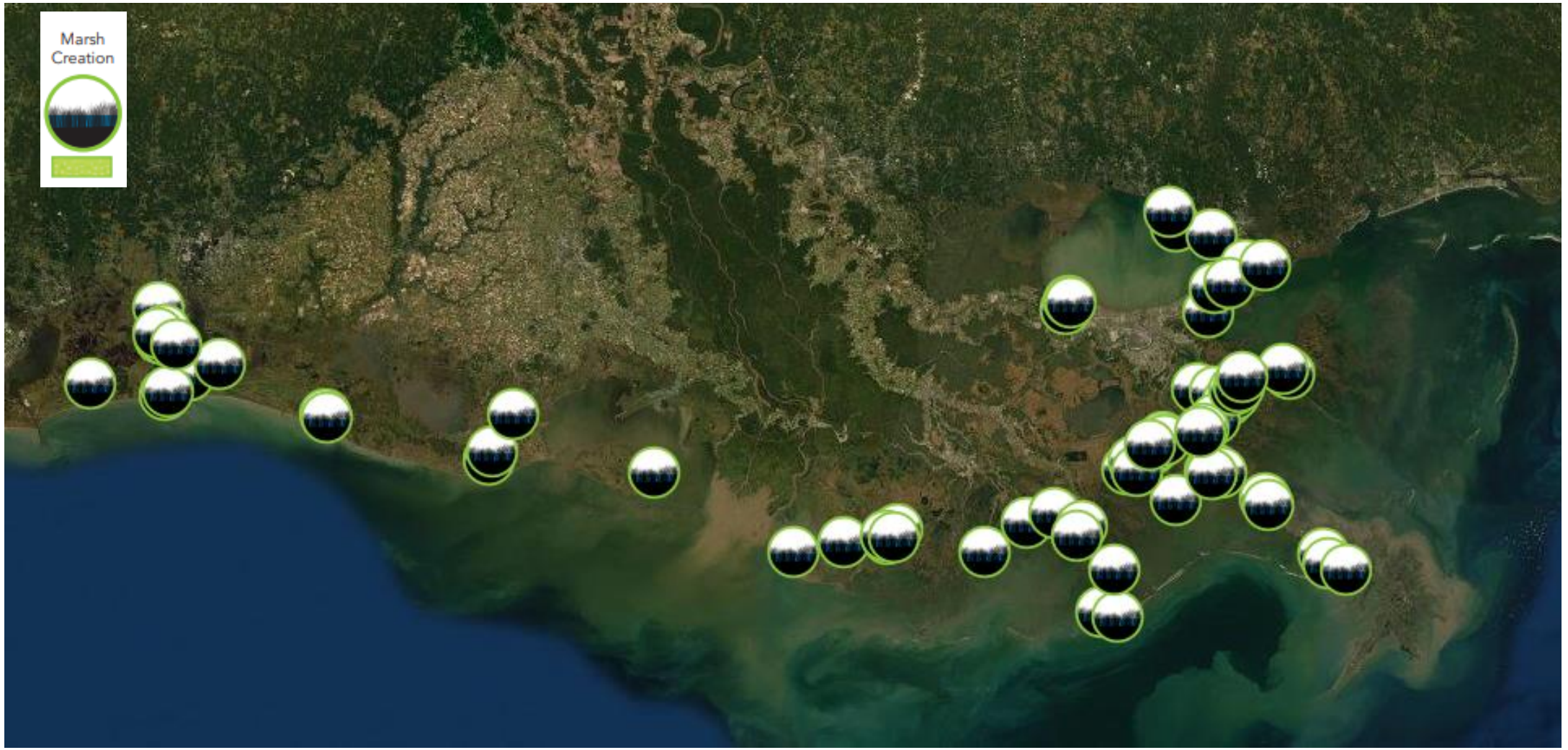
Introduction and Background

Types of Projects in Coastal Louisiana



https://cims.coastal.louisiana.gov/outreach/projects/OPL_Full_page.html

Marsh Creation



https://cims.coastal.louisiana.gov/outreach/projects/OPL_Full_page.html

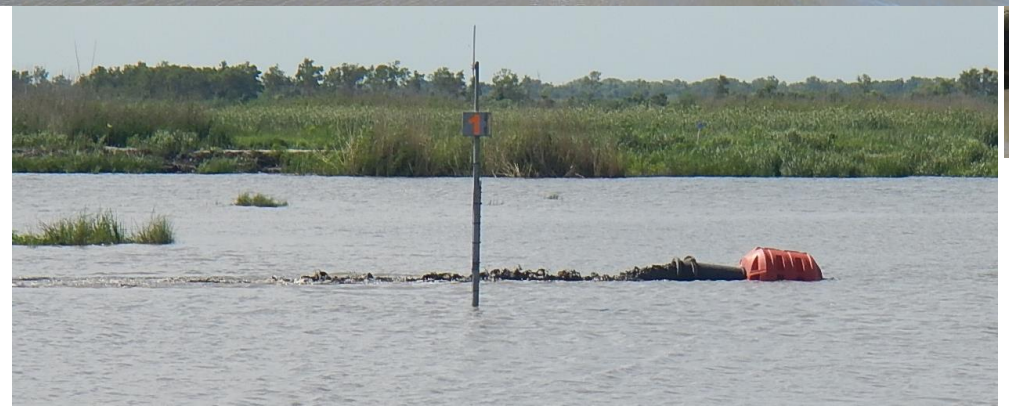
What is Marsh Creation?

- Goal of marsh creation project is to create wetland habitat in degraded coastal marsh regions while maximizing ecological benefits for the project design life (typ. 20 years)

Images from BA-43 Lake Hermitage Marsh Creation Project

What is Marsh Creation?

- Dredges material from borrow source to marsh creation area via hydraulic cutterhead dredge



Images from TV-66, TE-138, and BA-39 Projects

Earthen Containment Dikes

- Build earthen containment dikes from in-situ material to contain the marsh fill material

Image from BA-43 Lake Hermitage Project

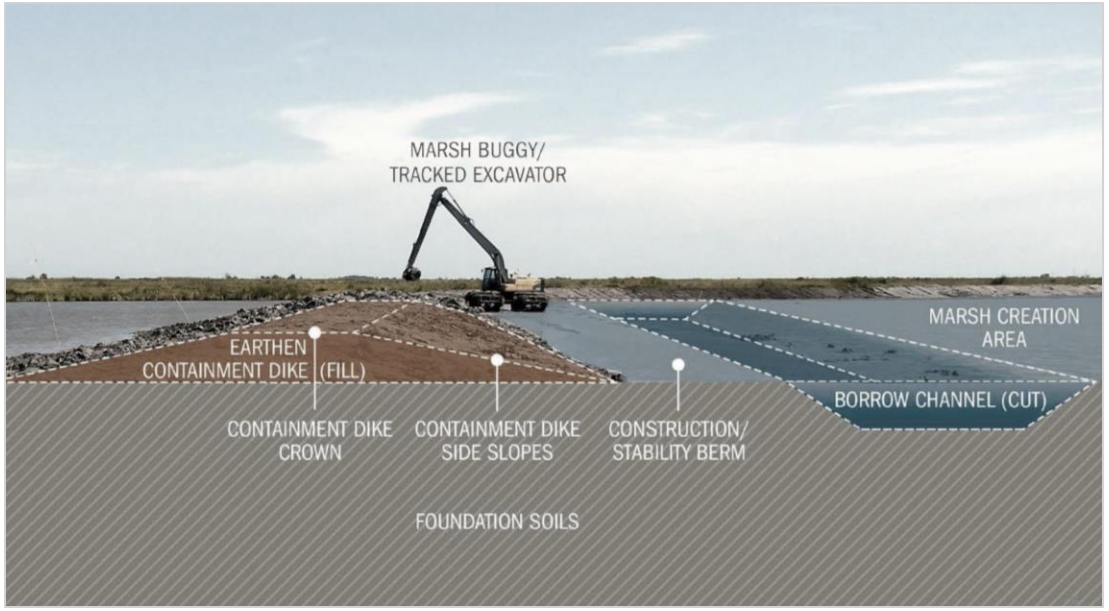
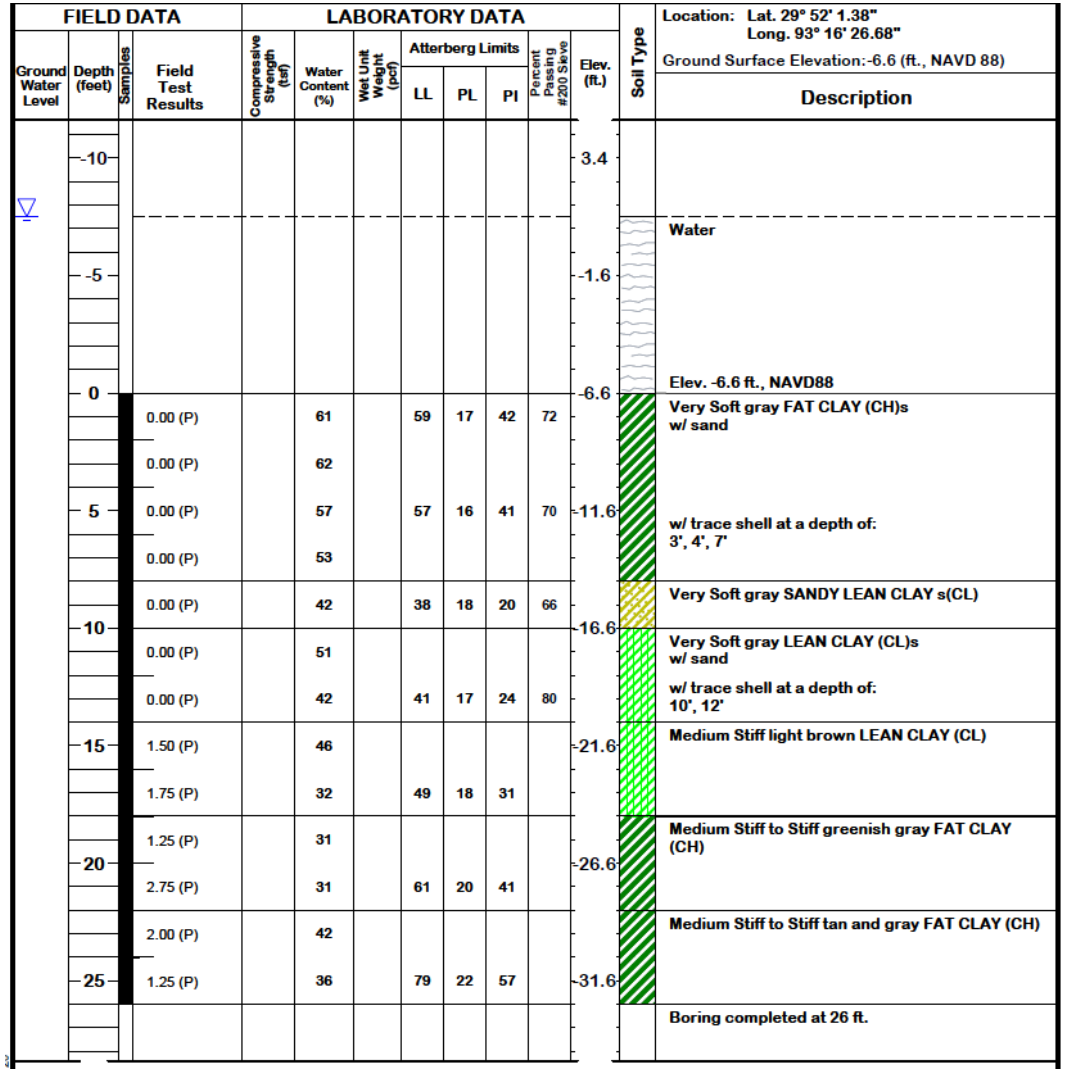


Image from GeoEngineers

Mixed Sediment Borrow Sources

- Predominately clays, but may see some silts, sands, and organics mixed in

- The most common type of borrow source we see



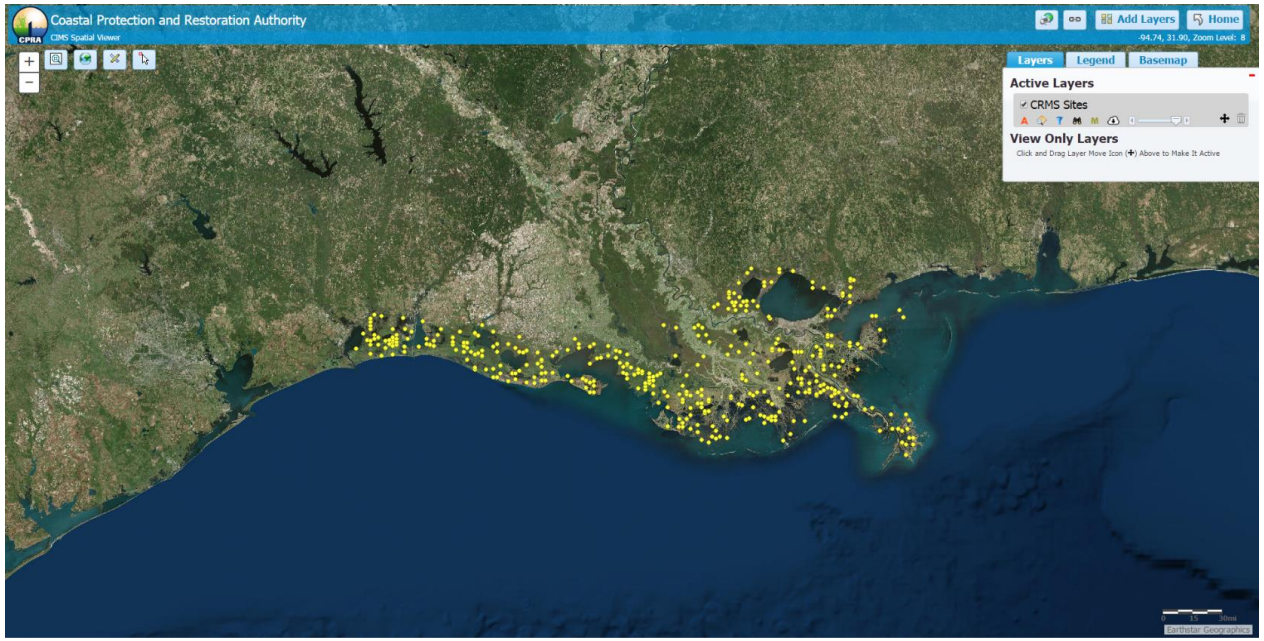
From CS-78 No Name Bayou Marsh Creation Project – Ardaman & Associates

Marsh Creation Design

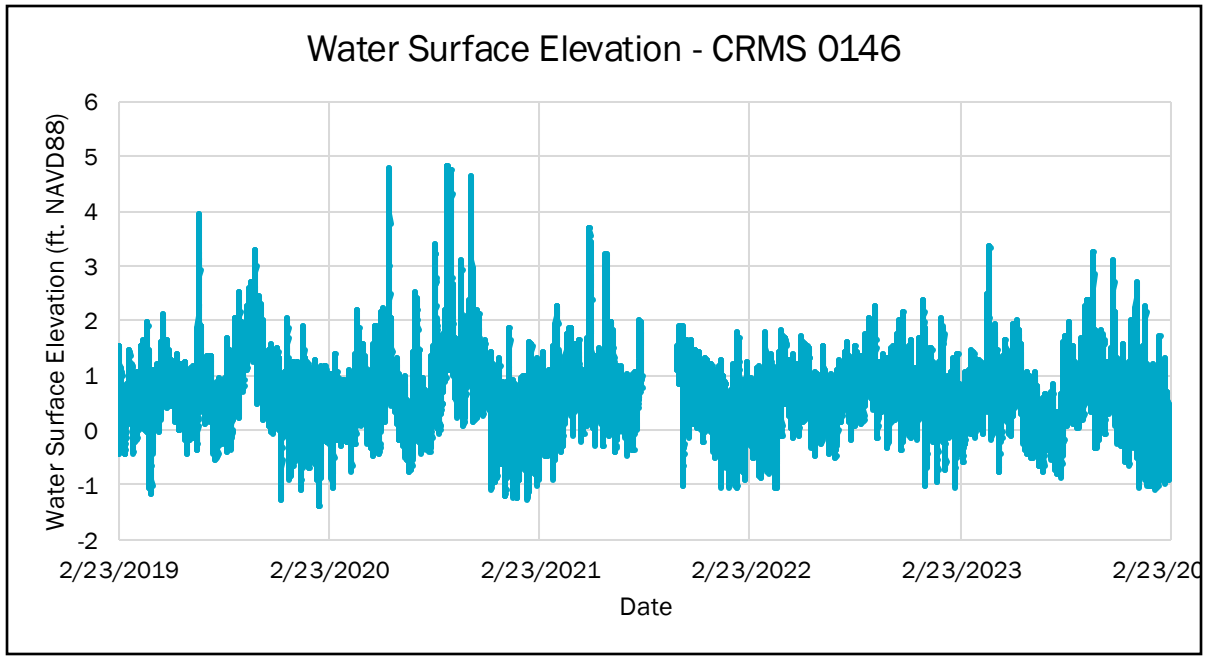
Hydrologic Conditions

- Marsh elevation targets are hydrology based

- Water level data taken from Coastwide Reference Monitoring System (CRMS) stations



https://www.lacoast.gov/crms_viewer/Map/CRMSViewer



Percent Inundation Range

- Tidal range does not take other non-tidal includes into account
  - Meteorological events
  - River discharge
  - Management regimes

- Percent inundation, or frequency that a certain elevation of marsh is flooded, takes these additional occurrences into account

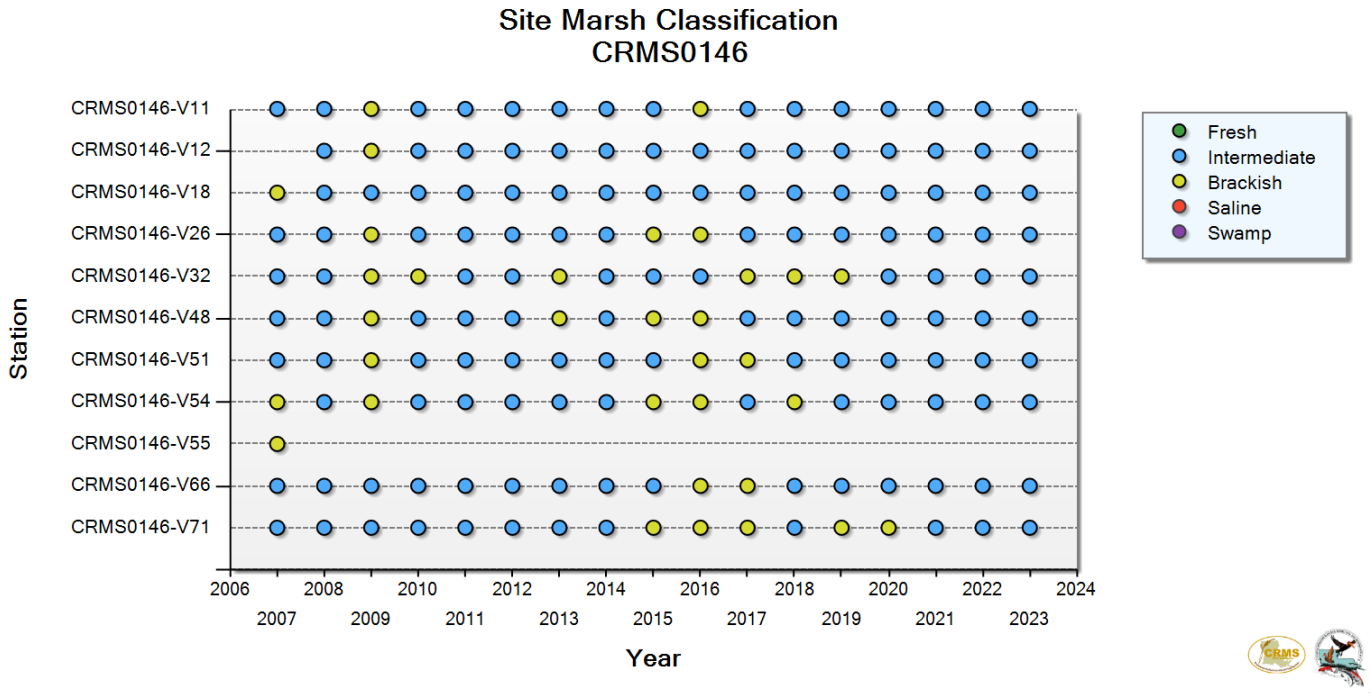
Percent Inundation Levels for CRMS0146	
% inundated	Marsh Elevation (Past 5 years) (ft. NAVD88 Geoid 12A)
1%	2.570
5%	1.700
10%	1.390
20%	1.100
30%	0.910
40%	0.770
50%	0.620
60%	0.470
65%	0.390
70%	0.310
80%	0.110
90%	-0.150

Marsh Creation Project Goal

- Maintain an optimal inundation range based on the marsh type for a majority of the project life

Optimal marsh inundation ranges in Louisiana	
Marsh Type	**Optimal Inundation Range**
Fresh	10%-90%
Intermediate	10%-90%
Brackish	10%-65%
Saline	20%-80%

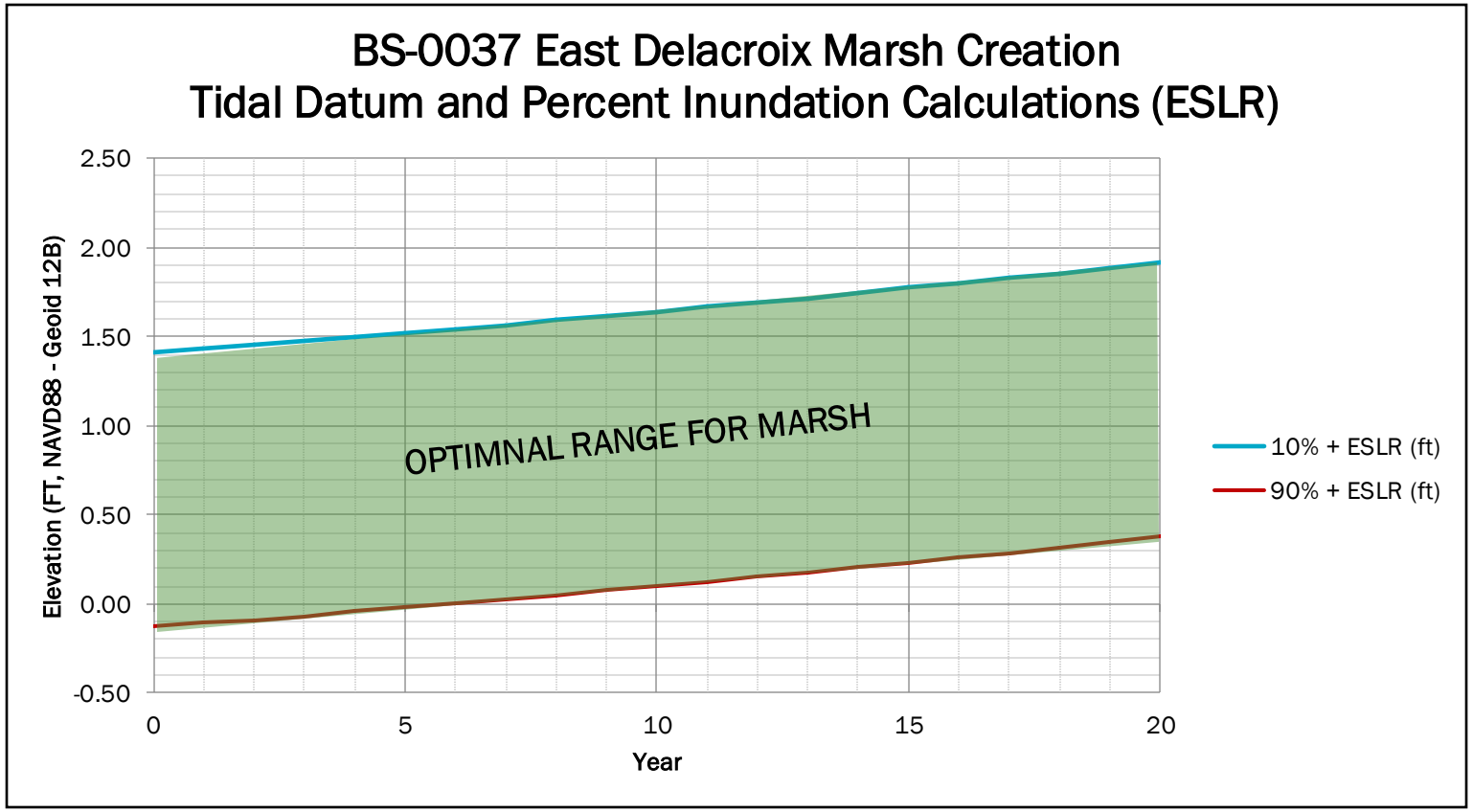
CPRA Marsh Creation Design Guidelines 1.0



https://www.lacoast.gov/crms_viewer/Map/CRMSViewer

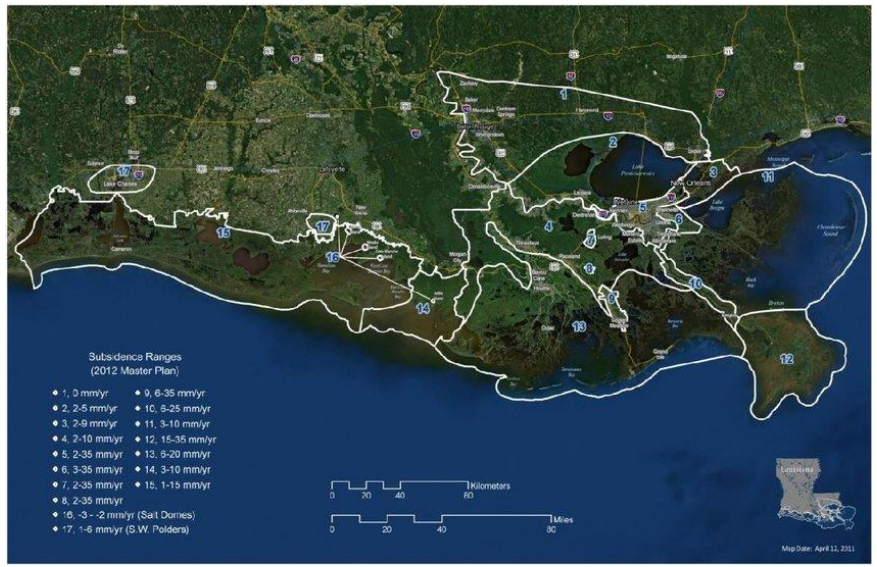
Sea Level Rise

- Eustatic Sea Level Rise (ESLR) is applied to inundation levels across the project life

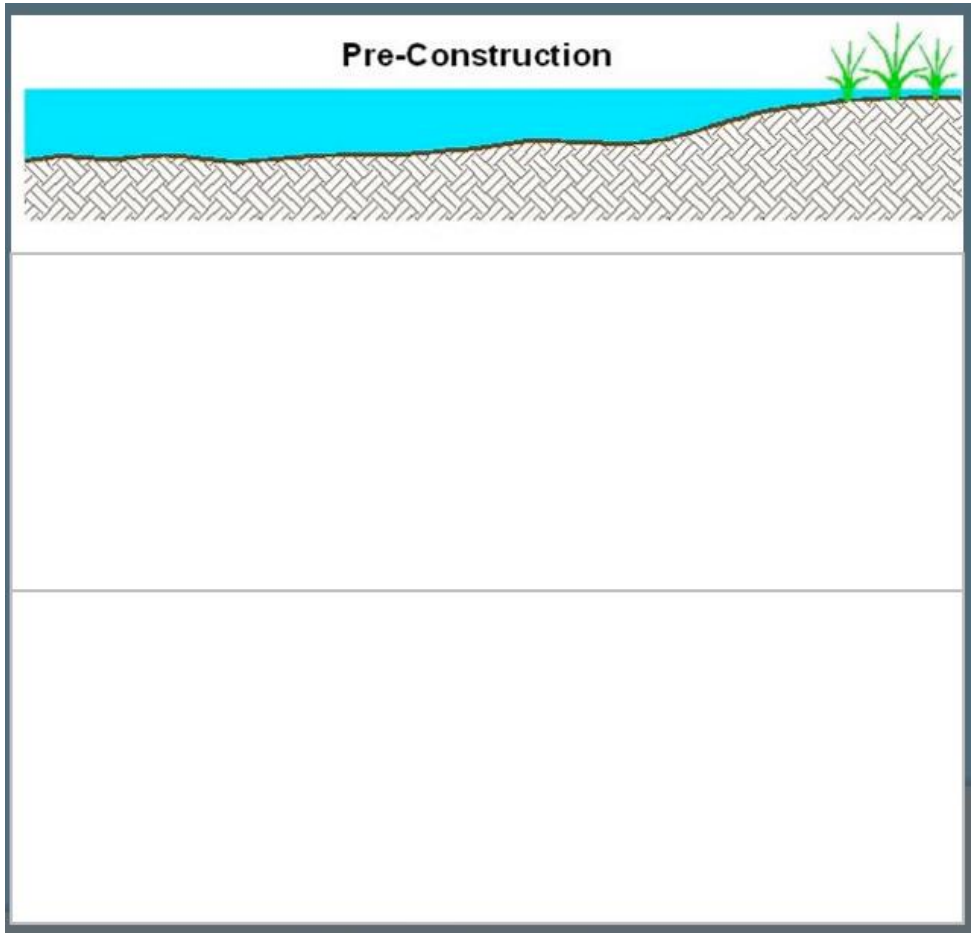


Marsh Settlement

- Marsh settlement consists of
  - Consolidation settlement of the marsh fill (slurry)
  - Foundation settlement of the existing foundation soils
  - Subsidence

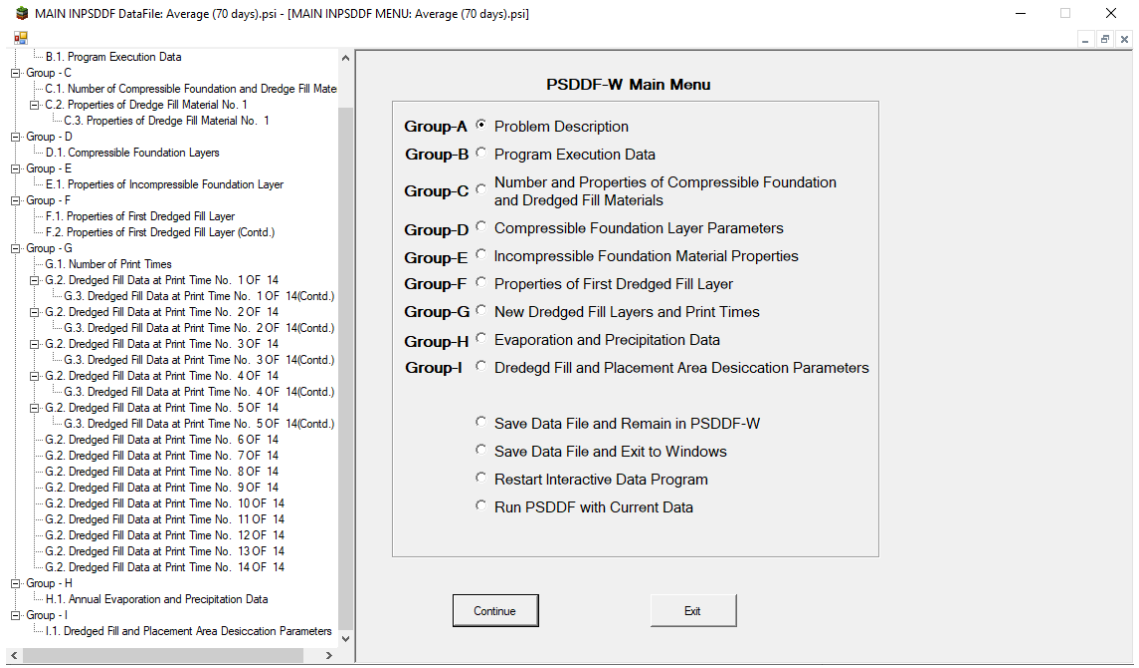


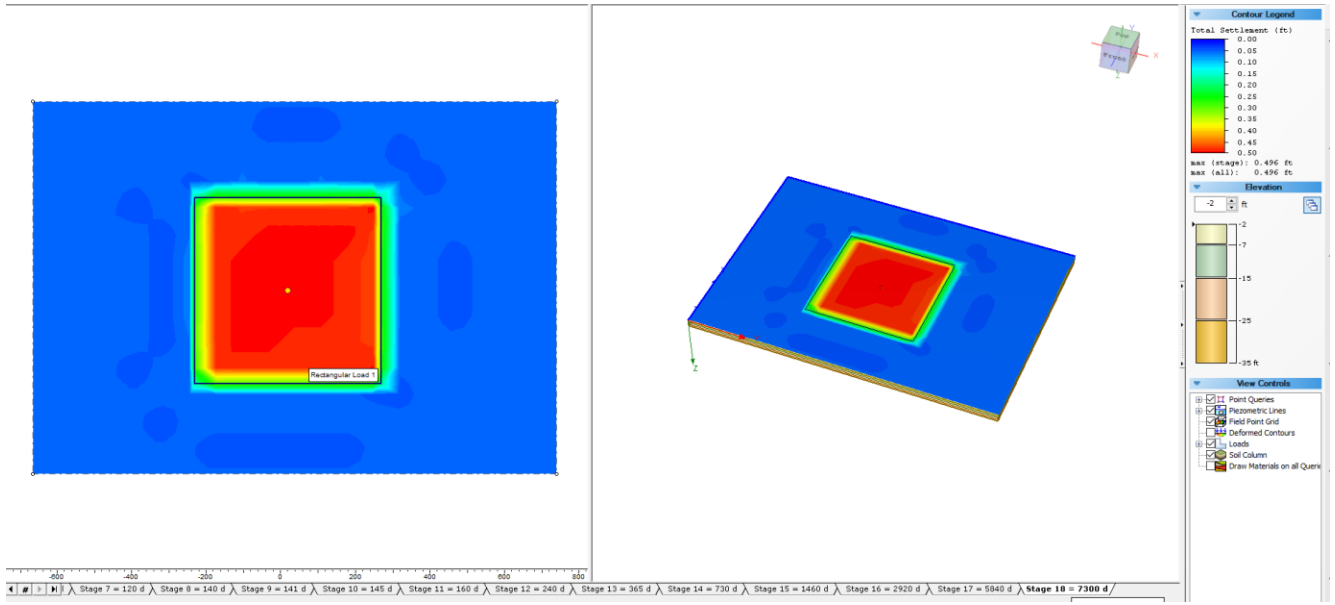
2023 Coastal Master Plan



Marsh Settlement – Geotechnical Analysis

- PSDDF – consolidation settlement of marsh fill and foundation settlement
- Settle3 – foundation settlement





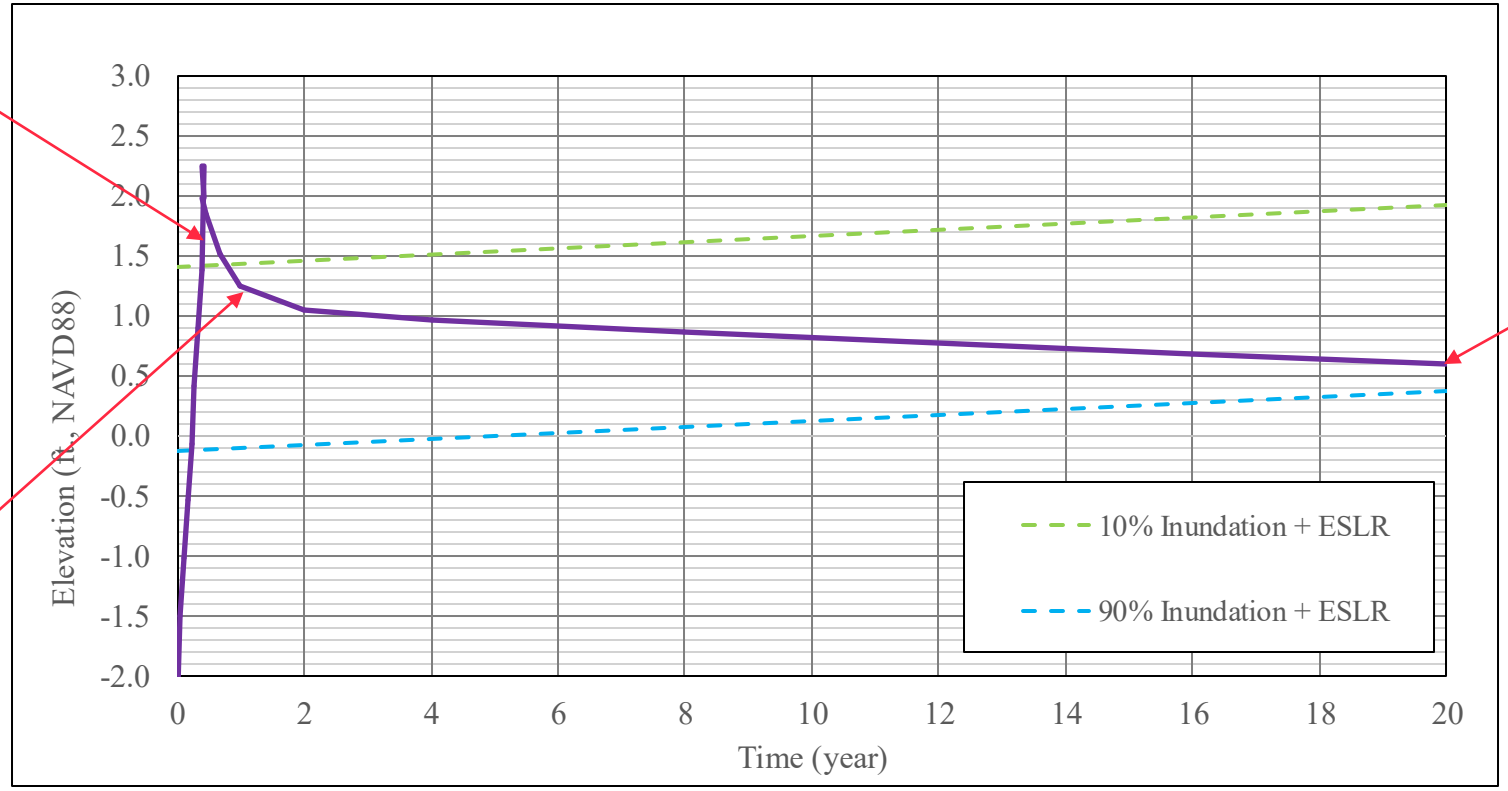
*PSDDF = Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill

Marsh Settlement Curve

- Create a settlement curve of the marsh platform that includes all factors (fill settlement, foundation settlement, subsidence)

Upward slope at the beginning is during construction

Marsh settles into optimal range within the first year



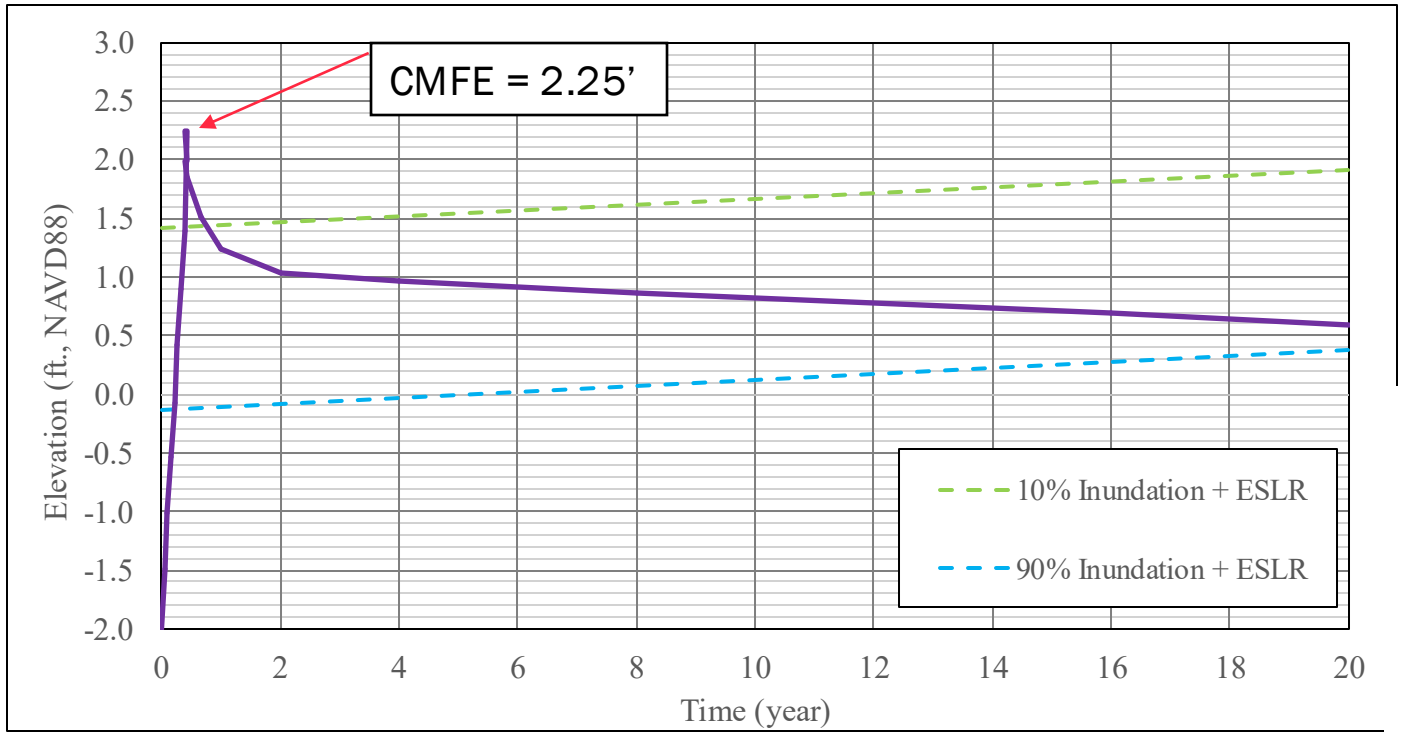
Stays within range for the entire project and is just above the lower limit at year 20

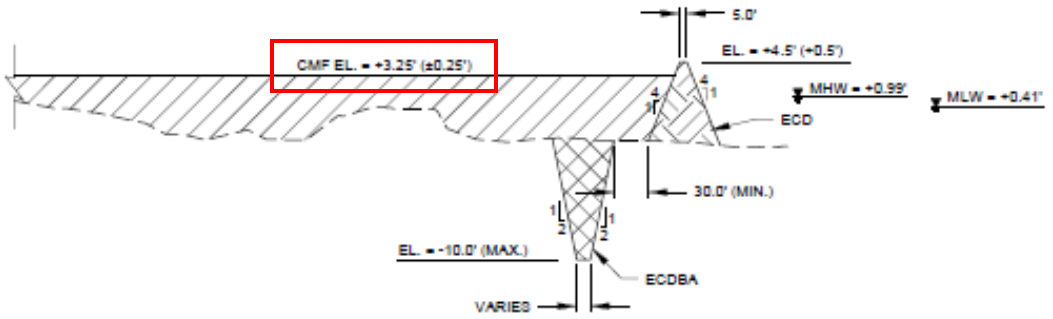
Constructed Marsh Fill Elevation Based Acceptance

Constructed Marsh Fill Elevation (CMFE)

- Marsh fill elevation at the end of construction

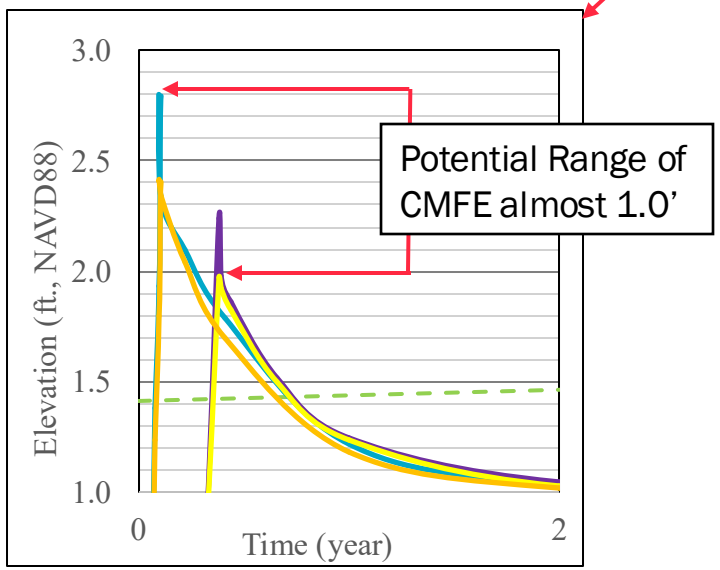
- Typically used for acceptance (grade stakes, surveys)

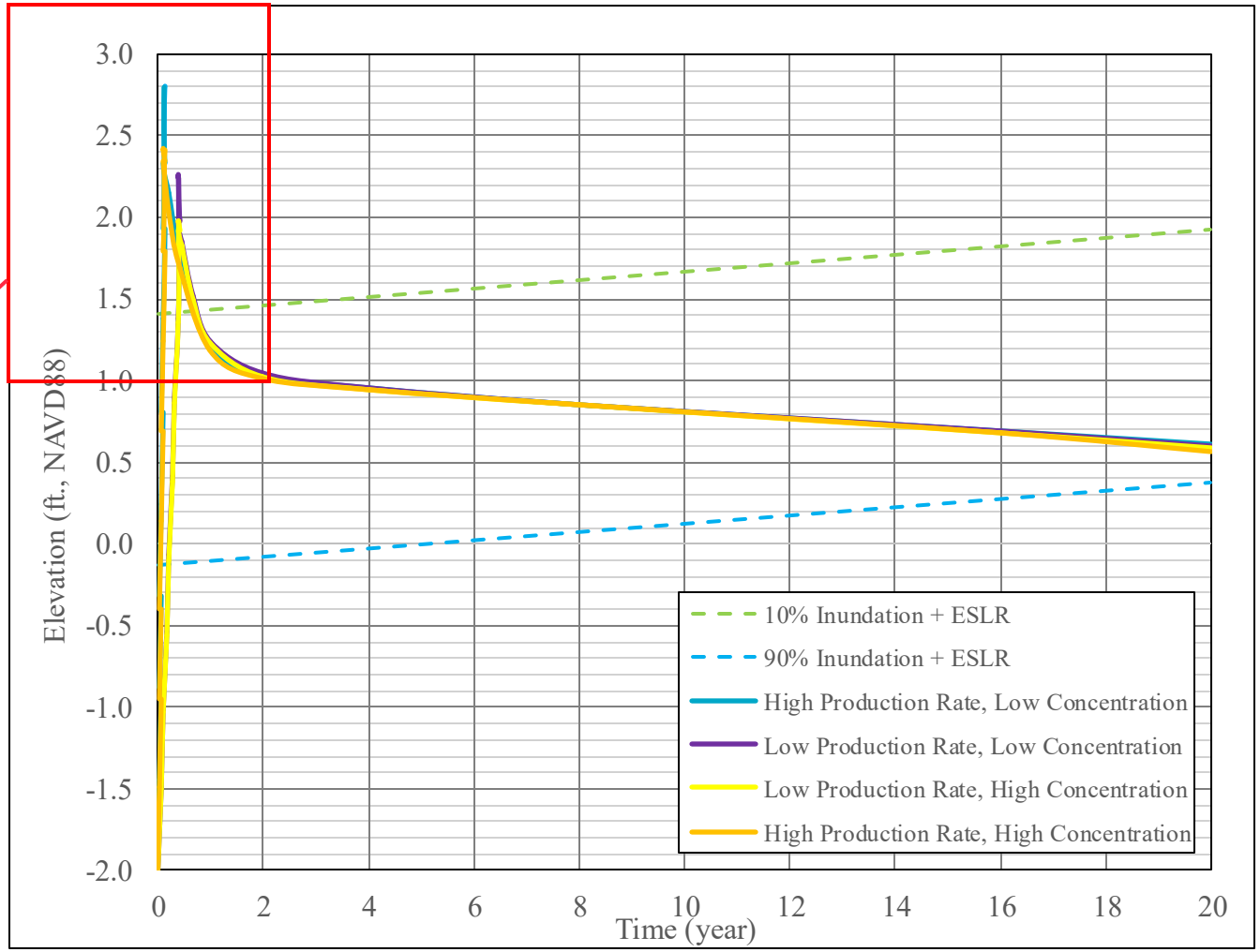




Problems with CMFE Based Acceptance

- One curve and one CMFE is not realistic
- Several contractor dependent factors can influence CMFE
  - Production rate
  - Slurry density/concentration





Production Rate

- Rate at which borrow material is being dredged
- Typically in cubic yards/hour

Table 3-3. Specifications for Typical Dustpan and Cutterhead Dredges.

Dredge Type	Pipeline Diameter in.	Weight tons	Length ft	Width ft	Height ft	Draft in.	Freeboard in.	Dredge Pumps No.	Dredge Pumps hp	Dredge Pumps Size	Dredge Pumps Drive	Production Rate cu yd/hr	Dredging Depth ft	Depth of Single Pass Excavation in.
Dustpan	32	--	244	50	60	60	48	1	2100	38	Steam	3500	60	60
Cutterhead	6	18.5	44	11	20	34	14	1	175	8	Diesel	25-95	12	18
Cutterhead	8	18.5	44	11	20	35	13	1	175	8	Diesel	45-105	12	18
Cutterhead	10	72.5	90	17	33	43	17	1	335	12	Diesel	60-300	25	18
Cutterhead	12	73.5	90	20	33	42	18	1	520	14	Diesel	120-540	25	18
Cutterhead	14	87	95	20	33	43	17	1	520	16	Diesel	160-700	25	21
Cutterhead	16	166	130	28	55	55	17	1	1125	18	Diesel	240-875	40	21
Cutterhead	20	316	180	32	70	54	42	1	1700	24	Diesel	310-1365	50	24
Cutterhead	24	326	185	32	70	56	40	1	2250	24	Diesel	515-1615	50	30
Cutterhead	30	350	225	36	67	60	36	1	3600	30	Diesel	575-2500	50	36

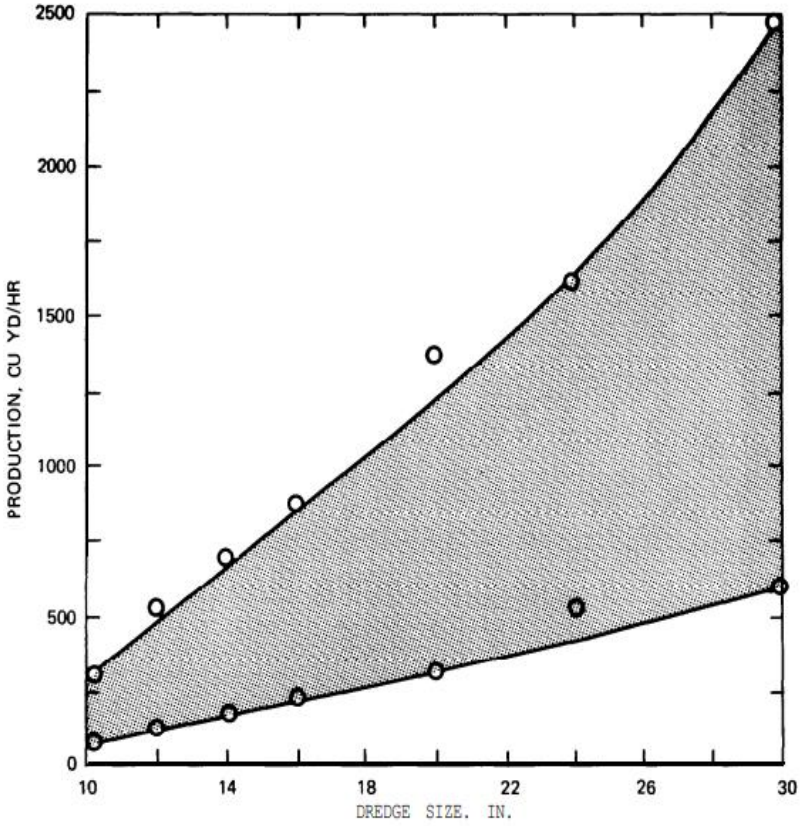


Figure 3-4. Typical cutterhead dredge production according to dredge size.

High production rate = less time to settle during construction = high CMFE

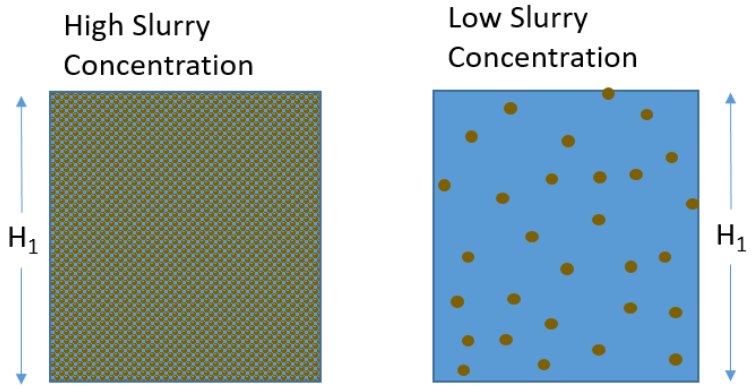
Low production rate = more time to settle during construction = low CMFE

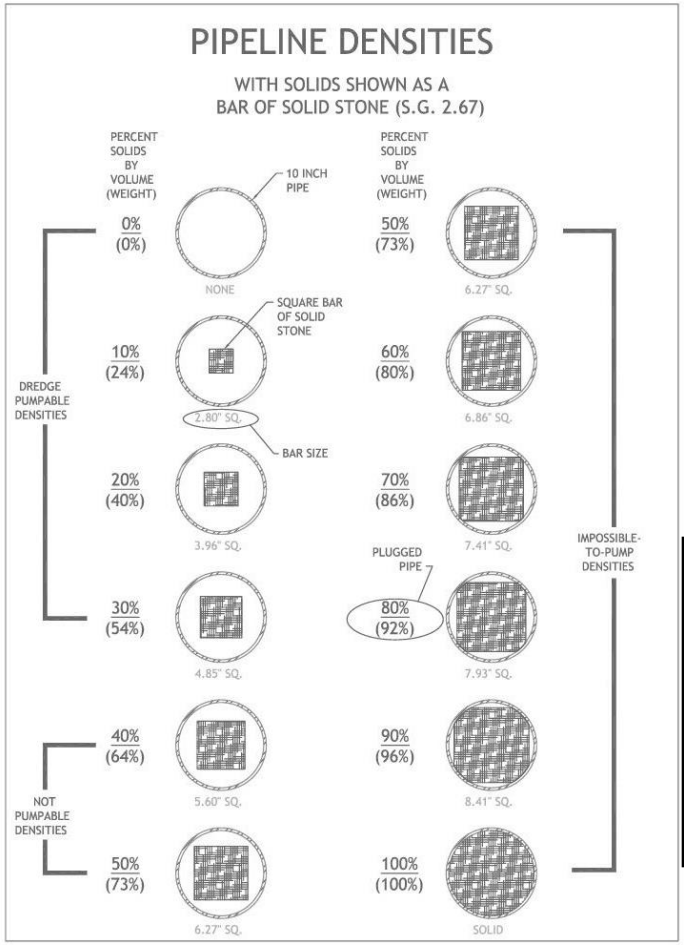
The faster the production rate, the higher the CMFE

Density/Concentration

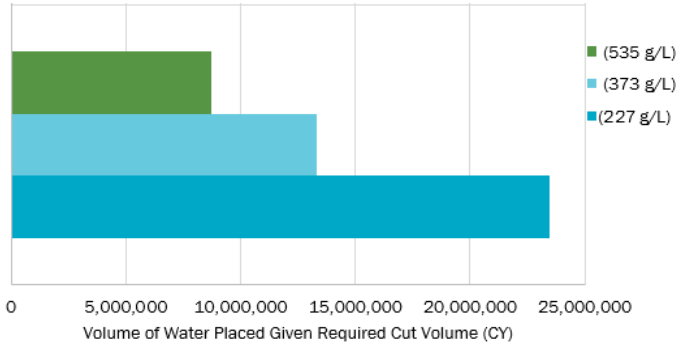
- Water is added to borrow material to create slurry

- Density/concentration → amount of solids per total volume of slurry
  - Indication of how much water is added





https://www.willardsays.com/discharge-pipeline/slurry-density/



<u>High</u> concentration = less water= <u>low</u> CMFE

<u>Low</u> concentration = more water = <u>high</u> CMFE

The more water added, the higher the CMFE

Variability During Construction

- Production rate and density can vary from project to project
- It can also vary throughout construction of one project
- This can cause issues with creating a uniform marsh platform

Volume Calculations

Calculating Marsh Volumes

- Estimated cut and fill volumes are calculated for all marsh creation projects
- Contractors are paid per cubic yard of material cut for mixed sediment projects

SUMMARY OF ESTIMATED QUANTITIES

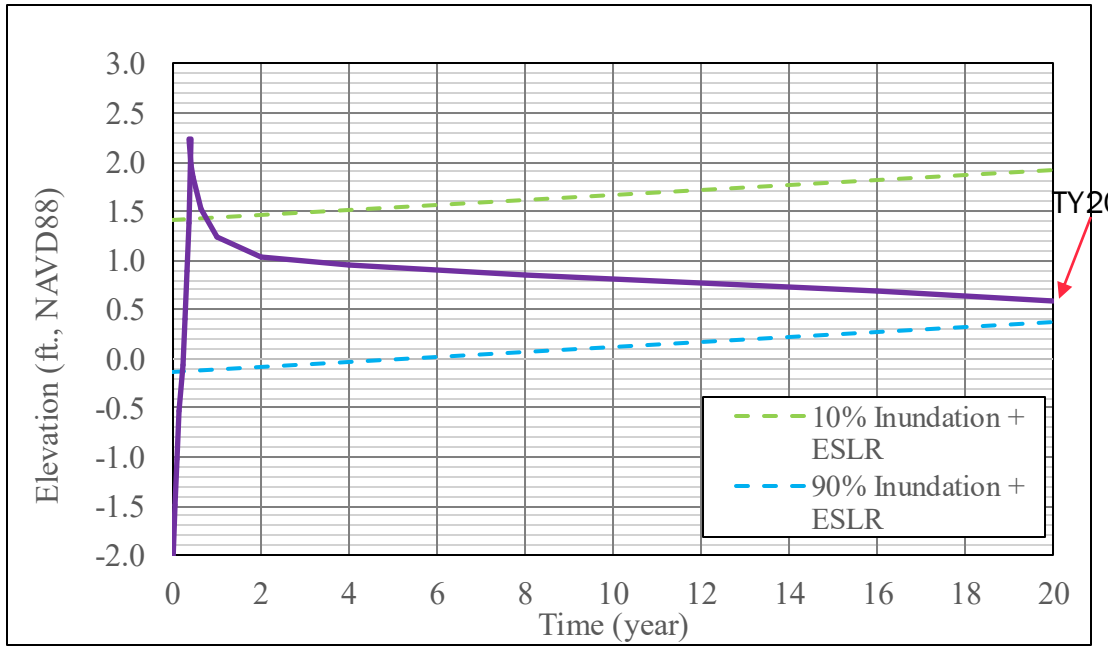
BASE BID

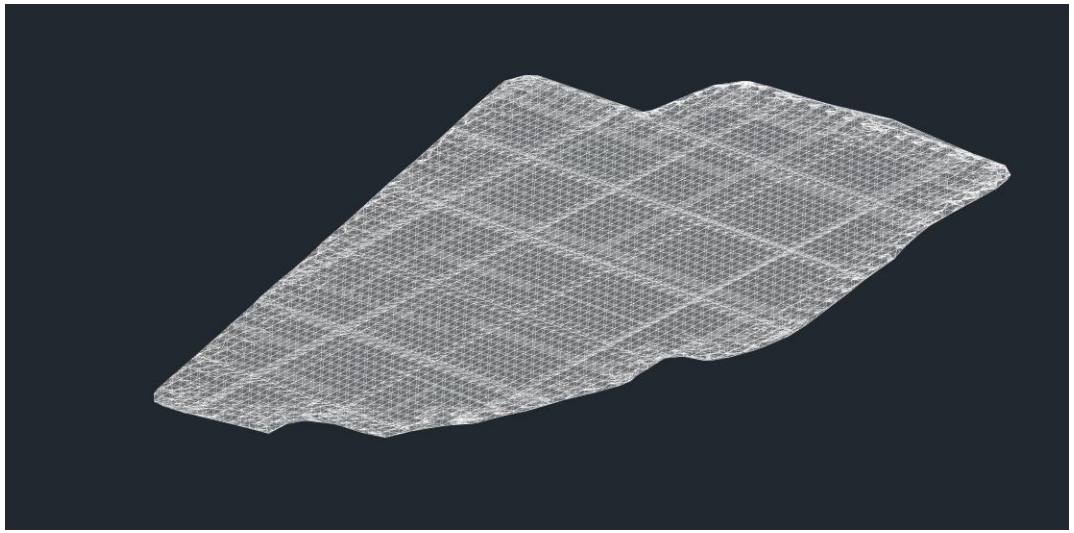
ITEM No.	DESCRIPTION	UNIT	ESTIMATED QUANTITY
1	MOBILIZATION AND DEMOBILIZATION (TS-100)	LS	1
2	SURVEYS (TS-200)	LS	1
3	GRADE STAKES (TS-250)	EA	30
4	INSTRUMENTED SETTLEMENT PLATES (TS-271)	EA	3
5	EARTHEN CONTAINMENT DIKES (TS-300)	LF	16,580
6	INTERNAL TRAINING DIKES (TS-301)	LF	8,040
7	HYDRAULIC DREDGING AND MARSH CREATION (TS-400)[1]	CY	1,510,000

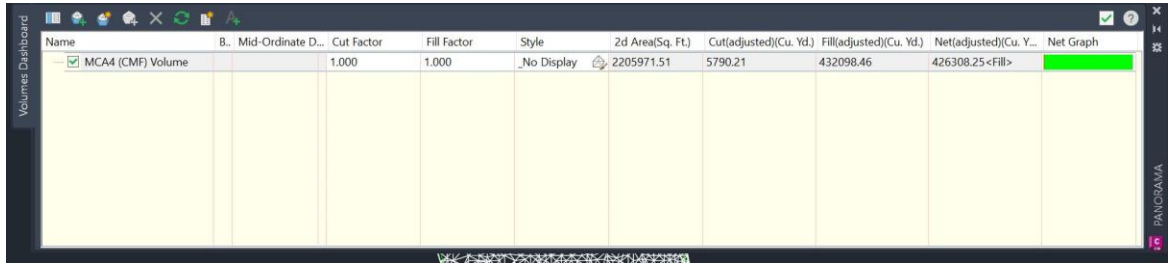
Calculating Marsh Fill Volumes

- Surface created using survey data in AutoCAD Civil 3D

- Use fill elevation at TY20 from settlement curve + foundation settlement and subsidence







Calculating Marsh Fill Volumes

- Why use the TY20 elevation?

  - Mixed sediment projects are paid on the cut

  - Water is added to pump material to MCA and increases void ratio (ratio of voids to solids)

  - Void ratio decreases again when soil consolidates

  - Closest it will be to in-situ is at end of project life

In-situ Borrow Area Sample – Low Void Ratio

Dredged Slurry – High Void Ratio

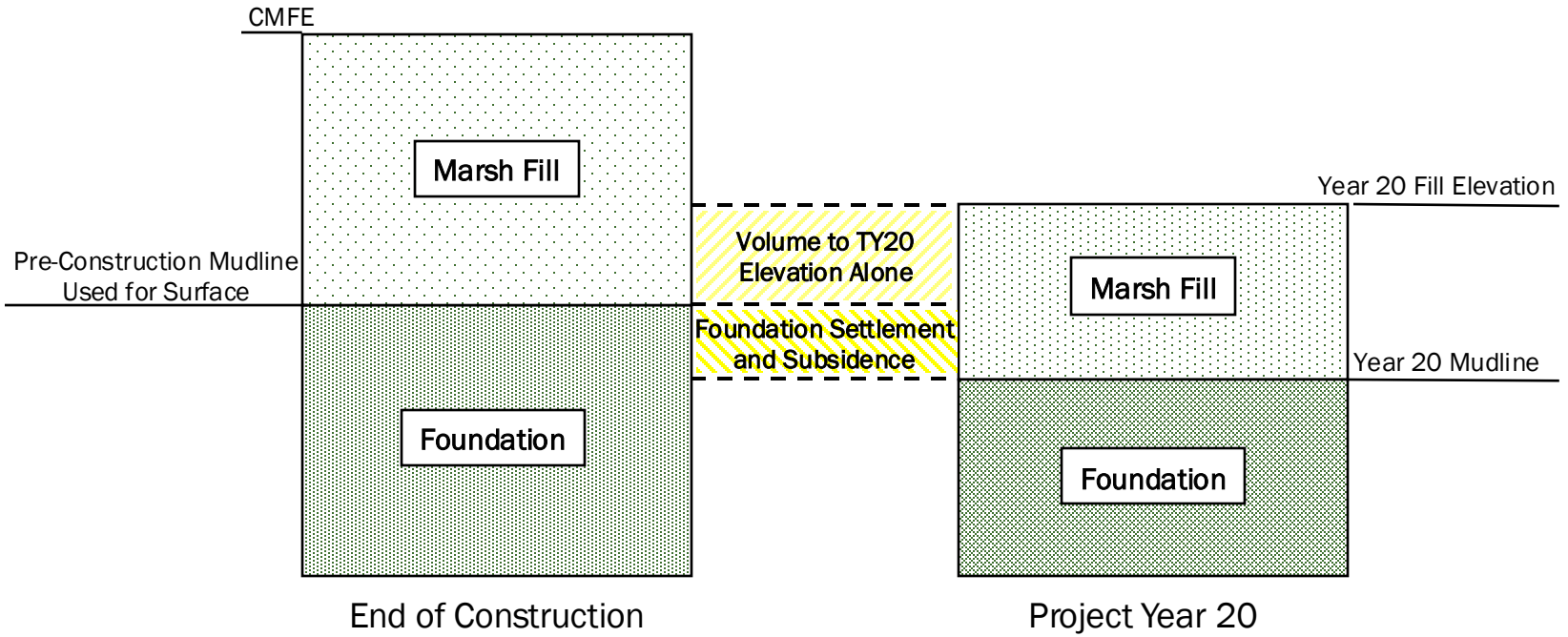
Images from BS-39, BA-43, and TE-139 Projects

Consolidated Marsh - Low Void Ratio

Calculating Marsh Fill Volumes

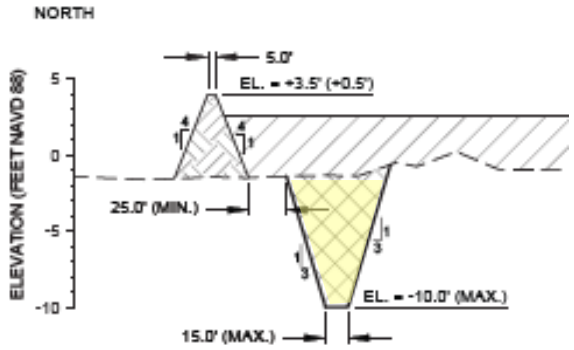
- Why add foundation settlement and subsidence?

  - The pre-construction mudline is used for surface



Calculating Marsh Fill Volumes

- Add back in containment dike borrow backfill



Section from CS-78 No Name Bayou Marsh Creation Project

Calculating Marsh Cut Volumes – Cut to Fill

- Apply a cut to fill ratio because projects are paid on the cut
- Cut to fill ratio accounts for
  - How close does the marsh fill get to the original state (void ratio) in the borrow area?
  - Additional losses during construction

$$C:F = \frac{1+e_{borrow}}{1+e_{TY20}} + losses$$

Comes from soil boring data

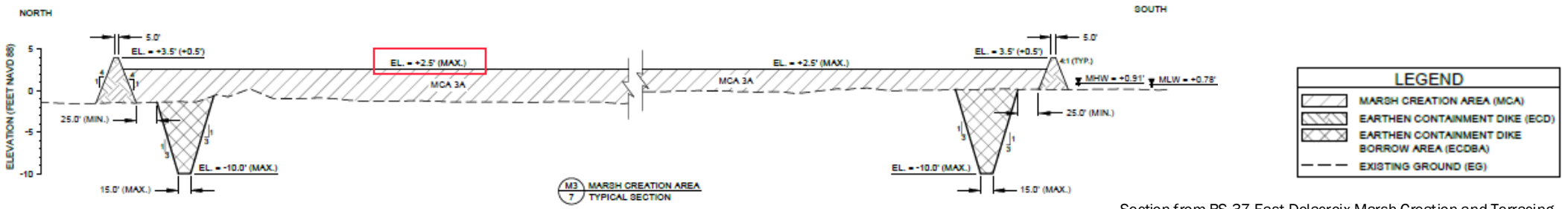
Comes from PSDDF

Example Cut to Fill Calculation	
e_{ave} borrow	2.30
e_{ave} fill at TY20	2.80
Cut to fill	0.87
Cut to Fill w/ 15% for losses	1.0

Volume Based Acceptance

Volume Based Acceptance

- Utilizes the volume as the acceptance criteria rather than CMFE
- Avoids uncertainty of CMFE based on the contractor's means and methods
- Based on borrow area survey
- Still give a maximum CMFE to ensure earthen containment dikes are not overtopped
- Ensure that worst case scenario (low concentration, high production) will not exceed this max



Section from BS-37 East Delacroix Marsh Creation and Terracing

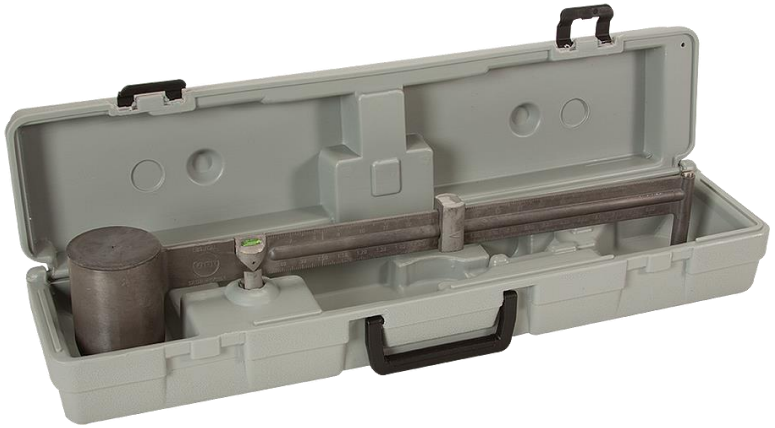
Additional Considerations

- Making sure dredged material is uniformly placed

  - Require contractor to provide dredge pipeline outfall plan that details uniform placement strategies, outfall locations, proposed volumes at outfall location, etc.

  - Require marsh fill is within 1.0’ from highest elevation to lowest elevation

  - Mud balance testing at grade stake locations to confirm uniform fill across area



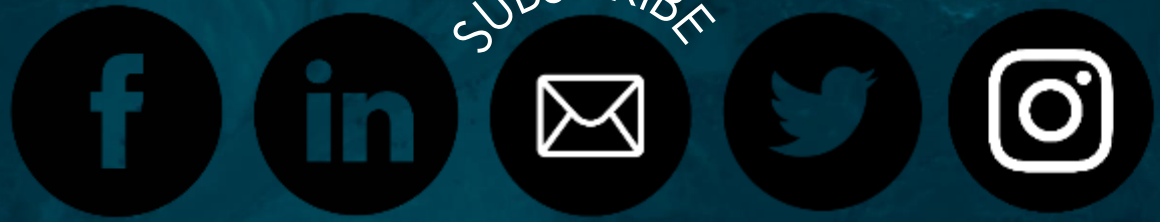
https://www.humboldtmfg.com/mud-balance.html

Volume Based Acceptance in Practice

- Has been utilized by the Natural Resources Conservation Service (NRCS)
- Used for the CS-78 No Name Bayou Marsh Creation Project that is currently in construction
- Hope to see success in this method and utilize for more projects in the future!

CS-78 No Name Bayou Marsh Creation Project – Google Earth

Thank You



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