BAREFOOT BEACH SURVEY & ANALYSIS
JULY 2018

BAREFOOT BEACH PROPERTY OWNERS ASSOCIATION

PREPARED BY
HUMISTON & MOORE ENGINEERS
H&M FILE 28013

Date of Photograph March 23, 2018

SUBMITTED TO:
BAREFOOT BEACH PROPERTY OWNERS ASSOCIATION

HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

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INTRODUCTION

This report by Humiston & Moore Engineers (H&M) presents the analysis of a post-Irma[1] survey, conducted in September of 2017 in comparison to historical surveys conducted along Barefoot Beach in Collier County. The post-Irma survey was conducted by the U.S. Army Corps of Engineers (USACE) between September 18th & 25th, 2017.

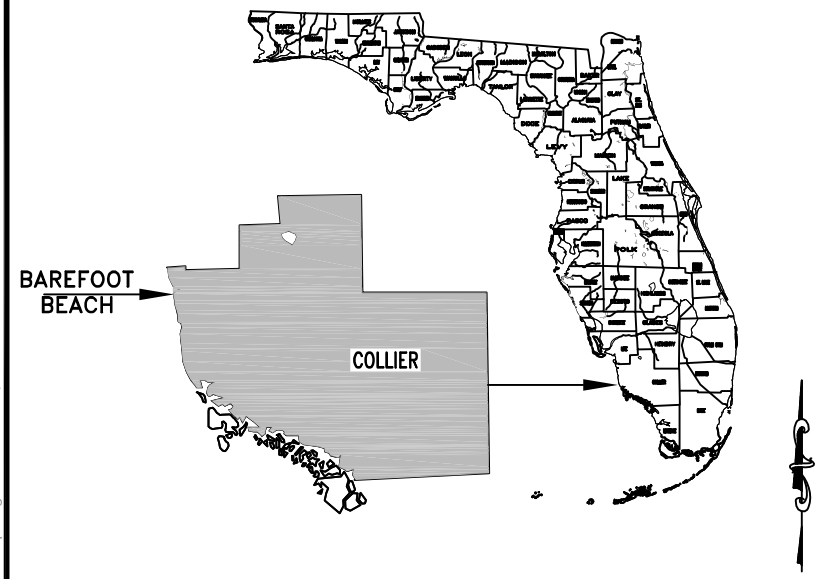
Barefoot Beach located in Collier County on the southwest coast of Florida as shown in **Figure 1** is approximately 8,100 feet long, bounded on the north by the Collier/Lee County border and to the south by Barefoot Beach County Preserve Park. The portion of Barefoot Beach referenced and analyzed in this report is the residential section of Barefoot Beach ranging from the Department of Environmental Protection (DEP) reference monuments R-1 south to R-9[2].

The beaches adjacent to Barefoot Beach extend approximately 2.5 miles north to Big Hickory Pass in Lee County and approximately 1.4 miles south to Wiggins Pass in Collier County. Big Hickory Pass has closed and been reopened mechanically while Wiggins Pass has been hydraulically dredged numerous times since 1984.

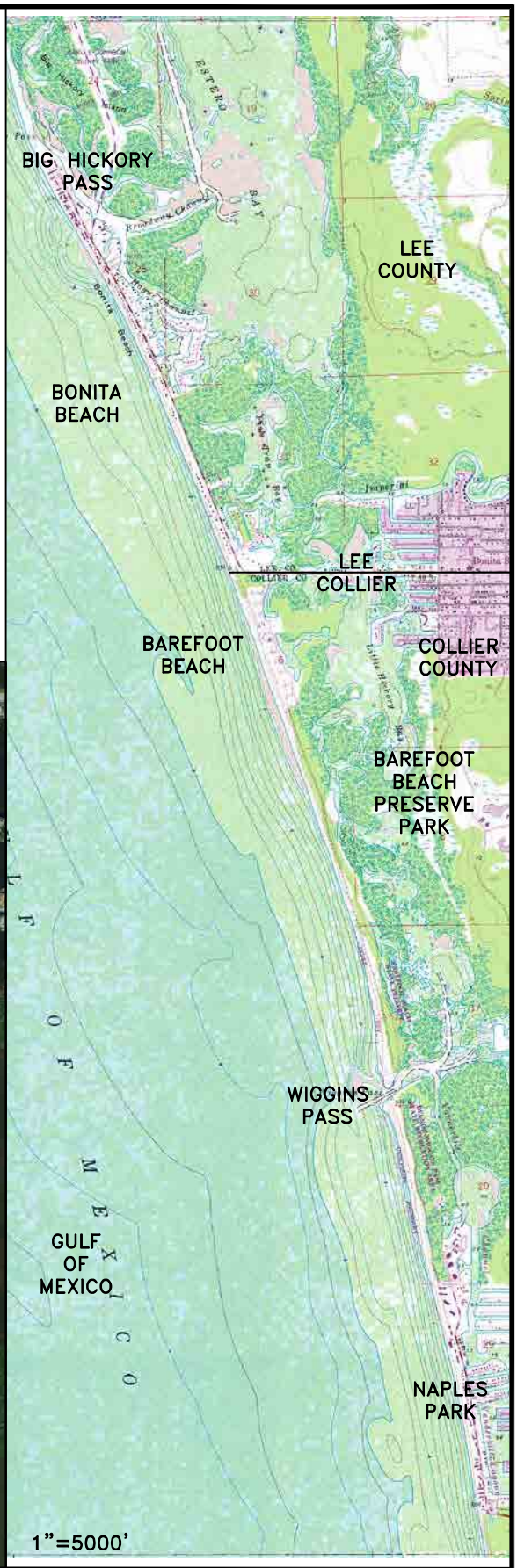
The bays east of Barefoot Beach are part of the Wiggins Pass Estuarine Area and the Cocohatchee River System, and are protected due to the Outstanding Florida Waters designation. Portions are designated Class II or coastal waters generally for shellfish propagation and harvesting. To the north they connect with the Gulf Coast Intracoastal Waterway (ICW) system managed by the West Coast Inland Navigation District (WCIND).

Barefoot Beach - March 23, 2018

[1] The center of Hurricane Irma impacted Collier County on September 10, 2017 as a Category 3 major hurricane.
[2] Coastal Range Monuments or "R" monuments are generally spaced 1,000 feet apart along the Florida coastline and are occasionally labeled "T" as monuments are lost and replaced.



DATE OF PHOTOGRAPH: DECEMBER 2, 2017.
PHOTOGRAPH PROPERTY OF
COLLIER COUNTY APPRAISER'S OFFICE.



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BAREFOOT BEACH PROJECT LOCATION MAP		
FOR: BAREFOOT BEACH PROPERTY OWNERS ASSC.		
DATE: 5/17/18	FILE: LOC MAP	SCALE: SHOWN
JOB: 28013	DATUM: NONE	FIGURE: 1

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STORM ACTIVITY

According to the National Oceanic and Atmospheric Administration (NOAA), eleven hurricanes tracks are located within 100 nautical miles of Barefoot Beach from 2000 to 2017 as listed in **Table 1**.

Table 1. Hurricanes within 100 Nautical Miles of Barefoot Beach 2000-2017 (NOAA)[3]

Date	Hurricane
2001-September	Gabrielle
2004-August	Charley
2004-August	Frances
2004-September	Ivan
2004-September	Jeanne
2005-August	Katrina
2005-October	Wilma
2006-August	Ernesto
2008-August	Fay
2010-July	Bonnie
2017-September	Irma

Additionally Collier County was impacted by Tropical Storm Leslie in October 2000 and a meteotsunami[4] in January 2016. A graph of the observed water levels at the Naples Tide Station on January 17, 2016 documenting the meteostunami and the storm track for Hurricane Irma is included in **Appendix A**.

Tropical Storm Alberto impacted Collier County recently on May 26, 2018 after the post-Irma survey was conducted. Although the changes to the beach were not captured in the recent survey, photographs acquired along the beach on May 27 are provided in **Appendix B** showing the condition of the beach as the storm passed to the north as a subtropical depression.

Oblique aerial images acquired on March 23, 2018 are provided in **Appendix C** showing the location of the DEP reference monuments. These photographs are also shown on the cover and within the body of this report.

HISTORY

Appendix D contains aerial images of Barefoot Beach dating to 1944. Generally there has been relatively little change in the beach with the exception of the closing of a small break, or inlet, in the beach near monument R-5 visible in the 1944 image.

A dune restoration project was conducted for Barefoot Beach in 2001 to reconstruct the dune overwashed by Tropical Storm Gabrielle. The 1 to 2 feet of sand washed from the top of the dune, 30 to 50 feet upland of the dune from monument R-1.5 south to R-5.2, was relocated to the original dune footprint and replanted with native vegetation.

[3] Some of these hurricanes may have been downgraded to tropical storms when they passed the project area.

[4] Meteotsunamis have the characteristics similar to earthquake-generated tsunamis, but are caused by air pressure disturbances often associated with fast moving weather systems, such as squall lines. These disturbances can generate waves in the ocean that travel at the same speed as the overhead weather system. Development of a meteotsunami depends on several factors such as the intensity, direction, and speed of the disturbance as it travels over a water body with a depth that enhances wave magnification. NOAA 2015

Post Hurricane Frances September 7, 2004

The nearest beach nourishment project placing sand in the vicinity of Barefoot Beach since 2000 is the disposal of approximately 50 to 70,000 cubic yards of sand south of Barefoot Beach, dredged from Wiggins Pass, and placed in the nearshore at Barefoot Beach Preserve Park south of monument R-11 in 2005, 2009, 2011, and 2013 when the pass was realigned. This sand is not likely to have a significant influence on the beaches to the north as the net sand transport is generally north to south in Collier County.

Bonita Beach, located north of Barefoot Beach, in Lee County was nourished with 217,000 cubic yards of sand in 1995; 150,000 cubic yards of sand in 2004; and 134,500 cubic yards of sand in September 2014. The fill was placed from monument R-226 south to R-230, located approximately 1.8 miles north of Barefoot Beach, outside of the area of immediate influence of Barefoot Beach. Although the net southward sand transport along this section of coastline may be slowed by the sheltering effect of Sanibel Island, blocking waves from the northwest, some of this sand may eventually work its way south to benefit Barefoot Beach.

Barefoot Beach has not been nourished as part of the Collier Beach Nourishment Project. The Collier Beach project began in 1996 with the placement of 1.2 million cubic yards, of sand dredged from offshore, on the beach from Vanderbilt Beach south to Naples Beach. An additional 667,000 cubic yards was placed in 2005. Since the 2005 project there have been numerous truck haul projects to address specific areas of need in an effort to maintain the design beach width. The Collier Beach project now includes Vanderbilt, Pelican Bay, Clam Pass Park, Park Shore, and Naples beaches.

SURVEY DATA

Historically surveys of Barefoot Beach have been conducted at the DEP reference monuments shown in **Figure 2,** overlaid on an aerial image acquired on December 2, 2017**,** and along the profile lines shown at each monument. The analysis in this monitoring report is based on data from the surveys listed below and shown graphically in the beach profiles contained in **Appendix E.**

- 2000-June 48-month monitoring survey conducted by Coastal Engineering Consultants Inc. (CEC).
- 2003-June to May monitoring survey conducted by Coastal Planning and Engineering Inc. (CPE).
- 2015-June LIDAR[5] survey conducted by the USACE.
- 2017-September LIDAR survey conducted by the USACE.

The March 1973 survey courtesy of DEP is shown for reference on the beach profiles contained in **Appendix E** to help provide historical perspective but is not analyzed as part of the main analysis in this report because the offshore survey data at five of the nine monuments extends only 300-400 feet offshore, insufficient for the volumetric analysis. Additionally upland changes have occurred appearing to be a consequence something other than natural coastal processes as indicated by the beach profiles in **Appendix E** and the change in upland vegetation shown in the photographs provided in **Appendix D** dated 1973 and 1985. There was significant upland development in this period as well as impact from the June 1982 No-Name storm. Although volumetric change in reference to the 1973 survey will not be discussed, there is sufficient survey data to compare the shoreline position to other surveys. At the end of this report the 1973 and most recent survey will be compared in order to encompass a significant time span to eliminate short term variation in the coastline.

SHORELINE AND VOLUME CHANGE

Shoreline and volumetric change were determined at each monument for surveys conducted for the June 2000, June 2003, June 2015, and September 2017 surveys along the azimuths shown in the **Table 2**. Shoreline change is the horizontal distance between the position of the mean high water elevation on the beach face for different surveys while volumetric change compares the change in the volume of sand between surveys, by convention positive values indicate accretion and negative values indicate erosion.

The change in shoreline position was measured as horizontal movement of the mean high water elevation of +0.33 feet NAVD where the elevation intersects the beach slope, while the offshore limits used for the volumetric analysis, also shown in **Table 2**, are based on the intersection of the 2017 profile and the -11.3 feet NAVD depth of closure contour (DOC)[6] as described and used in Collier County monitoring reports for consistency. The upland limit for volumetric analysis, shown in **Table 2** was determined by the September 2017 vegetation line, shown in **Figure 2** and estimated using the 2017 orthorectified[7] image, at monuments R-1 south to R-9. The location of the DEP reference monuments varies in relation to the shoreline. This upland limit will be used as the *provisional baseline* similar to the baseline described for the Collier County Beach Nourishment project, for the analysis in this report. Both the upland and offshore limits are shown graphically on the beach profiles provided in **Appendix E**.

[5] Light Detection and Ranging (LIDAR): a remote sensing of survey method utilizing a pulsed laser to generate elevation data both above and below the surface of the water in conjunction with positional data. LIDAR data is not as precise as data collected by conventional survey procedures.

[6] Depth of closure in coastal engineering terminology typically means the depth beyond which no change in bottom elevation is seen from normal coastal processes measured by monitoring surveys. The depth of -11.3 feet NAVD was established early as part of the monitoring of Collier County beaches. There are cases of sand accumulation or loss beyond -11.3 feet NAVD and in those cases the analysis is conducted further offshore to ensure analysis of data within profile closure.

[7] Orthorectification is the process of removing the effects of image perspective (tilt) and relief (terrain) effects for the purpose of creating a planimetrically correct image. The resultant orthorectified image has a constant scale wherein features are represented in their 'true' positions. This allows for the accurate direct measurement of distances, angles, and areas (i.e. mensuration). OSSIM, https://trac.osgeo.org/ossim/wiki, 2018.

Table 2. Profile Information for Beach Volume Change Analysis

FDEP Monument	Easting Coordinate (FEET)	Northing Coordinate (FEET)	Monument Azimuth (DEG)	Distance from Monument to Upland Volume Limit (Ft)	Distance from Monument to Closure Depth (Ft)
R-1	379317.3	726607.8	270	93	565
T-2	379657.8	725666.7	270	116	500
R-3	379952.1	724695.7	270	47	530
R-4	380207.6	723739.8	270	-21	460
R-5	380603.8	722773.5	270	36	480
R-6	380896.0	721816.1	270	-6	440
R-7	381313.4	720858.3	270	64	500
T-8	381618.3	719845.0	270	32	500
R-9	381947.4	718923.7	270	59	600

The volumetric change was computed utilizing the average end area method at the distances between profiles shown in **Table 3**. The distances represent the perpendicular segment between the parallel monument azimuths.

Table 3. Beach Volume Change – Distance between Monuments

DEP Monument Range			Distance Between Monuments (Ft)
R-1	to	R-2	1,001
R-2	to	R-3	1,015
R-3	to	R-4	989
R-4	to	R-5	1,044
R-5	to	R-6	1,001
R-6	to	R-7	1,045
R-7	to	R-8	1,058
R-8	to	R-9	978
Total:			8,132

Escarpment at Monument R-8 on June 17, 2018


FIGURE 2: BAREFOOT BEACH PROVISIONAL BASELINE
DECEMBER 2, 2017
R-1
T-2
R-3
R-4
R-5
R-5
R-6
R-7
SEPTEMBER 2017
MHWL
(+0.33 NAVD)
T-8
PROVISIONAL BASELINE
ESTABLISHED AT THE
SEAWARD EDGE OF
VEGETATION AT EACH DEP
REFERENCE MONUMENT
R-9
0
500
1000
SCALE: 1" = 1000'
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Figure 3a shows a typical beach profile comparison for the survey conducted in 2000, and most recently in September 2017 with the elevation (referencing the NAVD vertical datum) on the vertical axis and the distance from monument (in feet) on the horizontal axis. Additionally, the bounds of the shore-normal limits for the volume analysis described in **Table 2** (and **Table 7)** along with the corresponding beach widths are included. The area change at this monument from the 6/2000 to 9/2017 surveys, denoting accretion and erosion, averaged with the area change at each adjacent monument is multiplied by the distance between the monuments to obtain the net volume change between adjacent monuments.

Figure 3a. Typical Beach Profile Comparison

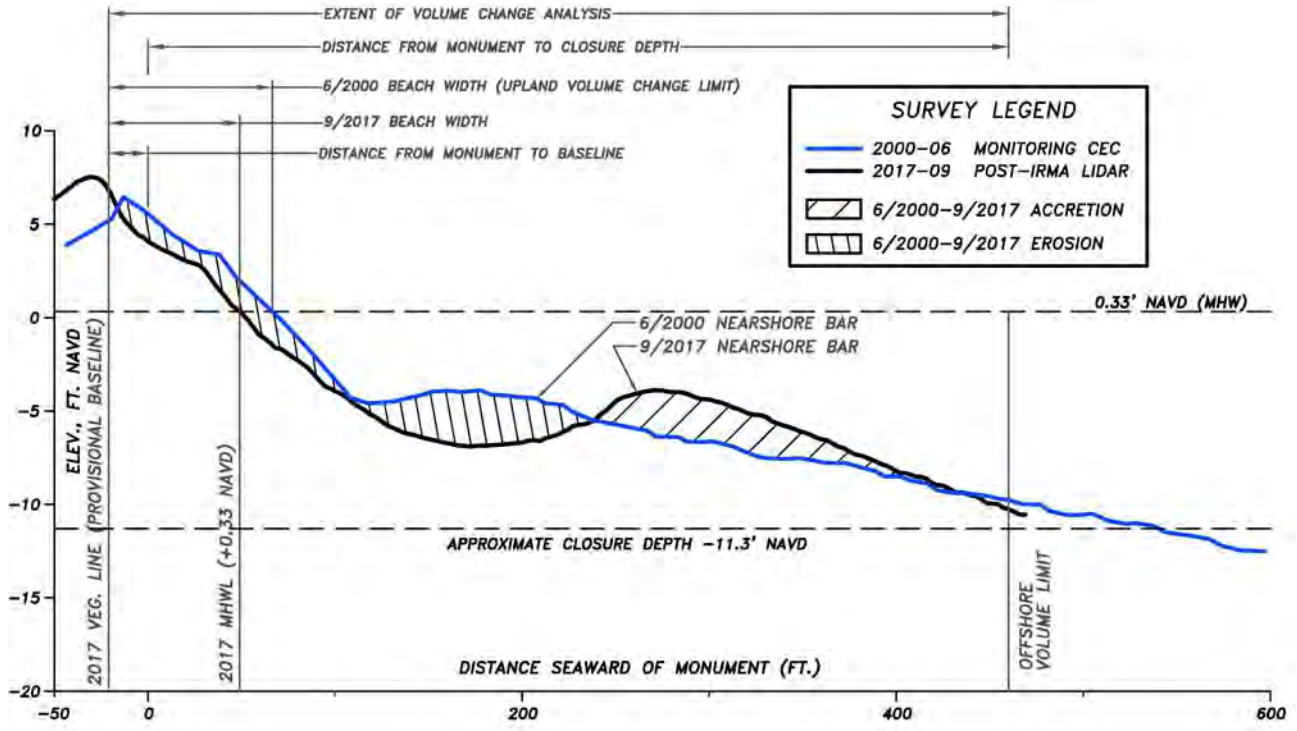

Figure 3b is a schematic depiction of the elements involved in the analysis of shoreline and volume change in this report. Two adjacent DEP reference monuments and associated monitoring azimuths are shown along with the MHWL, and approximate depth of closure (DOC). Also shown are comparative beach profiles at the adjacent monuments and the associated area change between the monitoring survey profiles being compared. Shoreline change is the difference in the "Distance from the Vegetation or Seawall[8] to MHWL", or *provisional baseline* to the MHWL, for different monitoring surveys. Volumetric change, determined by the formula shown (at the bottom of the figure) for the average end area method, utilizes the average cross sectional area change for different monitoring surveys at adjacent monuments and the length of beach between those monument profiles. The comparative profiles are analyzed from the *provisional baseline* to the approximate depth of closure as shown in the figure and **Table 2**.

In the following sections of this report, corresponding values between those shown in the Tables and report text are highlighted in blue for ease of reference. The volumes in cubic yards (CY) shown in the tables were rounded to the nearest value of 10 and distances are shown in feet rounded to the nearest whole number.

[8] This is the definition of the 2003 baseline used in Collier County Beach Nourishment Project. There is no seawall within this Barefoot Beach segment.

Figure 3b. Schematic Diagram for Typical Shoreline and Volumetric Change Analysis

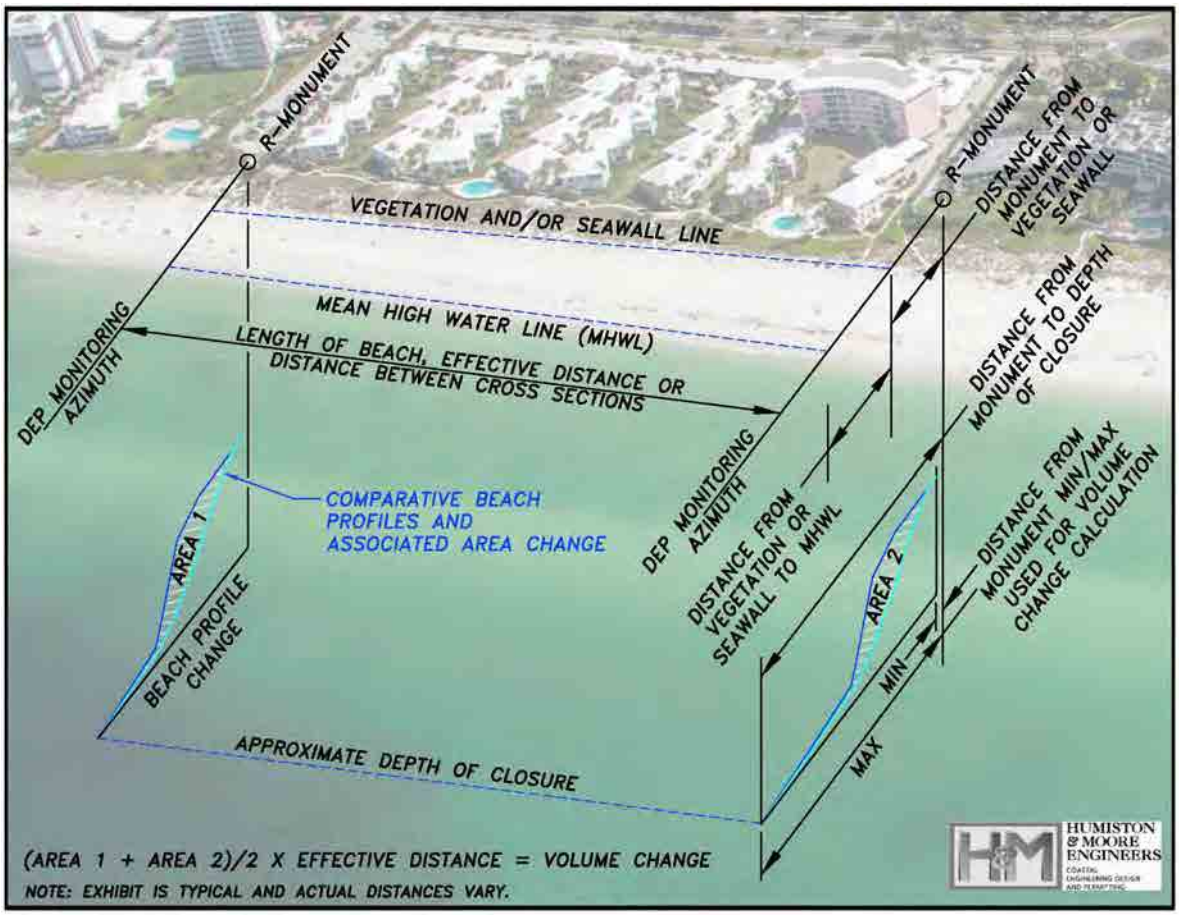

Table 4 shows the width of the dry beach as measured from the *provisional baseline* (shown in **Figure 2**) to the MHWL for DEP reference monuments R-1 to R-9 from 2000 to the most recent survey in 2017. The highest average width was in 2000 and 2015 with the reach averaging 91 feet in width. **Table 5** shows the shoreline (or beach width) change for the same monuments and time span. The impact of Tropical Storm Leslie and Hurricane Gabrielle was likely a major cause of the shoreline recession from 2000-2003 with all of the monuments losing dry beach width during this period. The average beach width narrowed by 14 feet (-14) from 91 to 77 feet but recovered by 2015 gaining back all 14 feet over the following 12 years only to be impacted by Hurricane Irma in 2017 losing an average width of 9 feet (-9) for the entire reach. Considering the 17 year span from 2000 to 2017 the majority of the loss in beach width is from monuments R-3 to R-6 inclusive, losing an average of 18 feet in width (-18) while the balance of the reach remained relatively stable.

Table 4. Beach Width – *Provisional Baseline* to MHWL

DEP Mon.	Beach Width - Baseline to MHWL - (Feet)				
	2000	2003	2015	2017	Average
R-1	98	80	98	93	**92**
T-2	76	52	76	71	**68**
R-3	96	71	84	78	**82**
R-4	88	81	80	**70**	**80**
R-5	93	90	90	78	**88**
R-6	100	78	93	80	**88**
R-7	98	89	103	**97**	**97**
T-8	90	72	96	84	**86**
R-9	81	81	101	85	**87**
	91	**77**	**91**	**82**	**85**

Table 5. Shoreline Change (2000-2017)

DEP Mon.	Shoreline Change - (Feet)				
	2000 to 2003	2003 to 2015	2015 to 2017		2000 to 2017
R-1	-18	18	-5		-5
T-2	-24	24	-5		-5
R-3	-25	13	-6		-18
R-4	-7	0	-10	**-18**	-17
R-5	-3	0	-12		-14
R-6	-22	15	-13		-20
R-7	-9	14	-6		-1
T-8	-18	24	-12		-6
R-9	0	20	-16		4
Average:	**-14**	**14**	**-9**		**-9**

Table 6. Volume Change (2000-2017)

DEP Reference Monument			Volume Change (Cubic Yards)				
			2000-2003	2003-2015	2015-2017		2000-2017
R-1	to	R-2	-6,450	9,110	2,290		**4,950**
R-2	to	R-3	-10,980	9,820	340		**-820**
R-3	to	R-4	-7,120	1,730	920		-4,470
R-4	to	R-5	-2,510	-1,960	-730	**-17,440**	-5,190
R-5	to	R-6	-6,770	1,990	-1,140		-5,920
R-6	to	R-7	-7,800	5,790	150		-1,860
R-7	to	R-8	-8,280	7,620	2,400		**1,740**
R-8	to	R-9	-6,230	5,300	2,240		**1,320**
Total:			**-56,140**	**39,400**	**6,470**		**-10,250**

Table 6 shows the volume change between DEP reference monuments R-1 through R-9 for the time span from June 2000 to September 2017. The volume loss from 2000-2003 reflects the results of the shoreline analysis as the area was impacted by Tropical Strom Leslie and Hurricane Gabrielle during this time losing over 56,000 cubic yards (-56,140) of sand but gaining much of the volume back (39,400) in the subsequent 12 years. Although there were localized volumetric losses from 2015 to 2017, changes in the nearshore bar account for much of the gain in volume during this period. As noted in the shoreline analysis for the period from 2000 to 2017 the erosion occurred from monuments R-3 to R-7 losing 17,440 cubic yards (-17,440) of sand during this period while the remainder of the beach, north and south of this area, shows relative stability gaining over 7,100 cubic yards (4,950+-820+1,740+1,320) of sand.

Evaluation of the beach width, or the upland portion of the beach, is done without consideration to changes in the nearshore as shown previously in **Table 6** containing volumetric changes offshore to the depth of closure. In order to isolate upland volumetric changes to complement the information provided by changes in beach width, the limits of the volumetric analysis were adjusted to include the *provisional baseline* and the June 2000 MHWL as shown in **Table 7** (and **Figure 3a**). The last column in **Table 7** shows the change in the volume upland of the June 2000 MHWL for the 17 years from 2000 to 2017 with a total loss of 22,590 cubic yards (-22,590) of sand. The majority of the loss is again from monument R-3 south to R-7 although in this case the erosion continues further south to monument R-9. The volumetric loss from R-3 to R-7 (-17,530) is similar to the volume loss obtained when considering the entire beach profile as shown in **Table 6** for the same reach (-17,440).

Table 7. Upland Volume Change

DEP Reference Monument			Analysis Limits (Ft)		Vol. Chg. (CY)	
			Landward	Seaward	2000-2017	
R-1	to	R-2	93	191	780	
R-2	to	R-3	116	191	-1,400	
R-3	to	R-4	47	143	-3,510	-17,530
R-4	to	R-5	-21	67	-4,440	
R-5	to	R-6	36	129	-5,340	
R-6	to	R-7	-6	94	-4,240	
R-7	to	R-8	64	162	-2,490	
R-8	to	R-9	32	123	-1,950	
Total:					-22,590	

The approximate line of construction (LOC) as estimated based on the December 2, 2017 orthorectified image is shown in **Figure 4**, landward of the provisional baseline, along with the distance from the LOC to the September 2017 MHWL in order to estimate the distance from the shoreline to the buildings. **Table 8** shows this distance at the various years along with averages at each monument in the last column. In 2017 the distance from the MHWL to the buildings ranges from 139 feet at monument R-5 to over 260 feet (261) at T-8. Note, the average distance for the buildings from T-2 to R-5 is significantly less than the distance from R-6 to R-9, 154 and 230 feet respectively.

Table 8. Beach Width – 2017 Line of Construction to the 2017 MHWL

DEP Mon.	2017 Line of Construction to 2017 MHWL - (Feet) 2000	2003	2015	2017		Average
R-1	272	254	272	267		266
T-2	151	127	151	146		144
R-3	175	151	163	157	154	161
R-4	171	164	164	154		164
R-5	153	151	151	139		149
R-6	220	198	213	200		208
R-7	236	227	241	235	230	235
T-8	267	249	273	261		263
R-9	208	209	228	212		214
	206	192	206	197		200

Lely Barefoot Beach Unit 1 from Plat Book 12 pages 35-37 is contained in **Appendix F** showing a portion of the beach labeled "Tract BF". The location of the Tract BF was estimated and shown on **Figure 4.** The location of the tract is along the reach containing the shortest distances from the LOC to the MHWL, from T-2 to R-5. The seaward limit of the tract was determined by the location of the MHWL in 1978 appearing to be on average over 20 feet seaward of the September 2017 MHWL with the distance between the MHWL's generally decreasing to the north.

BEACH FILL

The Collier County Beach nourishment project utilizes a *Design Standard* beach width (either 85 or 100 feet depending on location) from a corresponding fixed baseline established in 2003. The baseline was set at the seawall, edge of vegetation, building line or equivalent, at each monument, and the beach width was determined by the distance from the baseline to the mean high water elevation of +0.33 NAVD at each DEP reference monument. The distance from the MHWL to the 2003 baseline provides the width of the dry sandy beach and is compared to the *Design Standard* (85' or 100') for the project area. This same analysis was conducted in this report based on the *provisional baseline* or seaward edge of vegetation shown in the December 2, 2017 orthorectified aerial image.

Currently in Collier County the amount of fill required to maintain the *Design Standard* width is based on the existing width of the dry sandy beach in comparison to the *Design Standard* width of either 85 or 100 feet and the background erosion rate for the project area. The *Design Standard* is limited on its seaward extent by the location of hardbottom[9], a natural resource potentially located in the nearshore, requiring a buffer from sand placement so sand placement and post fill adjustment does not cover any hardbottom. As an example Vanderbilt Beach, the portion of the Collier Beach nourishment project beach closest to Barefoot Beach, has a 100 foot *Design Standard* width because the beach can be filled to the 100-foot width plus advance fill[10] without sand covering any hardbottom as the profile equilibrates.

Barefoot Beach shows a loss of 18,260 cubic yards (-17,440-820;Table 6) of sand in the 17 years from 2000 to 2017 yielding an annual erosion rate of approximately -1,074 cubic yards per year (-18,260/17)

[9] Hard Bottom is characterized as mixed sessile communities of algae, sponges, octocorals and stony corals. This habitat occurs in subtidal, intertidal, and supratidal zones throughout Florida's coastal waters. Hard Bottom is composed of attendant epibenthic biota on a rocky substrate composed of coquina, limestone, or relic coral, molluscan, and annelid reefs. Coquina is a limestone composed of broken shell debris. Limestone rock (many different strata) occurs as high- or low-relief outcrops of calcium carbonate. FWC 2012

[10] The County also incorporates advance fill (fill placed in addtion to the fill to obtain the *Design Standard* width) extending the life of the project up to three years.

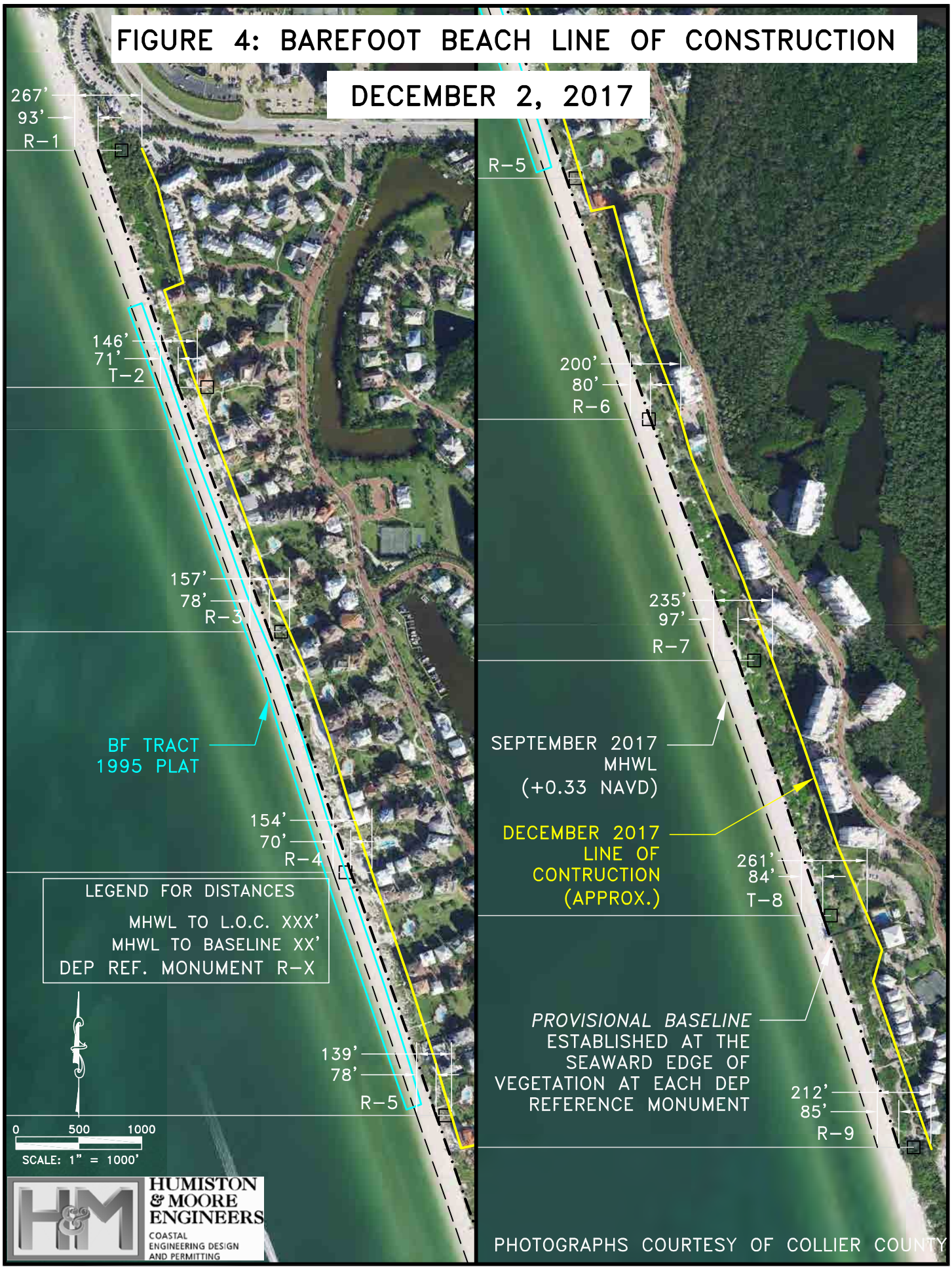
FIGURE 4: BAREFOOT BEACH LINE OF CONSTRUCTION
DECEMBER 2, 2017
267'
93'
R-1
146'
71'
T-2
157'
78'
R-3
154'
70'
R-4
139'
78'
R-5
R-5
200'
80'
R-6
235'
97'
R-7
261'
84'
T-8
212'
85'
R-9
BF TRACT
1995 PLAT
SEPTEMBER 2017
MHWL
(+0.33 NAVD)
DECEMBER 2017
LINE OF
CONTRUCTION
(APPROX.)
PROVISIONAL BASELINE
ESTABLISHED AT THE
SEAWARD EDGE OF
VEGETATION AT EACH DEP
REFERENCE MONUMENT
LEGEND FOR DISTANCES
MHWL TO L.O.C. XXX'
MHWL TO BASELINE XX'
DEP REF. MONUMENT R-X
0
500
1000
SCALE: 1" = 1000'
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COASTAL ENGINEERING DESIGN AND PERMITTING
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over the entire reach from R-1 to R-9. **Tables 9 and 10** show the fill requirments for the 85 and 100 foot beach width standard based on a berm elevation of +3 feet NAVD, depth of closure of -11.3 NAVD, advance fill requirements, background erosion rate, time to construction, effective distance and beach width for each monument based on a similar analysis as conducted to determine fill requirments for the Collier Beach Nourishment Project.[11] Column 2 shows the 9/2017 post-Irma beach width, Column 3 - the additional width needed to obtain the *Design Standard* width, Column 4 - the volume required to obtain the *Design Standard* width, Column 5 - the volume requried for 3 years of advance fill, Column 6 - the volume required to offset the erosion from July 2018 until the anticipated time of construction (estimated to be 2020), and Column 7 - the total of Columns 4 thru 6 or the total volume required.

Table 9. *Design Standard* vs. Fill Required – 85 Foot *Design Standard* for Barefoot Beach, Berm Elevation +3 NAVD

Column	*2*	*3*	*4*	*5*	*6*	*7*
DEP Reference Monument	***9/2017 Beach Width (Ft)***	***Addional Width Required (Ft)***	***Design Standard Volume (CY)***	***Advance Fill Volume (CY)***	***Erosion Pre-Cont. Volume (CY)***	***Total Volume Req'd (CY)***
R-1 Taper	*93*	*-*	*0*	*0*	*0*	*0*
T-2	*71*	*14*	*7,632*	*425*	*448*	*8,505*
R-3	*78*	*7*	*3,927*	*423*	*445*	*4,795*
R-4	*70*	*15*	*8,025*	*429*	*452*	*8,906*
R-5	*78*	*7*	*3,683*	*431*	*455*	*4,569*
R-6	*80*	*5*	*2,763*	*432*	*455*	*3,649*
R-7 Taper	*97*	*-*				
T-8	*84*	*1*	*Minimal volume required - No fill this portion*			
R-9	*85*	*0*				
Totals:			*26,030*	*2,140*	*2,260*	***30,430***

Table 10. *Design Standard* vs. Fill Required – 100 Foot *Design Standard* for Barefoot Beach, Berm Elevation +3 NAVD

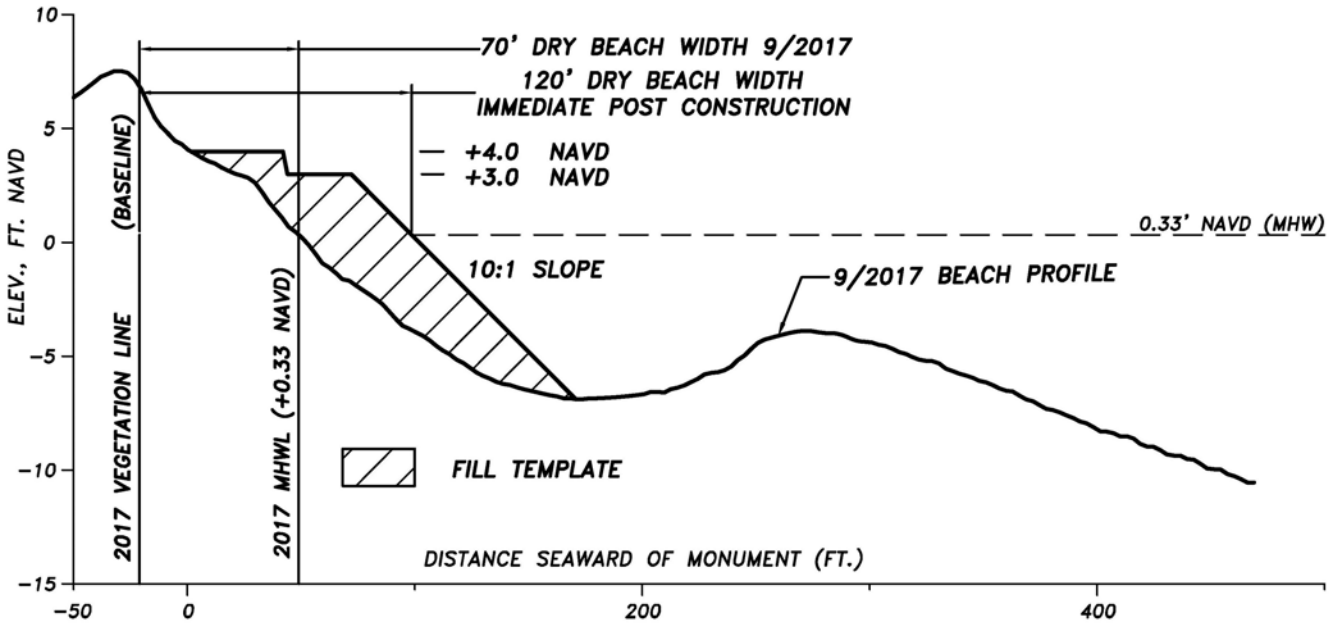
Column	*2*	*3*	*4*	*5*	*6*	*7*
DEP Reference Monument	***9/2017 Beach Width (Ft)***	***Addional Width Required (Ft)***	***Design Standard Volume (CY)***	***Advance Fill Volume (CY)***	***Erosion Pre-Cont. Volume (CY)***	***Total Volume Req'd (CY)***
R-1 Taper	*93*	*7*	*914*	*106*	*111*	*1,131*
T-2	*71*	*29*	*15,638*	*425*	*448*	*16,511*
R-3	*78*	*22*	*11,888*	*423*	*445*	*12,756*
R-4	*70*	*30*	*16,104*	*429*	*452*	***16,985***
R-5	*78*	*22*	*11,808*	*431*	*455*	*12,694*
R-6	*80*	*20*	*10,889*	*432*	*455*	*11,776*
R-7	*97*	*3*	*1,726*	*444*	*467*	*2,637*
T-8	*84*	*16*	*8,521*	*430*	*453*	*9,403*
R-9 Taper	*85*	*15*	*1,995*	*103*	*109*	*2,207*
Totals:			*79,480*	*3,220*	*3,400*	***86,100***

[11] CP&E, Collier County Conceptual Renourishment Project Analysis May 2011 Revised October 2011

Establishing the 85-foot *Design Standard* along Barefoot Beach would require approximately 30,000 cubic yards (30,430) of sand placed from monument T-1.5 south to R-6.5, tapered at the ends where the fill template interscets the exisiting beach. Monuments T-2 and R-4 require more fill in the vicinity because the beach width is the lowest in this reach. Similarly the establishment of the 100-foot standard would require approxiamately 86,000 cubic yards (86,100) of sand placed over the entire reach from R-1 to R-9 with the majority of the fill placed from T-2 south to R-6, tapered to the existing beach at the north and south termination of the fill template.

A typical beach fill profile is shown in **Figure 5** (R-4 is shown for example) with a typical fill template used during the Collier Beach restoration project with a berm at +3 NAVD. This template can be altered to accomadate local conditions, building location, and the permitted limiits pending location of hardbottom. The beach fill analysis shown in **Table 10** has a total fill quantitiy of 16,985 cubic yards for monument R-4 represented by the template shown in **Figure 5** extending the beach width from approximately 70 to 120 feet immediately post-constrction. This template is designed to maintain the 100 foot *Design Standard* width for three years as it will equilabrate and will likely continue to recede pending post construction conditions.

Figure 5. Typical Beach Fill Profile – (R-4 shown for example)



SEA LEVEL RISE (Excerpt from the Collier County Beach Nourishment Project Monitoring Report – June 2018)

Sea Level Rise (SLR) has not previously been considered in the annual beach monitoring reports, but the evidence for the connection between climate change and SLR is controversial, yet scientifically undeniable. This section of the monitoring report is a synopsis of the sea level rise information contained in **Appendix G**.

The Bruun Rule uses conservation of mass to determine shoreline change associated with water level rise. This simplified theoretical approach is based upon a redistribution of the existing sediment while maintaining an equilibrium profile shape. As sea level rises, it necessarily results in that the profile must also rise in order to maintain the equilibrium relationship between profile shape and water level. This requires a redistribution of coastal sediments, in this case beach sand. As the profile rises, it also moves landward causing shoreline recession, and the recession is observed as erosion providing the extra sand necessary for the profile to maintain its shape as it rises. The Bruun Rule does not consider

other factors associated with the dynamic coastal system, such as the effects of longshore sediment transport, inlets, beach nourishment, and the long-term onshore migration of sediment, a phenomenon observed due to tide and wave induced shear stresses on the continental shelf, the effects of which are most likely to be apparent in long term geologic processes.

It is clear there are many variables effecting the movement of the position of the shoreline. However, as a simple exercise to illustrate the effectiveness of beach nourishment relative to the effect of SLR, a comparison was made between what would have occurred theoretically, in Collier County, due to measured SLR and application of the Bruun Rule. This was done in comparison to what actually occurred in Collier County over the same time interval including the effect of beach nourishment.

Although SLR is not linear, it is close enough to being linear for relatively short periods of time, and the report by the International Panel on Climate Change (IPCC) states the SLR amounted to 3.2mm/year from 1995 to 2017. For 22 years this would be a total rise of 70.4mm or approximately 2.8 inches rise in sea level and theoretically would have caused recession of approximately -15 feet in shoreline position according to the Bruun Rule.

However, Collier County completed its first comprehensive nourishment in 1996 with 1.2 million cubic yards of sand, and has continued to nourish the beach regularly since 1996. Although there was only one other comprehensive nourishment of 667,620 cubic yards in 2005, due to market conditions driven mostly by the need for dredging equipment to repair damage caused by Hurricane Sandy in 2012, the cost of a comprehensive nourishment project scheduled for 2013, the prices bid at the time were prohibitively high. In response to this the County identified several areas within the project deemed the most vulnerable and most in need of nourishment and hauled sand in by truck to address the needs of those areas. Since then the policy has been to annually truck relatively small quantities of sand, incrementally, to areas most in need of nourishment, as opposed to the traditional nourishment practice of hydraulic dredging to place much larger quantities of sand over much longer sections of shoreline. This flexible approach to nourishment, based on the analysis of monitoring data such as the data this report is based, has shown this incremental approach to nourishment has been very effective.

This comparison of the results of SLR based on the Bruun Rule, to the actual shoreline changes based on survey data shows rather than erosion of an average of -15 feet between 1995 and 2017 due to SLR, the County's renourishment program has resulted in shoreline advance of an average of over +50 feet in the same time period of time. Additionally, the beach nourishment program has enabled Collier County to begin building vegetated dunes in the nourishment areas. These dunes not only add stability to the upper beach, they represent an additional supply of sand at a higher elevation than the beach berm, providing an additional measure of storm protection, plus after the impact of a storm the beach will be in better condition due to the presence of this extra source of sand.

CONCLUSIONS & RECOMMENDATIONS

The shoreline and volume change generally shows a stable beach with fluctuations, both erosion and recovery, in response to storm activity. There were loses in beach width as shown in **Tables 4 and 5** for the periods from 2000-2003 and from 2015-2017 spanning only 2-3 years, both periods having active hurricane seasons impacting Collier County beaches. The beach subsequently recovered, and the most recent survey shows the post-Irma width of the beach varying from 70 to 97 feet (Table 4); with an average width of 82 feet (Table 4). The data in **Tables 4 and 5** may seem insufficient to identify trends because, generally speaking, the longer the interval between surveys the more likely the short term changes such as storm impacts and seasonal changes will not affect the data analysis. In order to maximize the interval between surveys, the most recent survey and the 1973 shoreline position were compared as shown in **Table 11**[12]. The erosion occurred from monument R-3 to T-8 losing an

[12] Volume change was not analyzed for the 1973 survey due to insufficient offshore survey data. Additionally upland changes have occurred appearing to be a consequence something other than natural coastal processes as indicated by the change in upland vegetation shown in the photographs provided in **Appendix D** dated 1973 and 1985.

average of 19 feet (-19) in 44 years or approximately -0.4 feet per year. Although there are short term changes to Barefoot Beach as it is impacted by storms and has normal localized fluctuations, the longer term analysis indicates a relatively stable beach consistent with the trend shown in **Table 4 and 5**.

Table 11. Shoreline Change 1973 to 2017

DEP Mon.	Beach Width (Ft) 1973	2017	1973 to 2017
R-1	74	93	19
T-2	60	71	10
R-3	85	78	-7
R-4	88	70	-18
R-5	98	78	-20
R-6	102	80	-22
R-7	127	97	-31
T-8	104	84	-20
R-9	87	85	-2
Average:	92	82	-10

-19

The two events during the 12-year interval from 2003 to 2015 possibly having a measurable effect on the Barefoot Beach is the nourishment of Bonita Beach approximately 1.8 miles north of Collier County monument R-1. It was nourished with 150,000 cubic yards in 2004 and 134,500 cubic yards in 2014. Additionally, sand has been periodically placed in the nearshore of Barefoot Beach Preserve Park from Wiggins Pass maintenance dredging. Due to the sheltering effects of Sanibel Island, annual wave energy from the north is reduced along Barefoot Beach. Sand from these projects may have contributed to the 14 foot increase in beach width in the same time period, between R-1 and R-9. The small annual changes on the order of ±1 foot per year indicate this section of beach is relatively stable, and under these circumstances an increase in the sand budget due to nourishment of the updraft beach, could have had a positive influence on Barefoot Beach. **Table 6** also shows there was an increase in total sand volume of over 40,000 cubic yards (39,400;Table 6) during this same period. The conclusion from this data is nourishment of updrift beaches *may* increase the sand supply to Barefoot Beach. It is recommended Barefoot Beach request Collier County Coastal Zone Management Department include Barefoot Beach in annual monitoring to get enough data before drawing definitive conclusions. More frequent survey intervals would also assist in a more accurate assessment of storm impacts. As part of the County's annual monitoring beach survey, Barefoot Beach would only incur the additional cost of surveying and analyzing nine monuments, saving on the associated mobilization cost if the survey were conducted separately.

The buildings closest to the MHWL are located from monuments T-2 south to R-5 having an average distance from the building to the MHWL of 154 feet (154;Table 8) while the buildings from R-6 to R-9 average 230 feet (230;Table 8) from the MHWL. Monuments R-3 to R-6 exhibit the largest shoreline loss having an average loss of 18 feet (-18;Table 5) in 17 years from 2000 to 2017 or in the 44 years since 1973 monuments R-3 to T-8 lost an average of almost 20 feet (Table 11;-19). If fill were placed, then the beach from R-3 to R-5 would be the logical place to receive additional volume to provide more protection for the buildings during storm events.

The location of the BF Tract shown on the Plat drawings contained in **Appendix F** was approximated and compared to the September 2017 MHWL. The seaward boundary of the tract appears to be approximately 20 feet seaward of the September MHWL.

The majority of the volume loss on Barefoot Beach occurred from 2000-2003 as the area was impacted by Tropical Storm Leslie and Hurricane Gabrielle losing over 57,000 cubic yards (-56,140;Table 6) of sand. The area gained almost 46,000 cubic yards (39,400+6,470;Table 6) in the subsequent 14 years from 2003-2017. A background erosion rate for the beach was determined by the volumetric loses occurring from 2000-2017 from monuments R-2 south to R-7: -18,260 cubic yards (Table 6) in 17 years representing an annual erosion rate of -1,074 cubic yards per year. The volumetric loss of 18,260 cubic yards determined analyzing the entire beach profile as shown in **Table 6** was supported by the volume change considering the upland portion of the profile only, as shown in **Table 7**.

Total Volume change out to depth of closure for the period from 2000 to 2017 shows a loss of over 10,000 cubic yards (-10,250;Table 6) of sand or less than 1.3 cubic yards per foot of beach (-10,250/ 8,132;Table 3). This does not indicate a serious erosion problem, however, based on the idea of adaption to sea level rise (SLR) nourishment is recommended, including raising the elevation and possibly width of the dune, be part of the Barefoot Beach Management Plan, as part of a regional SLR Adaption Plan. Although the county has to yet develop an Adaption Plan, when they do, this will be an important element. Barefoot Beach does not have a very substantial dune as was demonstrated by Hurricane Gabrielle in September 2001, and even more recently with Subtropical Storm Alberto in May 2018.

The Collier County Beach restoration project utilizes a *Design Standard* beach width of 85 or 100 feet based on the location of the offshore hardbottom for the reach. The County currently monitors the hardbottom as part of the Collier Beach Restoration project from Wiggins Pass south to Naples Beach. A sidescan survey of the offshore near Barefoot Beach to locate hardbottom would determine the maximum fill template width for Barefoot Beach and subsequent monitoring would likely be required if a permit application were filed for nourishment of Barefoot Beach.

Utilizing the method of fill determination for the Collier Beach project volumetric quantities were determined for both the 85 and 100 *Design Standard* for Barefoot Beach based on the previously established parameters. If the 85-foot *Design Standard* were utilized the reach from monument R-1.5 south to R-6.5 would be filled with over 30,000 cubic yards (30,430;Table 9) of sand. The 100-foot *Design Standard* would require over 86,000 cubic yards (86,100;Table 10) of sand spanning the entire reach from R-1 to R-9.

Tropical Storm Alberto recently impacted Barefoot Beach on May 26, 2018. The photographs provided in **Appendix C** indicate additional loss in beach width beyond the losses documented by surveys as a consequence of Hurricane Irma. Many of the dune walkovers are in need of repair as well as the signs showing the location of the “R” monuments. An escarpment can be noted near monument R-8 in the photographs as well as the beach profile provided in **Appendix E**.

Although Barefoot Beach appears to be relatively stable in the long term as shown in the historical photographs provided in **Appendix D**, the reach reacts to storm impacts and recovers. The dune system is relatively small supported by a narrow beach collectively offering limited storm protection and environmental habitat. The recreational uses, environmental habitat, and storm protection provided by the beach and dune system along this stretch of beach has been compromised over time particularly after the storm effects of Hurricane Irma. Over the 17 years analyzed the buildings from monument T-2 to R-5 have been relatively close to the MHWL compared to other portions of Barefoot Beach and part of those areas have suffered the most shoreline recession. If a storm were to impact Barefoot Beach there is currently no permit in place to authorize nourishment. Although nourishment at this point may be considered optional, it is recommended Barefoot Beach initiate coordination with Collier County Coastal Zone Management Department to be added to the Collier Beach Nourishment Project in order to begin the permitting process, allowing time for compliance with the required environmental conditions and consideration of other logistical concerns e.g. financing, monitoring, development of an erosion control line, and a sidescan and environmental survey to determine the location of any hardbottom potentially effected by nourishment.

REFERENCES

CP&E, Collier County Conceptual Renourishment Project Analysis May 2011 Revised October 2011

CP&E, Collier County Beach Nourishment Post-Construction Engineering Report, October 2006

CP&E, North Collier County Beach Renourishment Project - Renourishment Engineering Report, September 2003

Collier County Property Appraiser's Office, December 2, 2017 Rectified Aerial Images

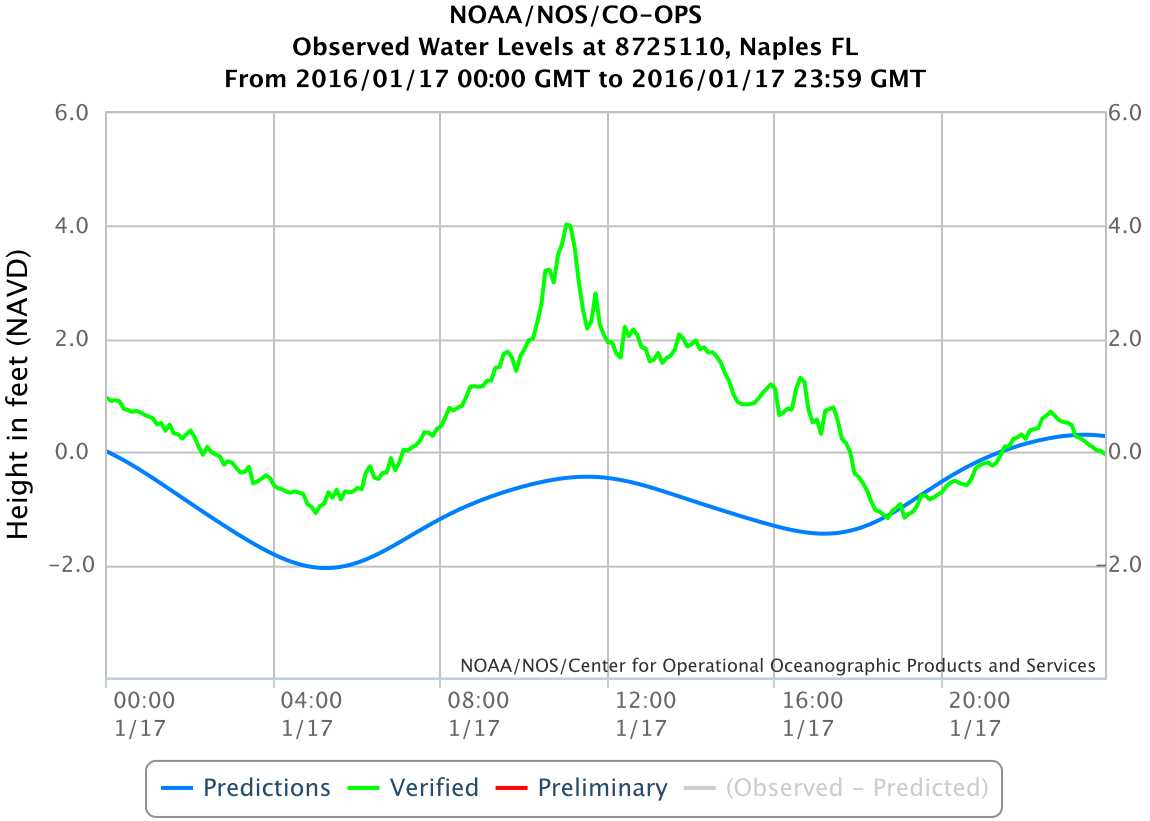
Florida Department of Environmental Protection, JCP Collier County Beach Renourishment Project, Permit 0331817-004-JM, October 2, 2015

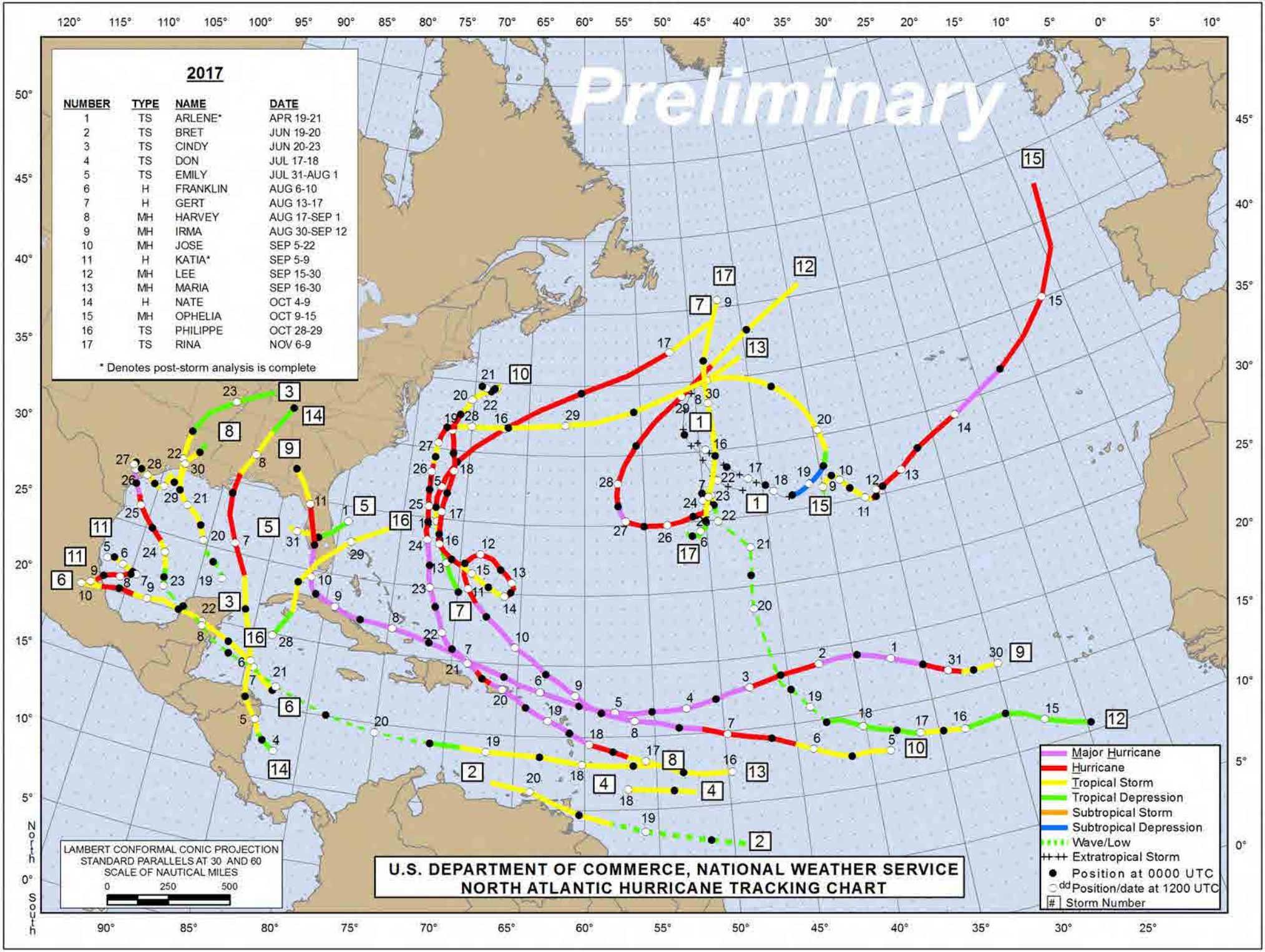
Humiston & Moore Engineers, Collier County Beach Nourishment Project 2018 Post Irma and Annual Monitoring Report, June 2018

Humiston & Moore Engineers, Post Tropical Storm Gabrielle Dune Restoration Program, October 15, 2001

Appendix A

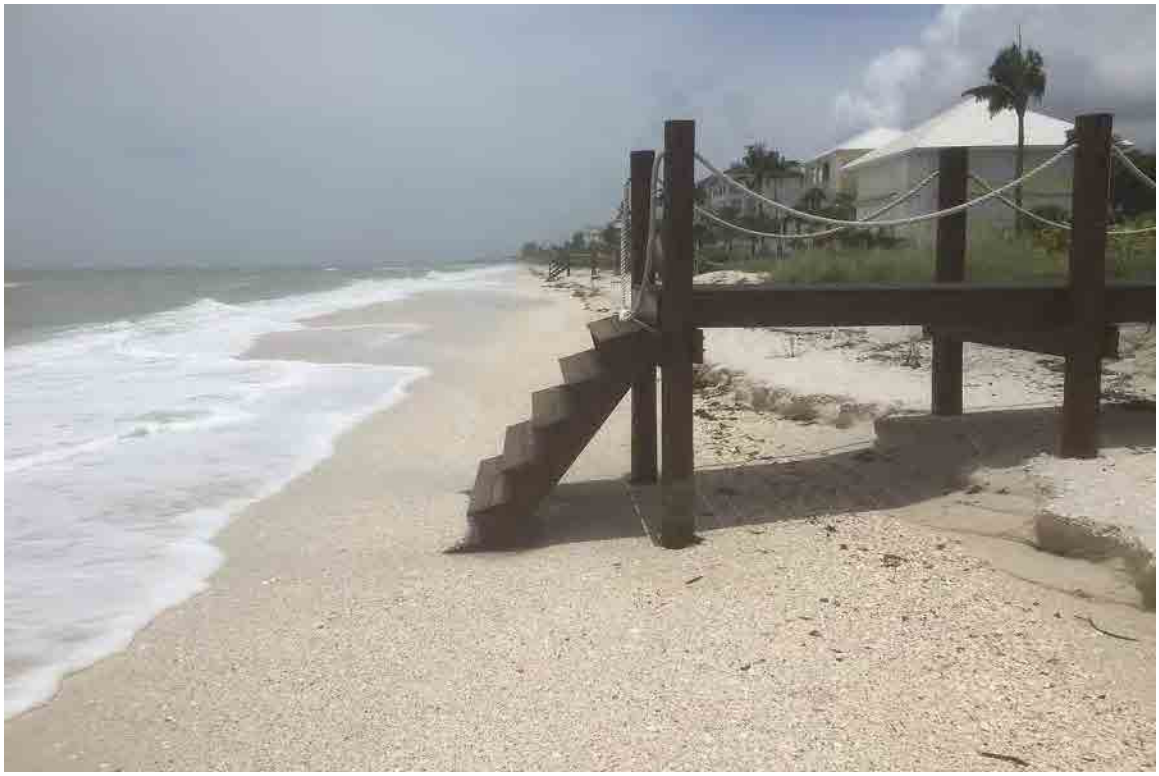
Major Storm Information

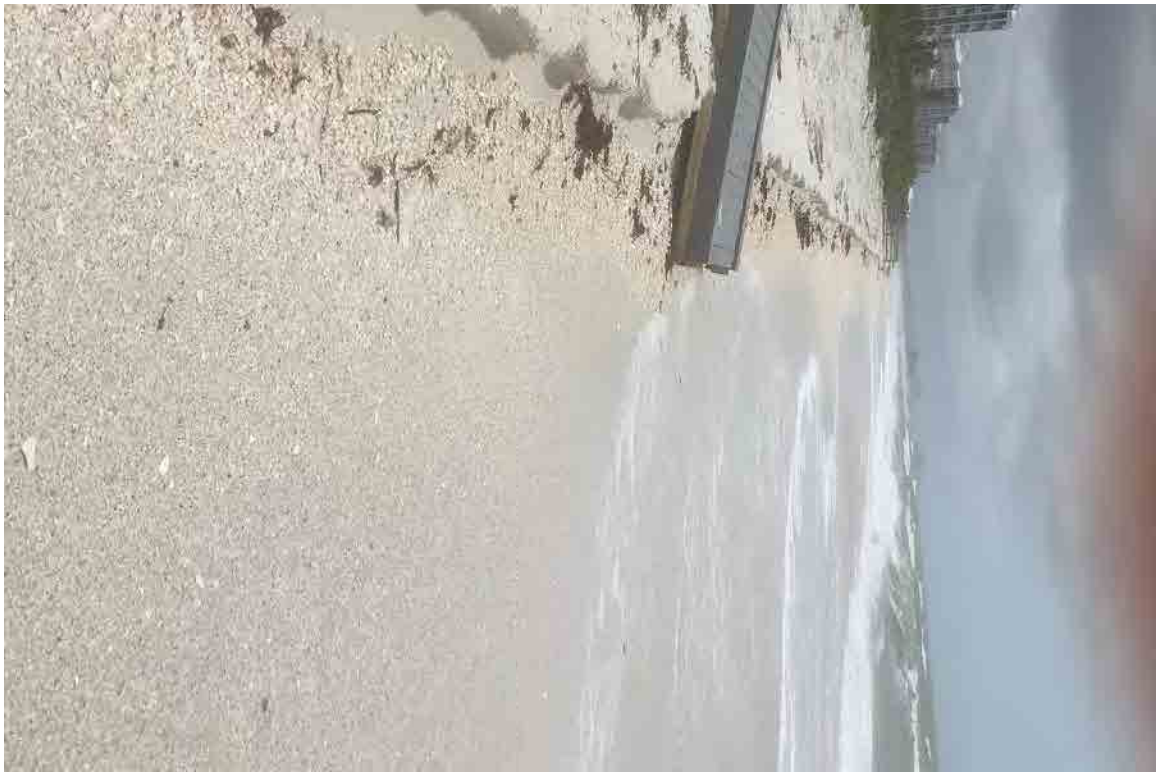

NOAA/NOS/CO-OPS
Observed Water Levels at 8725110, Naples FL
From 2016/01/17 00:00 GMT to 2016/01/17 23:59 GMT
Height in feet (NAVD)
6.0
4.0
2.0
0.0
-2.0
NOAA/NOS/Center for Operational Oceanographic Products and Services
00:00 1/17
04:00 1/17
08:00 1/17
12:00 1/17
16:00 1/17
20:00 1/17
Predictions
Verified
Preliminary
(Observed - Predicted)

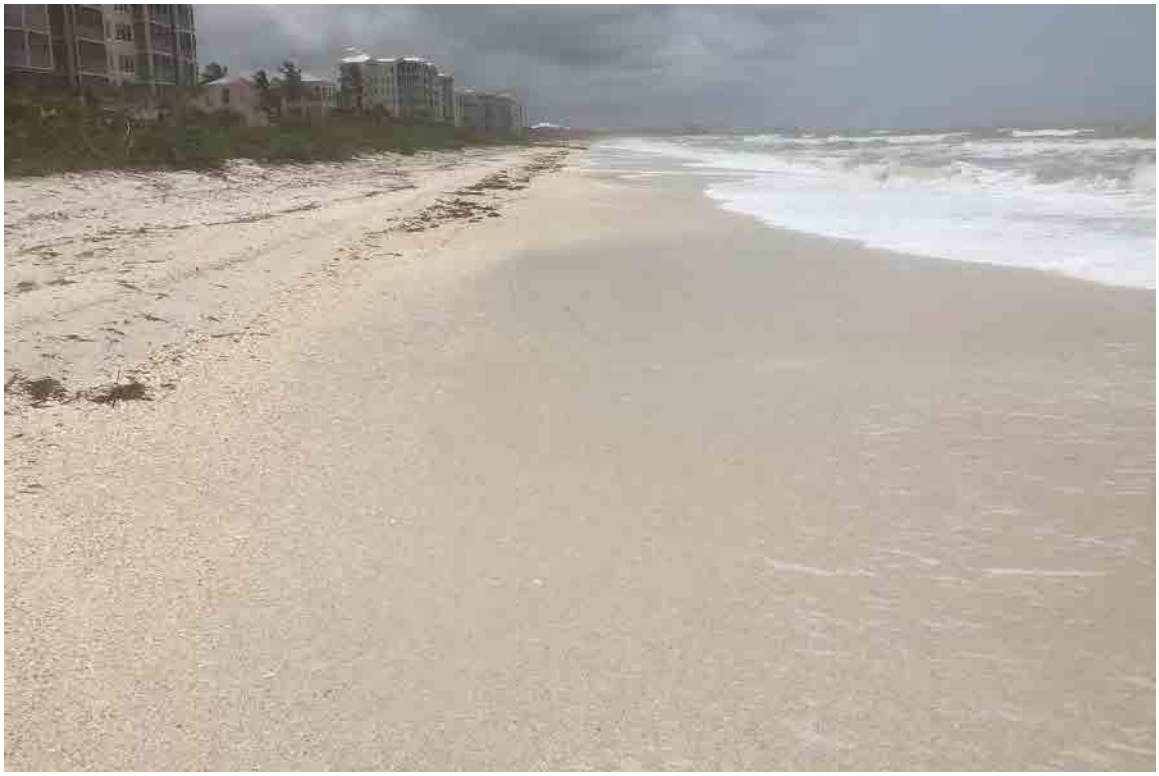

Preliminary
2017
NUMBER TYPE NAME DATE
1 TS ARLENE* APR 19-21
2 TS BRET JUN 19-20
3 TS CINDY JUN 20-23
4 TS DON JUL 17-18
5 TS EMILY JUL 31-AUG 1
6 H FRANKLIN AUG 6-10
7 H GERT AUG 13-17
8 MH HARVEY AUG 17-SEP 1
9 MH IRMA AUG 30-SEP 12
10 MH JOSE SEP 5-22
11 H KATIA* SEP 5-9
12 MH LEE SEP 15-30
13 MH MARIA SEP 16-30
14 H NATE OCT 4-9
15 MH OPHELIA OCT 9-15
16 TS PHILIPPE OCT 28-29
17 TS RINA NOV 6-9
* Denotes post-storm analysis is complete
LAMBERT CONFORMAL CONIC PROJECTION
STANDARD PARALLELS AT 30 AND 60
SCALE OF NAUTICAL MILES
0 250 500
U.S. DEPARTMENT OF COMMERCE, NATIONAL WEATHER SERVICE
NORTH ATLANTIC HURRICANE TRACKING CHART
Major Hurricane
Hurricane
Tropical Storm
Tropical Depression
Subtropical Storm
Subtropical Depression
Wave/Low
Extratropical Storm
Position at 0000 UTC
dd Position/date at 1200 UTC
Storm Number

Appendix B

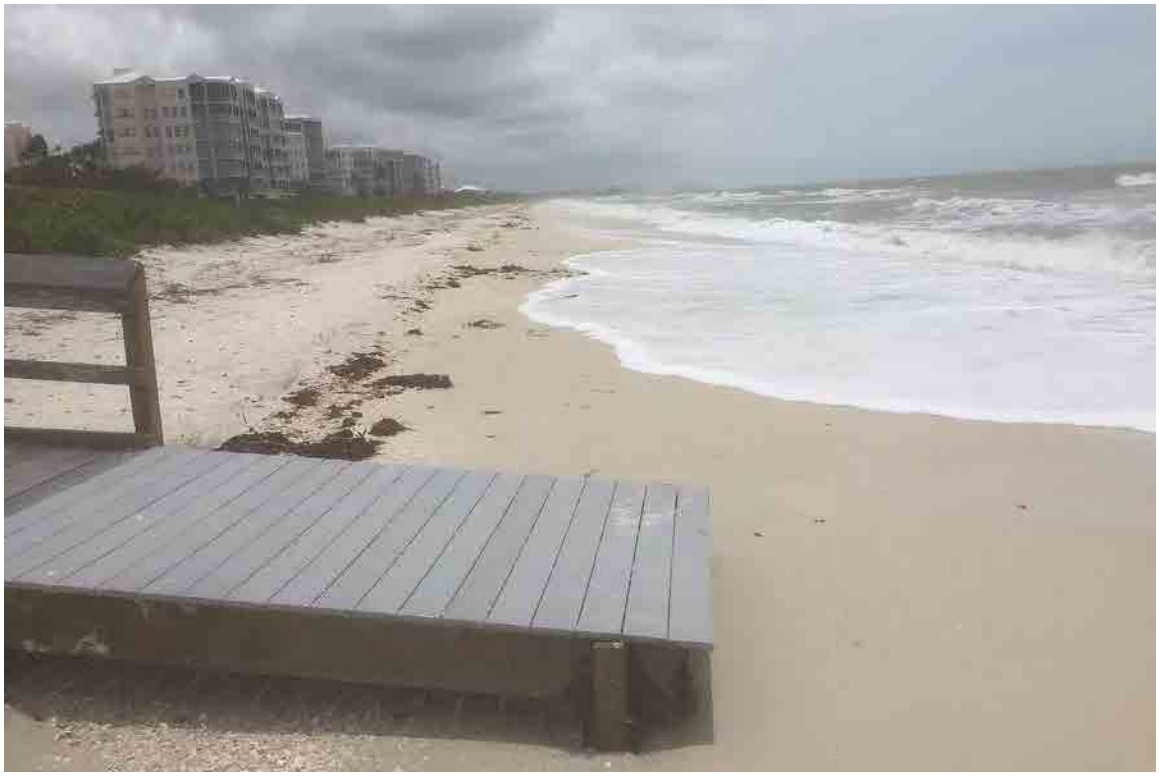
Ground Photographs taken on May 26, 2018





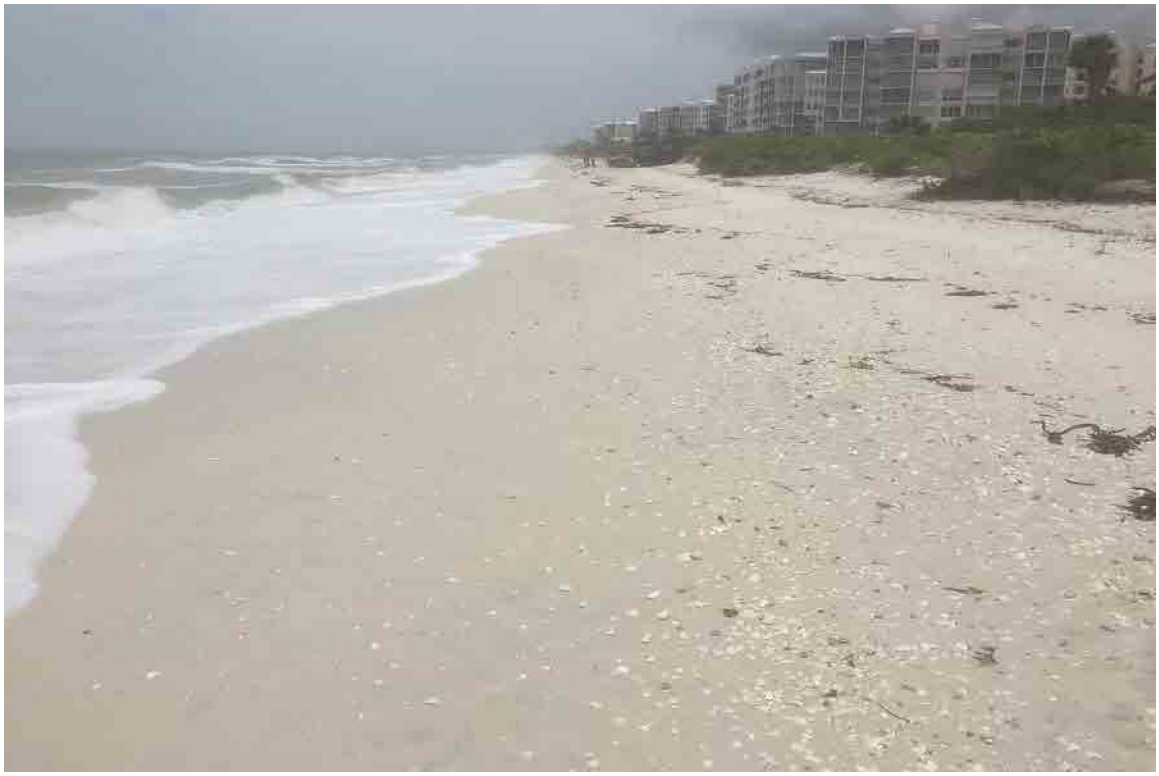



R06




R07

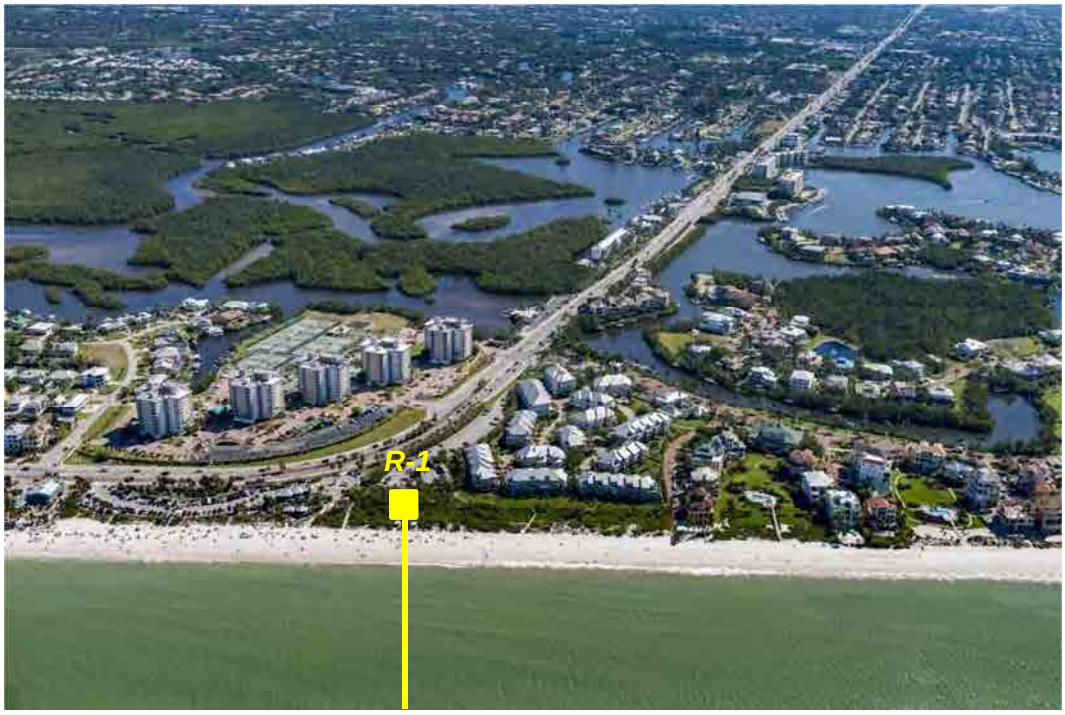

R08



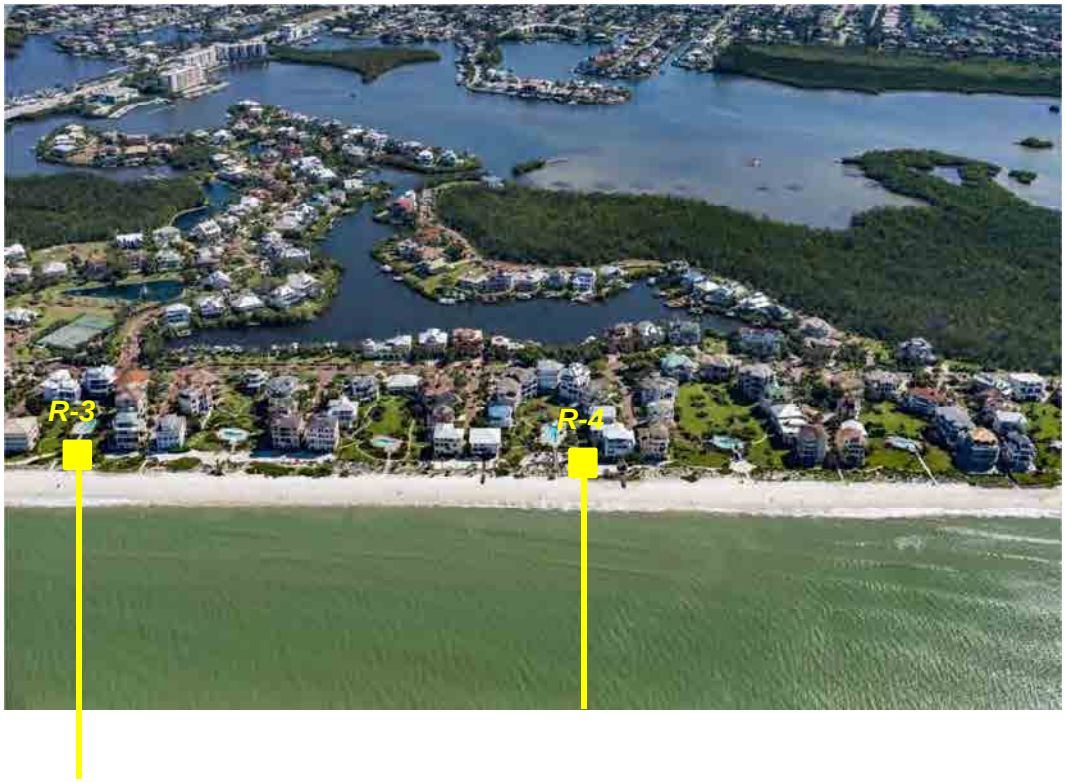
Appendix C

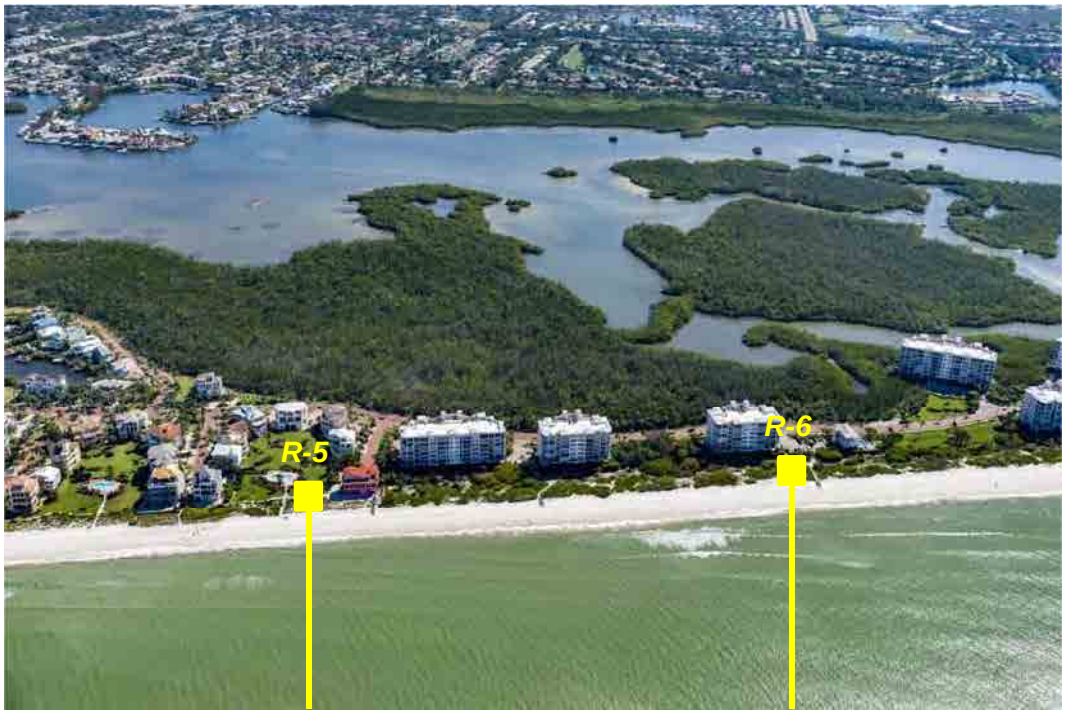
Aerial Photographs taken on March 23, 2018

Barefoot Beach - March 28, 2018

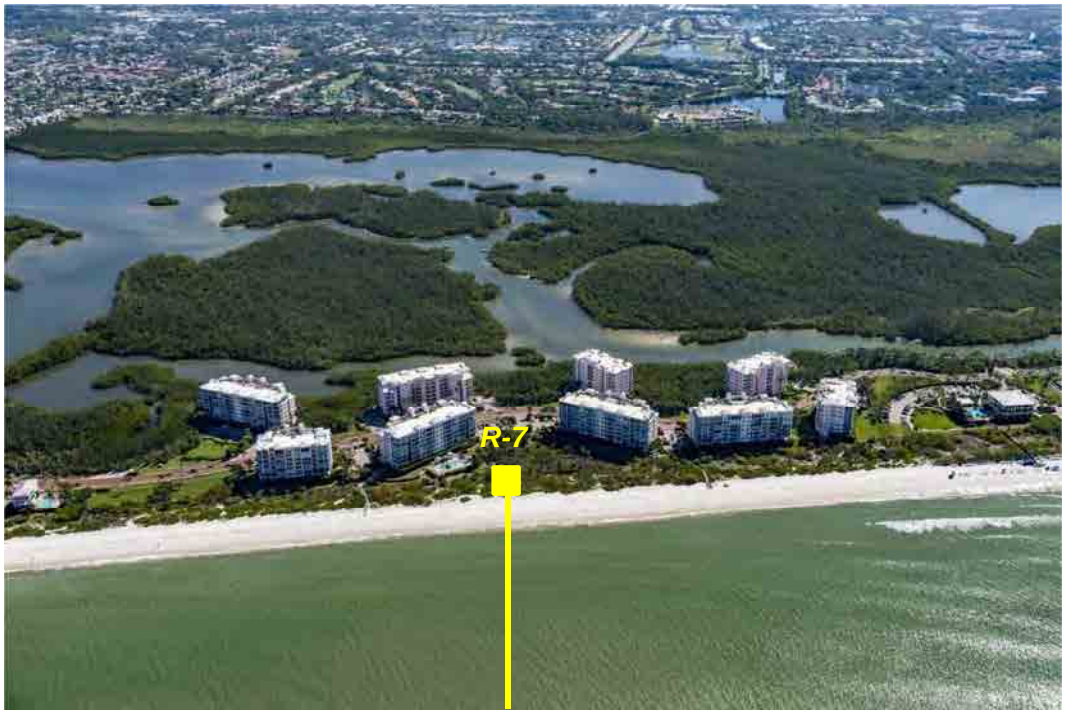


Barefoot Beach - March 28, 2018



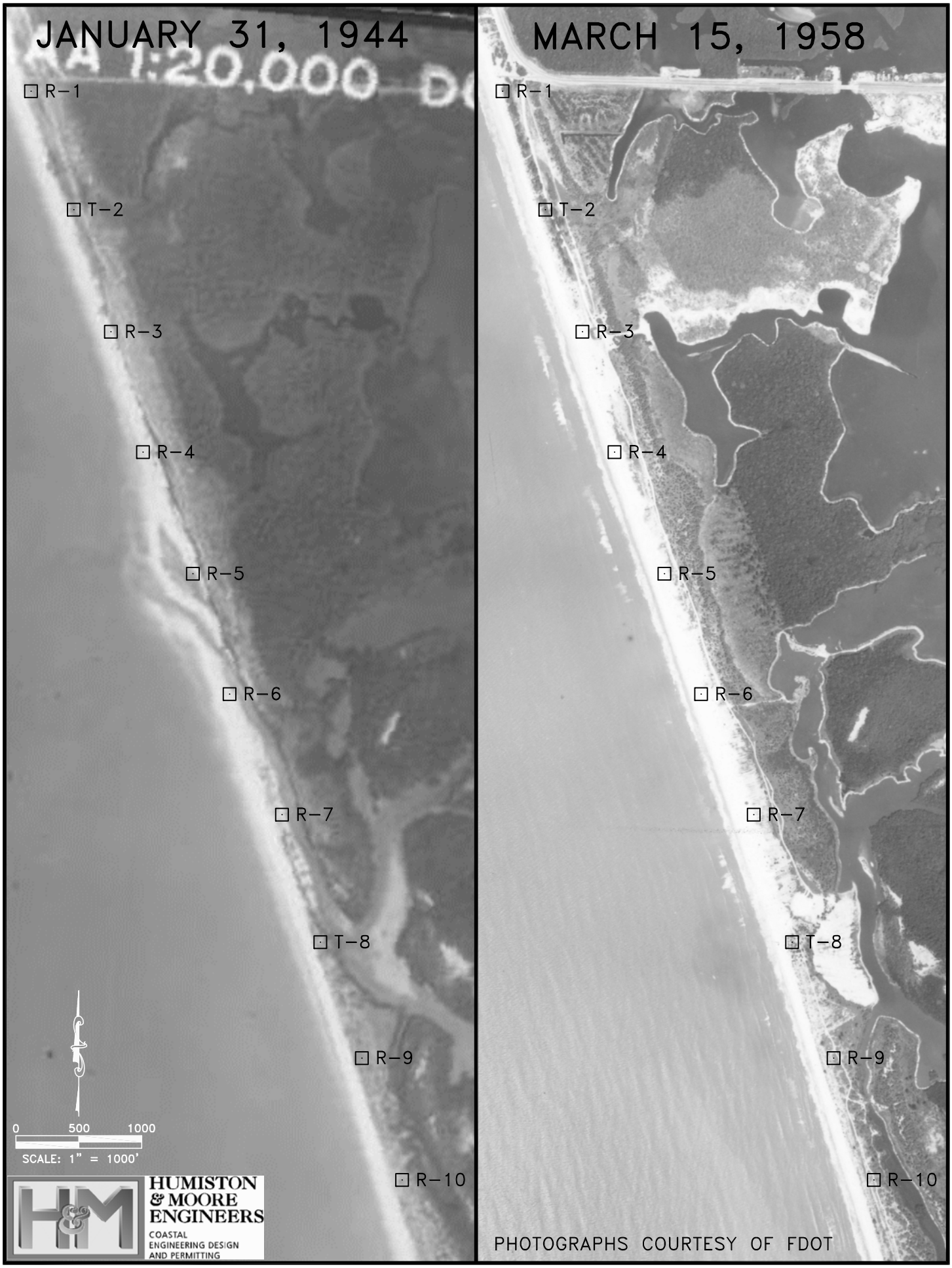


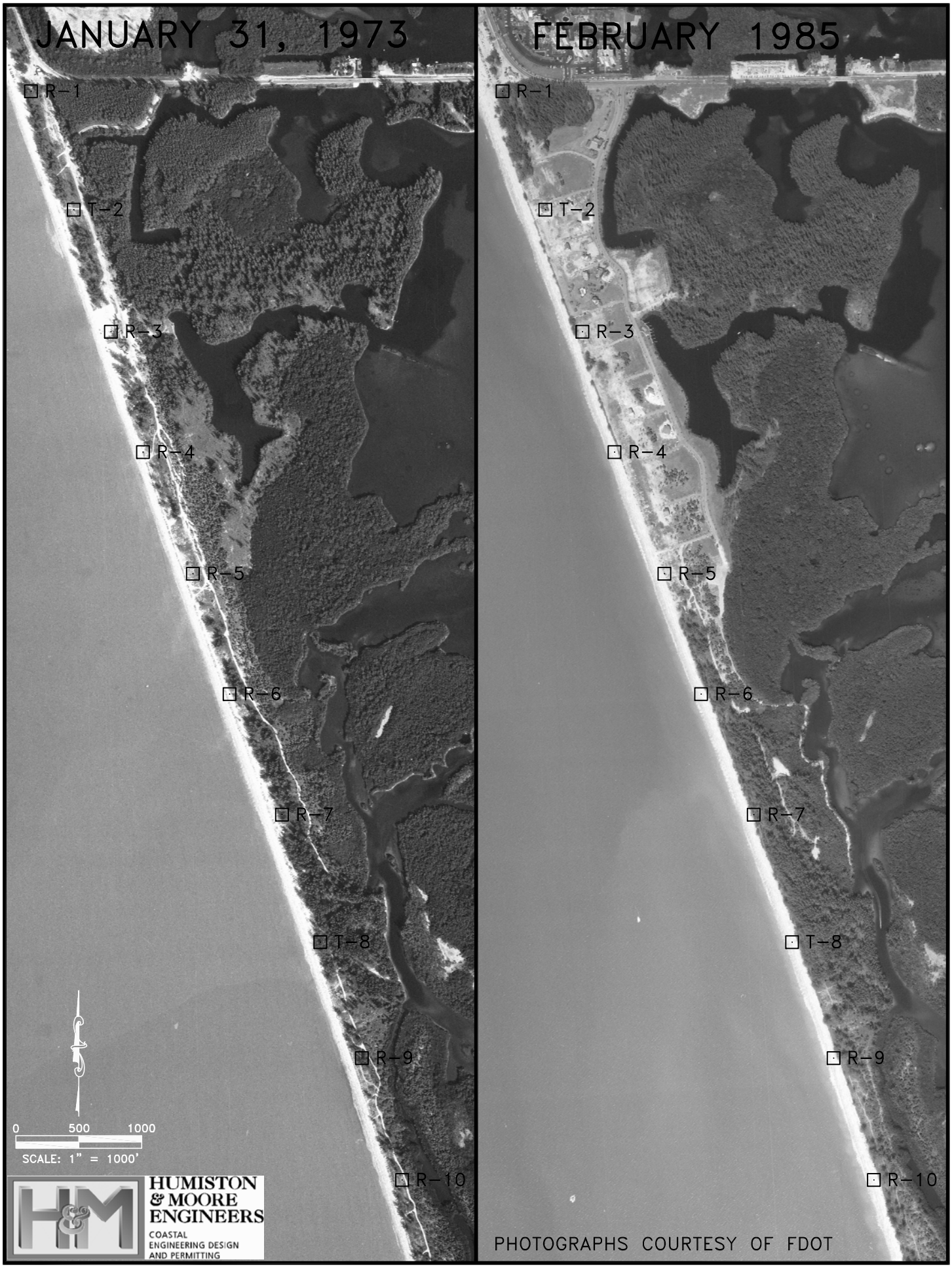
Barefoot Beach - March 28, 2018



Appendix D

Historical Aerial Images of Barefoot Beach


JANUARY 31, 1944
MARCH 15, 1958
R-1
T-2
R-3
R-4
R-5
R-6
R-7
T-8
R-9
R-10
0
500
1000
SCALE: 1" = 1000'
HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING
PHOTOGRAPHS COURTESY OF FDOT

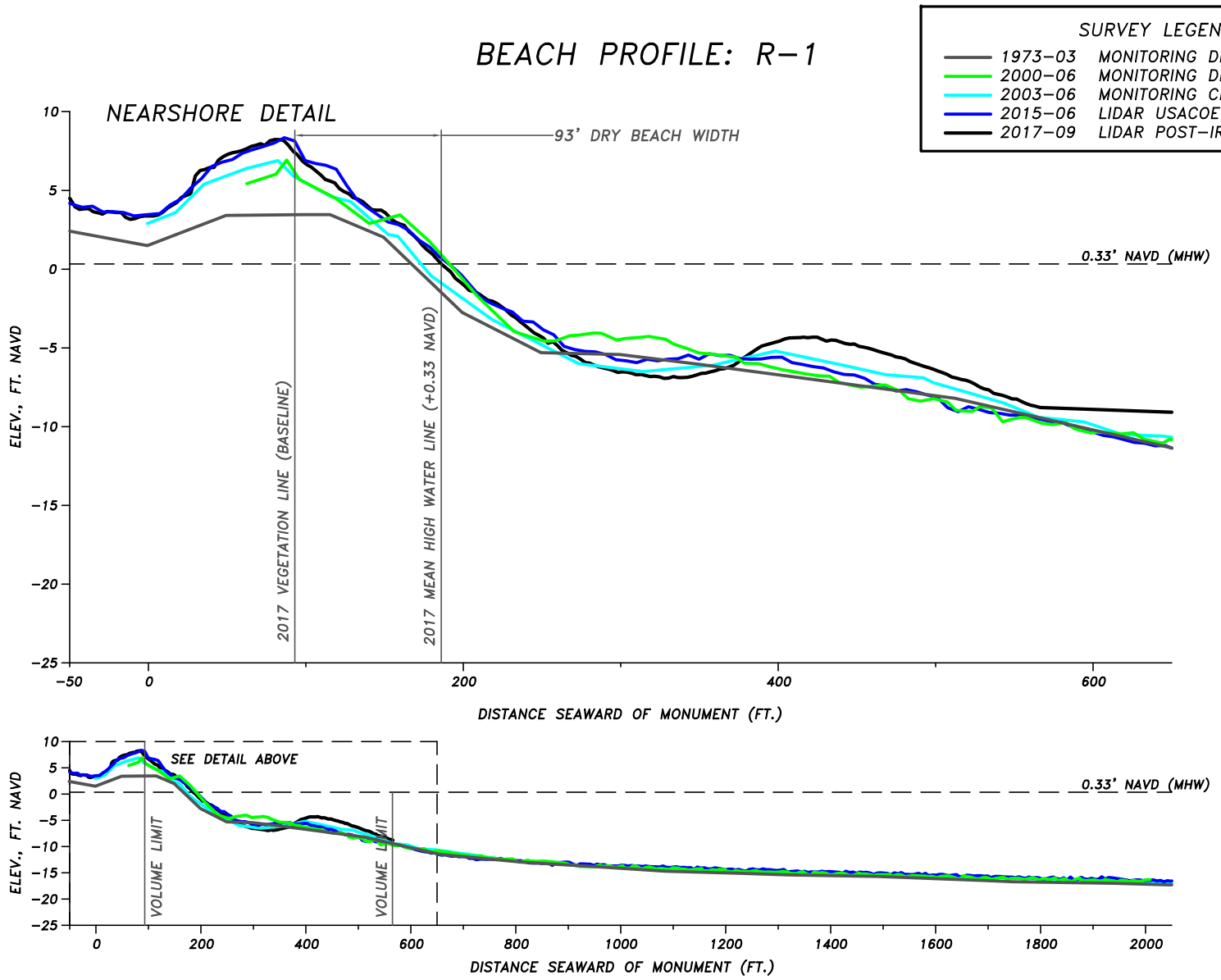

JANUARY 31, 1973
FEBRUARY 1985
R-1
T-2
R-3
R-4
R-5
R-6
R-7
T-8
R-9
R-10
0
500
1000
SCALE: 1" = 1000'
HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING
PHOTOGRAPHS COURTESY OF FDOT


JANUARY 2004
DECEMBER 2017
R-1
T-2
R-3
R-4
R-5
R-6
R-7
T-8
R-9
R-10
500
1000
SCALE: 1" = 1000'
HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING
PHOTOGRAPHS COURTESY OF COLLIER COUNTY

Appendix E

Beach Profiles R-1 through R-9

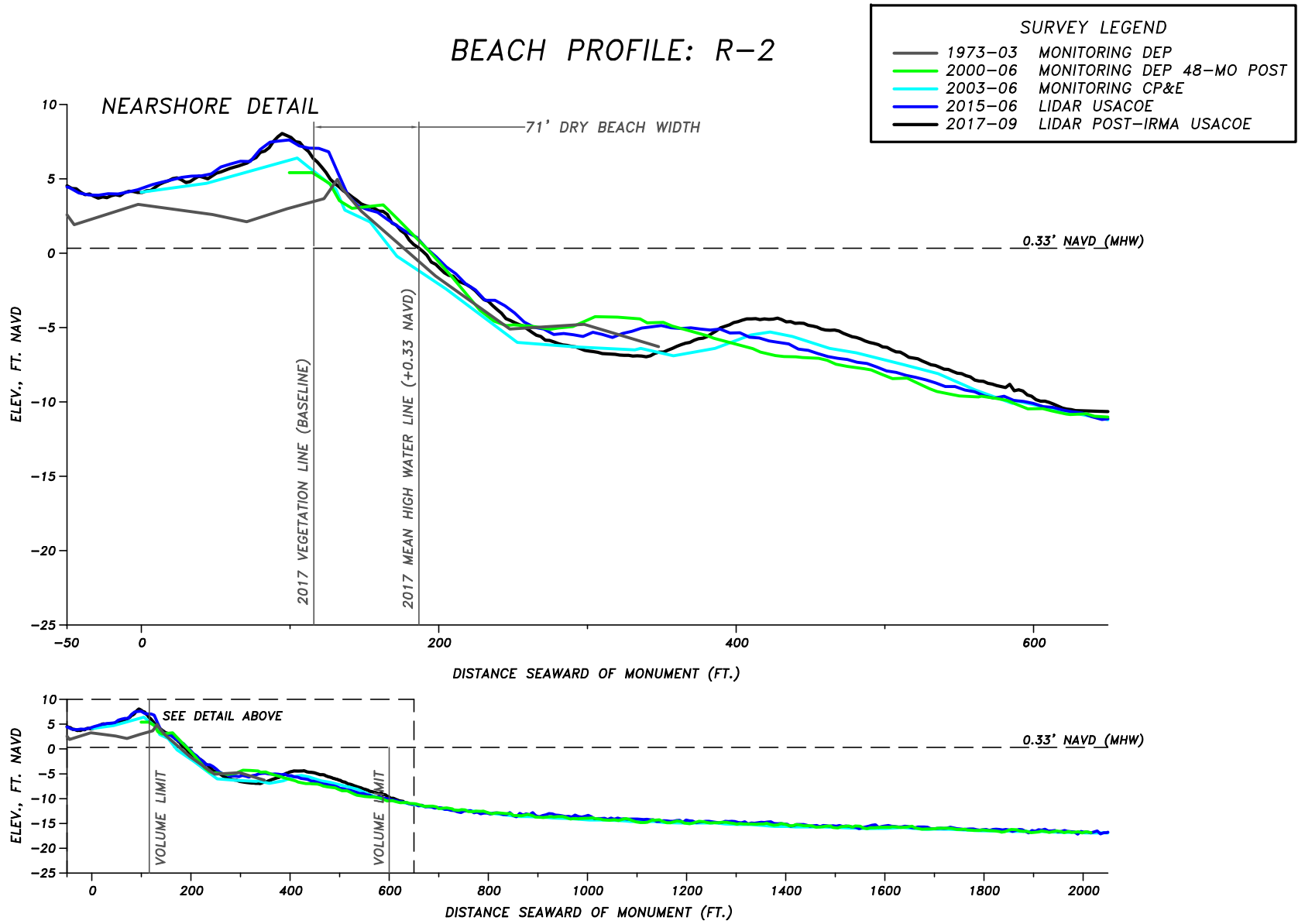
BEACH PROFILE: R-1



HUMISTON & MOORE ENGINEERS COASTAL ENGINEERING DESIGN AND PERMITTING	BAREFOOT BEACH MONITORING BEACH PROFILE		
	FOR: BAREFOOT BEACH PROPERTY OWNERS ASSC.		
	DATE: 5/15/18	FILE: SECTION	SCALE: SHOWN
	JOB: 28013	DATUM: NAVD	FIGURE:

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
PHONE: (239) 594-2021
www.humistonandmoore.com

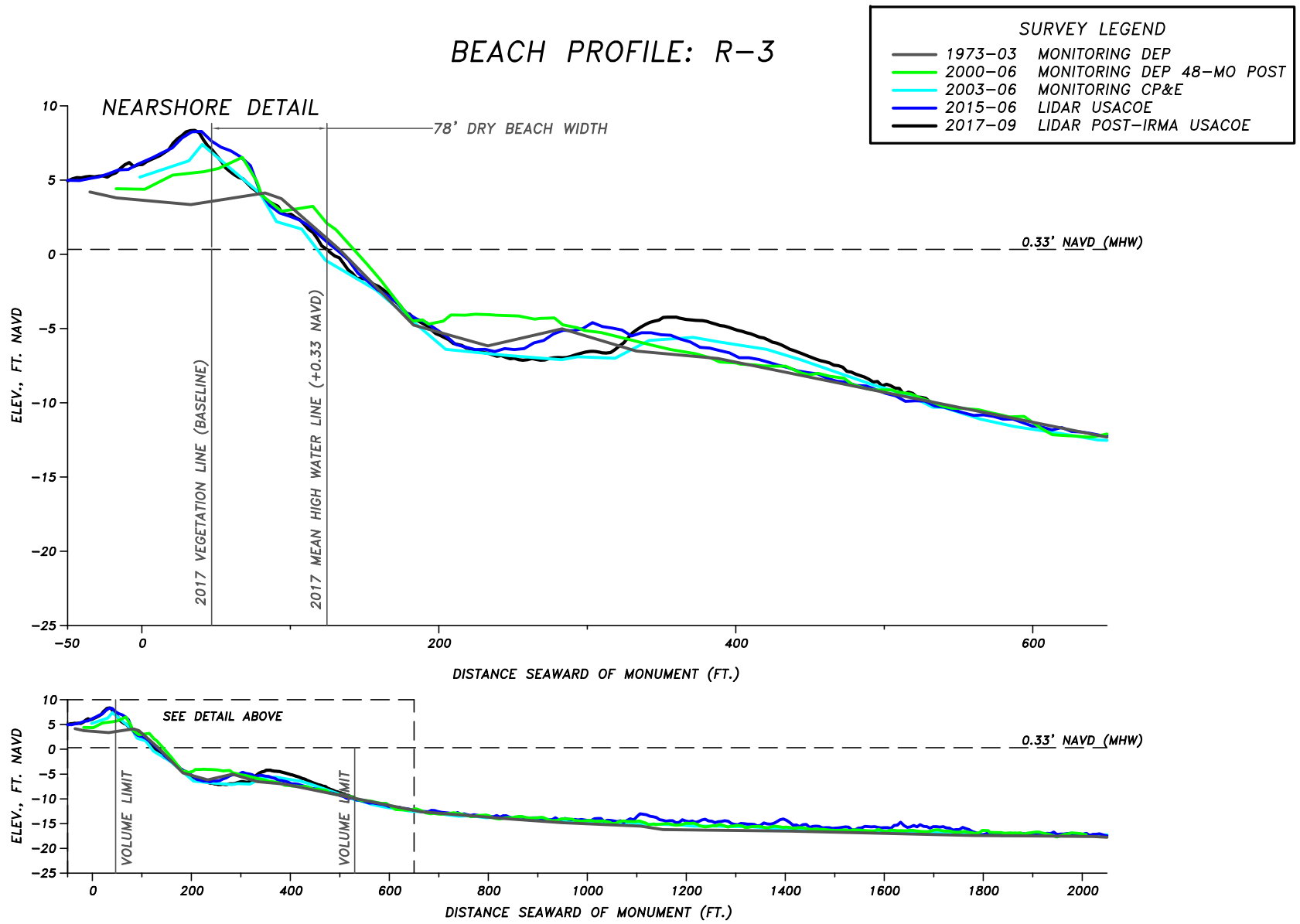
BEACH PROFILE: R-2



HUMISTON & MOORE ENGINEERS COASTAL ENGINEERING DESIGN AND PERMITTING	BAREFOOT BEACH MONITORING BEACH PROFILE		
	FOR: BAREFOOT BEACH PROPERTY OWNERS ASSC.		
	DATE: 5/15/18	FILE: SECTION	SCALE: SHOWN
	JOB: 28013	DATUM: NAVD	FIGURE:

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
PHONE: (239) 594-2021
www.humistonandmoore.com

BEACH PROFILE: R-3



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	FOR: BAREFOOT BEACH PROPERTY OWNERS ASSC.		
	DATE: 5/15/18	FILE: SECTION	SCALE: SHOWN
	JOB: 28013	DATUM: NAVD	FIGURE:

5679 STRAND COURT
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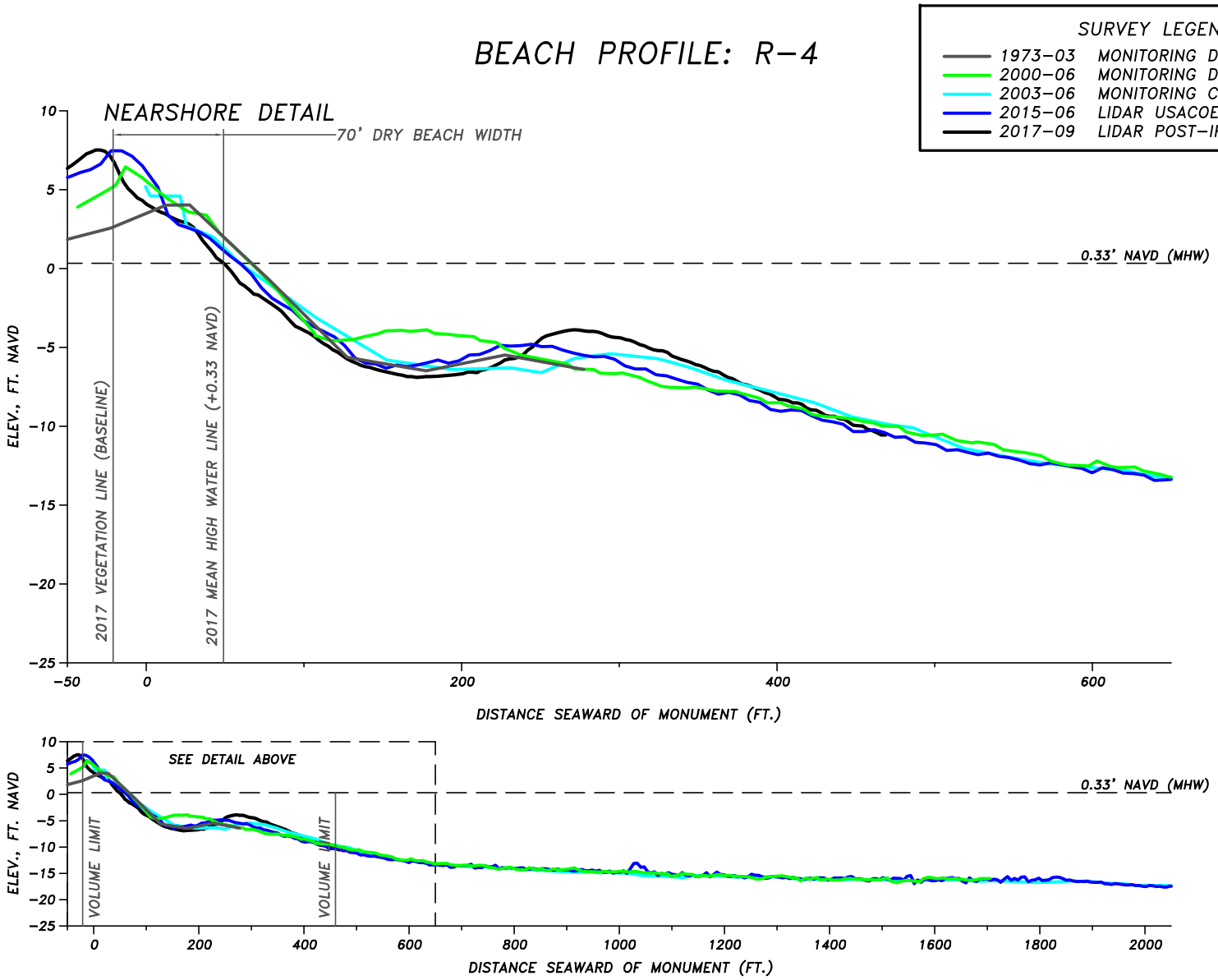
FAX: (239) 594-2025
PHONE: (239) 594-2021
www.humistonandmoore.com

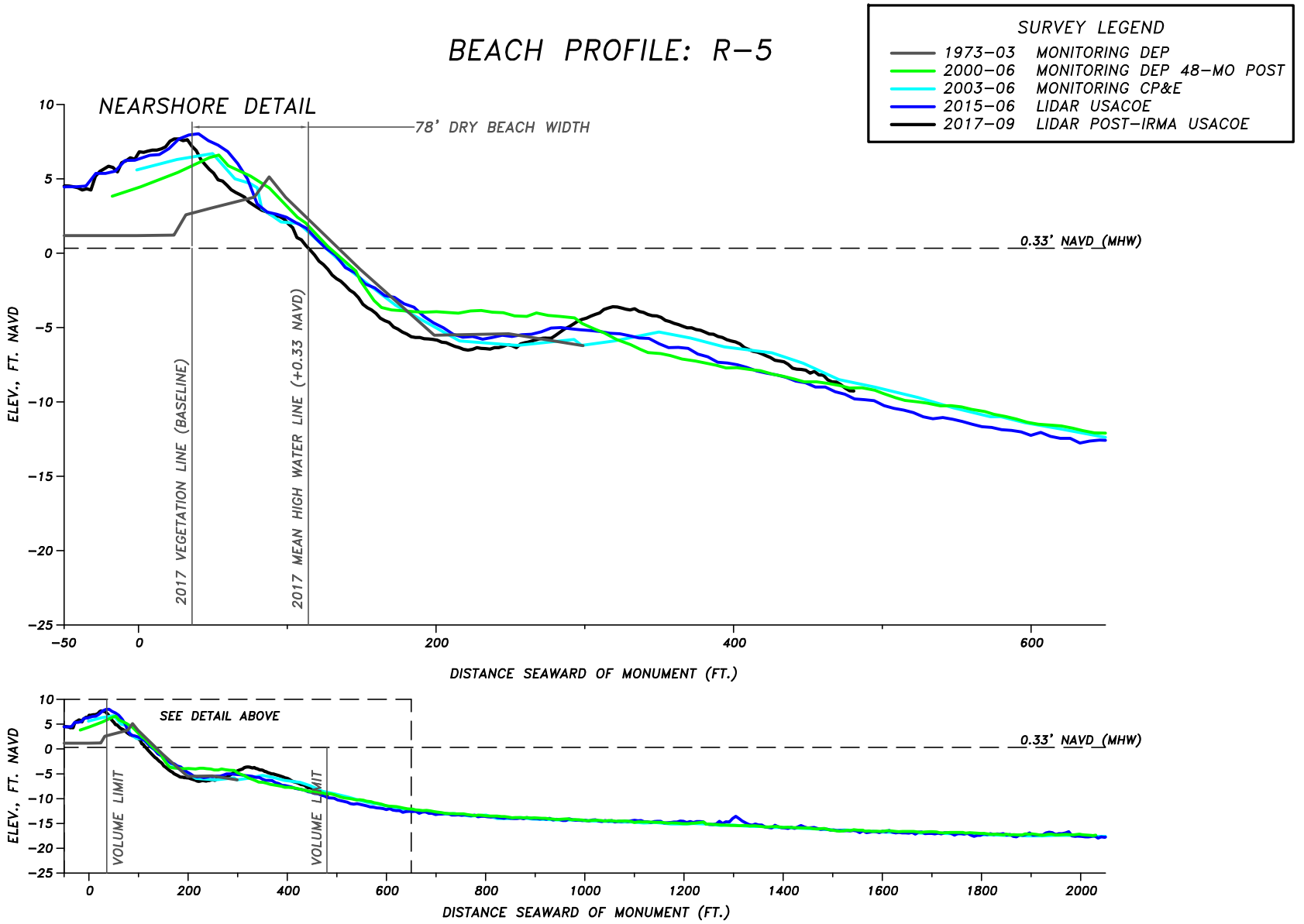
BEACH PROFILE: R-4



HUMISTON & MOORE ENGINEERS COASTAL ENGINEERING DESIGN AND PERMITTING	BAREFOOT BEACH MONITORING BEACH PROFILE		
	FOR: BAREFOOT BEACH PROPERTY OWNERS ASSC.		
	DATE: 5/15/18	FILE: SECTION	SCALE: SHOWN
	JOB: 28013	DATUM: NAVD	FIGURE:

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
PHONE: (239) 594-2021
www.humistonandmoore.com

BEACH PROFILE: R-5



HUMISTON & MOORE ENGINEERS COASTAL ENGINEERING DESIGN AND PERMITTING	BAREFOOT BEACH MONITORING BEACH PROFILE		
	FOR: BAREFOOT BEACH PROPERTY OWNERS ASSC.		
	DATE: 5/15/18	FILE: SECTION	SCALE: SHOWN
	JOB: 28013	DATUM: NAVD	FIGURE:

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
PHONE: (239) 594-2021
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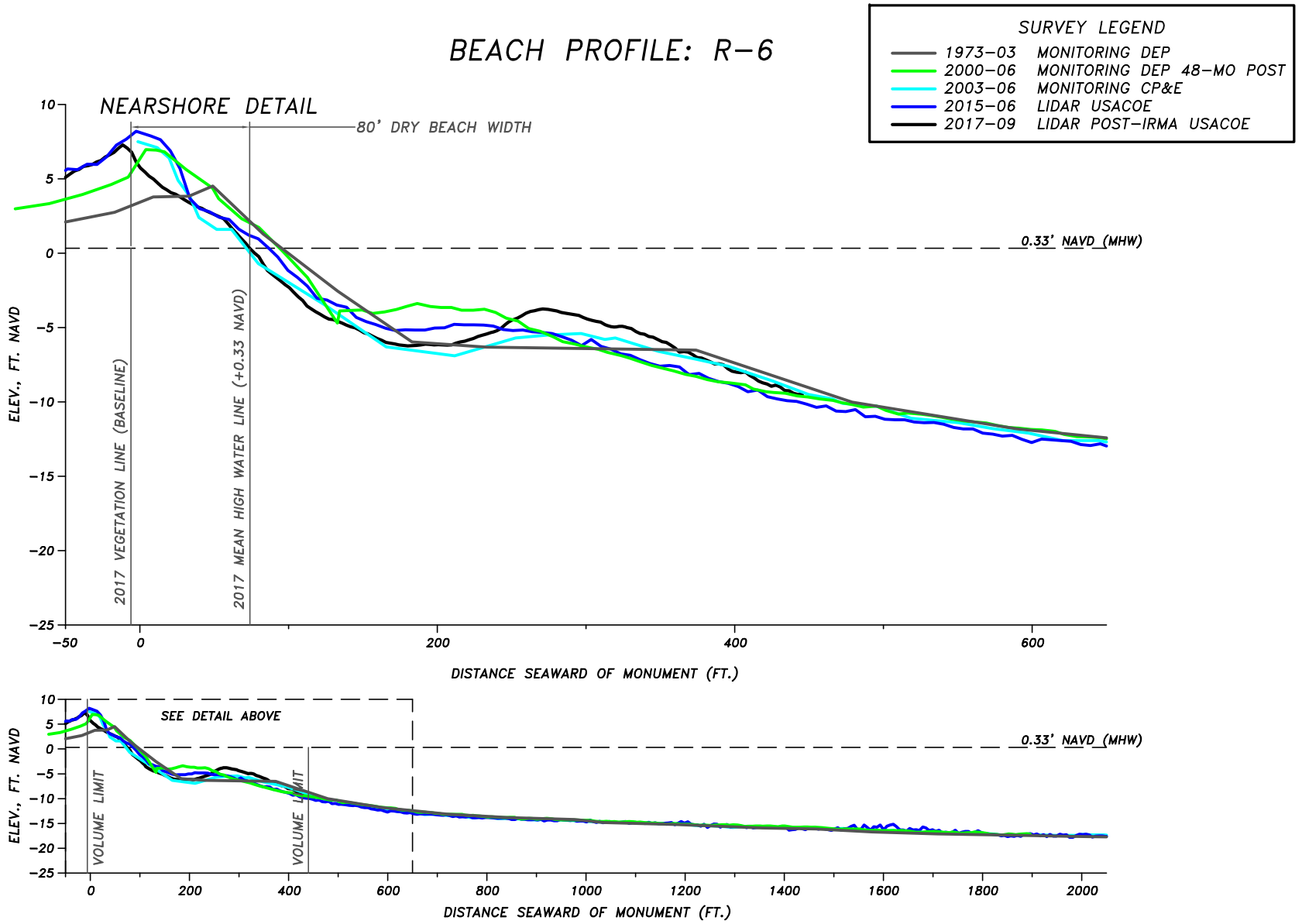
BEACH PROFILE: R-6



HUMISTON & MOORE ENGINEERS COASTAL ENGINEERING DESIGN AND PERMITTING	BAREFOOT BEACH MONITORING BEACH PROFILE		
	FOR: BAREFOOT BEACH PROPERTY OWNERS ASSC.		
	DATE: 5/15/18	FILE: SECTION	SCALE: SHOWN
	JOB: 28013	DATUM: NAVD	FIGURE:

5679 STRAND COURT
NAPLES, FL 34110
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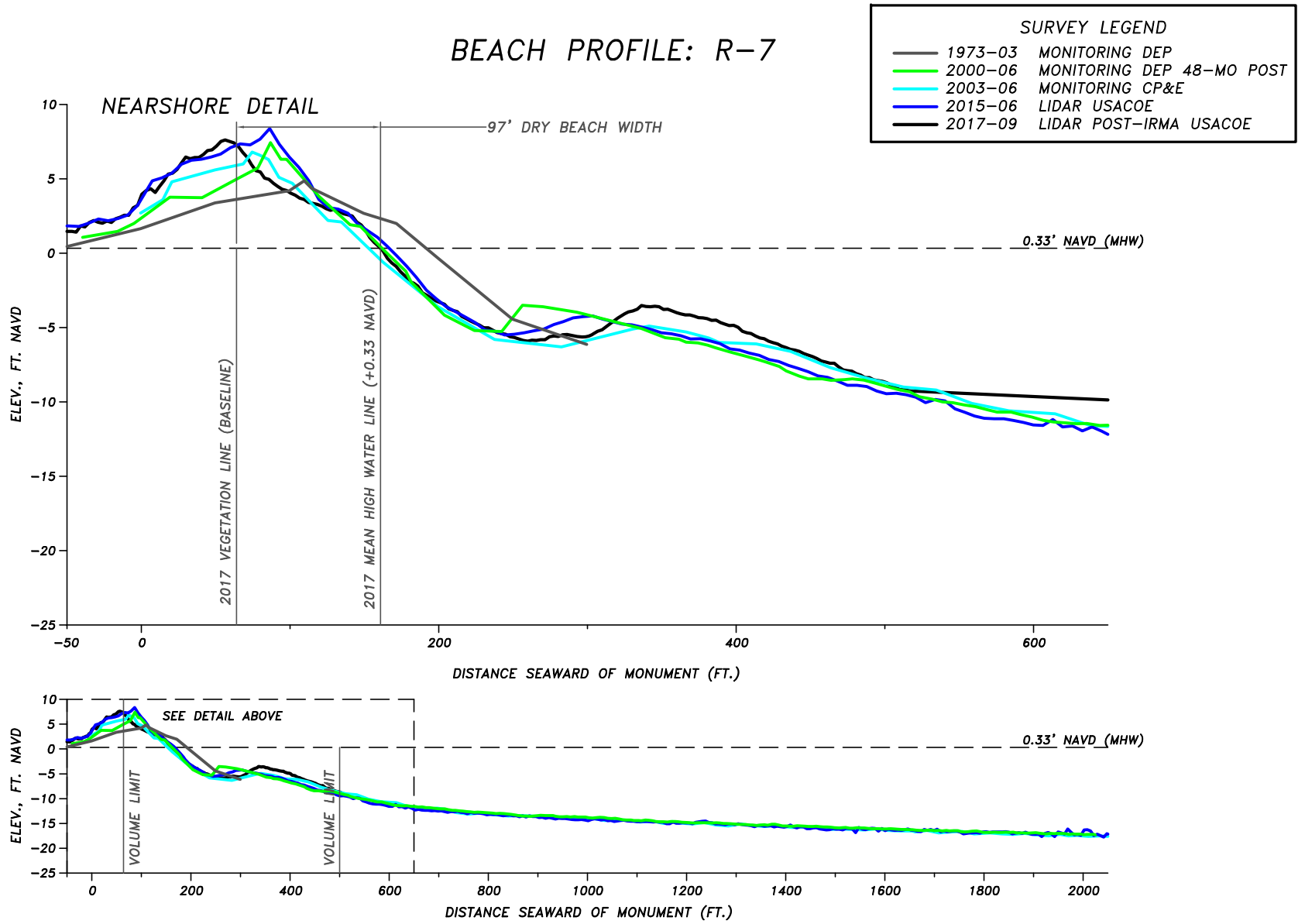
BEACH PROFILE: R-7



HUMISTON & MOORE ENGINEERS COASTAL ENGINEERING DESIGN AND PERMITTING	BAREFOOT BEACH MONITORING BEACH PROFILE		
	FOR: BAREFOOT BEACH PROPERTY OWNERS ASSC.		
	DATE: 5/15/18	FILE: SECTION	SCALE: SHOWN
	JOB: 28013	DATUM: NAVD	FIGURE:

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
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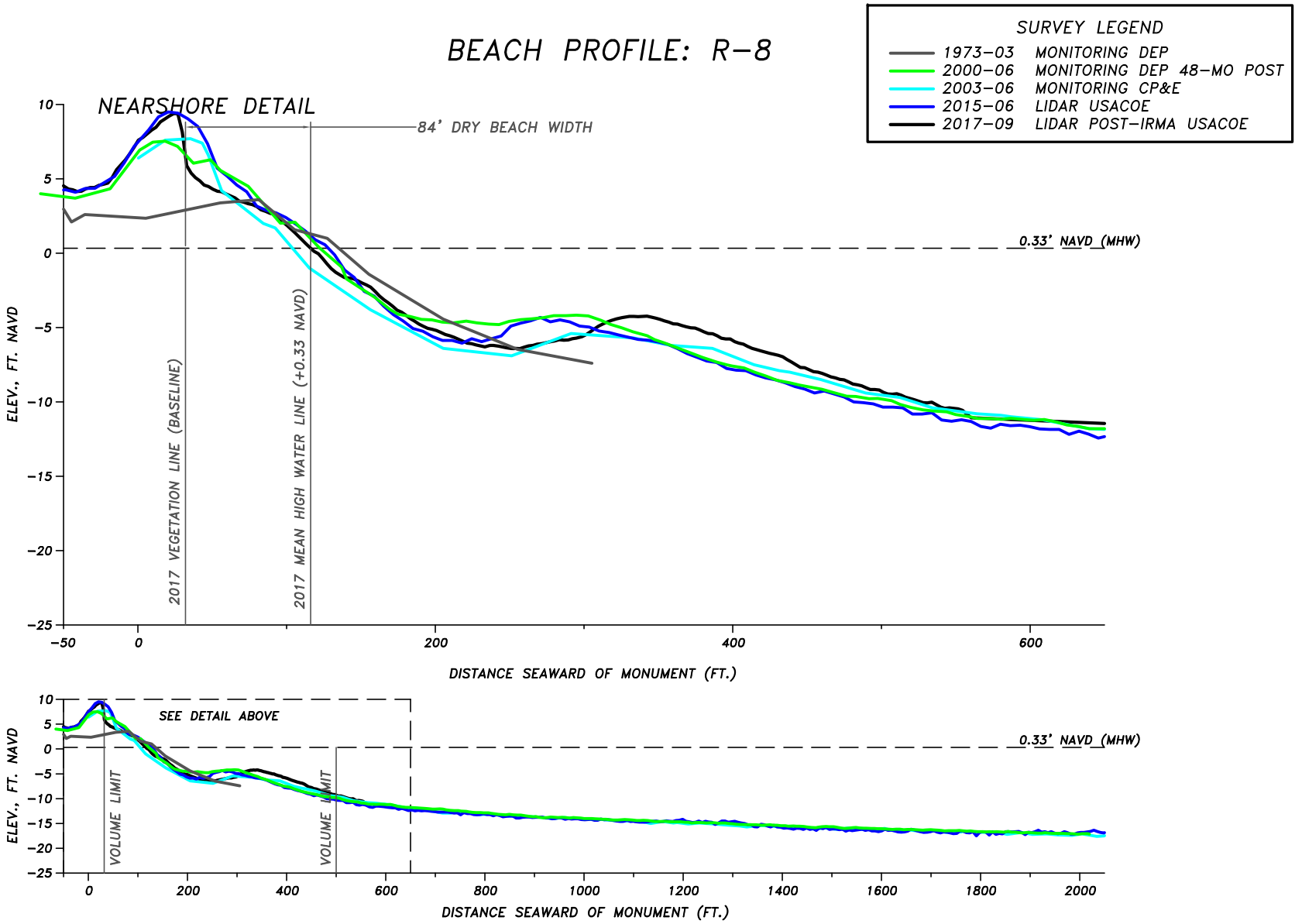
BEACH PROFILE: R-8



HUMISTON & MOORE ENGINEERS COASTAL ENGINEERING DESIGN AND PERMITTING	BAREFOOT BEACH MONITORING BEACH PROFILE		
	FOR: BAREFOOT BEACH PROPERTY OWNERS ASSC.		
	DATE: 5/15/18	FILE: SECTION	SCALE: SHOWN
	JOB: 28013	DATUM: NAVD	FIGURE:

5679 STRAND COURT
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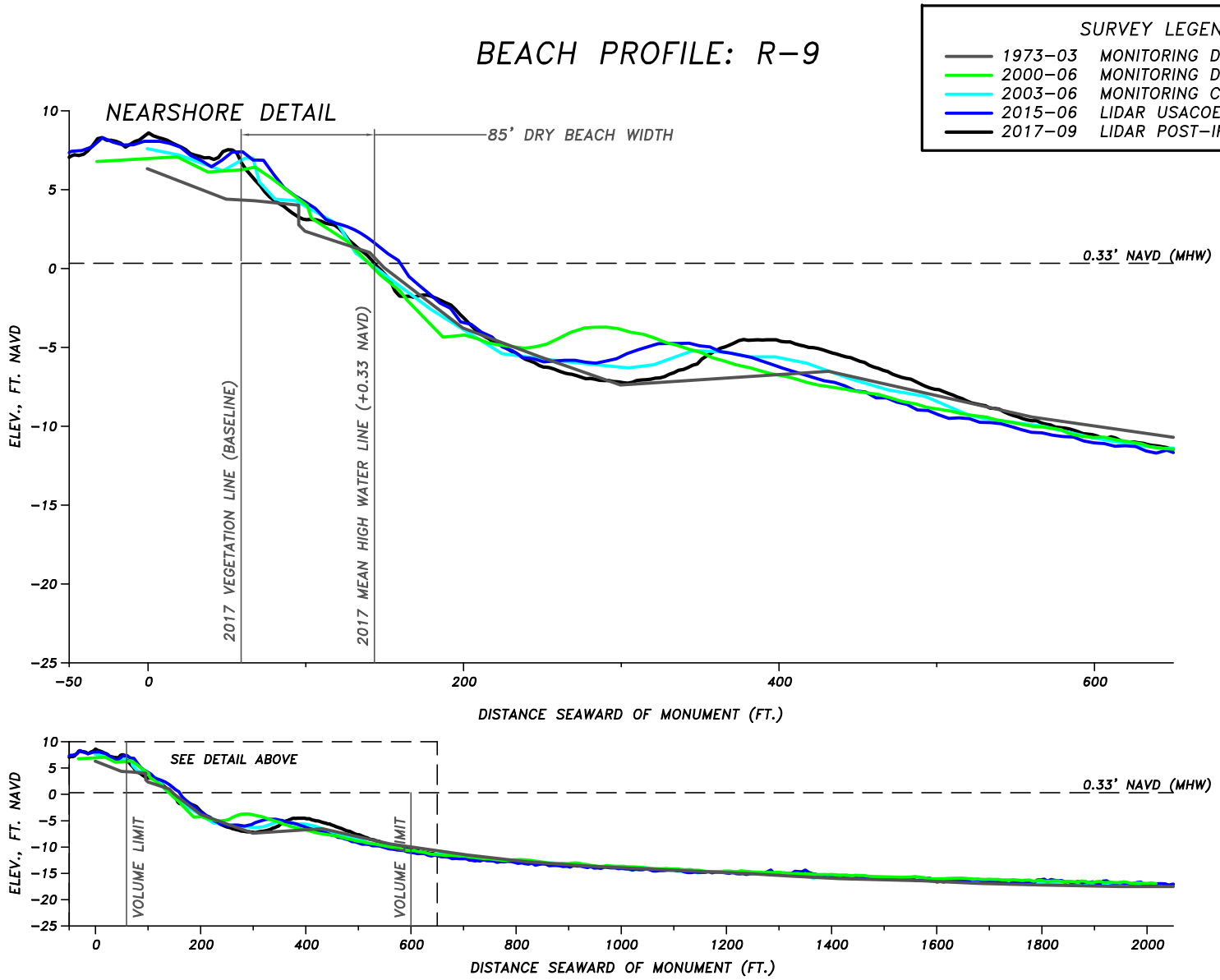
BEACH PROFILE: R-9



HUMISTON & MOORE ENGINEERS COASTAL ENGINEERING DESIGN AND PERMITTING	BAREFOOT BEACH MONITORING BEACH PROFILE		
	FOR: BAREFOOT BEACH PROPERTY OWNERS ASSC.		
	DATE: 5/15/18	FILE: SECTION	SCALE: SHOWN
	JOB: 28013	DATUM: NAVD	FIGURE:

5679 STRAND COURT
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Appendix F

Lely Barefoot Beach Unit 1 – Plat Book

LELY BAREFOOT BEACH UNIT ONE

PLAT BOOK 12 PAGE 34

RESOLUTION NO. 94-724
AUTHORIZING THE ACCEPTANCE OF REPLAT
RECORDED 10/14/94, OR 1994 PG 471
PLAT BOOK 12 PG 34-37

A PART OF SECTION 6 - TWP 48 S - RGE 25 E

COLLIER COUNTY, FLORIDA

STANLEY W. HOLE & ASSOCIATES, INC.
CONSULTING ENGINEERS
Naples, Florida

SURVEYOR'S NOTES

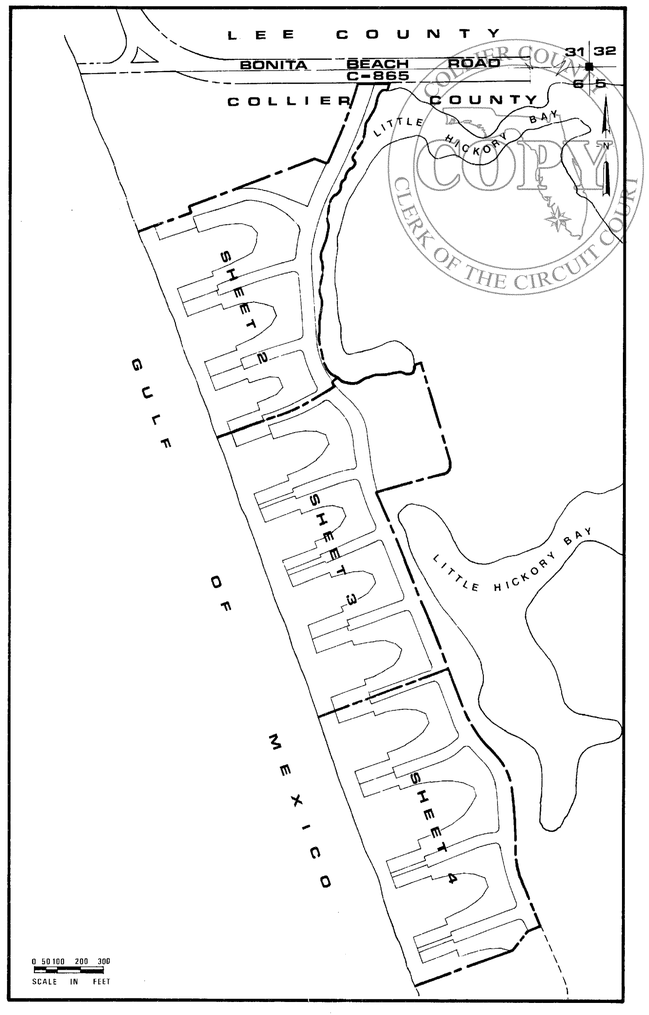
- ● Indicates Permanent Control Points set along the street right-of-way lines at change in direction
- ⊣⊢ Indicates P.C., P.T., P.R.C. or P.C.C.
- ⊙ Indicates Permanent Reference Monument set in accordance with Chapter 177, Florida Statutes

Basis of Bearing: North line of Section 6, Twp. 48S., Rg. 25E being N 89° 49' 01" W

SCALE: 1"= 50'
GRAPHIC SCALE IN FEET
50 0 50 100 150
FOR SHEETS 2, 3 & 4

DESCRIPTION

Commencing at the Northeast corner of Sec. 6, Twp.48S., Rg.25E.,thence run N89°49'01"W along the north line of said Sec.6 for 2410.64 feet, thence run S00°10'59"W for 50.00 feet to the south R.O.W. line of Bonita Beach Road (C-865) for the Point of Beginning thence S38°28'36"E for 32.02 feet, thence S00°10'59"W for 93.71 feet thence 145.10 feet along the arc of a curve having a radius of 346.72 feet, central angle 23°58'42" and chord bearing S12°10'20"W, thence S24°09'41"W for 88.58 feet, thence N67°01'27"W for 51.4[illegible] feet, thence S68°45'00"W for 580.00 feet, thence S19°47'42"E for 42.01 feet, thence S71°38'14"W for approximately 230 feet to the Mean High Water (MHW) of the Gulf of Mexico, thence running southeasterly along the MHW line of the Gulf of Mexico to the intersection of said MHW line with a line having a bearing of N70°21'30"E and passing through a point located S08°14'32"E - 3905.06 feet from the north 1/4 corner of Sec.6, Twp.48S, Rg.25E, thence N70°21'30"E for approximately 62 feet to the above located point thence N70°21'30"E for 378.95 feet, thence N38°38'55"E for 114.74 feet, thence N70°21'30"E for 60.00 feet, thence N19°38'30" W for 236.91 feet, thence 46.80 feet along the arc of a curve having a radius of 170.00 feet,a central angle of 15°46'25", chord bearing N11°45'17"W, thence N03°52'05"W for 292.37 feet, thence 150.90 feet along the arc of a curve having a radius of 230.00 feet, central angle of 37°35'28" and chord bearing of N22°39'49"W, thence N41°27'33"W for 150.80 feet thence 75.84 feet along the arc of a curve having a radius of 170.00 feet, central angle of 25°33'46" and chord bearing of N28°40'40"W, thence 92.77 feet along the arc of a curve having a radius of 959.55 feet, central angle of 05°32'22" and chord bearing N18°39'58"W, thence N21°26'09"W for 674.71 feet, thence 233.94 feet along the arc of a curve having a radius of 3443.50 feet, central angle of 03°53'33"and chord bearing N23°22'56"W thence 61.28 feet along the arc of a curve having a radius of 265.00 feet, central angle 13°14'55" and chord bearing N18°42'15"W, thence 45.05 feet along the arc of a curvehaving a radius of 25.00 feet, central angle of 103°15'24" chord bearing S63°42'15"E, thence N64°40'18"E for 158.59 feet, thence 104.94 feet along the arc of a curve having a radius of 606.75 feet central angle 9°54'34", chord bearing N69°37'35"E, thence N74°34'52"E for 11.90 feet, thence 36.87 feet along the arc of a curve having a radius of 25.00 feet, central angle 84°30'00", chord bearing N32°19'52"E, thence N09°55'08"W for 400.04 feet thence S 80°04'52"W for approximately 20 feet to the shoreline of a branch of Little Hickory Bay, thence running southwesterly, westerly, northerly and northeasterly along the said shoreline to its intersection with a line having a bearing of N00°10'59"E passing through a point located on the south R.O.W. line of Bonita Beach Road (C-865) and S89°49'01"E - 160.00 feet from the Point of Beginning, thence N0°10'89"E for approximately 100 feet to the point above described, thence S89°49'01"E for 160.00 feet to the Point of Beginning.



TITLE CERTIFICATION

STATE OF FLORIDA, COUNTY OF COLLIER

I, John W. Griffis III do hereby certify that I have examined the title to the hereon described property and find the title is vested to Lely Estates, INC, that the current taxes have been paid; and that I find that the property is free of encumbrances.

John W. Griffis III
ATTORNEY-AT-LAW Licensed in Florida

APPROVALS

PLANNING COMMISSION
This Plat approved by the Coastal Area Planning Commission this 2 day of August, 1978

Nevo J. Spagna
EXECUTIVE SECRETARY

ENGINEER

This Plat approved by the County Engineer this 2nd day of August 1978

Clifford B. Barksdale, PE 25395
COUNTY ENGINEER

HEALTH DEPARTMENT

This Plat approved by the County Health Department this 26th day of July 1978, provided that central water and central sewers are available and no individual potable water wells or individual sewage systems are permitted.

Robert R. Wheeler, R.S.
COUNTY SANITATION

ATTORNEY

This Plat approved by the County Attorney this 2d day of August, 1978

Donald W. Pickworth
COUNTY ATTORNEY

FILING RECORD

I HEREBY CERTIFY that this Plat has been examined by me and that it complies in form with the requirements of Chapter 177 laws of the State of Florida I further certify that said Plat was filed for record at 4:39 P.M., this 7th day of August A.D. 1978 and duly recorded in Plat Book 12 at Page 34-37 of the Public Records of Collier County, Florida.

William J. Reagan
CLERK OF THE CIRCUIT COURT IN AND FOR COLLIER COUNTY, FLORIDA
by Nancy Grunwald DC

DEDICATIONS

STATE OF FLORIDA, COUNTY OF COLLIER

KNOW ALL MEN BY THESE PRESENTS, THAT LELY ESTATES, INC. The Owner of the lands described hereon, has caused this plat of such lands to be made and hereby dedicates the following:

1) To Lely Barefoot Beach Homeowners Association, Inc. all road rights-of-way, same being shown as Tract "R" and the maintenance thereof, subject to easements hereafter set-forth, all without recourse to Collier County,

2) To corresponding Beach Garden Association, Inc. the area shown as Beach Garden along with the maintenance thereof without recourse to Collier County.

3) To Collier County the water distribution system and the sewage collection system within the limits of this plat.

KNOW ALL MEN BY THESE PRESENTS, THAT LELY ESTATES, INC. The Owner of the lands described hereon, has caused this plat of such lands to be made and hereby grants the following easements:

1) To Lely Barefoot Beach Homeowners Association, Inc. for the purpose of drainage and bikeways, to Florida Power and Light and United Telephone Company for the purpose of power and telephone service, and to South Florida Cable TV for the purpose of cable TV service an easement twenty-five feet in width adjacent to the west right-of-way line of the main north-south road and over the lots west of and fronting on the main north-south road, and an easement ten feet in width abutting all road rights-of-way extending westerly from the main north-south road and over the lots abutting these roads.

2) To the corresponding Beach Garden Association, Inc. a drainage easement ten feet in width on the Beach Garden along the perimeter of all Beach Gardens abutting the back lot lines.

3) Other drainage easements (D.E.) to Lely Barefoot Beach Homeowners Association, Inc. utility easements (U.E.) to Florida Power and Light, and United Telephone Company and a cable TV easement (T.V.E.) to South Florida Cable TV, respectively, as shown on this plat.

4) To Collier County, utility easements, as shown on this plat (C.U.E.) for the purpose of maintaining sewer and water and other municipal services.

5) To Collier County a utility easement over Tract "R" for the purpose of maintaining sewer and water and other municipal services.

6) To Collier County, its franchisees, and the North Naples Fire Control District an access easement to each of the Beach Garden areas as shown on this plat by (A.E.) for the sole purpose of permitting emergency and service vehicles to gain access to the Beach Garden areas.

Note: The line designated as the State Coastal Construction Setback Line is the line adopted by the State Cabinet as the seaward limit of Coastal Construction pursuant to Chapter 161 F.S. and except as modified by State Variance #74-75-B40. The variance was approved by the Florida State Cabinet on December 17, 1974 and included the Protective Covenants as recorded in O.R. Book 745 Page 1699-07 of the Public Records of Collier County.

The modification of the line as set forth in the variance is shown and designated as the Coastal Development Limit Line.

IN WITNESS THEREOF the above named Owners have caused these presents to be signed and attested to by the Persons named below and to be affixed hereto on this 12 day of July, 1978.

Pamela D. Ferguson
WITNESS

LELY ESTATES INC.
C.W. Duvernoy
OWNER

Declaration of Protective Covenants for Lely Barefoot Beach, Unit One are recorded in O.R. Book 767 Pages 556-67 of the Public Records of Collier County, Florida.

CORPORATE ACKNOWLEDGMENT

STATE OF FLORIDA, COUNTY OF COLLIER

I HEREBY CERTIFY that on this day, before me, all officers duly authorized in the State and County aforesaid to take acknowledgments, personally appeared C.W. Duvernoy to me known to be the Ex. Vice President respectively of the corporation named as dedicator on the foregoing plat, and that they severally acknowledged executing the same voluntarily under authority duly vested in them by said corporation and that the seal affixed thereto is the true corporate seal of said corporation.

WITNESS my hand and official seal in the County and State aforesaid this 12 day of July, 1978.

Anne A Love
NOTARY PUBLIC

My Commission Expires:

SURVEYOR'S CERTIFICATE

IT IS HEREBY CERTIFIED that this Plat is true and correct and was prepared from an actual survey of the property by me or under my supervision; that all monuments shown hereon actually exist or will exist prior to final acceptance of the subdivision, and their locations, size, type and material are correctly shown, as provided in the current Edition of Chapter 177 of the Florida Statutes.

Date July 12, 1978

R. Monte's
FLORIDA REGISTERED LAND SURVEYOR No. 2052

COUNTY COMMISSION

This Plat approved in regular open meeting by the Board of County Commissioners of Collier County, Florida, this 25th day of July, 1978, providing that the Plat is filed in the office of the Clerk of the Circuit Court of Collier County, Florida.

William J. Reagan
CLERK

John A. Riston
CHAIRMAN

LELY
BAREFOOT BEACH UNIT 1

RESOLUTION NO. 98-88, RENAMING STREET
OR 2402 PG 301, MARCH 26, 1998

RESOLUTION NO. 93-442, LOT LINE ADJ
RECORDED 10/20/93, OR 1876 PG 1020-22

RESOLUTION NO. 95-156, VACATE
RECORDED 3/3/95 , OR 2035 PG 1373-75

RESOLUTION NO. 84-164

TO VACATE THE TEN FOOT (10') ACCESS EASEMENT LOCATED ON LOTS 6 AND 7, BLOCK "B" LELY BAREFOOT BEACH, UNIT ONE.

RECORDED 8-31-84 IN OR 1099 PG 303-5
PLAT BOOK 12, PAGES ~~34-37~~ 35

Note: ℄ ROAD & SECTION LINE FROM D.O.T. STA. 160+69.48 WEST COINCIDE TO N.E. CORNER OF SECT. 6, TWP. 48S, RG. 25E

D.O.T. STA. 157+09.82

P.O.B.

S 38°28'36"E 32.02'

UNPLATTED

BONITA BEACH ROAD C-865

NORTH R.O.W. LINE

SOUTH R.O.W. LINE

N¼ CORNER SECTION

G.A.C. MONUMENT

ARC 240.71
R 570.67
Δ 24 09 32.5
T 122.17
CH 238.93
CH BR N77 44 15 W

LITTLE HICKORY BAY

DRAINAGE EASEMENT

UTILITY EASEMENT

TRACT R

TRACT A

TRACT C

5.00 U.E. & T.V.E.

LIMIT OF CANAL FILL
(D.E.R. PERMIT 11-10-3359
C.O.E. PERMIT 76K-0107)

10.0'x10.0 U.E.

LELY BEACH BLVD.

LITTLE BRANCH OF HICKORY BAY

BEACH GARDEN A

BEACH GARDEN B

BEACH GARDEN C

BLK-A

BLK-B

BLK-C

ANGUILLA LANE

BONAIRE LANE

CURACAO LANE

DOMINICA LANE

COLLIER COUNTY

STATE COASTAL CONSTRUCTION SETBACK LINE

COASTAL DEVELOPMENT LIMIT LINE

APPROX. MEAN HIGH WATER

GULF OF MEXICO

NUMBER	ARC	RADIUS	DELTA	TAN	CHORD	CHORD BRNG
1	200.55	277.96	041 20 19	104.86	196.23	S67 41 36.5E
2	42.08	817.69	002 56 55	21.04	42.07	S22 41 13.2W
3	145.10	346.72	023 58 42	73.63	144.05	N12 10 20.0E
4	170.21	406.72	023 58 42	86.37	168.97	S12 10 20.0W
5	342.77	757.69	025 55 12	174.37	339.86	S11 12 05.0W
6	284.86	367.95	044 21 27	150.00	277.80	S23 58 14.5E
7	157.86	376.72	023 58 42	80.00	156.51	S12 10 20.0W
8	356.34	787.69	025 55 12	181.27	353.31	S11 12 05.0W
8-1	92.34		006 43 01	46.22	92.29	S20 48 10.5W
8-2	213.54		015 31 58	107.43	212.89	S09 40 41.0W
8-3	50.96		003 40 13	25.24	50.95	S00 04 35.5W
9	308.09	397.95	044 21 27	162.23	300.45	S23 58 14.5E
9-1	33.87		004 52 33	16.94	33.86	S04 11 47.5E
9-2	217.26		031 16 50	111.41	214.57	S22 16 29.0E
9-3	56.96		008 12 04	28.53	56.91	S42 00 56.0E
10	113.85	360.01	018 07 12	57.41	113.36	S61 08 42.0W
11	128.29	558.53	013 09 38	64.43	128.01	N76 47 07.0E
12	99.75	570.80	010 00 44	50.00	99.62	S75 12 40.0W
13	182.51	252.96	041 20 19	95.43	178.58	S67 41 36.5E
14	325.74	227.96	081 52 19	197.72	298.73	N67 25 36.5W
14-1	73.18		018 23 32	36.91	72.86	N80 50 00.0E
14-2	71.85		018 03 35	36.23	71.56	S80 56 26.5E
14-3	127.39		032 01 04	65.40	125.74	S55 54 07.0E
14-4	55.32	227.96	013 24 08	26.78	55.20	N33 11 31.0W
15	91.23	817.69	006 23 31	45.66	91.18	N07 49 10.6E
16	104.11	595.80	010 00 44	52.19	103.98	S75 12 40.0W
16-1	28.36		002 43 39	14.18	28.36	S76 51 12.5W
16-2	75.75		007 17 05	37.93	75.70	S73 50 50.5W
17	95.38	545.80	010 00 44	47.81	95.28	N75 12 40.0E
17-1	63.46		006 39 41	31.76	63.42	N73 32 08.5E
17-2	31.92		003 21 03	15.96	31.92	N78 32 30.5E
20	83.56	583.53	008 12 16	41.85	83.49	N74 18 26.0E
20-2	48.72	583.53	004 47 01	24.37	48.70	S76 01 03.3W
20-3	34.84		003 25 15	17.42	34.83	S71 54 55.5W
21	67.96	533.53	007 18 00	34.03	67.93	N73 51 17.3E
21-1	60.43		006 29 21	30.25	60.39	N73 26 58.5E
21-2	7.55		000 48 37	3.78	7.55	N77 05 58.0E
22	135.64	427.95	018 09 35	68.39	135.07	N22 23 25.5W
23	81.22	335.01	013 53 23	40.81	81.02	N63 15 37.0E
23-2	19.77	335.01	003 22 50	9.89	19.77	N58 00 20.0E
23-3	61.45		010 30 33	30.81	61.36	S54 57 01.5W
24	40.04	25.00	091 45 47	25.78	35.90	S67 05 39.5W
25	16.37	25.00	037 30 24	8.49	16.08	N07 44 16.5W
26	73.93	817.69	005 10 49	36.99	73.90	S08 25 32.6W
27	32.98	25.00	075 35 37	19.39	30.64	N42 25 13.6E
28	42.77	25.00	098 01 27	28.77	37.74	N50 46 14.3W
29	34.98	25.00	080 10 04	21.04	32.20	S38 19 31.5W
30	17.30	817.69	001 12 43	8.65	17.30	S05 13 46.7W
31	38.90	25.00	089 09 06	24.65	35.09	N57 54 10.0W
32	38.31	25.00	087 47 07	24.06	34.67	N12 25 22.0E
33	186.72	367.95	029 04 29	95.41	184.72	N16 17 45.6W
34	98.14	367.95	015 16 55	49.36	97.85	N38 28 27.6W

BASIS OF BEARING: NORTH LINE OF SECTION 6, TWP. 48S., RG. 25E BEING N 89° 49' 01"W

SCALE 1"=50'

GRAPHIC SCALE IN FEET

50 0 50 100 150

SEE SHEET 3

RESOLUTION NO. 95-50, REPLAT
RECORDED 1/20/95 , OR 2022 PG 1879

LELY BAREFOOT BEACH UNIT 1

CURVE TABLE						
NO	ARC LENGTH	RADIUS	DELTA	TAN	L.CH.	CH. BRG
2	82.73	265.00	17 53 12	41.70	82.39	N16 23 06W
3	233.94	3443.50	03 53 33	117.02	233.90	N23 22 56W
4	78.46	1820.43	02 28 10	39.24	78.45	N59 47 56E
5	20.56	25.00	47 09 31	10.91	20.00	N44 59 05E
6	18.69	25.00	42 50 29	9.81	18.26	N0 0 55W
7	38.52	25.00	88 16 11	24.26	34.82	N65 34 14W
8	72.26	338.15	12 21 12	36.27	72.12	N76 22 54E
9	83.04	385.15	12 21 12	41.66	82.88	N76 22 54E
10	91.37	55.36	38 40 28	47.50	89.65	N26 46 44W
11	56.96	397.95	08 12 04	28.53	56.91	N42 00 55W
12	113.86	360.0	18 07 13	57.41	113.38	N61 08 42E
13	79.54	1845.43	02 28 10	39.77	79.53	N69 47 56E
14	231.91	3413.50	03 53 33	116.00	231.86	N23 22 56W
15	147.6	3413.50	02 28 40	73.82	147.60	N24 05 22W
16	84.30	3413.50	01 24 53	42.15	84.29	N22 08 36W
17	92.09	295.00	17 53 12	46.42	91.72	N16 23 06W
18	71.12	105.36	38 40 28	36.97	69.78	N26 46 44W
19	40.02	25.00	91 43 49	25.76	35.88	N24 25 45E
20	32.33	3383.50	0 32 51	16.17	32.33	N2, 42 34W
21	77.65	360.15	12 21 12	38.98	77.50	N76 22 54E
22	40.02	25.00	91 43 40	25.76	35.88	N67 50 50W
23	57.09	3368.50	0 58 26	28.54	57.09	N21 55 22W
24	39.26	25.00	89 58 422	24.99	35.35	N21 17 58.9E
25	111.62	165.36	38 40 28	58.03	109.51	N26 46 44W
26	16.27	3383.50	0 16 32	8.14	16.27	N23 49 38W
27	41.68	385.01	06 13 54	20.96	41.85	N67 05 20E
28	80.51	3383.50	01 21 48	40.26	80.50	N24 38 46W
29	78.22	325.00	13 47 26	39.30	78.03	N18 25 59W
30	9.26	25.00	21 14 12	4.69	9.21	N22 09 22W
31	70.05	385.15	10 25 13	35.12	69.95	N77 20 54E
32	12.99	385.15	0 86 59	6.50	12.99	N71 10 17E
33	14.62	335.15	02 29 58	7.31	14.62	N71 27 17E
34	28.22	25.00	64 40 32	15.82	26.74	N65 06 29E
35	26.12	25.00	59 51 09	14.39	24.94	N52 37 55E
36	13.15	25.00	30 08 51	6.73	13.00	N7 37 55E
37	12.66	427.95	01 41 43	6.33	12.66	N45 16 06W
38	35.14	25.00	80 31 26	21.17	32.31	N84 25 57W
39	71.85	1820.43	02 15 18	35.93	71.85	N69 41 30E
40	5.81	1820.43	0 12 02	3.40	5.81	N70 55 35E
41	58.24	385.01	08 40 01	29.18	58.19	N59 38 22E
42	1.87	427.95	0 15 02	0.94	1.87	N44 17 44W
43	45.05	25.00	103 15 24	31.57	39.20	N63 42 145W
44	104.94	6067.5	09 54 34	52.60	104.81	N89 37 35E
45	36.87	25.00	84 30 00	22.71	33.62	N32 19 52E
46	21.46	265.00	04 38 20	10.73	21.45	N9 45 385W
47	61.28	265.00	13 14 55	30.78	61.14	N18 42 14.8W
48	98.14	367.95	15 16 55	49.36	97.85	N38 28 27.8W

BASIS OF BEARING: NORTH LINE OF SECTION 6, TWP. 48 S., RG. 25 E BEING N89° 49' 01"W

TRACT B

COMMUNITY RECREATION CENTER

BRANCH OF LITTLE HICKORY BAY

UNPLATTED

BEACH BLVD.

LELY

TRACT R

DOMINICA LANE

ST. EUSTACIUS LANE

FELIPE LANE

GUADELOUPE LANE

HISPANIOLA LANE

BLK-D

BLK-E

BLK-F

BLK-G

BEACH GARDEN D

BEACH GARDEN E

BEACH GARDEN F

BEACH GARDEN G

STATE COASTAL CONSTRUCTION SETBACK LINE

COASTAL DEVELOPMENT LIMIT LINE

APPROX. MEAN HIGH WATER

GULF OF MEXICO

SEE SHEET 2

SEE SHEET 4

SCALE: 1"=50'

GRAPHIC SCALE IN FEET

50 0 50 100 150

LELY BAREFOOT BEACH UNIT 1

BASIS OF BEARING: NORTH LINE OF SECTION 6, TWP. 48S., RG. 25E BEING N 89° 49' 01" W

LITTLE BRANCH OF HICKORY BAY

LITTLE BRANCH OF HICKORY BAY

UNPLATTED

UNPLATTED

SEE SHEET 3

CURVE TABLE						
NO	LENGTH	RADIUS	DELTA	TAN.	L.CH.	CH.BRG
1	92.77	959.55	05 32 22	46.42	92.73	N18 39 58W
2	75.84	170.00	25 33 46	38.56	75.22	N28 40 40W
3	150.90	230.00	37 35 28	78.28	148.21	N22 39 49W
4	46.80	170.00	15 46 25	23.55	46.65	N11 45 17W
5	63.32	230.00	15 46 25	31.86	63.12	N11 45 18W
6	62.14	235.80	15 05 54	31.25	61.96	N78 34 58E
7	75.31	285.80	15 05 54	37.88	75.09	N78 34 58E
8	111.54	170.00	37 35 28	57.86	109.55	N22 39 49W
9	68.68	174.94	22 29 34	34.79	68.24	N59 47 14E
10	49.05	124.94	22 29 34	24.84	48.73	N59 47 14E
11	39.27	25.00	90 00 00	25.00	35.36	S66 26 09E
12	86.96	899.55	05 32 22	43.52	86.93	N18 39 58W
13	80.61	1870.43	02 28 10	40.31	80.61	N69 47 56E
14	79.54	1845.43	02 28 10	39.77	79.53	N69 47 56E
15	89.87	929.55	05 32 22	44.97	89.83	N18 39 58W
16	89.23	200.00	25 33 46	45.37	88.49	N28 40 40W
17	58.66	149.94	22 29 34	29.61	58.48	N59 47 14E
18	131.22	200.00	37 35 28	68.07	128.88	N22 39 49W
19	68.72	260.80	15 05 54	34.56	68.53	N78 34 58E
20	55.06	200.00	15 46 25	27.71	54.89	N11 45 17W
21	32.73	200.00	17 17 58	16.99	31.23	N60 05 08W
22	5.54	25.00	12 42 02	2.78	5.53	N74 54 52E
23	37.52	230.00	9 20 46	18.80	37.48	N20 34 11W
24	19.71	230.00	4 54 32	9.86	19.70	S27 41 49W
25	34.34	25.00	78 41 32	20.50	31.70	S09 11 41.3W
26	50.32	25.00	69 28 45	17.34	28.49	S83 16 50W
27	16.56	174.94	05 19 22	8.13	16.25	N68 22 20E
28	52.43	174.94	17 10 12	26.41	52.23	N57 07 35E
29	8.95	25.00	20 31 15	4.53	8.91	N21 43 10W
30	39.27	25.00	90 00 00	25.00	35.36	N86 27 33W
31	48.15	235.80	11 41 57	24.16	48.06	N76 52 59E
32	13.99	235.80	03 23 57	7.00	13.99	N84 25 57E
33	19.33	170.00	06 41 00	9.93	19.82	S38 07 03E
34	91.70	170.00	30 54 28	47.00	90.60	S19 18 18E
35	28.18	25.00	64 34 49	15.80	26.71	S28 25 20W
36	11.09	25.00	25 25 11	5.64	11.00	S73 25 20W
37	39.27	25.00	90 00 00	25.00	35.36	N48 52 05W
38	27.04	25.00	61 57 53	15.01	25.74	S11 20 26W
39	12.71	25.00	29 07 24	6.49	12.57	S56 53 04W
40	39.74	25.00	91 05 15	25.48	35.69	S25 54 09W
41	39.27	25.00	90 00 00	25.00	35.36	N41 07 55E
43	38.80	25.00	88 54 54	24.53	35.02	N64 05 52W

LELY BEACH TRACT R BLVD.

HISPANIOLA LANE

INAGUA LANE

JUMENTO CAY LANE

KAULA LANE

TRACT R

BLK-H

BLK-I

BLK-J

BLK-K

BEACH GARDEN H

BEACH GARDEN I

BEACH GARDEN J

BEACH GARDEN K

D.E.&U.E.

10' A.E.

10.0X15.0 U.E.

D.E. (DRAINAGE EASEMENT) 965'±

COASTAL DEVELOPMENT LIMIT LINE

STATE COASTAL CONSTRUCTION SETBACK LINE

COASTAL DEVELOPMENT LIMIT LINE

TRACT B F

TRACT B F

APPROX. MEAN HIGH WATER

GULF OF MEXICO

UNPLATTED

SCALE: 1"=50'

Appendix G

Sea Level Rise

Sea Level Rise

Sea Level Rise (SLR) has not previously been considered in Collier County's annual beach monitoring reports. Although some scientists have been sounding the alarm, the evidence for the connection between climate change and SLR is controversial, yet scientifically undeniable.

Historically sea level has been both much higher and much lower than it is today due to natural variations. When looking at all of the variables that influence SLR, and considering the wide ranges of time over which these changes take place, it is easy to see why there has been controversy. However, the preponderance of the evidence points to SLR as a direct consequence of global warming, and warming is to a significant degree the result of human activities releasing "greenhouse gases", trapping thermal energy from the sun as well as the earth's own internal thermal energy.

Opinions vary widely regarding SLR, and the proper rate of SLR that should be the criteria for adaption needs to be determined. While scientific debate is always healthy, and the most reliable criteria may change over time as more information becomes available, there is little doubt the best source of information on climate change and SLR is the Intergovernmental Panel on Climate Change (IPCC) established in 1988 by two United Nations Organizations. These are the World Meteorological Organization and the United Nations Environmental Program to assess "the scientific, technical and socioeconomic information relevant for the understanding of the risk of human-induced climate change." Review by experts and governments is an essential part of the IPCC process. For its first task, the IPCC was asked to prepare, based on available scientific information, a report on all aspects relevant to climate change and its impacts and to formulate realistic response strategies.

The first assessment report of the IPCC served as the basis for negotiating the United Nations Framework Convention on Climate Change (UNFCCC). Since then, the IPCC has remained the most important source for the Convention's scientific, technical and socio-economic information. The relationship between the UNFCCC and the IPCC has become a model for interaction between science and decision makers. Furthermore, the Assessment Reports (AR) specifically address SLR as a direct result of climate change, and it provides a detailed assessment of how climate change is directly related to SLR through a number of global physical processes.

The IPCC makes a compelling case for climate change as a real phenomenon, and human activities releasing greenhouse gases are responsible to a significant degree. As a result many countries are responding with a degree of urgency to reduce the release of greenhouse gasses contributing to climate change, in part due to the understanding that SLR is a direct result of climate change. The most recent IPCC Assessment Report is the 5th report (AR5). Chapter 13 of AR5 is specific to the issue of SLR. AR5, Chapter 13 was prepared by over 70 authors, all of whom are world experts on the different phenomena that contribute to sea level rise. The IPCC publishes an updated AR about every 6 years and the reports include the results of credible data collection, studies, and reports generated during that 6 year interval between publication of Assessment Reports.

A direct result of the solid and still growing consensus that SLR needs to be addressed is many coastal communities are developing Adaption Plans. Miami-Dade County is one of the best examples of this, where they took the lead in organizing a task force made up of

representatives of the four counties that make up southeast Florida; Monroe, Miami-Dade, Broward, and Palm Beach Counties. Miami-Dade County followed up on the recommendations made by the original consortium of 4 counties by putting together its own task force to make practical recommendations to develop a SLR Adaption Plan. The plan was adopted into the County's Comprehensive Development Master Plan (CDMP), the provisions the County began implementing in 2014.

This adaption plan lists potential impacts of SLR and based on the various sections of the County having the lowest elevations and are situated close to the coastline, it sets priorities based on the relative vulnerability of specific parts of the County, so the response to SLR will be the most efficient. The response includes upgrading storm water infrastructure, raising road elevations, and similarly raising the elevations of other designated elevation requirements contained in their CDMP.

Beach restoration is one of the important elements of Adaption Plans in many areas, and in many cases one of the easiest to initiate implementation particularly since many coastal communities in Florida already have some level of beach maintenance in place. Beach nourishment projects typically have a life ranging from 5 to 10 years. Looking at it this way, design of beach nourishment projects may not necessarily be concerned with long term trends many times longer than the typical life of a nourishment project, and accordingly beach projects in recent history have simply been designed to be responsive to conditions as they exist at the time of construction. There is ample reason to modify this policy in light of information in the IPCC report.

The reason for the importance of beach nourishment as a SLR adaption measure is rather simply described by what is known as the Bruun Rule, developed by Per Bruun who was a professor of Coastal Engineering at the University of Florida.

The Bruun Rule uses conservation of mass to determine shoreline change associated with water level rise. This simplified theoretical approach is based upon a redistribution of the existing sediment while maintaining an equilibrium profile shape. As sea level rises, it necessarily results that the profile must rise too in order to maintain the equilibrium relationship between profile shape and water level. This requires a redistribution of coastal sediments, in this case beach sand, so that as the profile rises it also moves landward causing shoreline recession, and that recession is observed as erosion which provides the extra sand necessary for the profile to maintain its shape as it rises. The Bruun Rule does not consider other factors associated with the dynamic coastal system, such as the effects of longshore sediment transport, inlets, beach nourishment, and the long-term onshore migration of sediment, which is a phenomena which has been observed due to tide and wave induced shear stresses on the continental shelf, the effects of which are most likely to be apparent in long term geologic processes.

It is clear that there are many variables that effect the movement of the position of the shoreline. However, as a simple exercise to illustrate the effectiveness of beach nourishment, a comparison was made between what would have occurred theoretically, in Collier County, due to measured SLR and application of the Bruun Rule, in comparison to what actually occurred in Collier County over the same time interval which includes the effect of beach nourishment.

Although SLR is not linear, it is close enough to being linear for relatively short periods of time and the IPCC report states that SLR amounted to 3.2mm/yr. from 1995 to 2017. For 22

years this would be a total rise of 70.4mm. This is approximately 2.8 inches rise in sea level that theoretically would have caused recession of approximately -15 feet in shoreline position according to the Bruun Rule.

However, Collier County completed its first comprehensive nourishment in 1996 with 1.2 million cubic yards of sand, and has continued to nourish the beach regularly since then, although there was only one other comprehensive nourishment of 667,620 cy in 2005. Due to market conditions driven mostly by the need for dredging equipment to repair damage caused by Sandy in 2012, the cost of a comprehensive nourishment project scheduled for 2013, the prices bid at that time were prohibitively high. In response to this the County identified several areas that were the most vulnerable and most in need of nourishment and hauled sand in by truck to address the needs of those areas. Since then the policy has been to annually truck relatively small quantities of sand, incrementally, to areas most in need of nourishment, as opposed to the traditional nourishment practice of hydraulic dredging to place much larger quantities of sand over much longer sections of shoreline. This flexible approach to nourishment, based on the analysis of monitoring data such as the data upon which this report is based, has shown this incremental approach to nourishment has been very effective. This also maintains a more consistent level of storm protection and environmental habitat.

This comparison of the results of SLR based on the Bruun Rule, to the actual shoreline changes based on survey data shows that rather than erosion of and average of -15 feet between 1995 and 2017 due to SLR, the County's renourishment program has resulted in shoreline advance of an average of +51.5 feet over the same time period. Additionally, the beach nourishment program has enabled Collier County to begin building vegetated dunes in the nourishment areas, which not only adds stability to the upper beach, the dunes represent an additional supply of sand at a higher elevation than the beach berm, which provides an additional measure of storm protection. Also, after the impact of a storm, the beach will be in better condition due to the presence of this extra source of sand.

All of this means that Collier County, although it has no official SLR Adaption Plan, is already implementing one of the first and most effective adaption alternatives that is included in most adaption plans in areas that have sandy beaches. This is because a healthy beach and dune system provides very effective storm protection to upland structures and infrastructure. It also maintains a wide beach for Collier County's tourist oriented economy, nesting habitat for endangered sea turtles, and foraging, nesting and roosting habitat for many species of coastal waterbirds, some of which are also on the endangered species list.

While beach restoration is an extremely important element of a SLR Adaption Plan, it appears that this is currently the only plan being implemented by Collier County at this time in the way of adaption. The County may want to consider following the example of Miami-Dade in developing a Comprehensive SLR Adaption Plan. A good place to start would be to form a Task force as Miami-Dade did initially, perhaps in this case made up of the coastal counties in SW Florida.