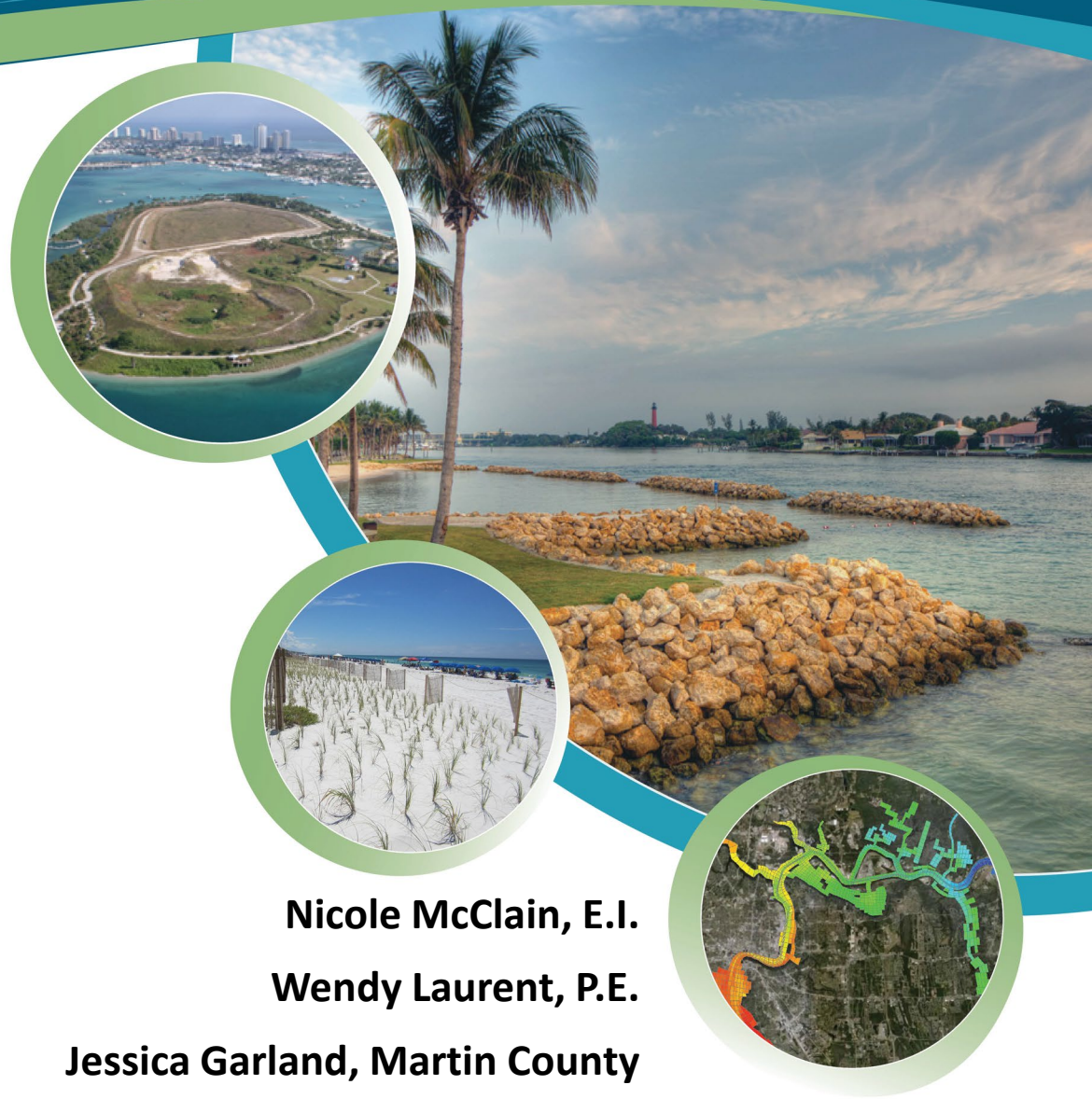
TAYLOR ENGINEERING, INC.

Martin County Four Mile Beach Resilience: Optimization of the Beach Template

FSBPA Tech Conference

February 8, 2024



Nicole McClain, E.I.

Wendy Laurent, P.E.

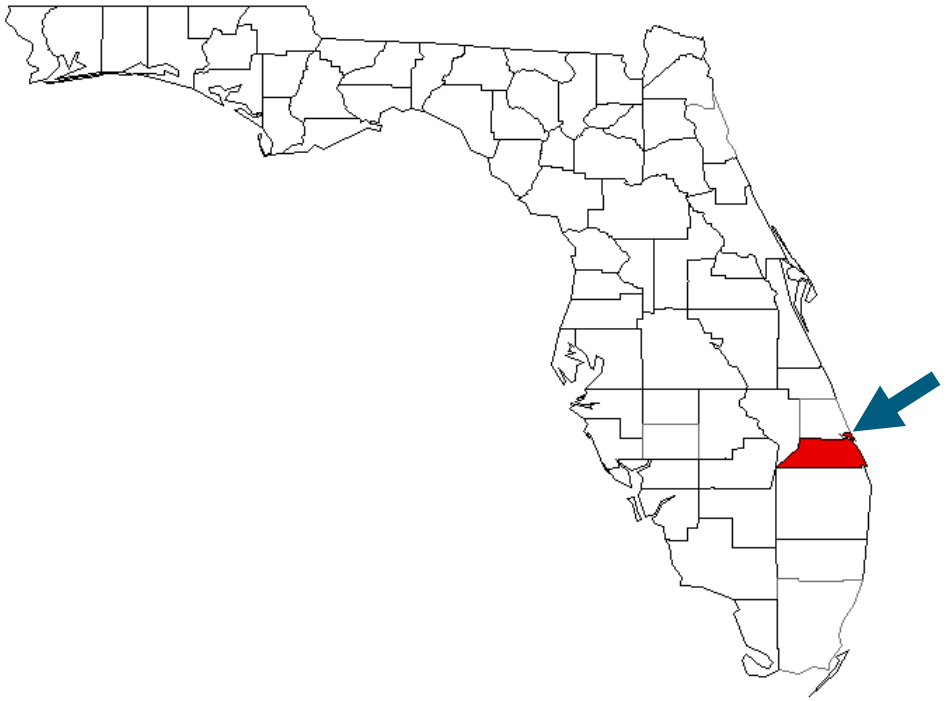
Jessica Garland, Martin County

Presentation Outline

- Martin County Shore Protection Project & Resilience
- Beach Nourishment History and Design Parameters
- XBeach Modeling
- Evaluation of Alternative Designs
- Summary
- Recommendations

Martin County Shore Protection Project (SPP)

- Northern-most 4 miles of Martin County (R-1 to R-25)
  - County Line & Glasscock Beach (R-1)
  - South of the Marriott & Stuart Beach (R-25)
- Federal participation (R-1 to R-23) expires in **2045**
- Authorized in the Water Resource Development Act of 1990 (WRDA, 1990)
  - GDM- General Design Memorandum (USACE, 1994)
  - LRR – Limited Reevaluation Report (USACE, 2011)



Martin County SPP Resilience

- The County is investigating options to modify the project design in the future to increase the project's resilience and storm protection benefits

- Purpose of our study:
  - Model current and alternative templates using XBeach (2D mode)
  - Evaluate results and recommend next steps
  - Begin discussions with permitting agencies before next nourishment

Beach Nourishment History

Project Year	Placed Volume (cy)	Placement Area	Borrow Area
1995	1,340,000	R-1 to R-25	Gilbert Shoal
2001	178,000	R-16.2 to R-22.3	Gilbert Shoal
2002	126,000	R-13.5 to R-16.2	Gilbert Shoal
2005	885,000	R-1 to R-25.6	Gilbert Shoal
2013	613,017	R-1 to R-25	St. Lucie Shoal
2018	427,763	R-1 to R-19.8	St. Lucie Shoal

3,567,780 cy

2,229,780 cy

GDM: Renourishment of 589,000 every 11 years (53,600 cy/yr)

LRR: Renourishment of 787,800 cy every 13 years (60,600 cy/yr)

Some quick math of what has been occurring…

$$\frac{2{,}229{,}780\ cy}{(2024-2001)} = \sim 97{,}000\ cy/yr$$

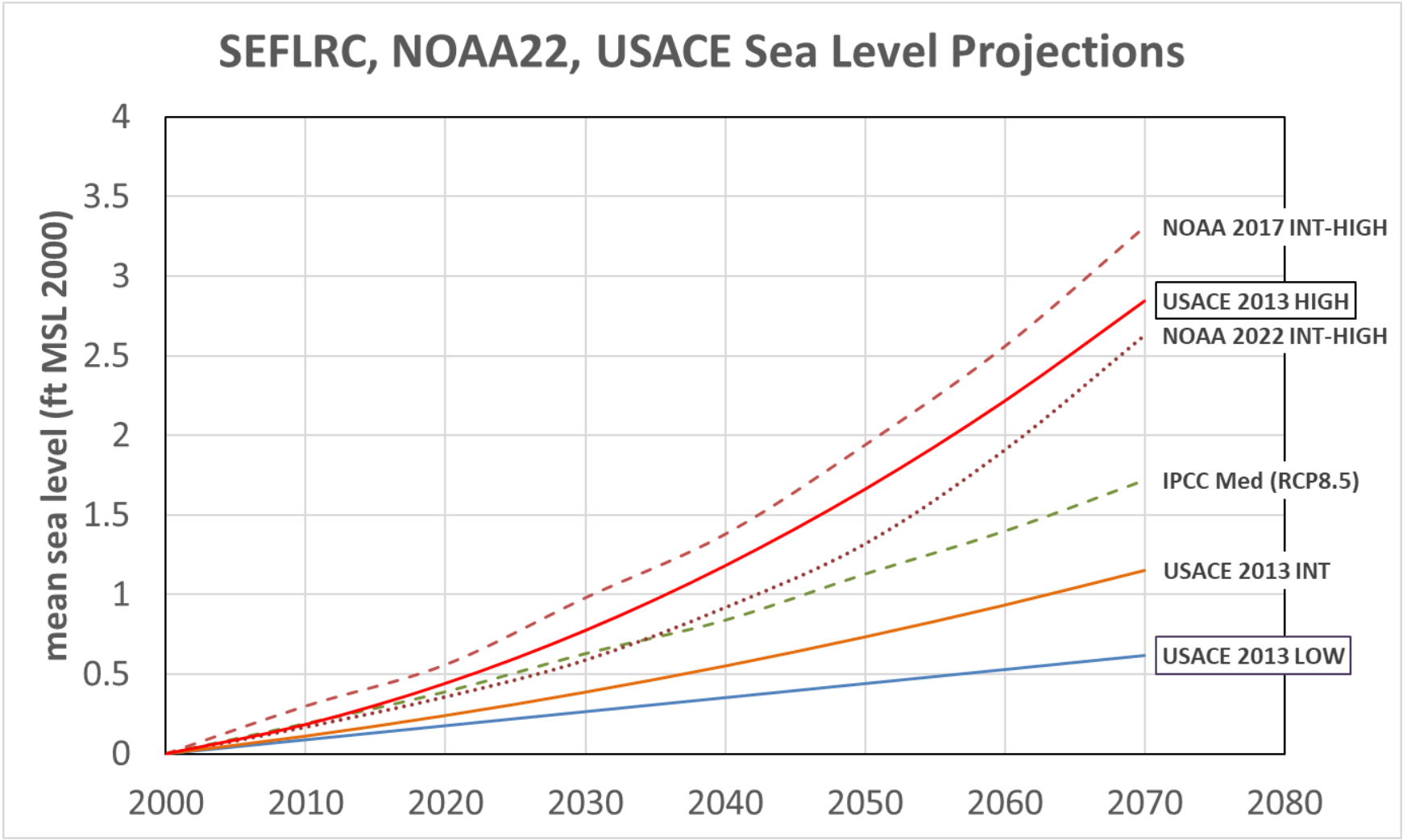
Project Design Parameters

- 4 construction templates
- Variable reference datums
  - Tidal vs geodetic datums
    - MHW; MSL; MLW
    - NAVD88; NGVD29
- MHW varies over project design life

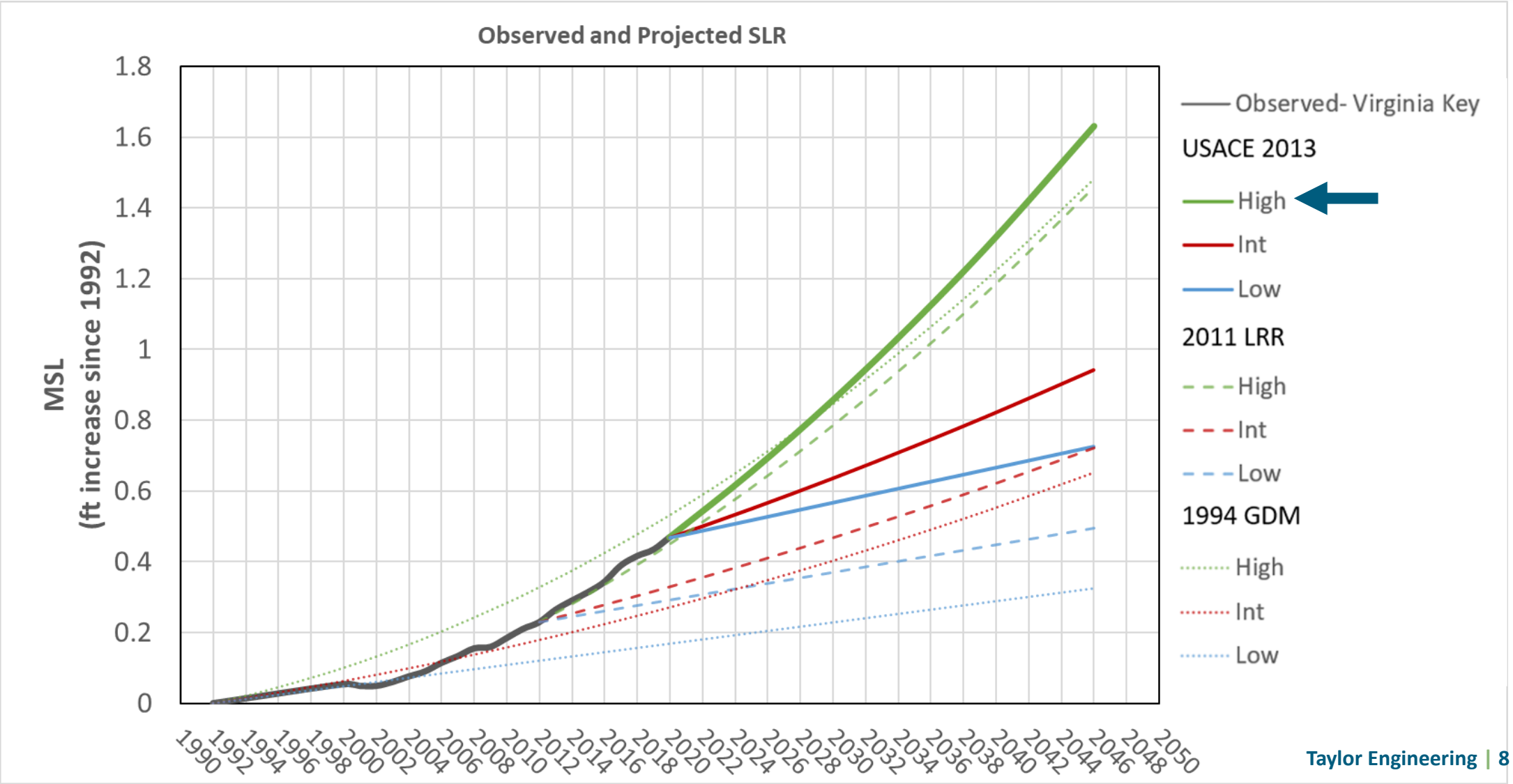
Document	Datum	Conversion to NAVD88	MHW Elevation	Dune Elevation	Berm Elevation
1993/1994 GDM	MSL	-1.5 ft	+0.3 ft-NAVD88 *+1.8 ft MSL*	+11.0 ft-NAVD88 *+12.5 ft MSL*	+6.5 ft-NAVD88 *+8.0 ft MSL*
	MLW	-2.6 ft	+0.3 ft-NAVD88 *+2.9 ft MLW*	+11.0 ft-NAVD88 *+13.6 ft MLW*	+6.5 ft-NAVD88 *+9.1 ft MLW*
1994/1995 Permit Documents	NGVD29	-1.5 ft	+0.45 ft-NAVD88 *+1.95 ft NGVD29*	+11.0 ft-NAVD88 *+12.5 ft NGVD29*	+6.5 ft-NAVD88 *+8.0 ft NGVD29*
2001 & 2003 Permit Documents	NGVD29	-1.5 ft	+0.3 ft-NAVD88 +1.8 ft NGVD29	+11.0 ft-NAVD88 *+12.5 ft NGVD29*	+6.5 ft-NAVD88 *+8.0 ft NGVD29*
2005 Permit Documents	NGVD29	-1.5 ft		+12.1 ft-NAVD88 *+13.6 ft NGVD29*	+6.5 ft-NAVD88 *+8.0 ft NGVD29*
2013 Permit Documents	NAVD88	-	+0.4 ft-NAVD88	+11.0 ft-NAVD88	+6.5 ft-NAVD88 with "turtle-friendly" sections sloping to +5.5 ft-NAVD88
2018 Permit Documents	NAVD88	-	+0.51 ft-NAVD88	+11.0 ft-NAVD88	+7.5 ft-NAVD88 sloping to +5.5 ft-NAVD88

Water Level History and Projections

- Future MHW → ***SEFLRC? USACE?***

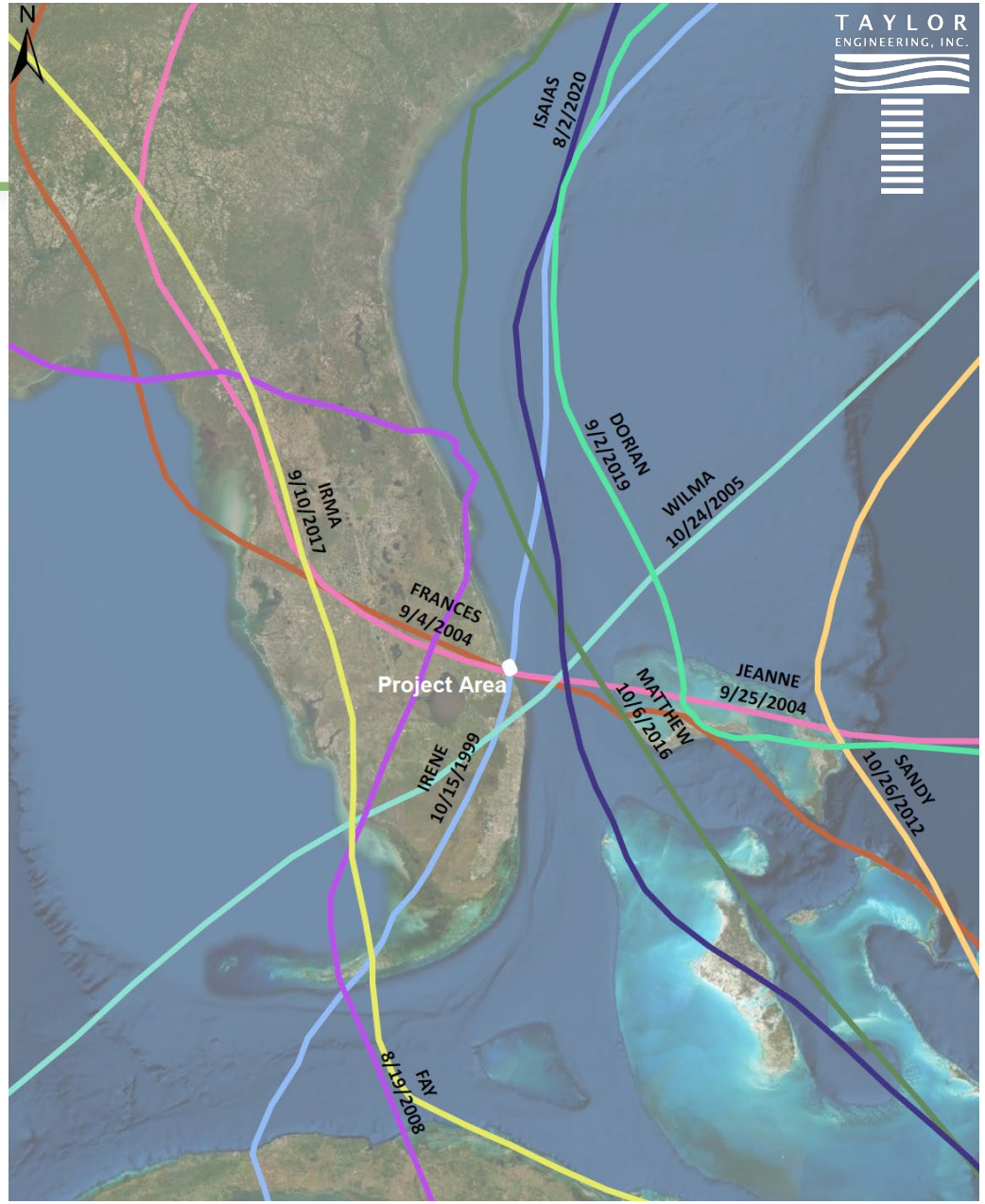


Water Level History and Projections



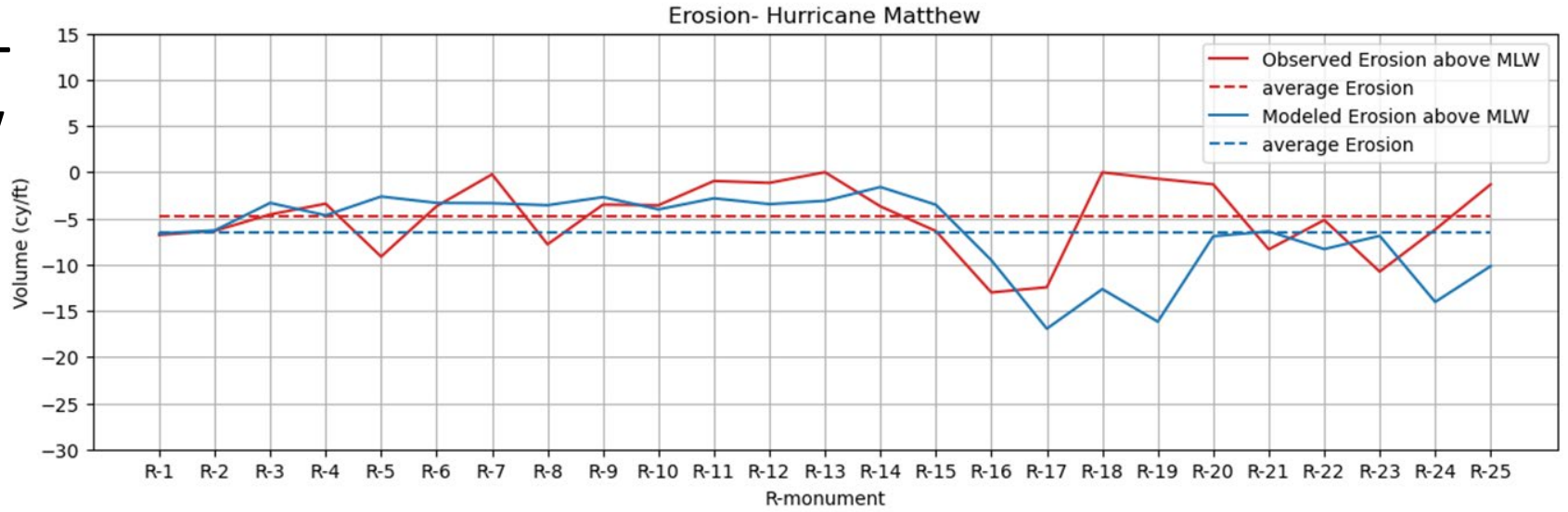
Significant Storms

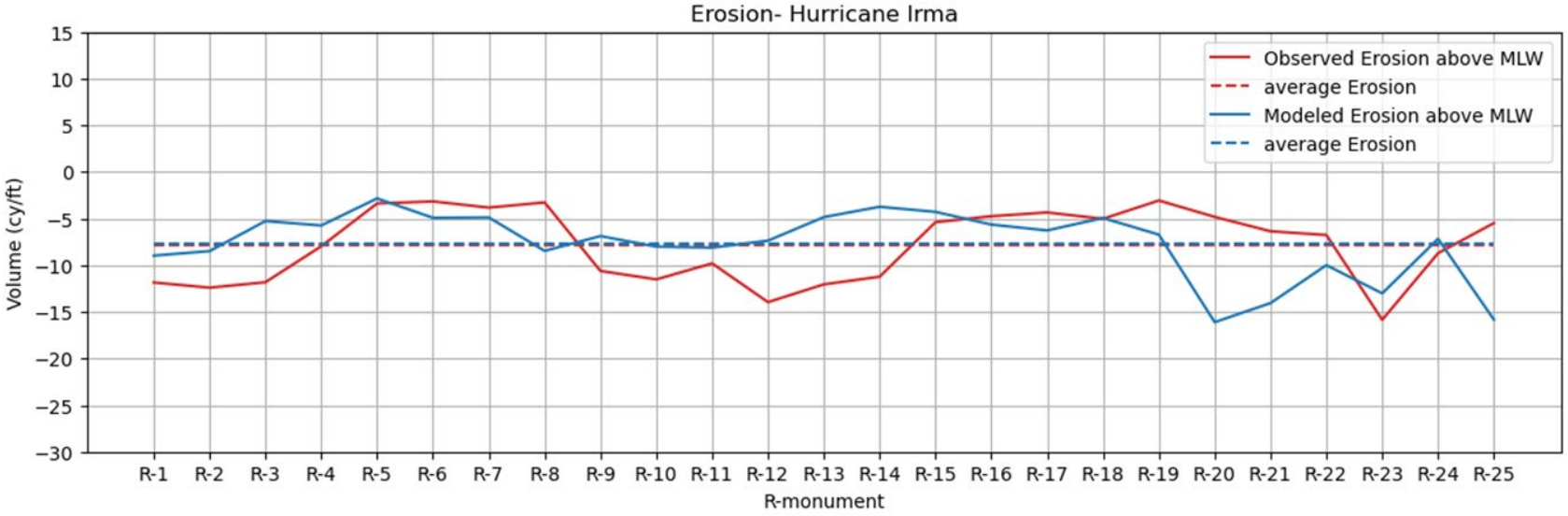
- Tropical Systems
  - Hurricane Frances and Jeanne (2004), Hurricane Wilma (2005), Hurricane Matthew (2016), Hurricane Irma (2017), Hurricane Dorian (2019), Hurricane Isaias (2020), Hurricane Nicole (2022)
- Extratropical Systems
  - Nor'easters
  - County personnel describe their impacts as being serious, often overtopping the berm and causing extensive erosion for days on end



XBeach Modeling

- Model Calibration – Hurricane Matthew
- Model Validation – Hurricane Irma





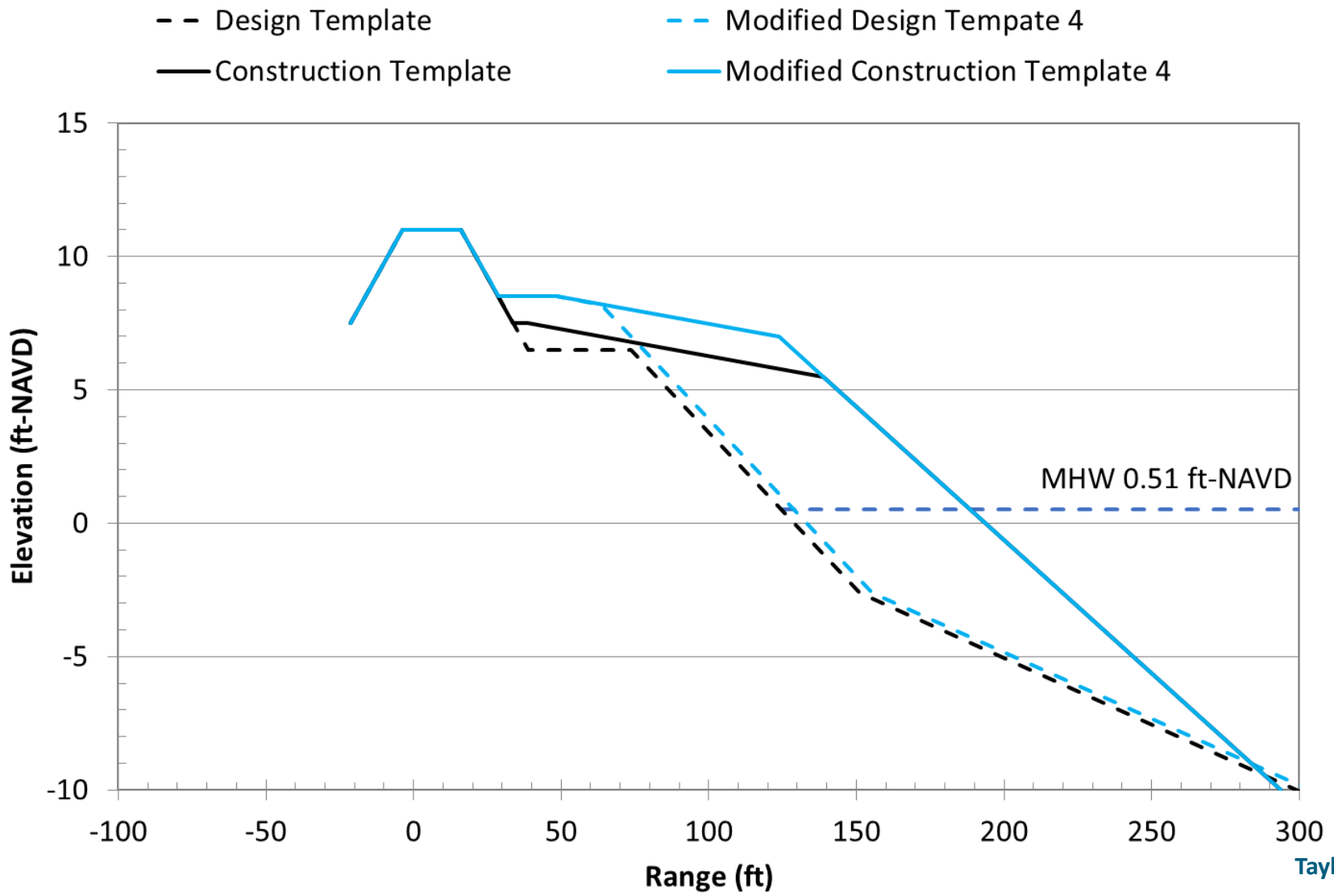
Alternative Templates

- 4 Modified Templates
- First
  - Storm – Hurricane Irma (October 2017)
  - SLR – 2024
- Then
  - Additional Storm – Extratropical cyclone (December 2019)
  - Additional SLR – 2046

Template	Dune	Dune Slope	Berm[1]	Nearshore Slope	Approximate Increase in Volume Density[2]
Design Template	20 ft crest at +11.0 ft-NAVD88	1V:5H	35 ft wide berm which then slopes at 1V:8.5H to MLW then 1V:20H below MLW	1V:8.5H 1V:20H	--
2018 Construction Template	20 ft crest at +11.0 ft-NAVD88	1V:5H	5 ft back berm at+7.5 ft-NAVD88 sloping at 1V:50H to +5.5 ft-NAVD88	1V:10H	--
Modified Template 1	20 ft crest at +11.85 ft-NAVD88	1V:5H	5 ft wide back berm at +8.35ft-NAVD88 sloping at 1V:50H for 100 ft to +6.35 ft-NAVD88	1V:10H	7.9 cy/ft
Modified Template 2	20 ft crest at +11.0 ft-NAVD88	1V:5H	20 ft wide western berm at +8.5 ft-NAVD88 sloping at 1V:10H to the 90 ft wide eastern berm at +7.5 ft-NAVD88	1V:10H	3.8 cy/ft
Modified Template 3	20 ft crest at +11.0 ft-NAVD88	1V:5H	+8.5 ft-NAVD88 sloping at 1V:50H	1V:10H	3.1 cy/ft
Modified Template 4	20 ft crest at +11.0 ft-NAVD88	1V:5H	20 ft wide western berm at +8.5 ft-NAVD88 sloping at 1V:50H for 75 ft to +7.0 ft-NAVD88	1V:10H	4.4 cy/ft

[1]- Modeled templates are eroded to a berm width of 35 ft
[2]- compared to the 2018 construction template using the western dune crest and an assumed tie in of -5 ft-NAVD88

Alternative Templates



Evaluation of Alternative Designs – Criteria

- Contour tracking
  - Berm, MHW, and MLW positions
- Volume changes
  - Dune to MHW, MHW to MLW
- Profile wetting
  - Water level instances greater than:
    - +5.5 ft-NAVD88
    - +4.5 ft-NAVD88
    - +3.5 ft-NAVD88
    - +2.5 ft-NAVD88

Evaluation of Alternative Designs

Positive Values – Shoreline Advance
Negative Values – Shoreline Recession

- Contour tracking – Berm, MHW, and MLW positions

Template	Storm	Increase in Water Levels Due to SLR	Berm (+6.5 ft-NAVD88)	MHW (+0.51 ft-NAVD88)	MLW (-2.6 ft-NAVD88)
			Average Contour Position Change (ft)	Average Contour Position Change (ft)	Average Contour Position Change (ft)
Design Template	Hurricane Irma-October 2017	-	-30.9	-15.7	61.3
Design Template	Hurricane Irma-October 2017	2024 (+0.22 ft)	-34.5	-13.8	64.2
Modified Template 1	Hurricane Irma-October 2017	2024 (+0.22 ft)	-31.4	-16.6	55.1
Modified Template 2	**Hurricane Irma-October 2017**	**2024 (+0.22 ft)**	**-29.4**	**-14.2**	**64.5**
Modified Template 3	Hurricane Irma-October 2017	2024 (+0.22 ft)	-30.1	-15.5	64.5
Modified Template 4	Hurricane Irma-October 2017	2024 (+0.22 ft)	-30.3	-16.3	61.9

Evaluation of Alternative Designs

Positive Values – Accretion
Negative Values – Erosion

- Volume changes – Dune to MHW, MHW to MLW

Template	Storm	Increase in Water Levels Due to SLR	Normalized Added Volume	Dune to MHW	MHW to MLW	Dune to MLW
				Average Volume Change (cy/ft)	Average Volume Change (cy/ft)	Average Volume Change (cy/ft)
Design Template	Hurricane Irma-October 2017	-	1.00	-8.14	2.51	-5.63
Design Template	Hurricane Irma-October 2017	2024 (+0.22 ft)	1.00	-8.75	2.71	-6.04
Modified Template 1	**Hurricane Irma-October 2017**	**2024 (+0.22 ft)**	**1.09**	**-8.63**	2.06	**-6.57**
Modified Template 2	**Hurricane Irma-October 2017**	**2024 (+0.22 ft)**	**1.01**	-9.37	**2.65**	-6.72
Modified Template 3	Hurricane Irma-October 2017	2024 (+0.22 ft)	1.03	-9.41	2.51	-6.91
Modified Template 4	Hurricane Irma-October 2017	2024 (+0.22 ft)	1.05	-9.48	2.29	-7.19

Evaluation of Alternative Designs

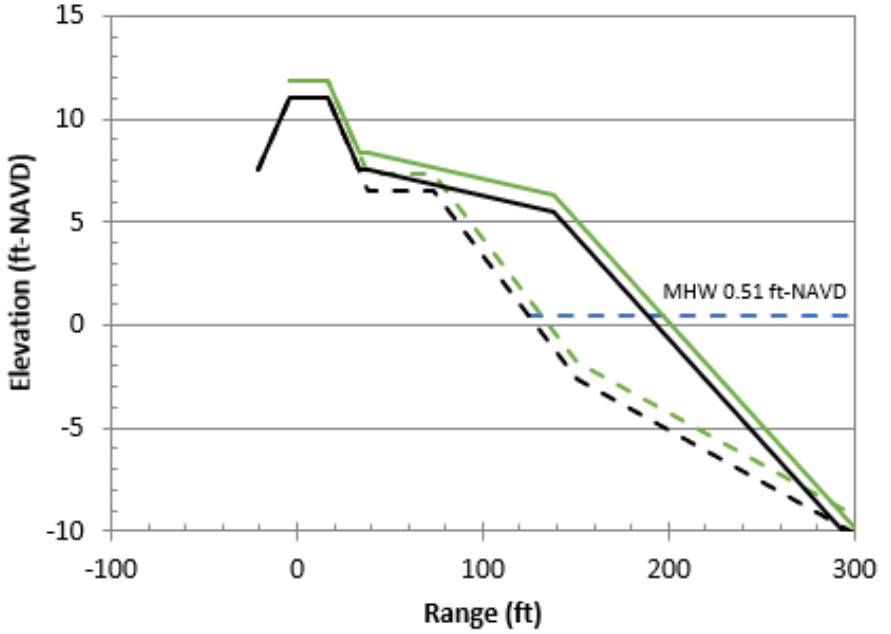
Greater Quantity of Instances – More Overtopping

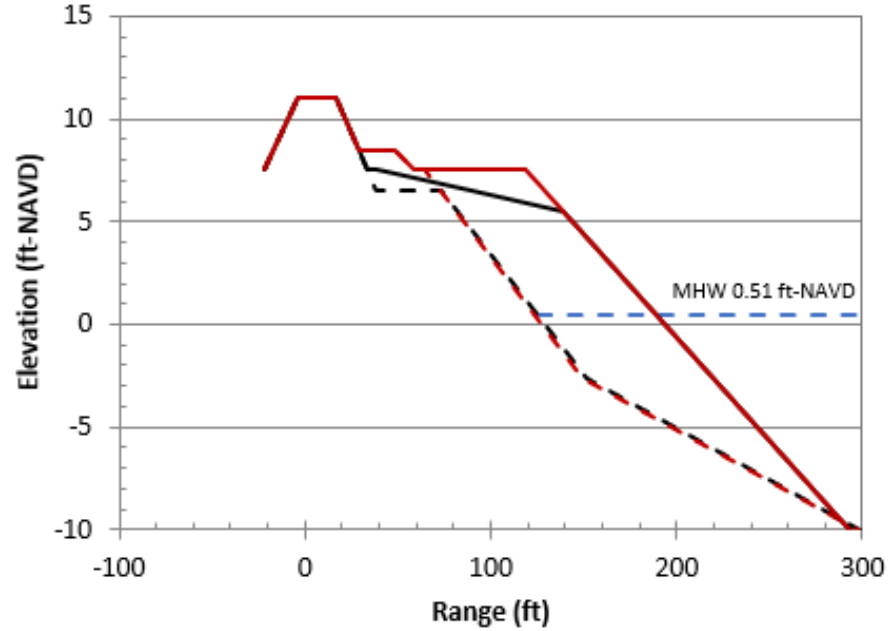
- Profile wetting – Water level instances greater than +5.5 ft-NAVD88, +4.5 ft-NAVD88, +3.5 ft-NAVD88, and +2.5 ft-NAVD88

Template	Storm	Increase in Water Levels Due to SLR	Water Level Instances Greater Than			
			+5.5 ft-NAVD88	+4.5 ft-NAVD88	+3.5 ft-NAVD88	+2.5 ft-NAVD88
Design Template	Hurricane Irma-October 2017	-	0	16	116	403
Design Template	Hurricane Irma-October 2017	2024 (+0.22 ft)	2	37	175	487
Modified Template 1	Hurricane Irma-October 2017	2024 (+0.22 ft)	2	32	174	473
Modified Template 2	**Hurricane Irma-October 2017**	**2024 (+0.22 ft)**	2	**31**	**173**	**467**
Modified Template 3	**Hurricane Irma-October 2017**	**2024 (+0.22 ft)**	**1**	35	179	473
Modified Template 4	**Hurricane Irma-October 2017**	**2024 (+0.22 ft)**	**1**	36	177	478

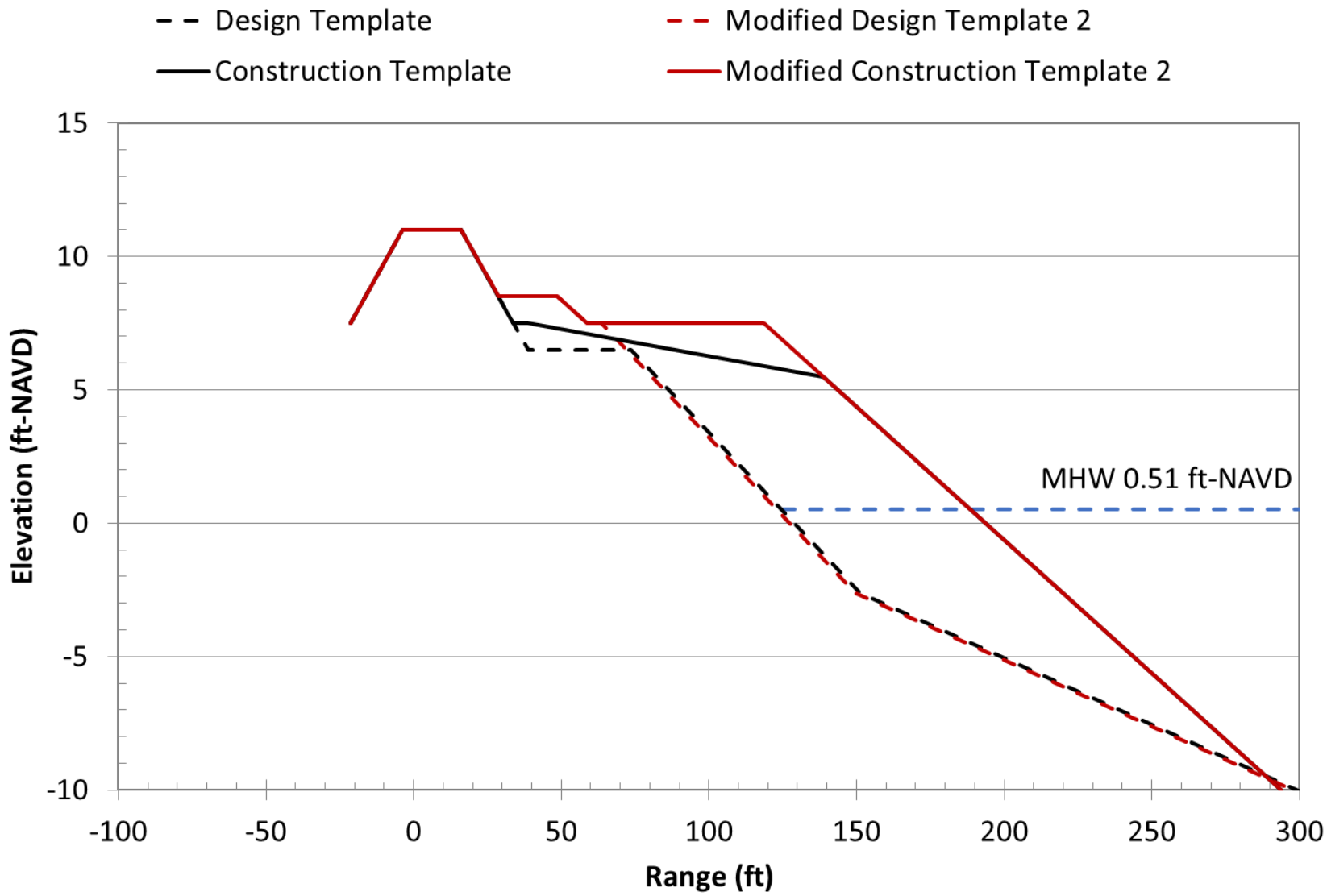
Best Performing Template

- Modified Template 1 vs 2
  - Modified Template 1
    - More costly (2x more volume)
    - Could require additional environmental studies (dune lift and seaward toe extension)
  - Modified Template 2
    - Selected for further analysis





Best Performing Template



Best Performing Template

Positive Values – Shoreline Advance
Negative Values – Shoreline Recession

- Modified Template 2 – Contour Tracking

Template	Storm	Increase in Water Levels Due to SLR	Berm (+6.5 ft-NAVD88) Average Contour Position Change (ft)	MHW (+0.51 ft-NAVD88) Average Contour Position Change (ft)	MLW (-2.6 ft-NAVD88) Average Contour Position Change (ft)
Modified Template 2	Hurricane Irma-October 2017	2024 (+0.22 ft)	-29.4	-14.2	64.5
Modified Template 2	December 2019 Extratropical Event	2024 (+	-3.3	-13.6	35.5
Modified Template 2	Hurricane Irma-October 2017	(+	-43.3	-8.0	67.4
Modified Template 2	December 2019 Extratropical Event	(+1.10 ft)	-13.9	-13.5	37.4

10.6 ft more recession

13.9 ft more recession

Less erosion at 2046

Best Performing Template

Positive Values – Accretion
Negative Values – Erosion

- Modified Template 2 – Volume Changes

Template	Storm	Increase in Water Levels Due to SLR	Normalized Added Volume	Dune to MHW	MHW to MLW	Dune to MLW
				Average Volume Change (cy/ft)	Average Volume Change (cy/ft)	Average Volume Change (cy/ft)
Modified Template 2	Hurricane Irma-October 2017	2024 (+0.22 ft)	1.01	-9.37	2.65	-6.72
Modified Template 2	December 2019 Extratropical Event	2024 (+0.18 ft)	1.01	-3.80	1.31	-2.50
Modified Template 2	Hurricane Irma-October 2017	2046 (+1.14 ft)	1.01	-11.93	3.65	-8.28
Modified Template 2	December 2019 Extratropical Event	2046 (+1.10 ft)	1.01	-6.31	1.24	-5.08

2.7 x more erosion

1.6 x more erosion

Best Performing Template

Greater Quantity of Instances – More Overtopping

- Modified Template 2 – Profile Wetting

Template	Storm	Increase in Water Levels Due to SLR	Water Level Instances Greater Than			
			+5.5 ft-NAVD88	+4.5 ft-NAVD88	+3.5 ft-NAVD88	+2.5 ft-NAVD88
Modified Template 2	Hurricane Irma-October 2017	2024 (+0.22 ft)	2	31	173	467
Modified Template 2	December 2019 Extratropical Event	2024 (+0.18 ft)	0	0	0	22
Modified Template 2	Hurricane Irma-October 2017	2046 (+1.14 ft)	25	169	459	697
Modified Template 2	December 2019 Extratropical Event	2046 (+1.10 ft)	0	0	13	463

Significantly more overtopping

Summary

- Can we increase dune/berm height/width?
  - Permit limits volume, easements limit placement to the west, hardbottom resources limit placement to the east…
  - Authorizing documents allow for an increase in the berm elevation
- Increased volume in template
  - Improved beach performance
  - Decreased overtopping of berm
- Increased water levels
  - Increased shoreline changes on the upper, subaerial beach
  - Decreased beach performance (2024 vs 2046)
  - Additional overtopping of berm

Looking Forward

- Reevaluate the historic erosion rate, underestimated?
  - GDM – 53,000 cy/yr
  - LRR – 60,600 cy/yr
  - Nourishment history indicates:
    - ~97,000 cy/yr placed between 2001 and 2024
- Update tidal datum and design elevations with next NTDE
- Planned renourishment next winter
  - In conversations with USACE to modify the template to include a small back berm and an increase in elevation

Nicole McClain, E.I.
nmcclain@taylorengineering.com

Wendy Laurent, P.E.
wlaurent@taylorengineering.com