Appendix H

Calculations Package

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ABBREVIATIONS

CPRA	Coastal Protection and Restoration Authority
CRMS	Coastwide Reference Monitoring System
CY	Cubic Yard
ECD	Earthen Containment Dike
ESLR	Eustatic Sea Level Rise
FT	Foot
ITD	Internal Training Dike
LF	Linear Foot
MCA	Marsh Creation Area
MHW	5-year Mean High Water
MLW	5 year Mean Low Water
MN	5-year Mean Tide Range
MTL	5-year Mean Tide Level
RSLR	Relative Sea Level Rise
SF	Square Foot
TY	Target Year

1.0 TIDAL DATUM EVALUATION

a) Given

Hourly hydrologic data was obtained from the CIMS database for the Coastwide Reference Monitoring System (CRMS) Station 0146 and Station 4355. The coordinates of the station are in the table below.

Station	Latitude	Longitude
CRMS4355	29.838956°	-89.822974°
CRMS0146	29.795421°	-93.416819°

Data was obtained for the most recent 5-year period from August 17, 2017 to August 17, 2022.

b) Calculations

The Mean High Water (MHW), Mean Low Water (MLW) and Mean Tide Level (MTL) were calculated for the 5 year period. The MHW is the mean of all high water elevations, MLW is the mean of all low water elevations, and MTL is the average of the MHW and MLW.

CRMS Station	**MHW** (ft NAVD88, GEOID12B)	**MLW** (ft NAVD88, GEOID12B)	**MTL** (ft NAVD88, GEOID12B)
CRMS 4355	+0.97	+0.55	+0.76
CRMS 0146	+1.06	+0.26	+0.66

2.0 PERCENT INUNDATION DETERMINATION

a) Given

The same hourly hydrologic data from CRMS0146 and CRMS 4355, explained in Section 1.0, was used for the percent inundation determination.

b) Calculations

Each percent inundation was calculated for the entire five year data set according to their corresponding percentile. Example calculations for CRMS 0146 are summarized in the following table.

% inundated	Calculation	Inundation Elevation, ft (NAVD88 Geoid12B)
1%	99th percentile of water elevations	+2.93
5%	95th percentile of water elevations	+1.81
10%	90th percentile of water elevations	+1.47
20%	80th percentile of water elevations	+1.14
30%	70th percentile of water elevations	+0.94
40%	60th percentile of water elevations	+0.78
50%	50th percentile of water elevations	+0.63
60%	40th percentile of water elevations	+0.49
65%	35th percentile of water elevations	+0.41
70%	30th percentile of water elevations	+0.33
80%	20th percentile of water elevations	+0.13
90%	10th percentile of water elevations	-0.14

3.0 SEA LEVEL RISE

Sea level rise was calculated by using rates using rates consistent with the 2023 Master Plan. The predicted rates range from 0.5 to 1.98 meters of sea level rise by 2100. The CPRA Planning and Research Division recommends the 1.0-m scenario for the purposes of this project. This accounts for approximately 6 inches of sea level rise over the 20 year project life.

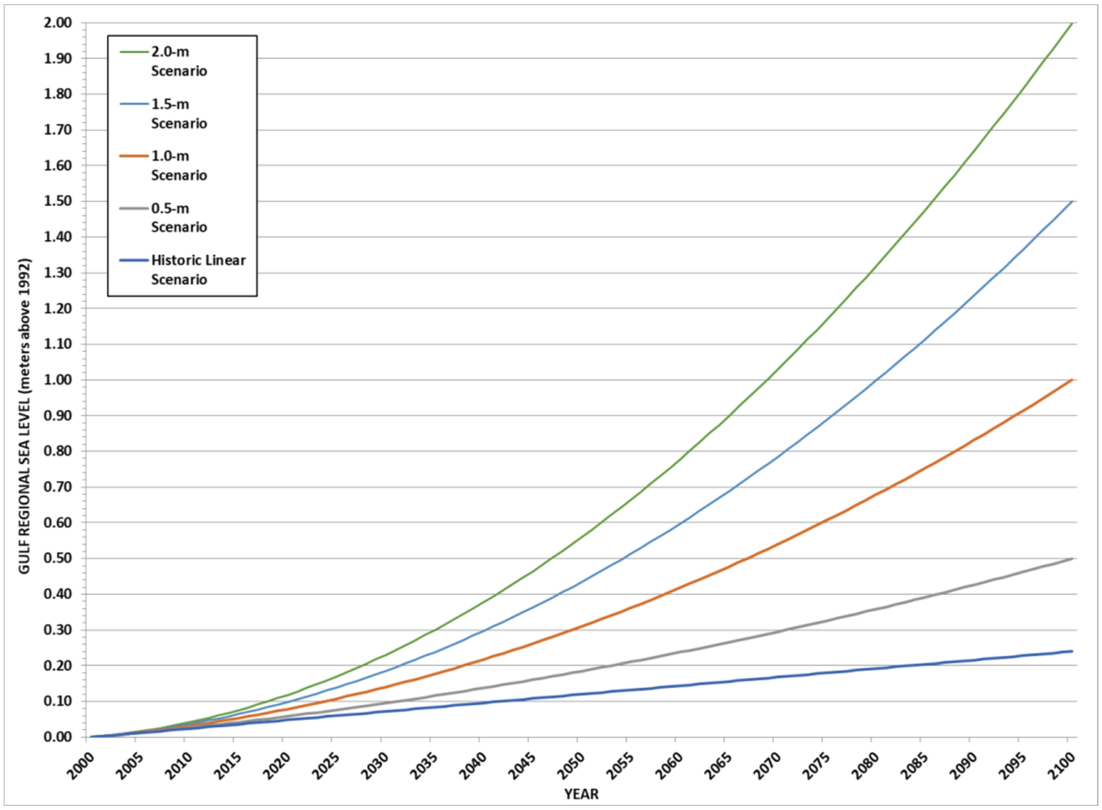


Figure 1: Gulf Sea-Surface Change Relative to 1992

Eustatic sea level rise was calculated using the following formula:

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

Where E is the change in eustatic sea level rise at time, t
a is the rate of ESLR, and
b is the acceleration factor

Subsidence rates are based on recent detailed subsidence studies completed in 2019 by Applied Coastal Research and Engineering (ACRE) and C.H. Fenstermaker and Associates in the Breton Sound and Barataria basin. The 2019 CPRA/ACRE report determined that Holocene geology and sediment consolidation are primary factors controlling subsidence. Results from this study indicate that the subisdence rates in the Breton Sound Basin generally range from 3.0-4.0 mm per year (0.16 inches/yr) (ACRE, 2019).

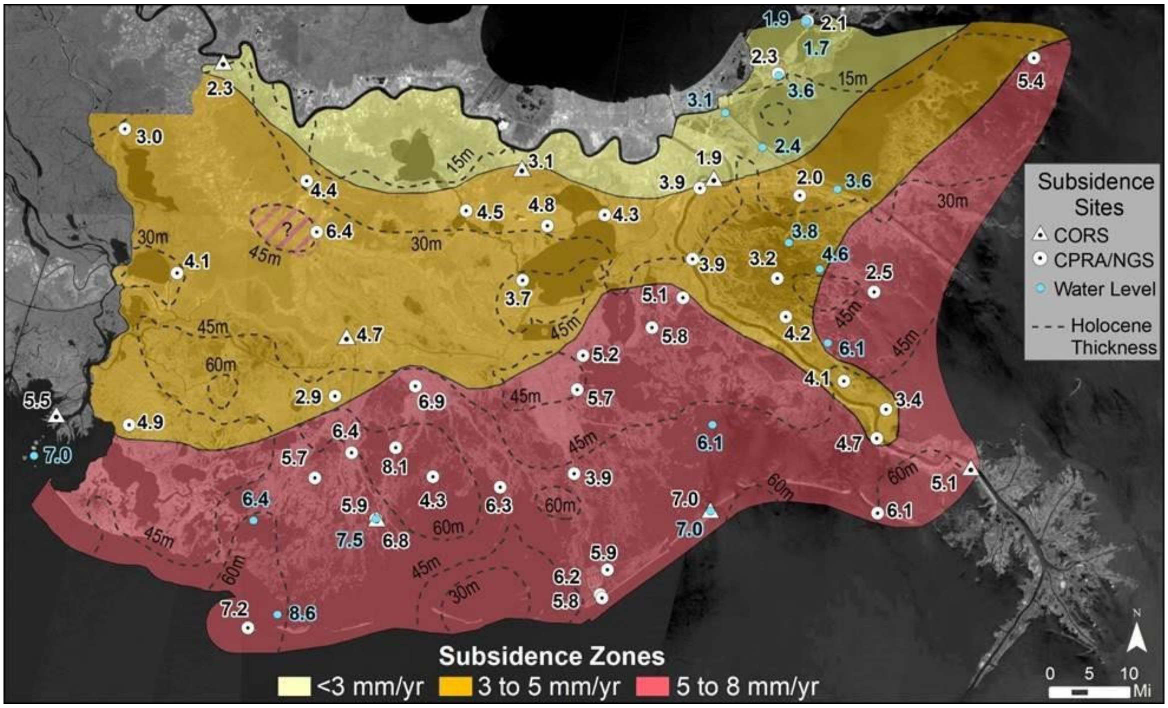


Figure 2: Regional Subsidence Zones for the south Louisiana deltaic plain as determined using recent high-resolution GPS surveys and water-level measurements.

The subsidence rate chosen for the design of BS-0041 was 4.0 mm per year.

The rates of eustatic sea level rise (ESLR) and subsidence were used to determine the annual incremental relative sea level rise (RSLR) for the BS-0041 project area over the 20-year project life.

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

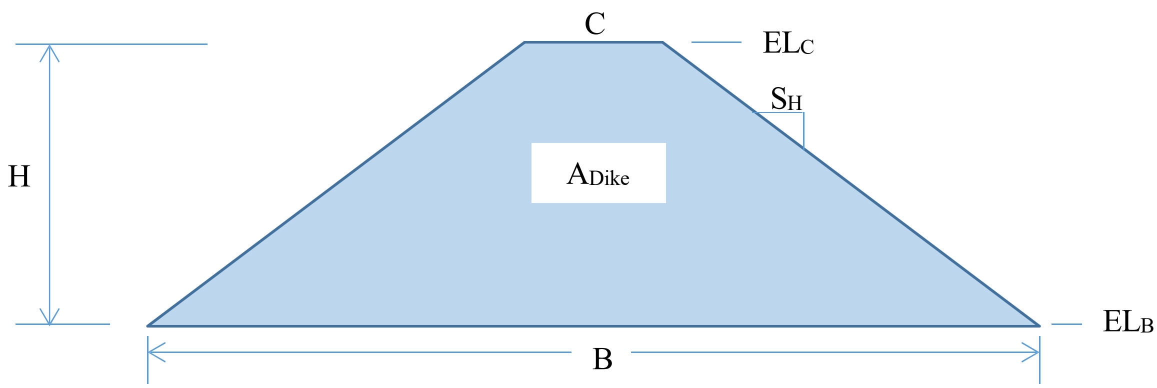
Where E is the change in relative sea level at time, t
a is the rate of ESLR
b is an acceleration factor, and
S is the rate of subsidence

The calculated annual incremental ESLR and RSLR are shown in the following table:

Year	Annual Incremental Subsidence (St) (St)	Annual Incremental Eustatic Sea Level Rise $(at + bt^2)$	Annual Incremental Relative Sea Level Rise $(at + bt^2 + St)$
	(ft)	(ft)	(ft)
2027	0.13	0.14	0.27
2028	0.03	0.159	0.189
2029	0.04	0.181	0.221
2030	0.05	0.203	0.253
2031	0.07	0.226	0.296
2032	0.08	0.250	0.33
2033	0.09	0.274	0.364
2034	0.11	0.299	0.409
2035	0.12	0.324	0.444
2036	0.13	0.349	0.479
2037	0.15	0.375	0.525
2038	0.16	0.402	0.562
2039	0.17	0.429	0.599
2040	0.19	0.457	0.647
2041	0.20	0.485	0.685
2042	0.21	0.513	0.723
2043	0.23	0.542	0.772
2044	0.24	0.572	0.812
2045	0.25	0.602	0.852
2046	0.27	0.633	0.903
2047	0.3	0.66	0.96

4.0 EARTHEN CONTAINMENT DIKE DESIGN

Parameter	Measure
Crown Width (ft)	5.0 ft
Side Slope (H:V)	3H:1V
Crown Elevation (ft)	ECD: +4.0 ft NAVD88, Geoid12B
Base Elevation (ft)	Surface created from xyz survey data



H = Dike Height
B = Base Width
C = Crown Width
EL_B = Base Elevation
EL_C = Crown Elevation
S_H = Side Slope

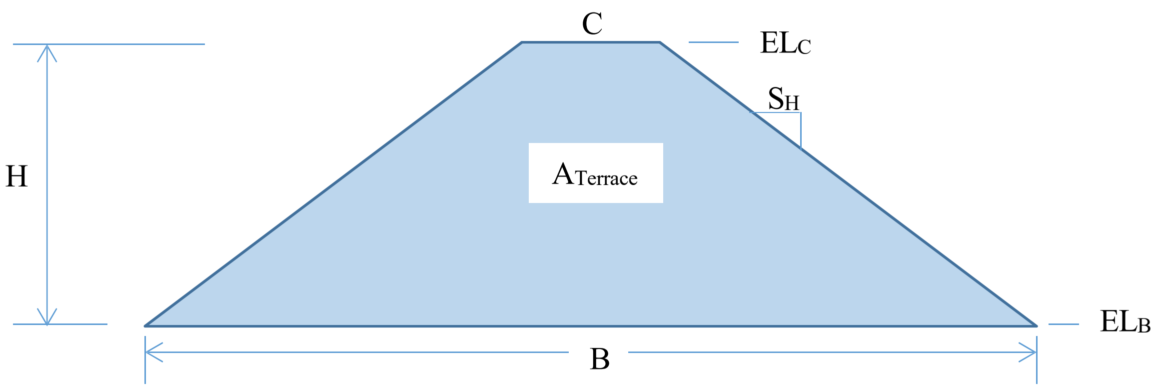
The total ECD lengths and fill volumes were calculated using both (1) AutoCAD Civil 3D, and (2) the Average End Area Method in Microsoft Excel. Results are summarized in the following tables.

Area	Length of Containment (ft)			Volume of Fill (CY)		
	Calculated	CAD	% Difference	Calculated	CAD	% Difference
MCA-1	11,000	10,900	0.0%	34,900	37,000	5.8%
MCA-2	5,200	5,000	3.9%	15,300	20,800	30.5%
MCA-3	13,200	13,200	0.0%	64,500	64,400	0.2%
Totals	**29,500**	**29,100**	**1.4%**	**114,700**	**122,200**	**6.3%**

*Note: Quantities selected for (highlighted): CAD lengths; larger volumes (to provide conservative estimate).

5.0 EARTHEN TERRACE DESIGN

Parameter	Measure
Crown Width (ft)	10.0 ft
Side Slope (H:V)	5H:1V
Crown Elevation (ft)	+4.5 (-0.25) ft NAVD88, Geoid12B
Base Elevation (ft)	Surface created from xyz survey data



H = Dike Height
B = Base Width
C = Crown Width
EL_B = Base Elevation
EL_C = Crown Elevation
S_H = Side Slope

The earthen terrace field contained a total of 29 linear earthen terraces each 250 feet long for a total of 7,250 feet. The total fill volume for one earthen terrace was calculated using AutoCAD Civil 3D. This volume was multiplied by the total number of terraces to determine the approximate terrace fill volume. A cut to fill ratio of 1.5 was applied to determine the total terrace cut volume. These calculations are summarized in the table below.

Number of Terraces	Length of Earthen Terrace (LF)	Total Length of Earthen Terraces (LF)	Total Earthen Terrace Fill Volume (CY)	C:F	Earthen Terrace Cut Volume (CY)	CY/LF
29	250	7,250	97,100	1.5	145,700	20

6.0 FILL AREA DESIGN

The elevation used for the volume calculations was determined by adding the total foundation settlement to the elevation at TY20 without subsidence. To account for the long-term predicted foundation settlement, each Marsh Creation Area is assigned value for foundation settlement based on the representative mudline elevation selected within each fill area. The foundation settlement value shown in the table below for each MCA will be added to the elevation used for calculating volumes. The elevation used for volume calculations for each Marsh Creation Area is summarized in the table below.

MCA	TY20 Elevation (ft NAVD88 Geoid 12B)	Total subsidence settlement (ft)	Total Foundation Settlement (ft)	Elevation for Volume (ft NAVD88 Geoid 12B)
1	+0.60	0.30	0.91	+1.85
2	+0.60	0.30	0.83	+1.70
3	+0.60	0.30	0.94	+1.85

A surface was created in AutoCAD Civil 3D utilizing the survey data. The marsh fill volume was calculated in AutoCAD Civil 3D. Volumes were also calculated in Microsoft Excel using the Average End Area Method. The table below shows the results of both of these calculations for required amount of fill material, not including dike backfill, with percent differences. The selected volume for each cell was the average of the Microsoft Excel and CAD volumes.

Marsh Fill Area Volume Calculations at CMFE			
Area	Volume (CY)		% Difference
	Calculated	CAD	
MCA-1	807,000	791,000	2.0%
MCA-2	276,000	310,000	11.6%
MCA-3	757,000	891,000	16.3%
Total	1,840,000	1,992,000	7.9%

The total cut for the earthen containment dikes was added to the marsh fill volume to account for backfill. A 1.1 cut to fill ratio was applied to determine the total cut volume. The results are summarized in the following table.

Fill Area	CMFE (ft NAVD88)	Area (ac)	Cut to Fill	Fill Volume* (yd^3)	Cut Volume (yd^3)	CY/ac
MCA-1	+2.5 (± 0.25)	148	1.1:1	855,000	941,000	6,400
MCA-2	+2.5 (± 0.25)	87	1.1:1	324,000	356,000	4,100
MCA-3	+2.5 (± 0.25)	143	1.1:1	921,000	1,013,000	7,100
Total	–	378	–	2,100,000	2,310,000	6,100

* Volume calculations shown in this table include ALL ECD borrow quantities

7.0 BORROW AREA DESIGN

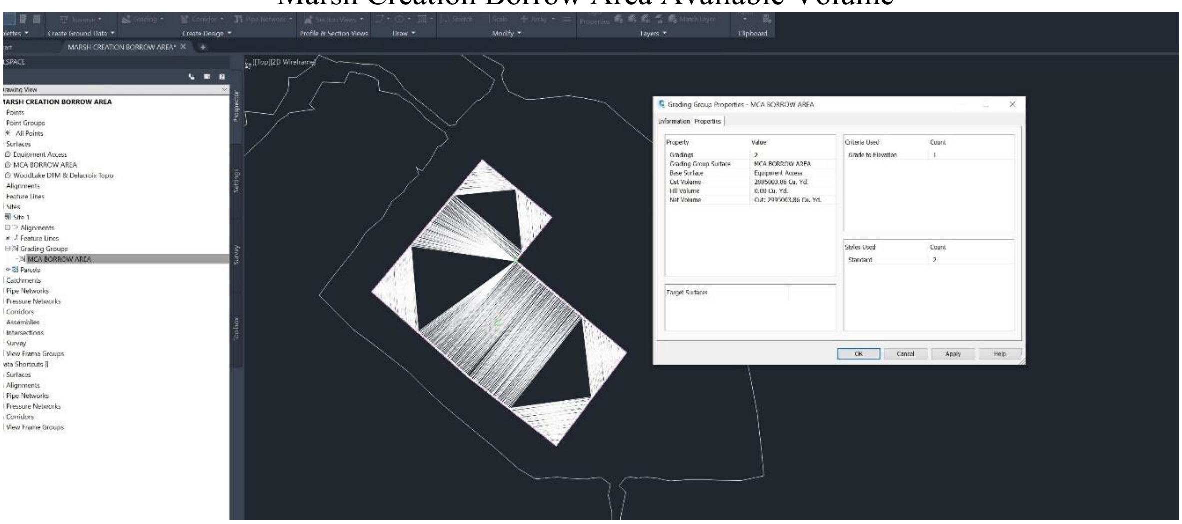
The available volume of borrow material in the borrow area was calculated using both (1) AutoCAD Civil 3D, and (2) the Average End Area Method in Microsoft Excel. The calculations assumed a design cut elevation of -20 ft NAVD88. The results are summarized in the following table.

Area (ac)	Cut Elevation (ft NAVD88)	Average Void Ratio	Available Volume (CY)		% Difference
			Calculated	CAD	
123	-20	2.81	3,043,000	2,995,000	1.6%

*Note: Quantities selected (highlighted) is the CAD volume.

Civil 3D Site Grading Screenshot:

Marsh Creation Borrow Area Available Volume



8.0 REFERENCES

All references used for design computations can be found in the references section of the BS-0041 95% Design Report.