Long Point Bayou Marsh Creation Project
95% Design Report
Appendix G: Design Calculations

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1.0 Tidal Datum Evaluation

A. Given:

Hourly hydrologic data was obtained from the following CRMS station using the CIMS database:

Station	CRMS0687
Location	**Lat, Long:** 29.9405823, -93.35432
Date of Record	5/1/2015-5/1/2020

B. Calculations:

The MHW and MLW were determined for each day from the CRMS station. The MHW and MLW values were averaged over the 5-year period to compute the average MHW, MLW, MTL, and MR values as follows:

- Mean High Water (MHW) – the arithmetic mean of all the high water elevations observed over the 5-year period.
- Mean Low Water (MLW) – the arithmetic mean of all the low water elevations observed over the 5-year period.
- Mean Tide Level (MTL) – the tidal datum equivalent to the average of MHW and MLW observed over the 5-year period: $MTL=(MHW+MLW)/2$
- Mean Tide Range (Mn) – the tidal range between the MHW and MLW elevations observed over the 5-year period: $MR=MHW-MLW$

Table 1: Tidal Datum Evaluation Calculations

Known Variables	Equation	Elev. Ft, NAVD88 GEOID18
MHW= 5- Year Mean High Water	Measured from Raw Data	+1.05
MLW=5-Year Mean Low Water	Measured from Raw Data	+0.06
MTL=5-Year Mean Tide Level	(MHW+MLW)/2	+0.56
MR=5-Year Mean Tide Range	MHW-MLW	+0.99

2.0 Percent Inundation Determination

A. Given:

See Section 1.0A Above

Percent inundation refers to the percentage of the year a certain elevation of land would be flooded, by taking into account both tidal and non-tidal influences. Using percent inundation rather than tidal range as a proxy for marsh health (depending on the marsh type) can give a more accurate representation of the water levels found in the area. The hourly data collected in Section 1.0A) was used to compute the percent inundation levels.

B. Methodology:

1. Collect the hourly hydrographic data from the CRMS stations.
2. Evaluate the marsh type present at CRMS 0687 to determine the ideal percent inundation range. For CS-0085, the CRMS stations show saline marsh, relating to a 20-80% optimal inundation range.

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

Figure 1: CPRA Marsh Creation Design Guidelines v1

3. For each inundation value, calculate the target percentile for the entire data set.
   - 1% Inundated = 99th Percentile of water level elevations
   - 10% Inundated = 90th Percentile of water level elevations
   - 20% Inundated = 80th Percentile of water level elevations
   - 30% Inundated = 70th Percentile of water level elevations
   - 40% Inundated = 60th Percentile of water level elevations
   - 50% Inundated = 50th Percentile of water level elevations
   - 60% Inundated = 40th Percentile of water level elevations
   - 70% Inundated = 30th Percentile of water level elevations
   - 80% Inundated = 20th Percentile of water level elevations
   - 90% Inundated = 10th Percentile of water level elevations

4. Apply RSLR to the computed inundation elevations to determine the target year 20 (TY20) tidal elevations.

C. Calculations:

Percent Inundated	Equation	Inundation Elev. Ft. NAVD88 GEOID18
10	0.9*Raw Data Elevations	1.36
20	0.8*Raw Data Elevations	1.11
30	0.7*Raw Data Elevations	0.94
40	0.6*Raw Data Elevations	0.79
50	0.5*Raw Data Elevations	0.66
60	0.4*Raw Data Elevations	0.51
65	0.35*Raw Data Elevations	0.43
70	0.3*Raw Data Elevations	0.35
80	0.2*Raw Data Elevations	0.14
90	0.1*Raw Data Elevations	-0.15

3.0 Sea Level Rise and Subsidence

The 2017 Coastal Master Plan provides predicted sea level rise rates for use in the design of marsh creation projects. These rates range from 0.5 to 1.98 meters of sea level rise by 2100 and are bracketed in various scenarios to account for uncertainty. CPRA's Planning and Research Division recommends the use of the 1.0-m gulf sea-level rise scenario shown below (Demarco, 2012). This accounts for nearly 6 inches of sea-level rise over the 20-year project design life.

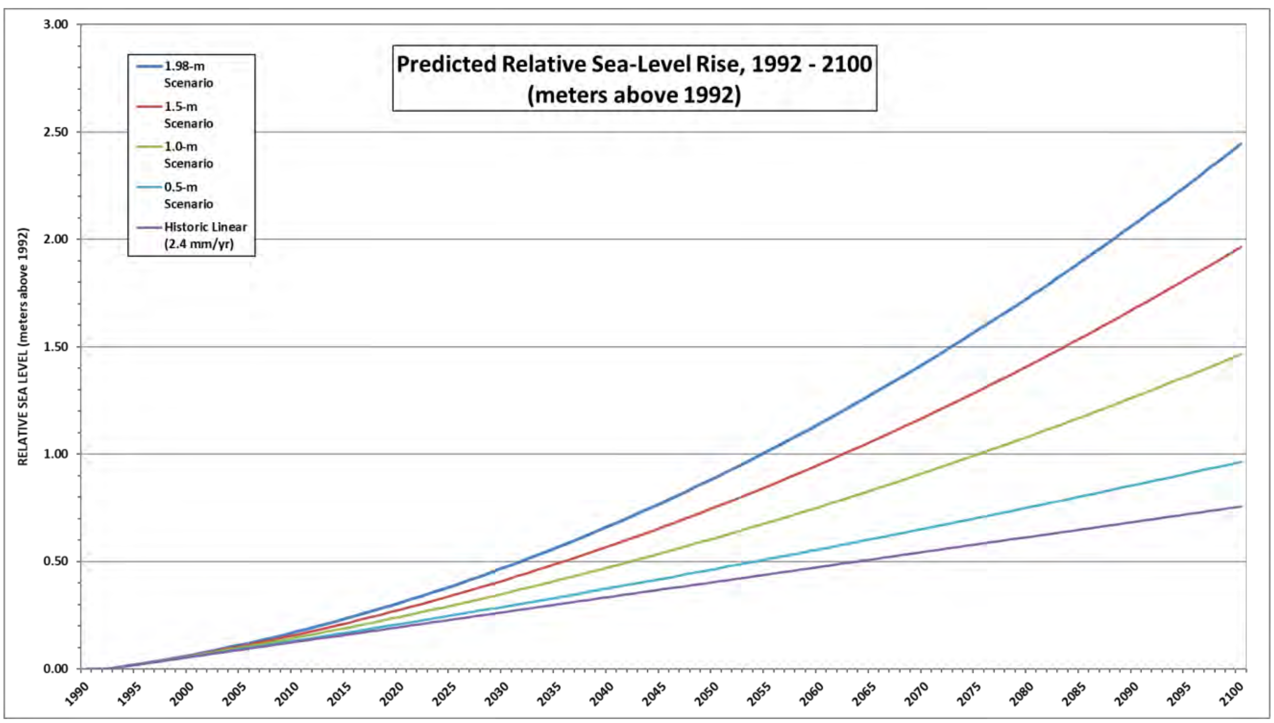

Figure 2: Gulf Sea-Surface Change Relative to 1992

Subsidence rates in this region are based on the 2017 Coastal Master Plan which uses the same rates from the 2012 Master Plan. The subsidence rates in the Calcasieu/Sabine basin are approximately 4.3 mm per year (0.014 ft/year) (Reed, Yuill 2016).

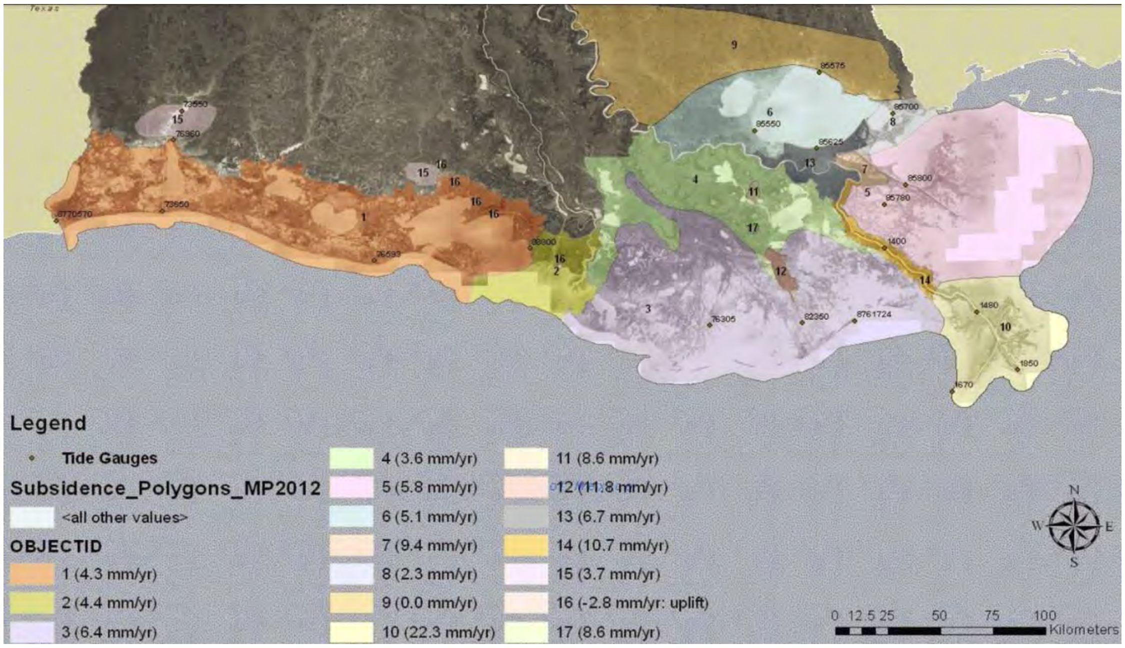

Figure 3: 2012 Coastal Master Plan - subsidence ranges in Coastal Louisiana

The rates of eustatic sea level rise (ESLR) and subsidence were used to determine the annual incremental relative sea level rise (RSLR) for the CS-0079 project area over the 20-year project life.

$$E(t) = at + bt^2 + St$$

Where *E* is the change in relative sea level at time, *t*
a is the rate of ESLR
b is an acceleration factor, and
S is the rate of subsidence

The annual incremental ESLR and RSLR is shown in the following table.

Table 2: Annual Incremental ESLR and RSLR (ft NAVD88, GEOID18)

Year	Annual Incremental Subsidence (St) (ft)	Annual Incremental Eustatic Sea Level Rise ($at+bt$) (ft)	Annual Incremental Relative Sea Level Rise ($at+bt^2+St$) (ft)
2020	0.000	0.404	0.404
2021	0.014	0.424	0.439
2022	0.028	0.445	0.473
2023 (TY0)	0.042	0.466	0.508
2024	0.056	0.488	0.544
2025	0.071	0.509	0.580
2026	0.085	0.532	0.616
2027	0.099	0.554	0.653
2028	0.113	0.577	0.113
2029	0.127	0.601	0.728
2030	0.141	0.624	0.765
2031	0.155	0.649	0.804
2032	0.169	0.673	0.842
2033	0.183	0.698	0.882
2034	0.198	0.724	0.921
2035	0.212	0.749	0.961
2036	0.226	0.776	1.001
2037	0.240	0.802	1.042
2038	0.254	0.829	1.083
2039	0.268	0.856	1.125
2040	0.282	0.884	1.166
2041	0.296	0.912	1.209
2042	0.310	0.941	1.251
2043	0.324	0.970	1.295

4.0 Containment Dike Design

1. Crown Width: 5.0 ft
2. Side Slope: 3H:1V
3. Freeboard: minimum 1.0 ft above target marsh elevation
4. Containment Dike Crown Elevation: +4.75 ft. NAVD88 GEOID18
5. Internal Training Dike Elevation: +2.75 ft. NAVD88 GEOID18
6. Survey Data: XYZ points from transects
7. Cut-to-fill Ratio: 1.4:1

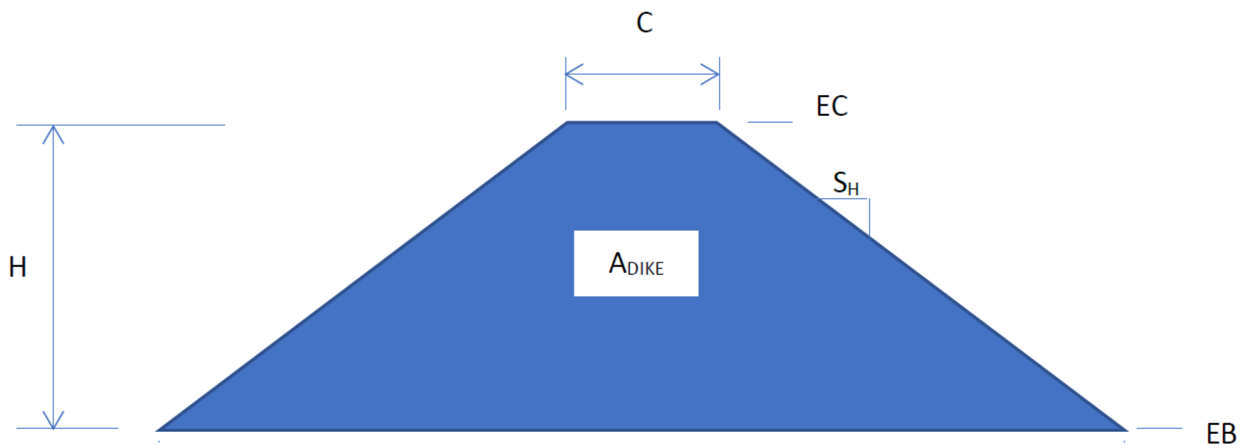

Figure 4: Earthen Containment Dike Geometry

Where: H=Dike Height
B= Base Width

C= Crown Width

EB= Base Elevation

EC= Crown Elevation

A_A = Cross-Sectional Area of dike at Point A

A_B= Cross-Sectional Area of dike at Point B

A_{A-B}= Average Cross-Sectional Area of dike between points A & B
L_{A-B}=Length between points A & B
S_H= Side Slope

The dike lengths and volumes were calculated in Civil 3D and are shown in the table below:

Reach	Borrow	Centerline Length (ft)	Fill Volume (CY)	Cut Volume (CY)	Dimension
Containment Dike - North	External Borrow	6,970	29,739	41,635	4.75' EL.; 5' crown width; 3:1 side slope
Containment Dike-Southeast and West	Internal Borrow*	12,709	42,245	59,143	
Internal Training Dike	Internal Borrow*	3,861	9,501	13,301	2.75' EL.; 5' crown width; 3:1 side slope
Total (w/ 1.4 cut to fill)				114,079	

**Internal Borrow Cut volume (59,143+13,301) = 72,444 CY will be backfilled by hydraulically dredged sediment from the Calcasieu Ship Channel.*

5.0 Fill Area Design

A. **Given**:

i. Cross-Sectional Survey Data of Marsh Fill Site: XYZ data for each fill area cross-section survey transect

ii. Volume Calculation Fill Elevation (plane height): +0.71 ft NAVD88 Geoid18 (20-year elevation from +2.75 ft CMFE) and +1.10 ft NAVD88 Geoid18 to offset the foundation settlement and subsidence of the exisiting surface.

B. Methodology:

i. Transect survey data was used to generate a 3-dimensional surface called a Triangular Irregular Network (TIN) surface in Civil 3D.

ii. Volume Calculations: The volume was calculated by taking the surface difference between the flat +1.10 ft. NAVD88 plane height surface and the existing mud line TIN surface.

These calculations were performed in Civil 3D and the required fill volume was **1,261,706 CY**.

5.1 Cut to Fill Ratio Marsh

This calculation below details a method for predicting the cut-to-fill ratio to be applied to marsh fill quantities.

A. **Given**:

i. Fine-grained or Clay sediment fraction of borrow area is 100%

ii. In-situ void ratio in borrow area =3.11

iii. Average void ratio in the MCA at year 20 from PSDDF=3.34

B. Methodology:

The cut-to-fill ratio for marsh fill was estimated 20 years after dredging using the following equation from EM1110-2-5025:

$$V_f = V_i\left\{\left(\frac{e_o - e_i}{1 + e_i}\right) + 1\right\}$$

Where:

V_f = volume of fine-grained dredged material after placement, yd3
V_i = volume of fine-grained sediments from borrow area, yd3
ei = average in-situ void ratio of the borrow area
e_o = void ratio after 20 years.

i. Cut to fill ratio = V_i/V_f

C. Calculation:

Re-arrange the formula in 5.1B to get:

$$\frac{V_i}{V_f} = \frac{1}{\left(\left(\frac{e_o - e_i}{1 + e_i}\right) + 1\right)}$$

Where

ei = 3.11

e_o = 3.34

$$\frac{V_i}{V_f} = \frac{1}{\left(\left(\frac{3.34 - 3.11}{1 + 3.11}\right) + 1\right)}$$

$$\frac{V_i}{V_f} = \frac{1}{\left(\left(\frac{0.23}{4.11}\right) + 1\right)}$$

$$\frac{V_i}{V_f} = \frac{1}{((0.055) + 1)}$$

$$\frac{V_i}{V_f} = \frac{1}{1.055}$$

$$\frac{V_i}{V_f} = 0.947$$

Although the calculated cut-to-fill ration is less than 1, considering losses due to dredging and dewatering cut-to-fill ratio 1.10 is selected for this project. The total volume (including containment dike volume) needed based on this evaluation is presented in the table below:

Marsh Fill Volume Only (CY)	**Dike Borrow Area Backfill Volume (CY)**	**Total Fill Volume (CY)**	**Marsh Cut-To-Fill**	**Total Cut Volume (CY)**
1,261,706	72,444	1,334,150	1.1:1	1,467,565

6.0 References

Reed, D. and Yuill, B. (2016). 2017 *Coastal Master Plan: Attachment C2-2: Subsidence. Version I.* (p. 15). Baton Rouge, Louisiana: Coastal Protection and Restoration Authority

DeMarco, K.E., Mouton, J. J., and Pahl, J.W. (2012). Guidance for Anticipating SLR Impacts on Louisiana Coastal Resources during Project Planning and Design: Technical Report, Version 1.4. State of Louisiana, Coastal Protection and Restoration Authority, Baton Rouge, Louisiana. 121 pp.

United States Army Corps of Engineers, EM 1110-2-5025 Dredging and Dredge Material Management. July 2015