Stephen and Jodi Straley

Seawall Rehabilitation and Extension Project

Basis of Design Report

Report to the City of Hollywood, Florida

And

Florida Department of Environmental Protection

By:

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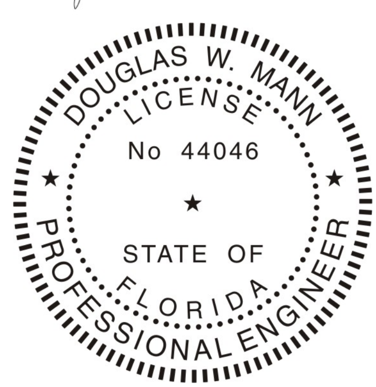


A. Introduction

This basis of design report is to provide an explanation of the design of the replacement and extension of the seawall. Sections within the report are intended to address requirements of both the Florida Department of Environmental Protection (FDEP) and the City of Hollywood.

i. Property History

Stephen and Jodi Straley have owned and lived in the residence at 5409 Surf Road since 1987 (Figure 1). The property includes two small, platted lots and lies between Surf Road and the City's platted (but unconstructed) Broadwalk. In the early 1950's, together with the two southerly adjacent owners, the original owner of the property constructed a seawall across the southern of the two Straley lots and a return wall back to the house's foundation system. The existing seawall is located at or immediately seaward of the seaward edge of the platted[1] Broadwalk. While the seawall provides upland protection to the southern half of the Straley Residence, the northern half of the property has no such protection.

Figure 1. Project site. (Source Google Earth). Arrow depicts the Straley Residence.

ii. Project Goal

The goal of this project is to replace the existing seawall and extend the seawall northward to the extension of the Straley's north property boundary at the Oak Street right of way (Figure 2.)

a) Historical Beach Conditions

The beach between Port Everglades and the Dade County line is erosive due to limited bypassing of sand to the south at Port Everglades. While the County is working towards a more regular bypassing of sand at

[1] Plat Book 4, Page 20 of the County records. Site is on sheet B.

the Port, it has not been implemented to date, though components may be initiated soon. The stabilizing effect of the sand bypassing on the beach several miles south of Port Everglades is not clear. The beach has been subject to periodic beach nourishment, which is cosponsored by the County and the USACE, subject to funding availability. A recent (2023) beach storm repair nourishment project was implemented by the USACE.

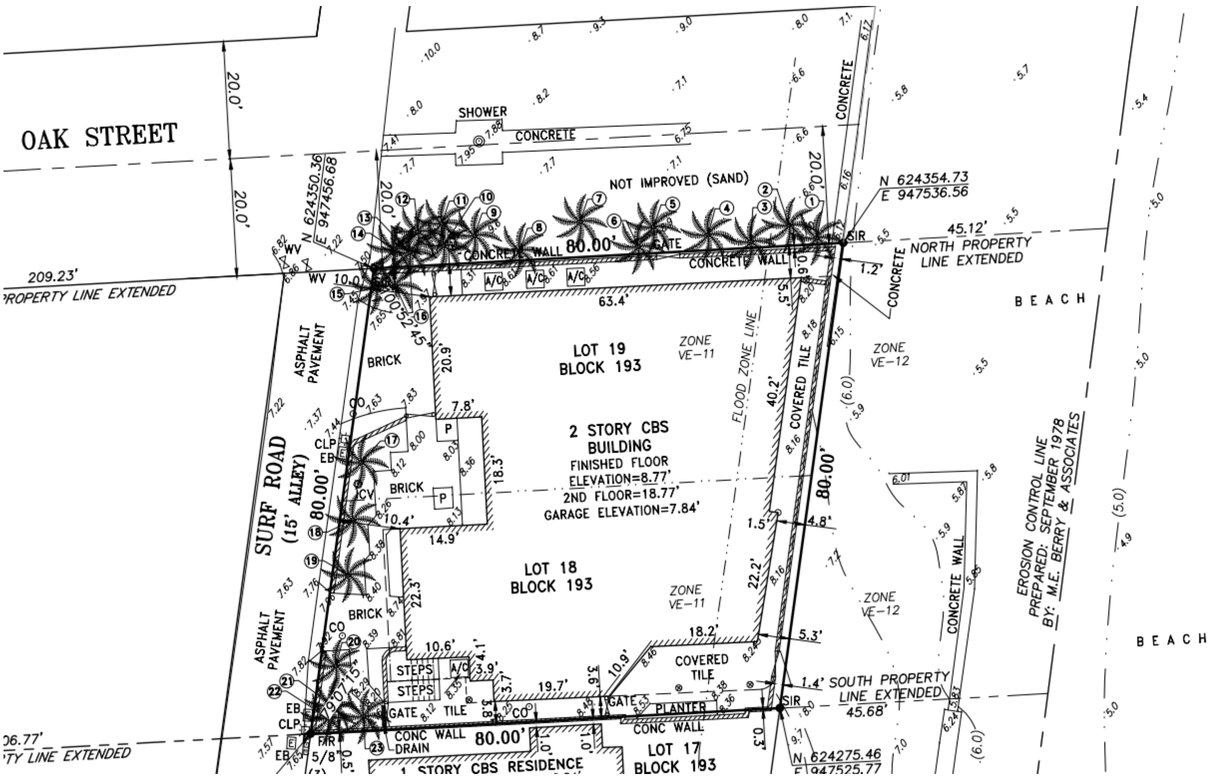


Figure 2. Portion of a boundary survey with the property lines extended seaward.
(Richard Cousins Land Surveying, Inc.)

As a result of the continual erosive conditions and periodic nourishment, the historic beach width has fluctuated significantly. Minimal beach widths occurred in 2004 (just before the 2005 nourishment) (Figure 3a), 2023 (Figure 3b), and similar conditions are documented in a 1975 aerial photograph which predated any beach nourishment program (Figure 3c). In all of the photographs, the shoreline receded to around the location of the existing seawall.

The owners also report that the beach has been subject to both tropical storm and northeaster type storm conditions, with the most severe conditions occurring during Hurricane Andrew[2] in 1992. These types of episodic storms have contributed to the vulnerability of the upland residence due to waves and storm surge overtopping the beach.

[2] Hurricane Andrew made landfall in southern Dade County with hurricane force winds extending into Broward County.

Figure 3a. Project site in January 2004 (Google Earth image). Arrow depicts the project site.

Figure 3b. Project site in 2023 prior to nourishment.

Figure 3c. 1975 Aerial by Bosworth (original in APTIM library). Arrow depicts the project site.

b) Existing Conditions

(1) Seawall Conditions

The cap on the northern portion of existing seawall is cracked and contains spalls and rust stains (Figure 4). These conditions are an indication of underlying steel reinforcement corrosion. This condition differs from that of the seawall in front of the southerly adjoining property where the seawall cap had been repaired at some time with a slightly higher (a few tenths of a foot) cap, and slightly wider concrete cap (Figure 5). No external signs of rust are evident on the concrete cap of the southern portion.

Figure 4. Cracking and rust stains observed on the northern portion of the seawall.

Figure 5. Cap on seawall in front of southerly adjoining property.

(2) Topographic Conditions

Recent topography of the beach from 0 feet NAVD to the centerline of Surf Road was collected by Richard Cousins, Land Surveying, Inc. The survey depicts the gently sloping beach (recently nourished by the USACE), the existing seawall, the topography of the Oak Street right of way, and topography of the adjacent beach areas. This survey serves as a basis of the design for the seawall replacement and extension.

(3) Expected Storm Surges

Broward County's shoreline is subject to storm surge caused principally from tropical storm systems. The expected storm surges for southern Broward County are provided by Chiu and Dean (1980) and are shown in Table 1. It should be noted that the elevations given by Chiu and Dean are presented in relation to the NGVD datum. As the FDEP model runs in the NGVD datum, all current survey data was converted to NGVD prior to numerical simulation, thence reconverted back to NAVD for plotting purposes.

Table 1. Expected total storm surge for Various Return Periods (From Dean and Chiu, 1980).

Combined Total Storm Tide Values for Various Return Periods

Return Period, TR (years)	Combined Total Storm Tide Level* above MSL (ft)		
	North	Middle	South
500	17.1	17.2	16.9
200	14.3	14.8	15.4
100	12.5	13.1	13.6
50	10.9	11.2	11.4
20	9.0	8.9	9.0
10	7.7	7.8	7.7

*Includes contributions of: wind stress, barometric pressure, dynamic wave setup and astronomical tides.

B. FDEP Regulatory Requirements

i. Introduction

FDEP applies the Chapter 161, F.S. and 62b-33, F.A.C. in determining whether to approve armoring permits such as the one proposed here. Principal in the FDEP's decision making is the determination as to whether the upland structure is eligible and whether the upland structure is vulnerable. These are discussed in the following sections.

ii. Eligibility

The existing single-family home was constructed by previous owners in the 1950's. The house does not sit on a foundation that was permitted or meets the requirements of Chapter 161, F.S. and Section 62B-33, F.A.C. Therefore, the structure is eligible for an FDEP armoring permit.

iii. Justification

A storm recession analysis utilizing the FDEP's high frequency dune erosion model was performed to determine if the Straley Residence is considered vulnerable (Section 62B-33, F.A.C.). A beach profile for the model was created by splicing offshore survey data from the FDEP monument R-102, shown in Figure 6, with upland survey data by Cousins Surveyors & Associates collected on July 12, 2024. The model uses this 1-dimensional survey data, an expected storm surge for a 15-year return-period interval, to calculate a new, eroded beach profile.

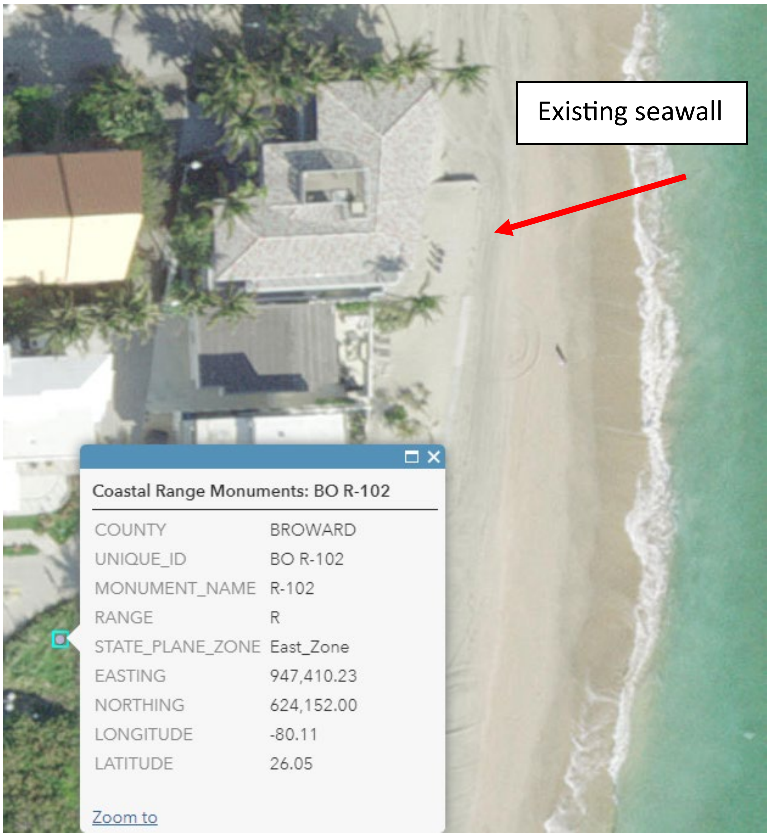


Figure 6. Coastal Range Monument BO R-102 proximity to Straley Residence.

The dune erosion model requires the input beach profile to extend from a distance offshore to the upland sand dunes, where the dunes are greater in elevation than the simulated storm surge peak elevation. Due to the low elevations of northern Hollywood, overtopping of beach, vegetated areas, and Surf Road was determined for high frequency storm surge events. The impacts of high frequency storm events on the beach profile in the vicinity of the residence were simulated by the inclusion of an artificial dune several hundred feet west of Surf Road. The dune was located sufficiently west to not affect the erosion processes in the immediate vicinity of the Straley Residence. This method permits the model to run, simulate the predicted waves and storm surge of the design storm at the residence without any computational errors. The dune recession for a 15-year return period storm is shown in Figure 7. For a 15-year return period storm event, the erosion extends under the Straley Residence to Surf Road. Therefore, there is justification for an armoring permit (Section 62b-33, F.A.C.).

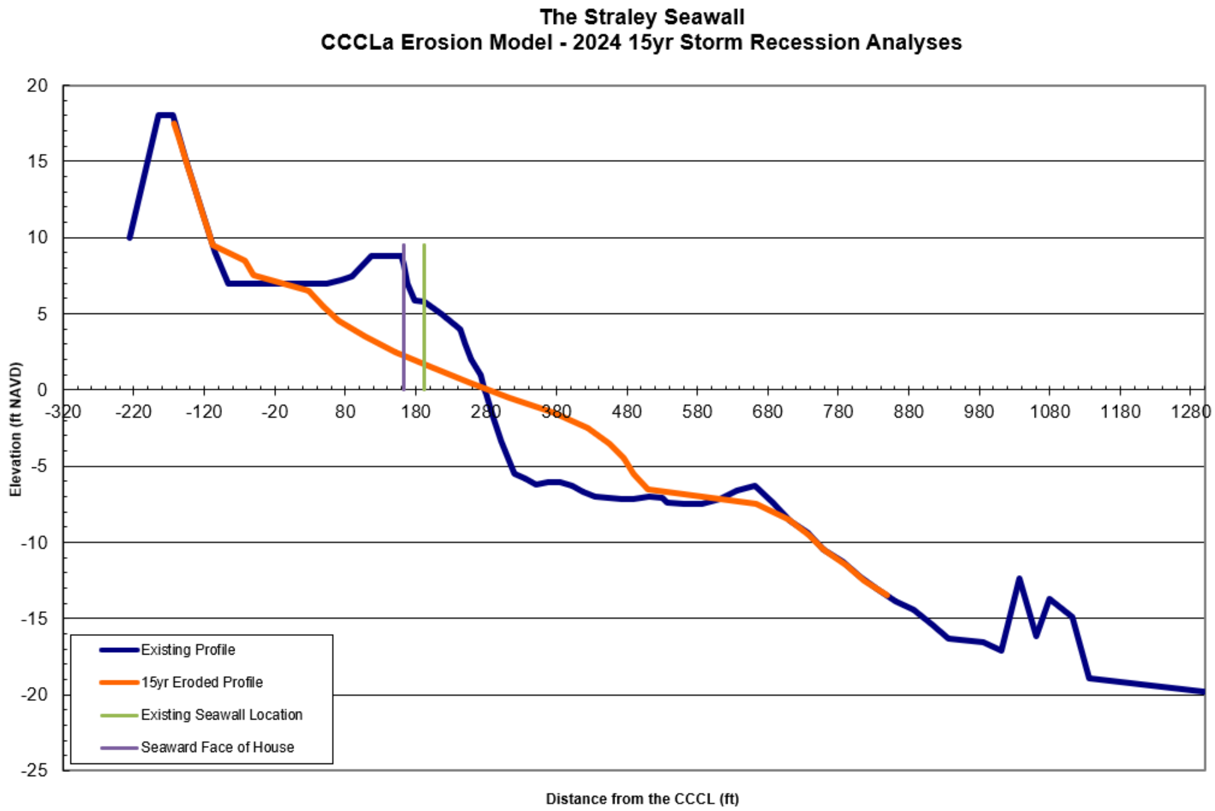


Figure 7. Pre- and post-storm beach profiles for a 15-year return period storm recession.

C. Design Approach

i. Design Parameters

The following parameters were specified for the design of the new seawall:

a. Top of seawall elevation: 6.25’ NAVD88

The elevation of the top of the new seawall was set to 6.25’ NAVD88 to match the elevation of the southerly adjoining seawall cap. While greater resiliency would be achieved through a higher seawall cap elevation, this elevation was stipulated at the request of the City of Hollywood.

b. Soil Profile and Depth of limestone rock: 13.5’ NAVD88

The soil profile at the seawall was assumed to be clean beach sands with a layer of limestone rock starting at approximately -13.5’ NAVD88. The depth was derived based on the presence of rock in offshore beach profiles. The rock layer presents a design limitation to the length and material of the sheetpile.

c. Eroded sand elevation in front of seawall: -3’ NAVD88

As mentioned above, the waterline has historically been observed at the foot of the seawall. In addition, storm induced scour at the toe of the wall can occur. Anecdotal observations of select south Florida oceanfront seawalls after storm events suggest that beach scour to elevations of -3’ NAVD88 is possible. Where possible, inclusion of this scour depth in the seawall stability analyses is recommended.

d. MHW and MLW datums

The mean high-water elevation is +0.56’ NAVD88, and the mean low water elevation is -2.06’ NAVD88 at the site.

ii. Design Alternatives

Both cantilevered and anchored seawall designs were considered. For each option, the resultant soil loads, maximum bending moment on the wall, and the necessary embedment depth for wall stability were determined. The results are summarized below.

a. Anchored Wall

An anchored wall design is the most cost-effective retaining wall system. This design will include a wall driven or vibrated to the rock layer with a concrete cap to provide lateral stiffness. Additionally, tieback rods are installed behind the seawall, connecting the concrete cap to concrete deadmen buried in the sand.

Design analysis suggested that a Truline Series 800 cellular sheet wall with 4 No. 5 bars in each cell will be effective in meeting the design parameters. The Truline cells are installed through the sand, then the sand is excavated from within the cells, steel reinforcing is installed, and the cells filled with 5000 psi compressive strength concrete via a tremie pour technique. Tie rods are one inch in diameter and the concrete deadmen are 4’ x 4’ x 8” precast slabs. Tie rods and deadmen will be buried within the beach.

This is the recommended solution and is included in the attached plans.

b. Cantilevered Wall

A cantilevered wall is a retaining wall designed to resist soil pressures through deep penetration into underlying soils. Cantilever walls typically require stronger materials and longer walls than an anchored wall.

Design analyses suggested that the cantilevered seawall design was not able to resist the calculated soil loading for the eroded beach case of -3 feet NAVD discussed above. The seaward sand will not provide sufficient support to prevent the wall from rotating forward. If the scour was limited to 0 feet NAVD then a solution using cost efficient materials could be used.

This solution is not recommended.

D. Seawall Interaction with Oak Street Right of Way

During a preliminary meeting with the City of Hollywood staff, the City requested that the effect of this northerly extension of the seawall be evaluated with a numerical model (unspecified). They noted that there was an apparent flow pattern as evidenced by beach wrack (decayed aquatic vegetation) curving into the Oak Street right of way (Figure 8). Staff was concerned that the construction of a seawall would result in impacts to the right of way or the adjacent property.

Figure 8. Close up view of Straley Residence and the Oak Street Right of Way. The arrow points to an apparent wrack line which may be reflective of the hydrodynamic flows during (the last) storm events.

i. Modeling Approach

The goal of the numerical simulations is to understand the hydrodynamic flows occurring within the Oak Street Right of Way under existing and proposed seawall conditions. For each of the simulations, the effects of the seawall northerly extension will be seen through differences in the numerical flow field.

ii. Method and Model Use

The proposed seawall is located at an approximate elevation of 6.25 feet NAVD and 90 feet behind the mean water line. The FEMA flood hazard map demarcates the property as a VE zone with a 1% annual chance of base flood elevation (BFE) of 11 feet. Thus, it can be presumed that during a hurricane like storm condition, the entire area will flood irrespective of the existence of a localized, low sea wall.

Under a more moderate flooding condition where waves and water level approach the seawall, it is prudent to assume, that short waves would dissipate (break) due to the high beach elevations and the distance from the water line. However, infra-gravity waves (wave runup and other long period hydrodynamic flows) can propagate further inland.

In order to model the infra-gravity wave motion, the XBeach (Roelvink et. al 2010) model can be utilized. XBeach is a short wave averaged, long wave resolving model. XBeach has been shown to successfully resolve the flooding due to infra-gravity propagation.

iii. Model Grid and Setup

An XBeach model was implemented in the study area. The grid domain covers ~820 feet alongshore and ~2000 feet in the cross-shore direction. The offshore model boundary is situated at the -24 feet NAVD elevation. The model grid resolution varies with increased resolution in the areas of concern Figure 9.

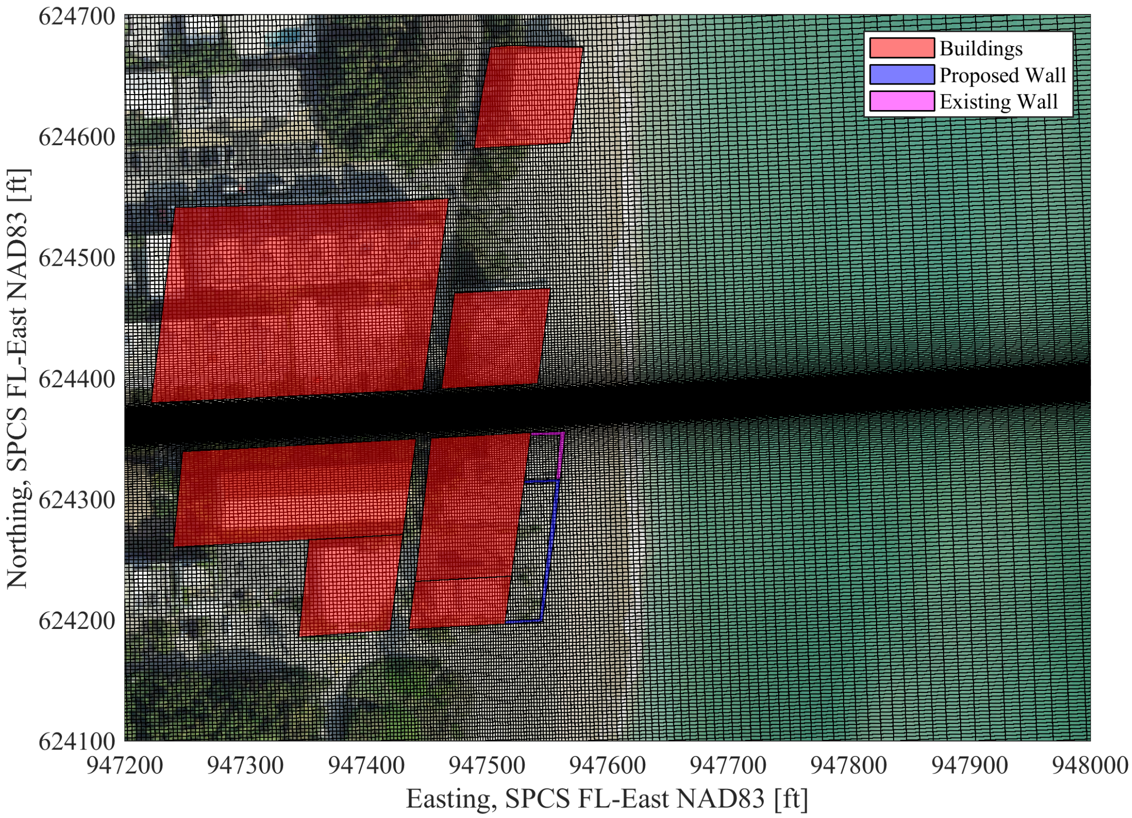


Figure 9. Model Grid in the area of concern.

The bathymetry for the model was extracted from Continuously Updated Digital Elevation Model (CUDEM) - 1/9 Arc-Second Resolution Bathymetric-Topographic Tiles provided by NOAA. The nearshore and beach elevations of the model were then updated to reflect the current conditions using the Richard Cousins Land Surveying, Inc. survey results. The nearshore model elevations are provided in Figure 10.

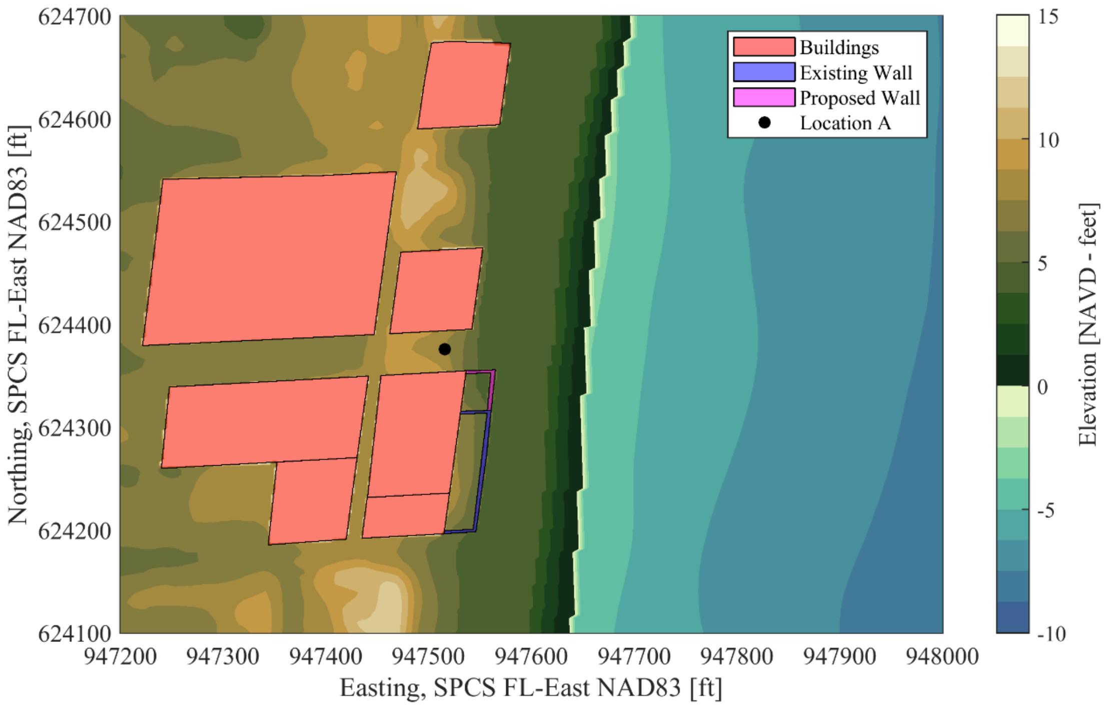


Figure 10. Nearshore model elevation. For purposes of the simulations, the buildings are impervious to flows.

As the focus of the investigation was the hydrodynamic flows, the morphology in the model was kept constant and not updated throughout the model run (i.e. no erosion or accretion).

Two model domains were constructed. One with existing conditions and the second reflecting the proposed seawall. Both models were forced with the exact same tide and wave forcings provided below.

iv. Wave and Surge Forcing Conditions

a. Storm Surge

Due to the temporarily wide beach, preliminary model simulations indicated that under normal tide conditions, waves, and wave runup do not reach the existing seawall. For this investigation, the storm surge was assumed to be a constant surge height of 4.5 feet NAVD. The surge level is less than a 10-year return period event (Table 1). This surge elevation was found to allow hydrodynamic flows to reach the seawall under existing beach conditions.

b. Wave Climate.

A JONSWAP spectral short-wave condition was applied over the surge level. To test a range of wave conditions, multiple significant wave heights, periods and directions were modeled (Table 2).

Table 2. Model forcings. JONSWAP spectral conditions were assumed offshore.

Significant wave height [feet]	3.3, 6.6, 8.2
Wave Period [s]	8, 10, 12
Wave Direction [degrees from north].	15,30,45,60,90,120,150

The corresponding infra-gravity waves forced by the short waves will be generated within the model. Figure 11 provides an example of a water level and wave height near the boundary.

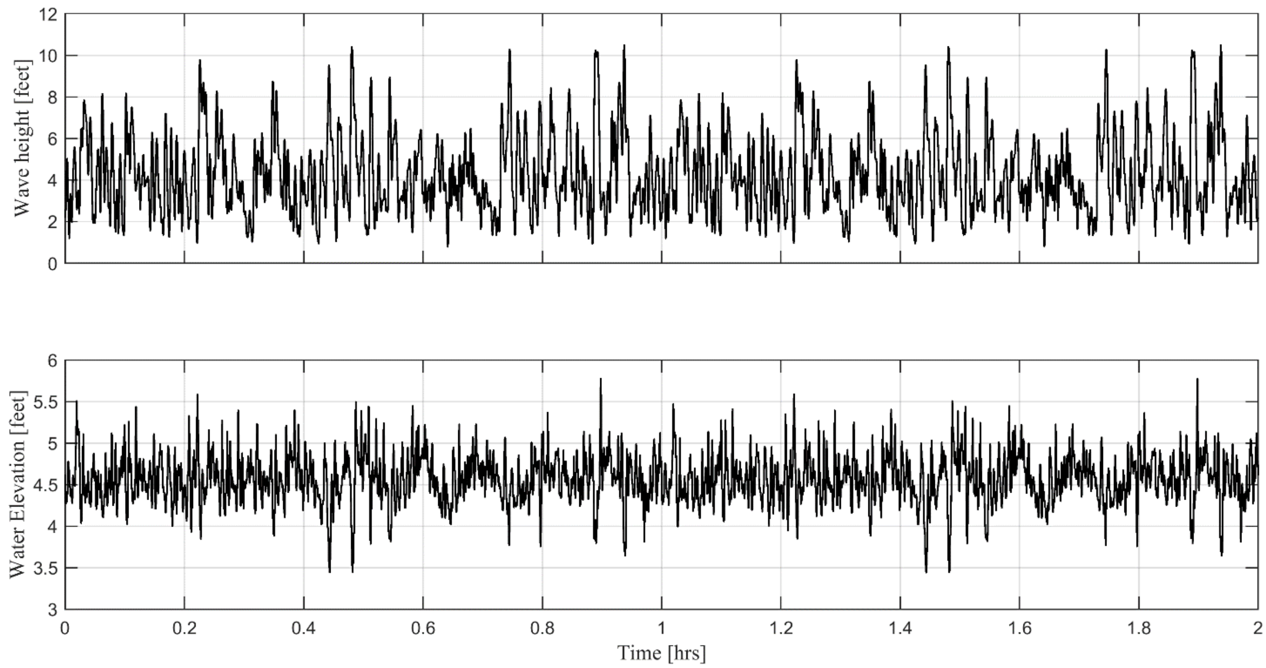


Figure 11. Wave height and water elevation (infra gravity waves and surge) near the model boundary for JONSWAP spectral condition of $H_s = 6.6$ ft, $Tp = 8s$.

v. Results

A total of 42 model runs were conducted. Each model was run for three hours with the first hour allowing the storm surge to build up to 4.5 feet NAVD. The model outputs were gathered for the last two hours. The model results contain wave heights, water levels and maximum water levels over the model domain. An example of maximum water depths in the study area for the existing and proposed conditions are provided in Figure 12. Individual cases are provided in Appendix A.

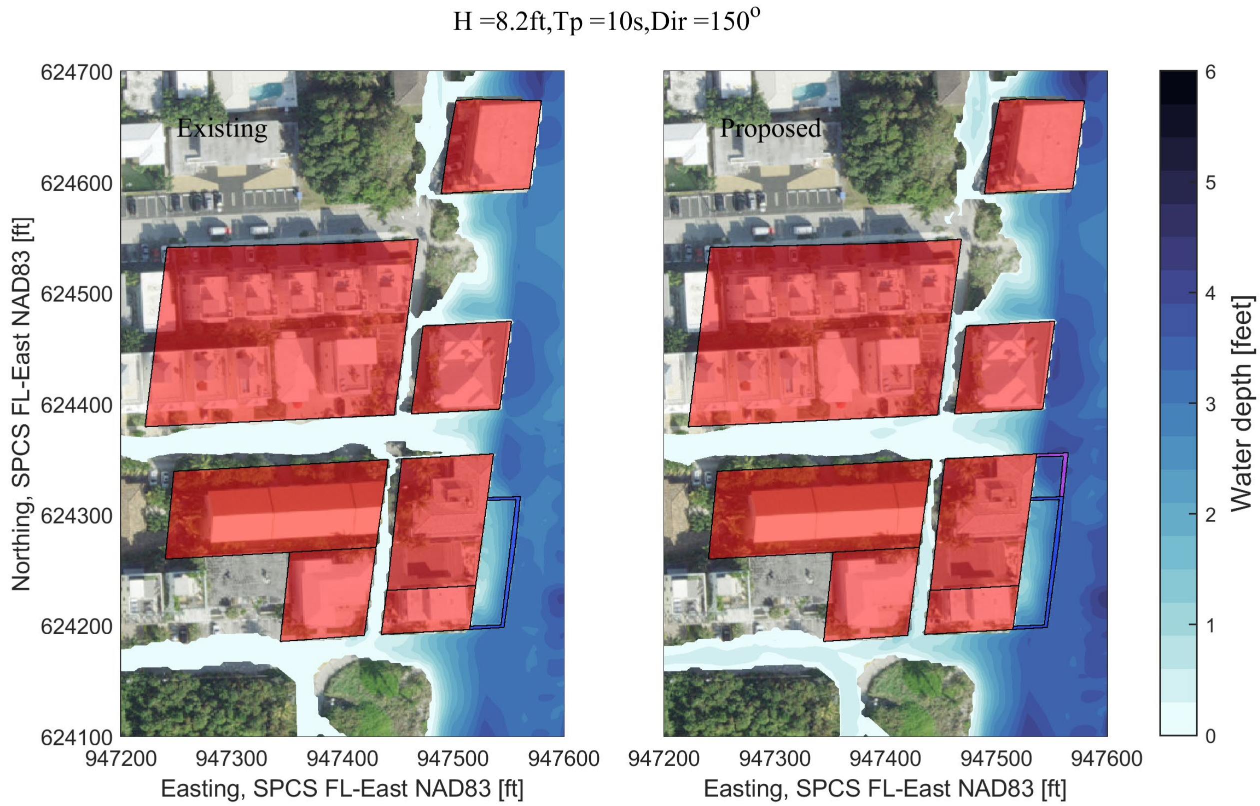


Figure 12. Maximum water depth during condition: H =8.2 feet, Tp =10s and Direction = 150 for existing (left) and proposed (right) conditions.

Water level time series are extracted at "location A" shown in Figure 10 for each model run. An example time series are provided in Figure 13. While there are differences of total water depth at elevation A for individual waves within the time series, there are no significant changes in the water depth due to the presence of the seawall extension.

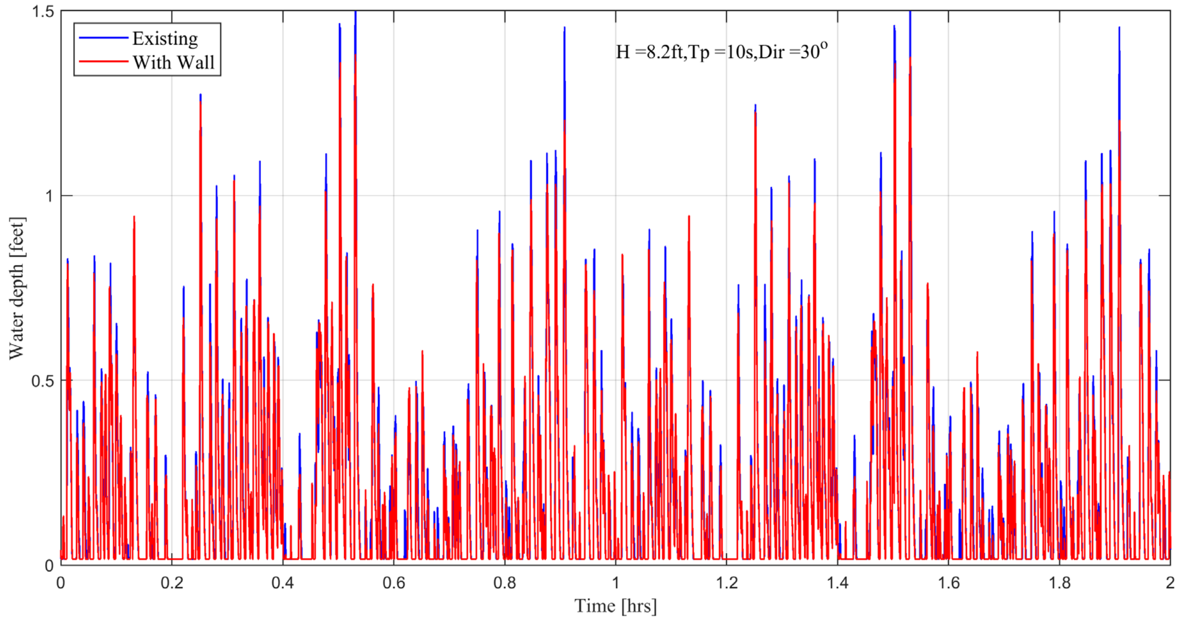


Figure 13. Time series at “location A” for existing and proposed water depths for condition H =8.2 ft, T =10 seconds, and Dir = 30 degrees.

The average of the largest 33% of water depth, ($\overline{h_{\max\frac{1}{3}}}$) , at “location A” for each model run was calculated. Figure 14 provides the comparison between $\overline{h_{\max\frac{1}{3}}}$ at “location A” for existing and proposed conditions. A point which falls on the upper side of the 1:1 line in Figure 15 depicts a case where the water depth at “location A” was larger with the proposed wall compared to current condition. Similarly, a point located below the 1:1 line depicts the inverse. It can be observed that there is no discernable difference in water depth with and without the proposed seawall extension for all cases modeled at “location A”.

vi. Model Summary

Simulation of waves and tides at the project were undertaken to determine if there were measurable differences in the hydrodynamic flows within the Oak Street Right of Way due to the extension of the seawall. Modeling was accomplished using the XBEACH model. While differences in individual waves/flows were observed, they contributed to no measurable change when averaged over the time domain. Therefore, no significant changes in the hydrodynamic flows are expected as a result of the northerly extension of the seawall.

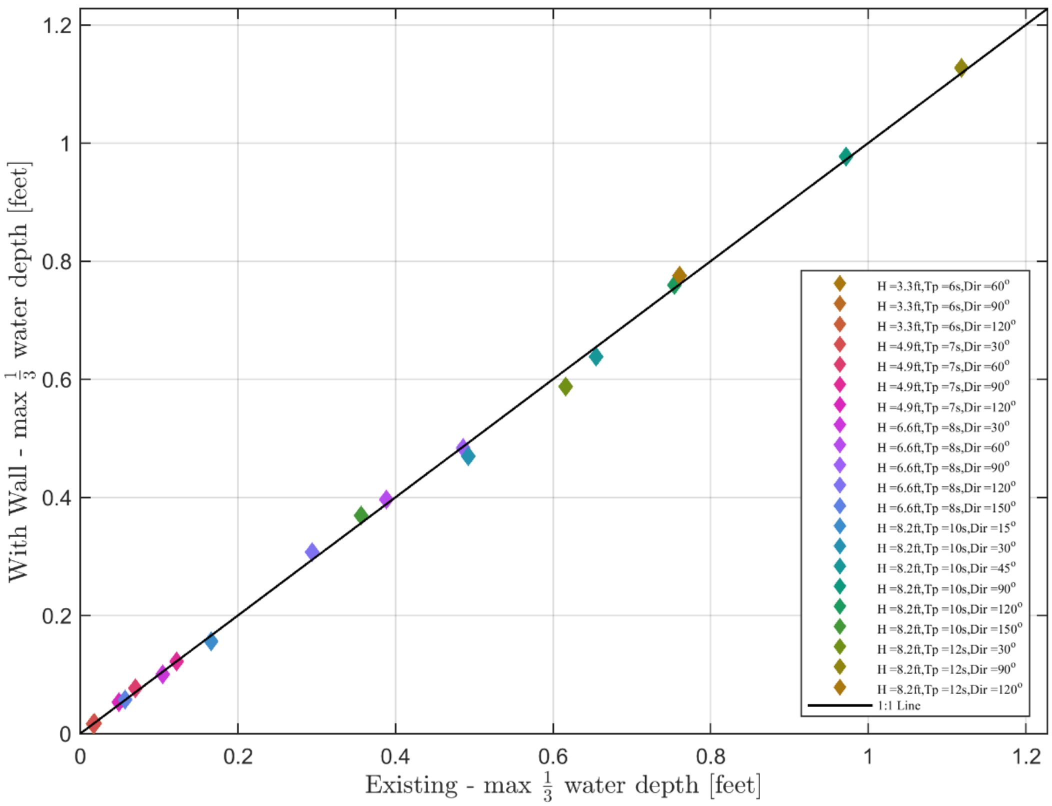


Figure 14. Comparison $\overline{h_{\max\frac{1}{3}}}$ for the existing and proposed for all cases at "location A".

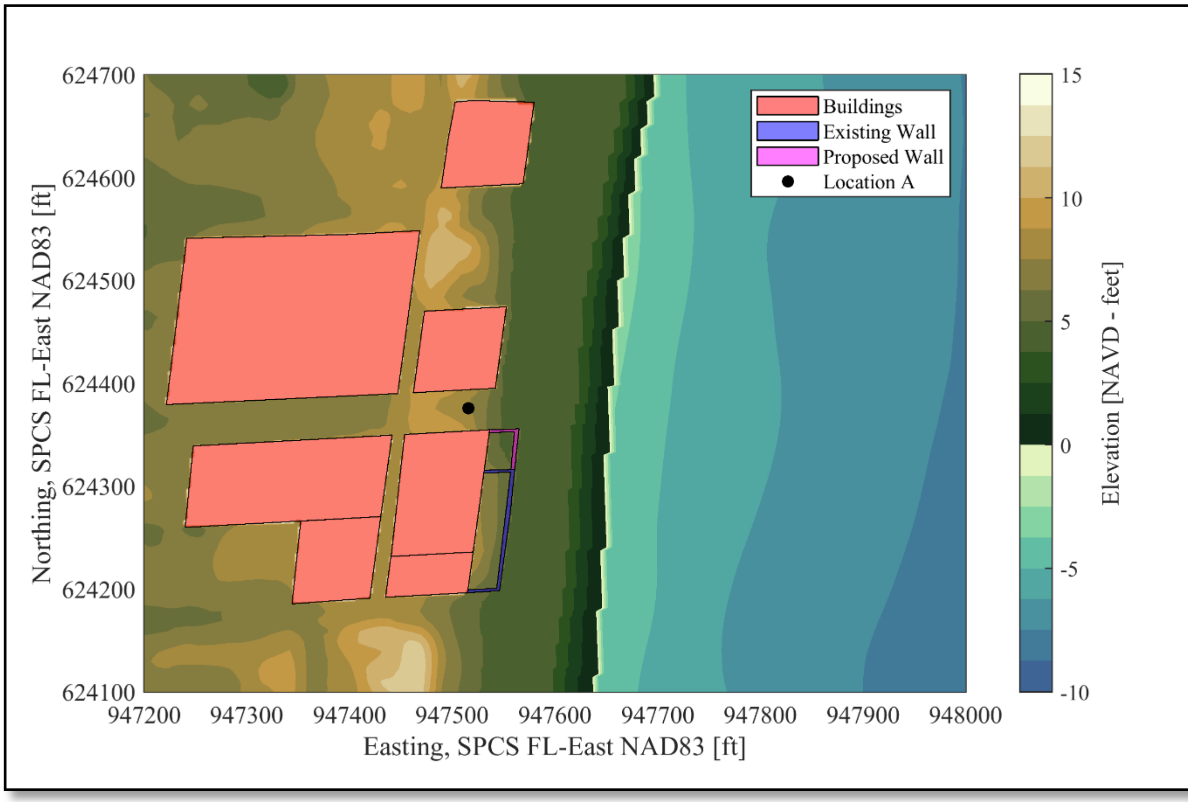
E. References

Dean, R. and Chiu, T.Y., "Hurricane Tide Frequency Analysis for Broward County, Florida", report to Department of Natural Resources Bureau of Beaches and Shores, Tallahassee, Florida, April 1981.

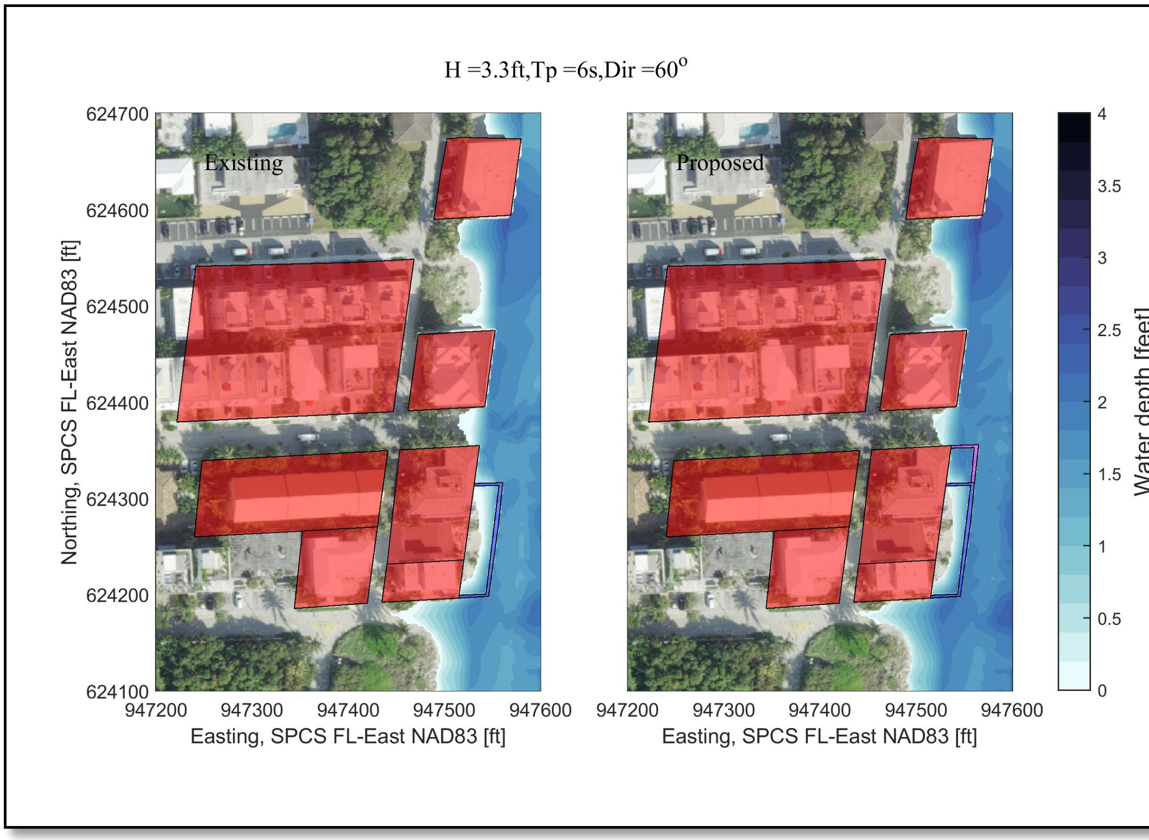
Roelvink, Dano, et al. "XBeach Model Description and Manual." Unesco-IHE Institute for Water Education, Deltares and Delft University of Technology. Report June 21 (2010): 2010.

Appendix A

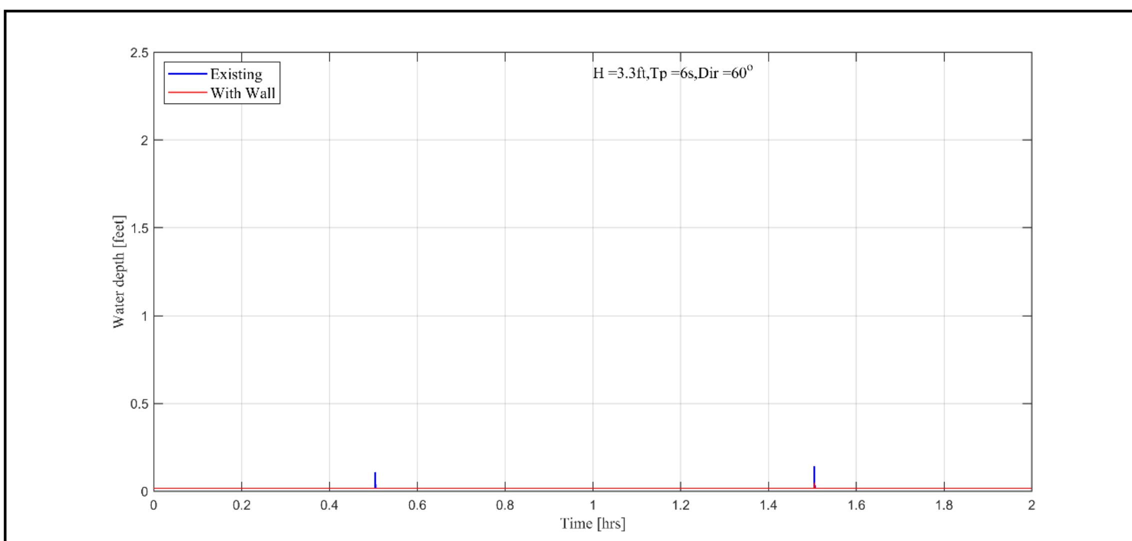
Individual Model Run Results



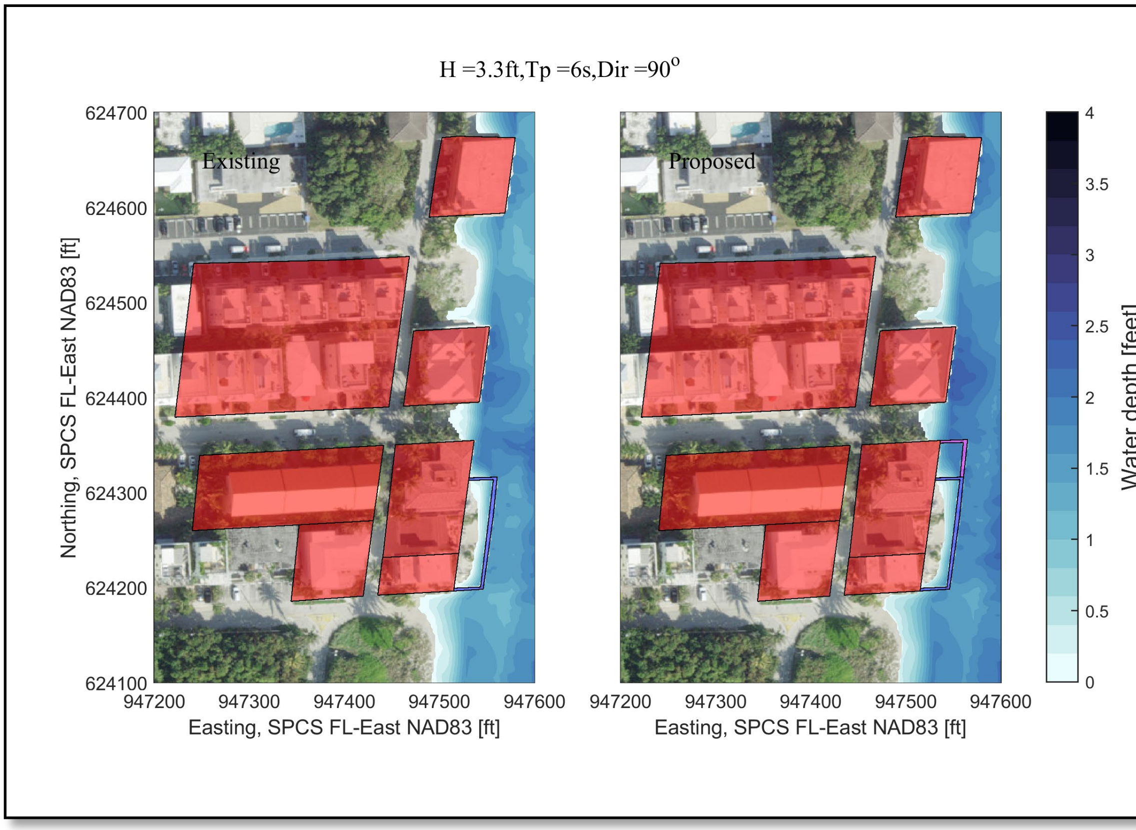
A1. XBeach model domain showing the existing buildings, existing seawall, proposed seawall, and a location "A" on Oak Street right-of-way where water depth time-series were recorded.



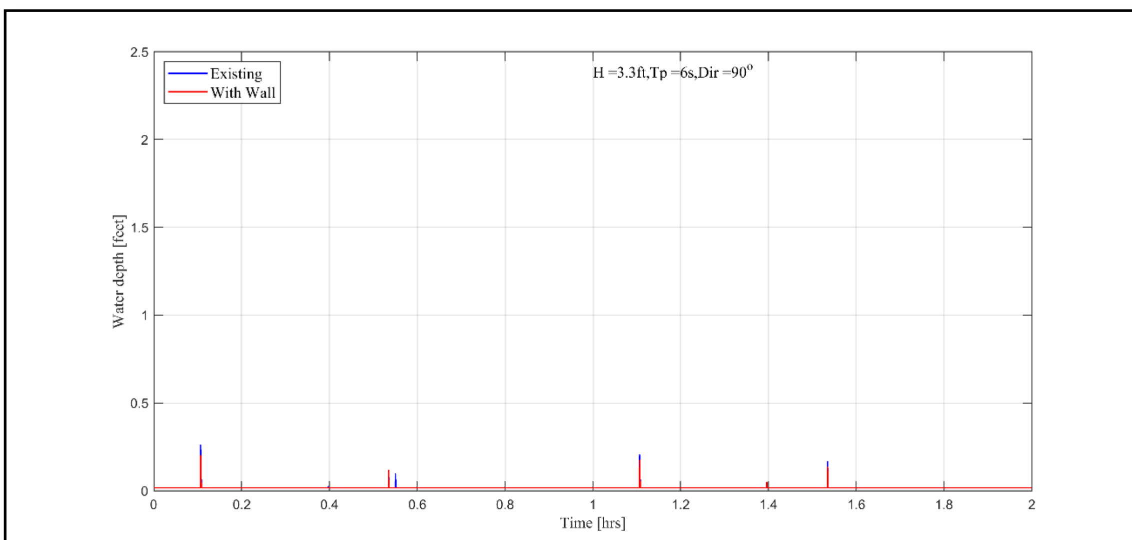
A2. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 3.3 ft, wave period = 6s, and wave direction = 60° from North.



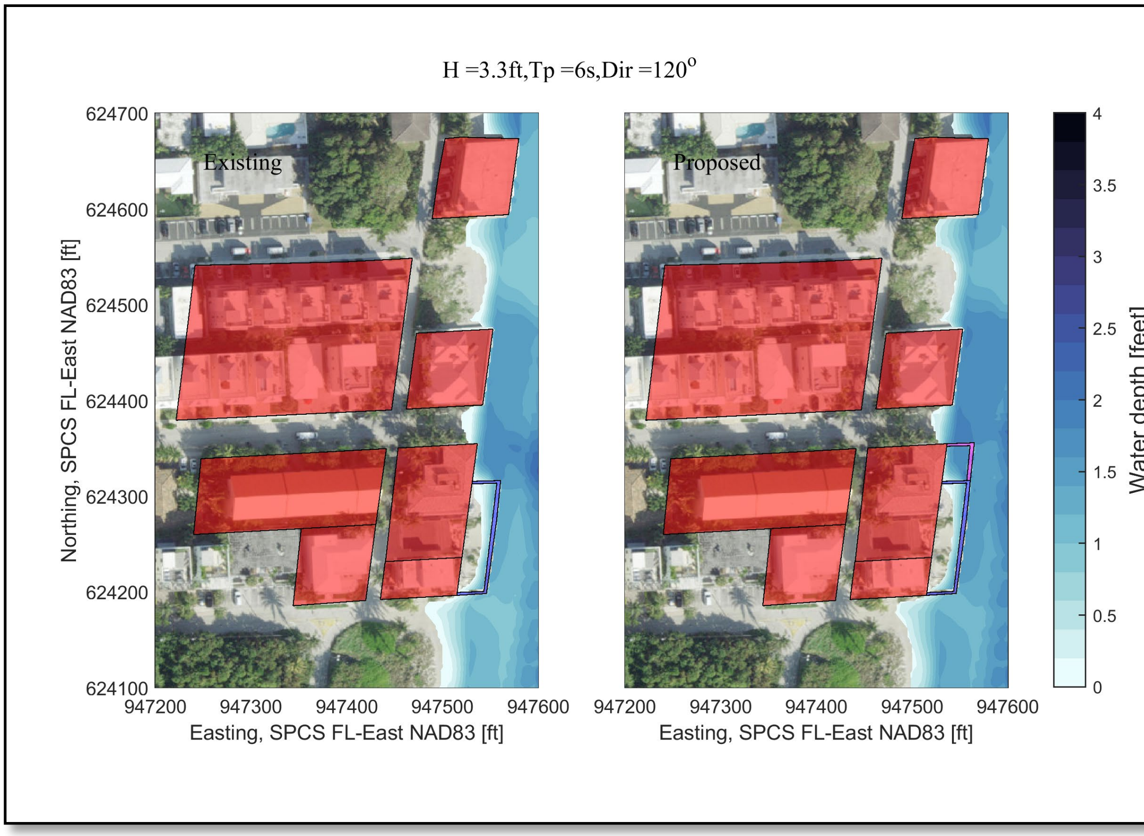
A3. Time-series of water depth recorded on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 3.3 ft, wave period = 6s, and wave direction = 60° from North.



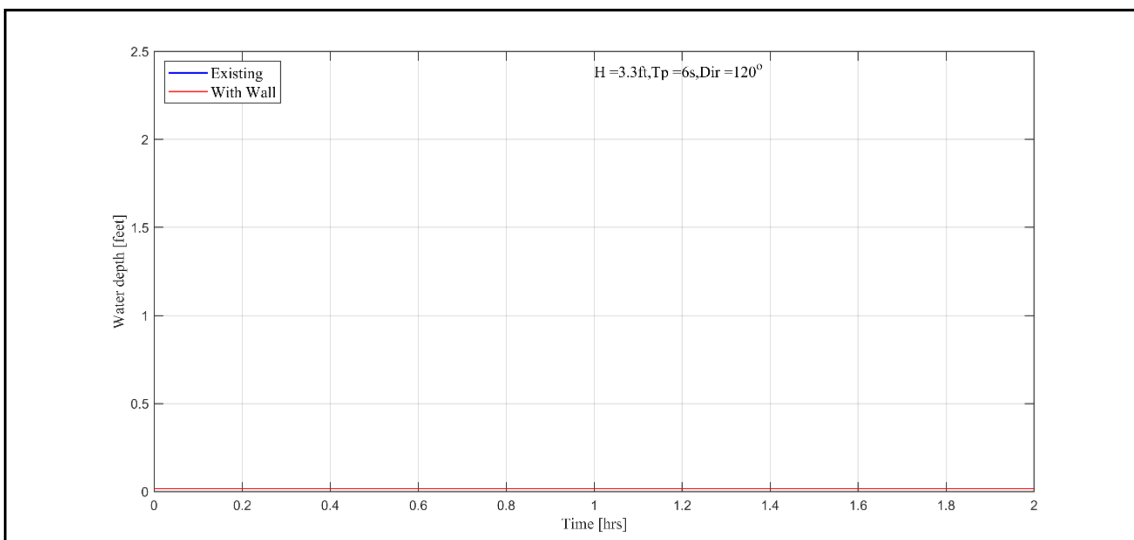
A4. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 3.3 ft, wave period = 6s, and wave direction = 90° from North.



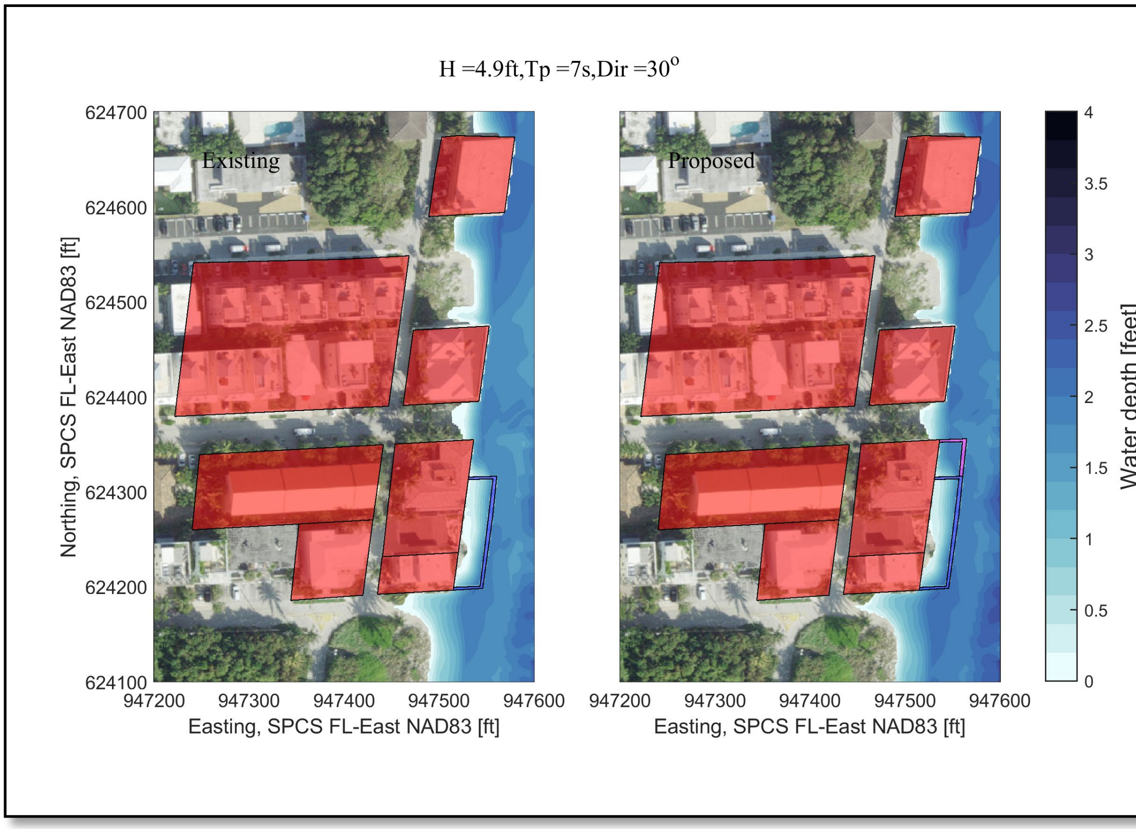
A5. Time-series of water depth recorded on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 3.3 ft, wave period = 6s, and wave direction = 90° from North.



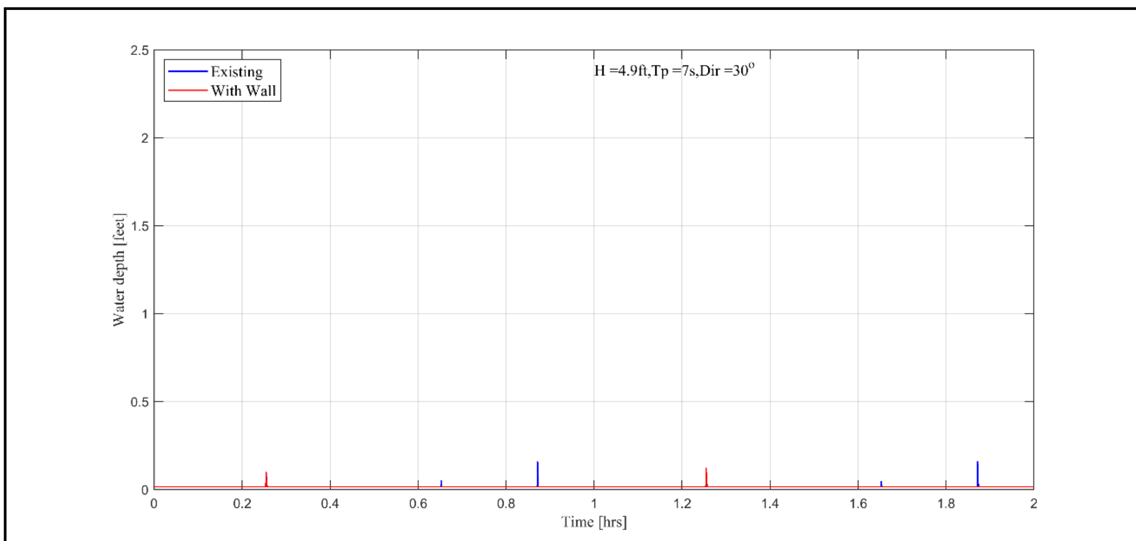
A6. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 3.3 ft, wave period = 6s, and wave direction = 120° from North.



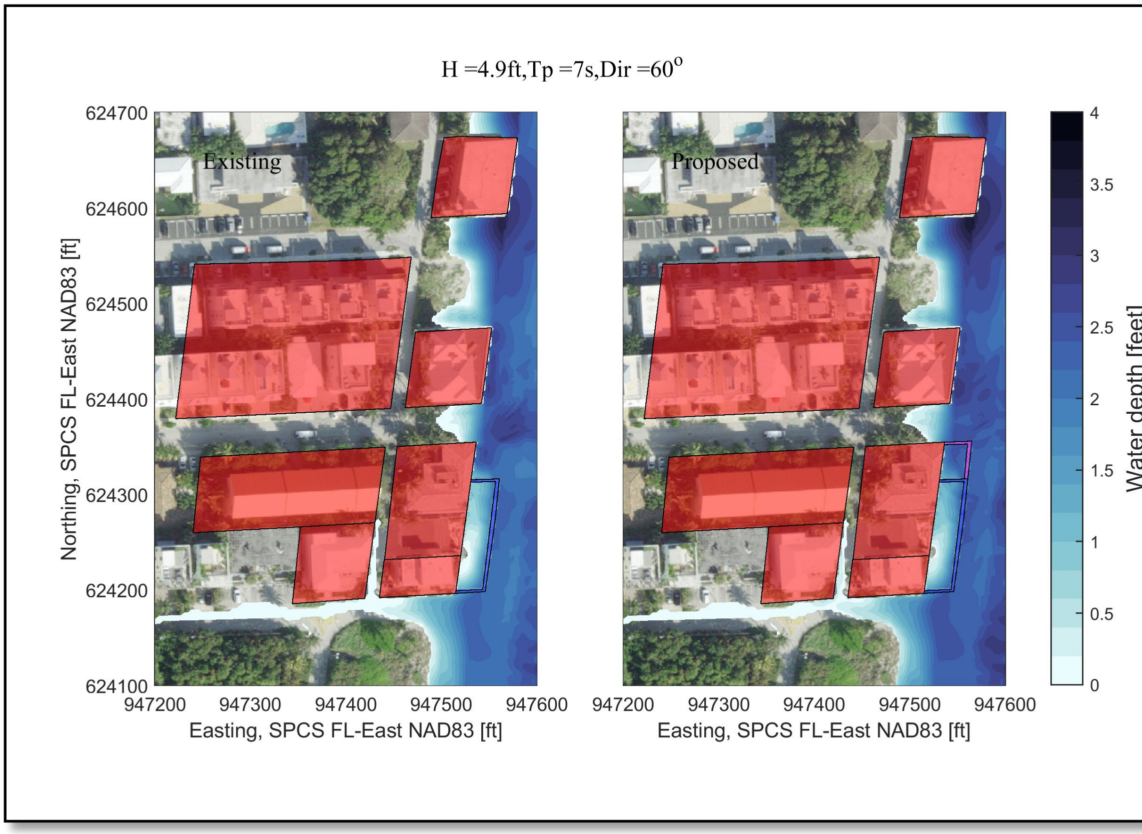
A7. Time-series of water depth recorded on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 3.3 ft, wave period = 6s, and wave direction = 120° from North.



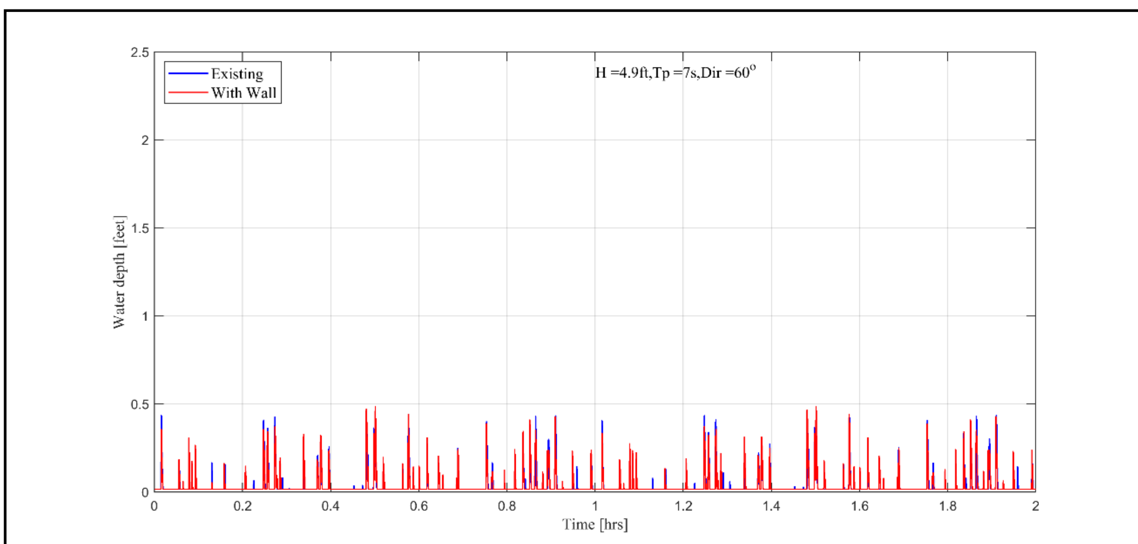
A8. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 4.9 ft, wave period = 7s, and wave direction = 30° from North.



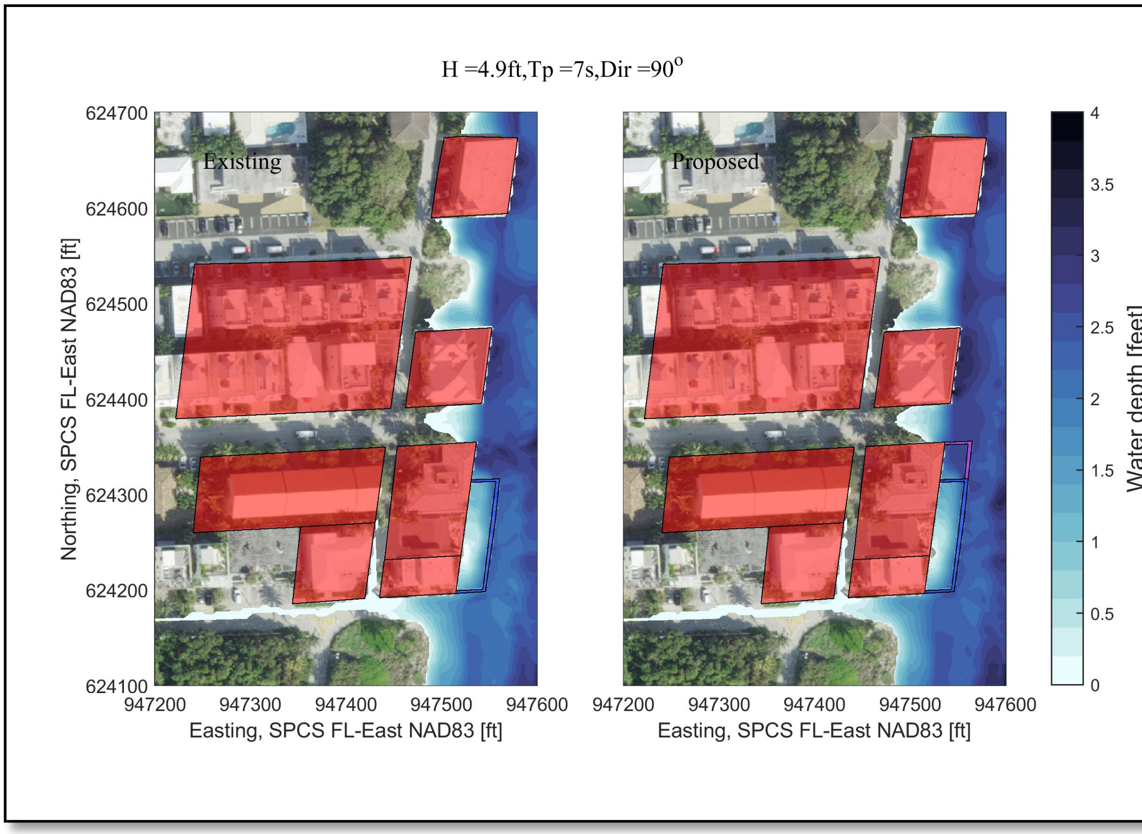
A9. Time-series of water depth recorded on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 4.9 ft, wave period = 7s, and wave direction = 30° from North.



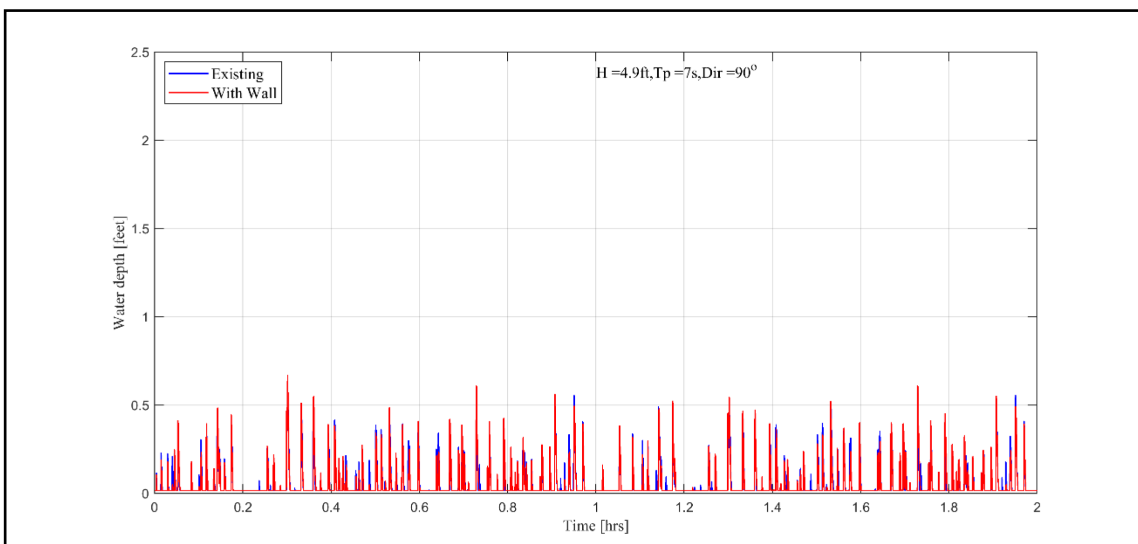
A10. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 4.9 ft, wave period = 7s, and wave direction = 60^{o} from North.



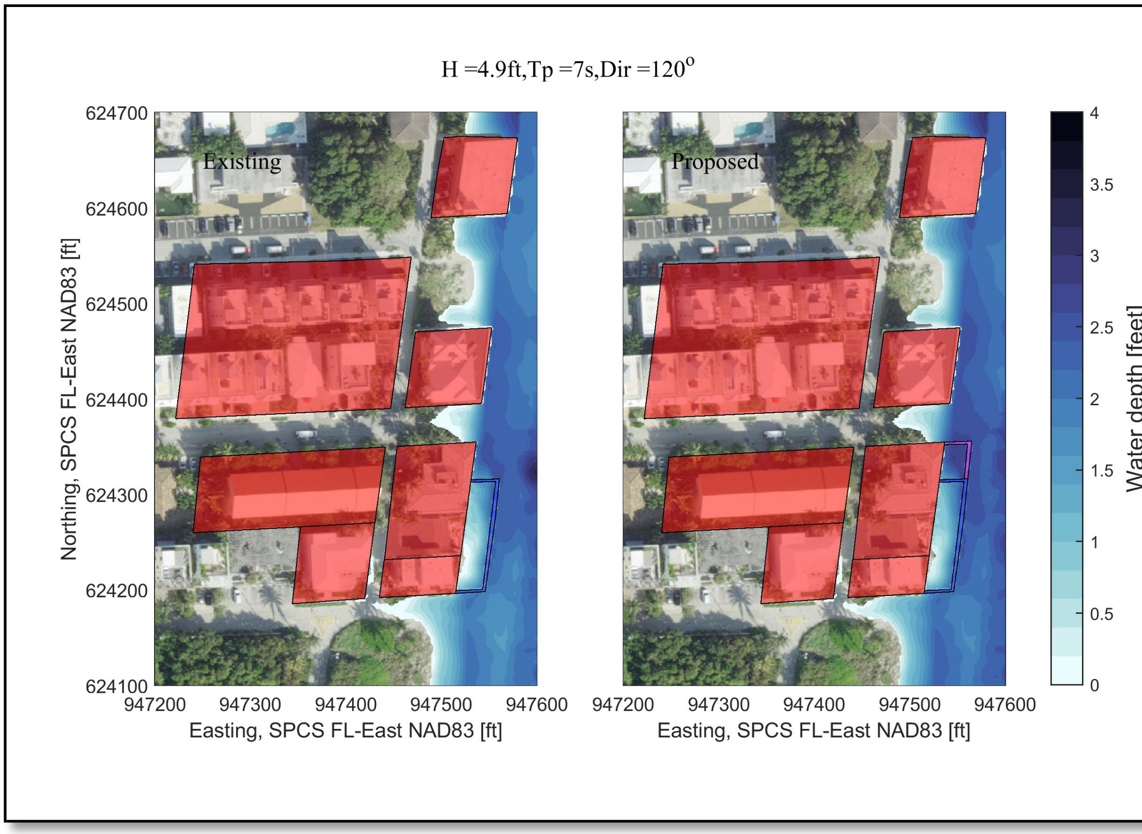
A11. Time-series of water depth recorded on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 4.9 ft, wave period = 7s, and wave direction = 60^{o} from North.



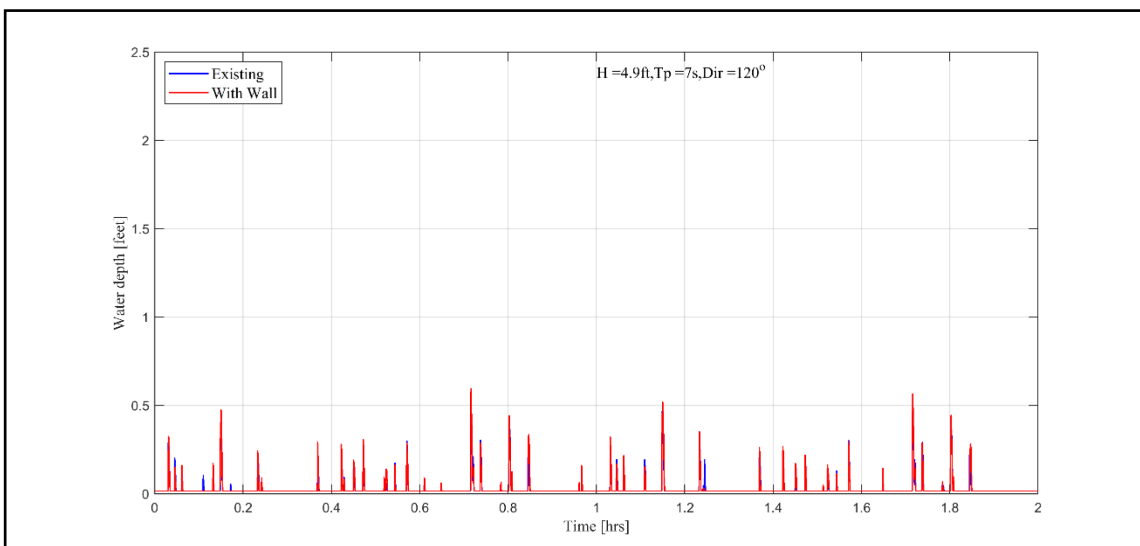
A12. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 4.9 ft, wave period = 7s, and wave direction = 90° from North.



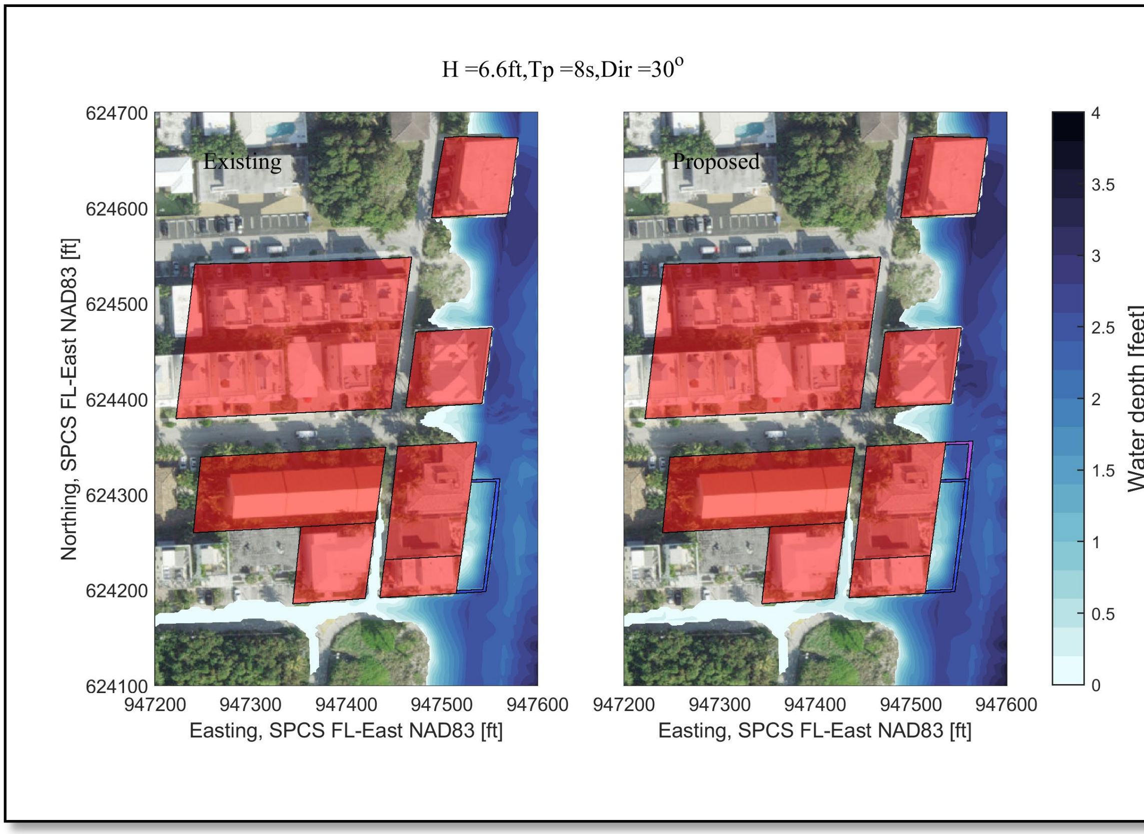
A13. Time-series of water depth recorded on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 4.9 ft, wave period = 7s, and wave direction = 90° from North.



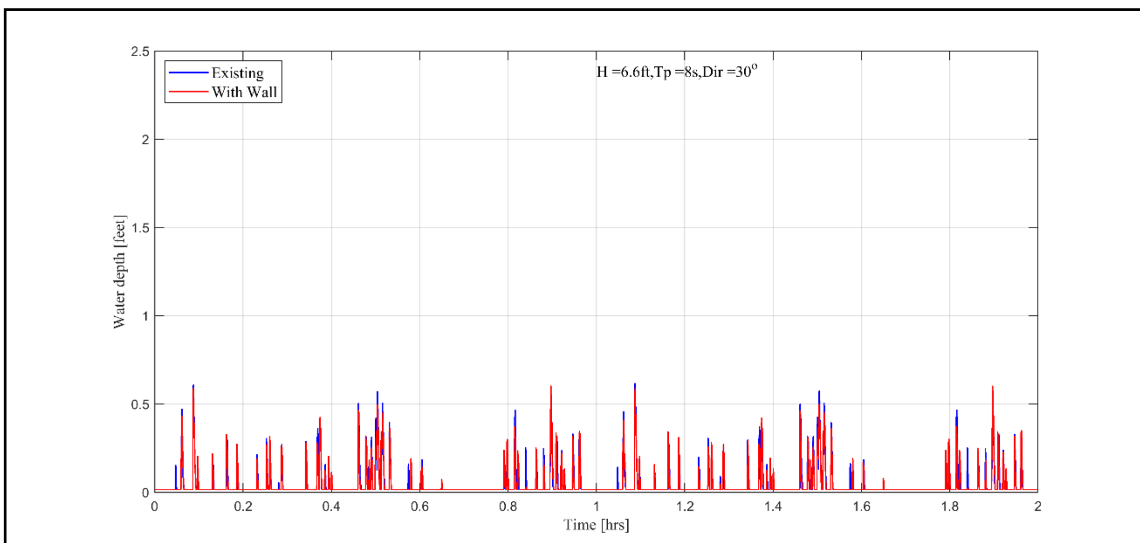
A14. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 4.9 ft, wave period = 7s, and wave direction = 120° from North.



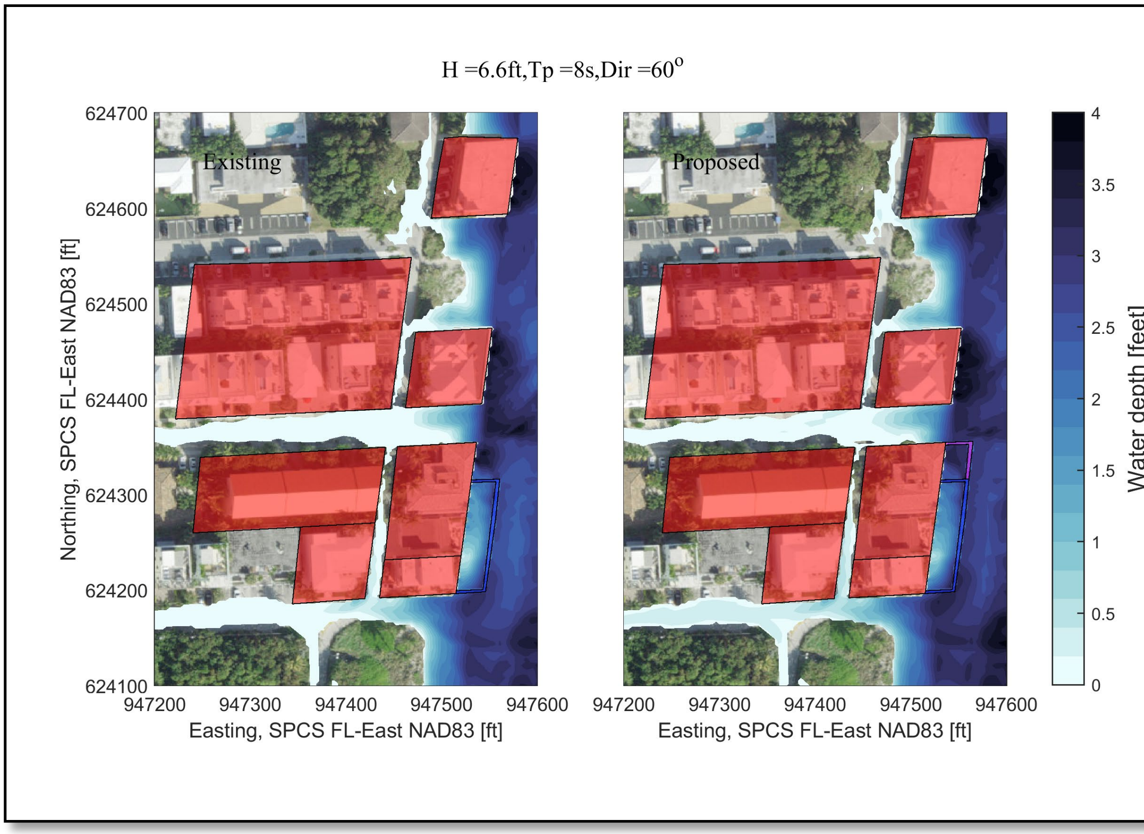
A15. Time-series of water depth recorded on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 4.9 ft, wave period = 7s, and wave direction = 120° from North.



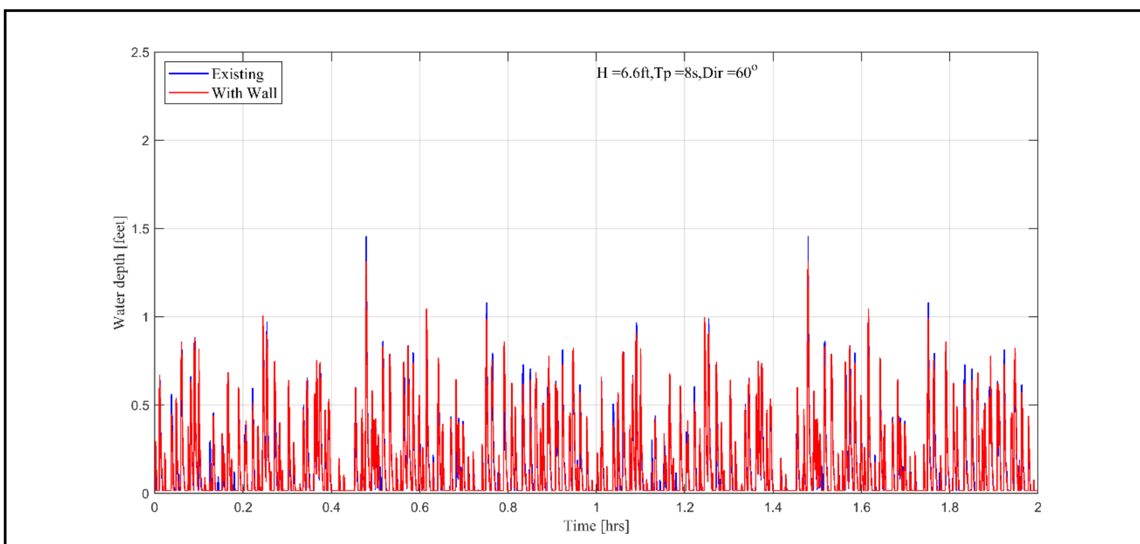
A16. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 6.6 ft, wave period = 8s, and wave direction = 30° from North.



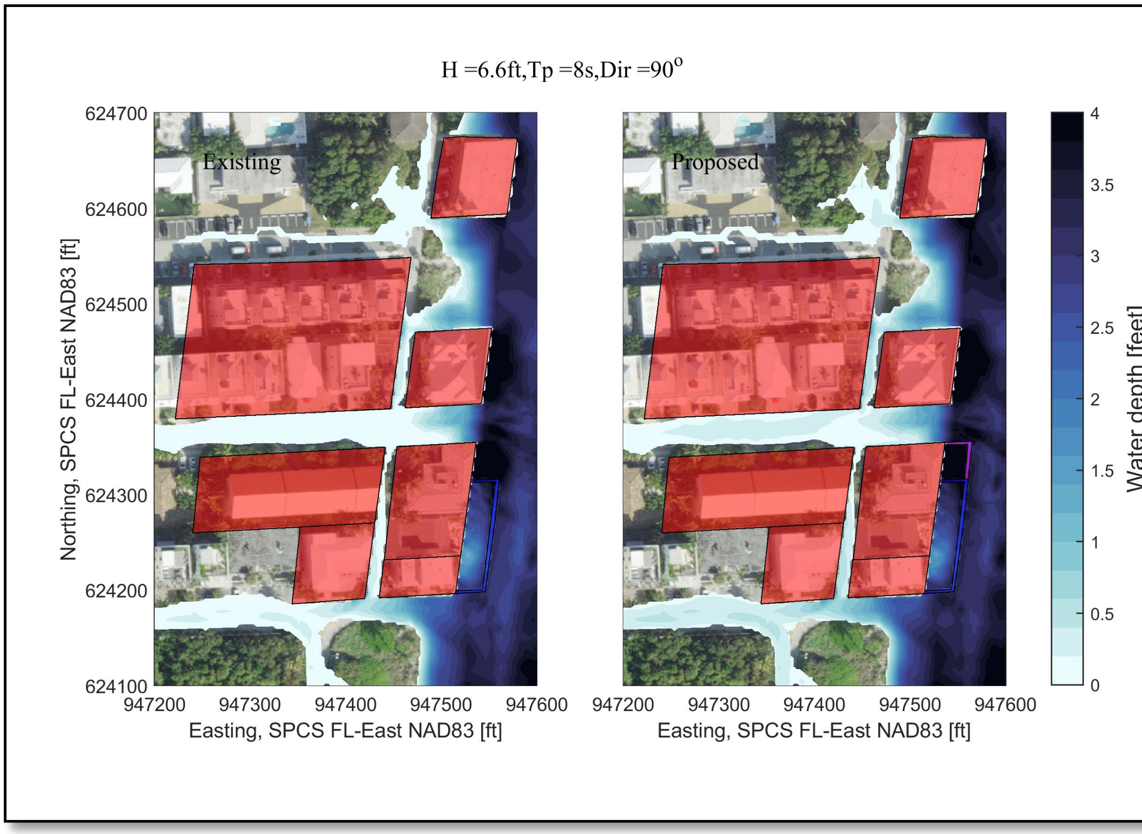
A17. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 6.6 ft, wave period = 8s, and wave direction = 30° from North.



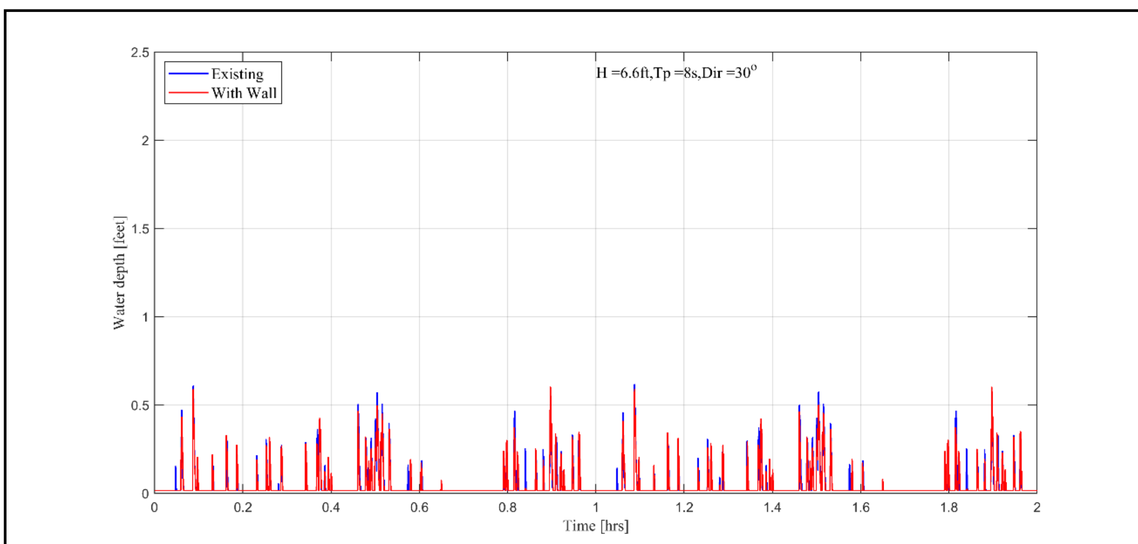
A18. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 6.6 ft, wave period = 8s, and wave direction = 60° from North.



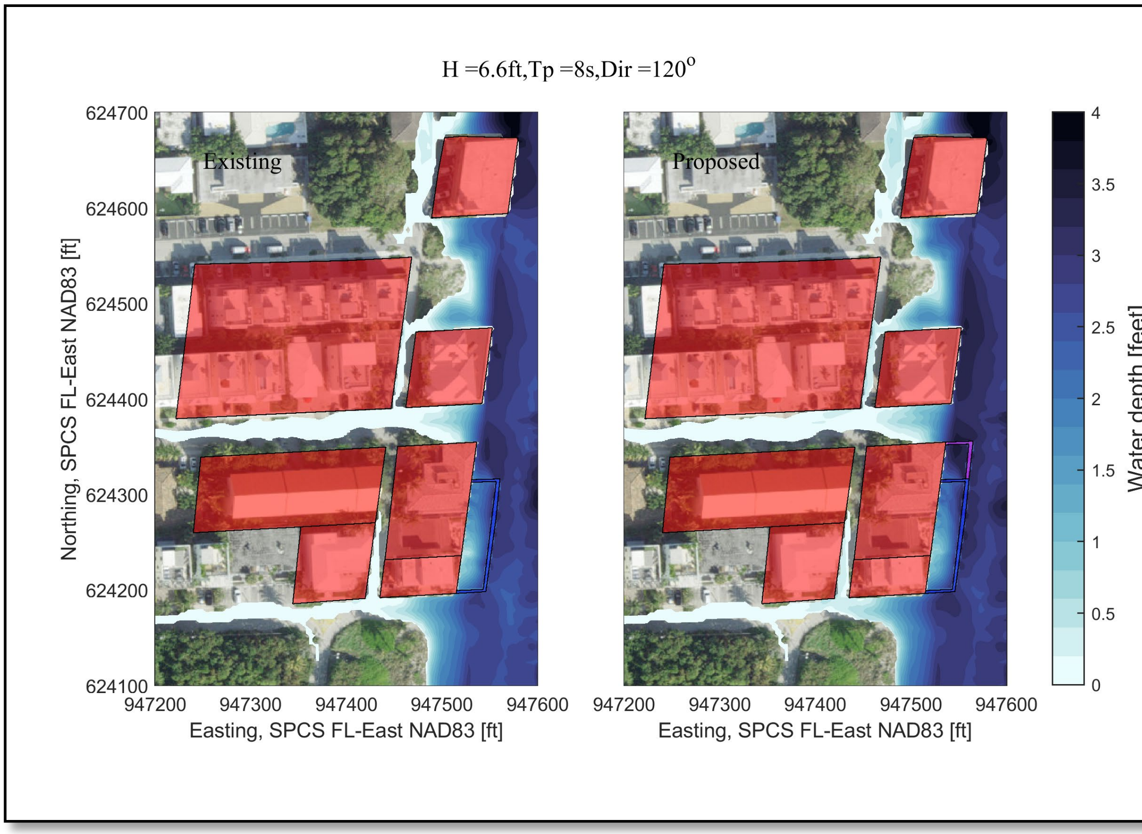
A19. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 6.6 ft, wave period = 8s, and wave direction = 60° from North.



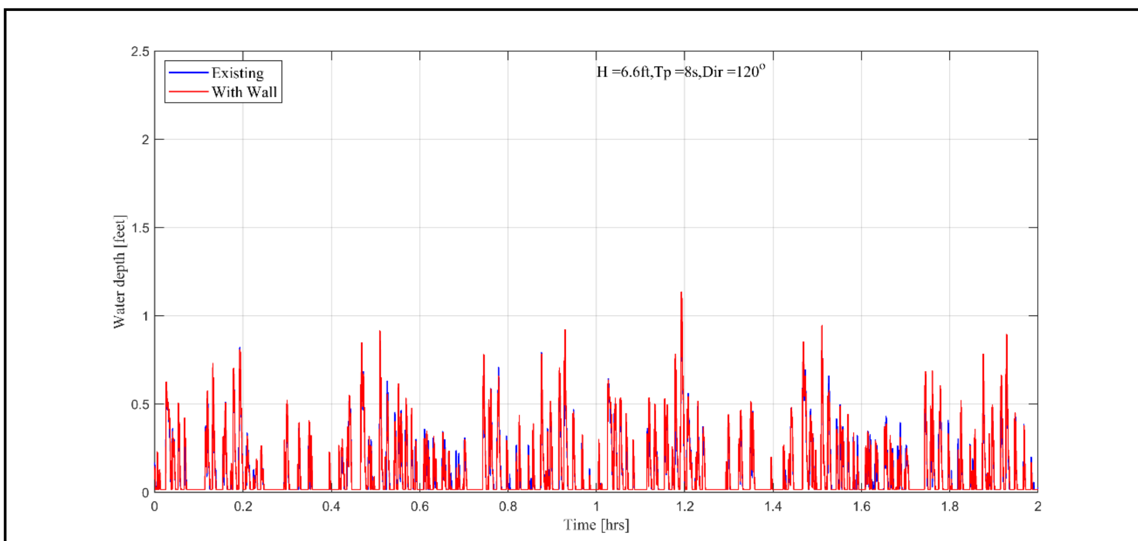
A20. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 6.6 ft, wave period = 8s, and wave direction = 90° from North.



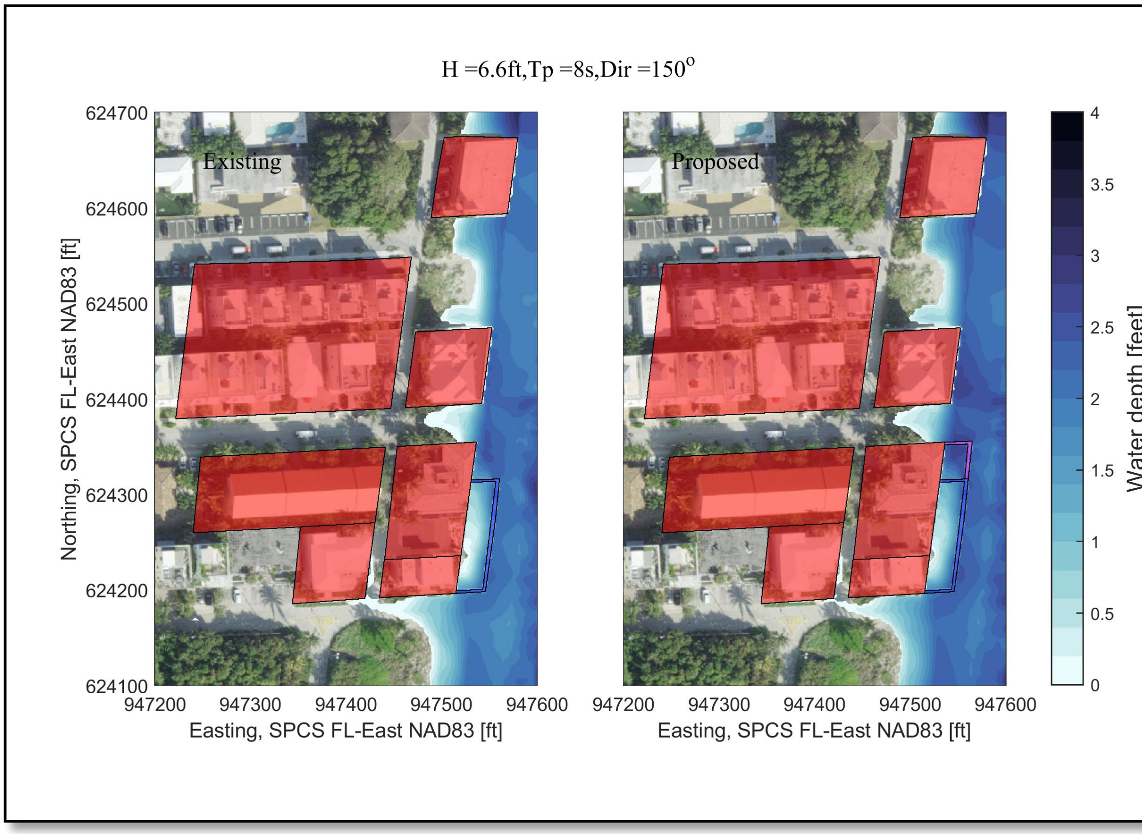
A21. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 6.6 ft, wave period = 8s, and wave direction = 90° from North.



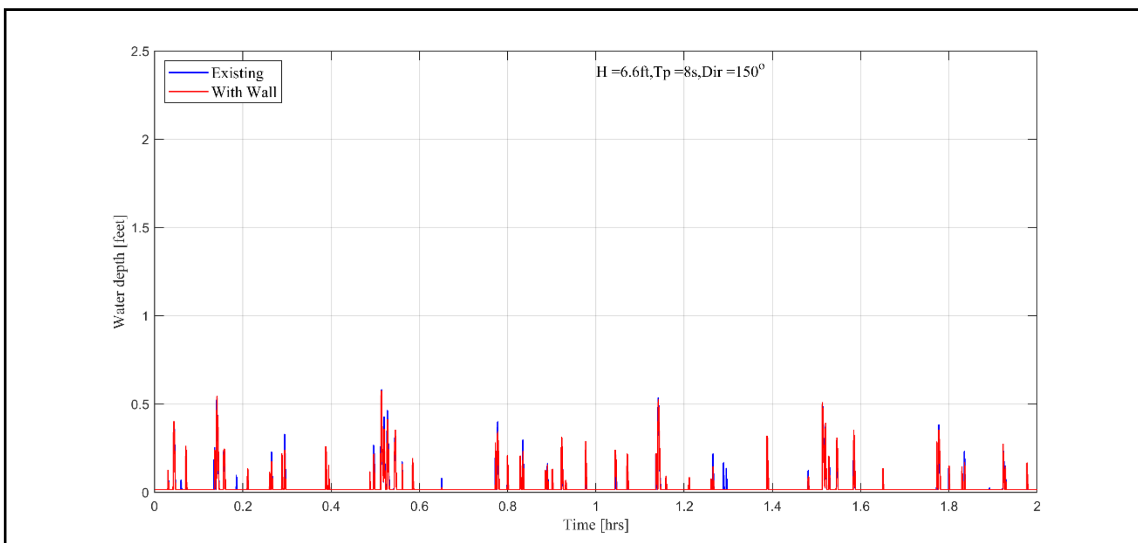
A22. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 6.6 ft, wave period = 8s, and wave direction = 120° from North.



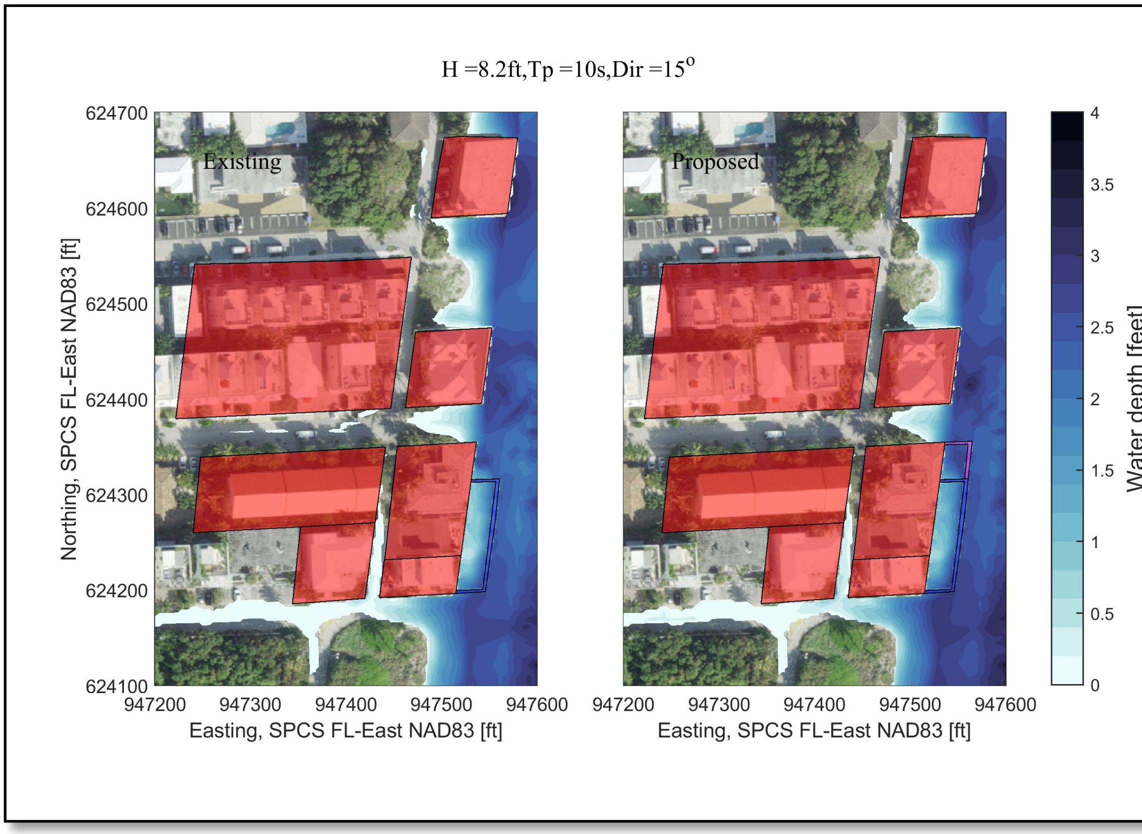
A23. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 6.6 ft, wave period = 8s, and wave direction = 120° from North.



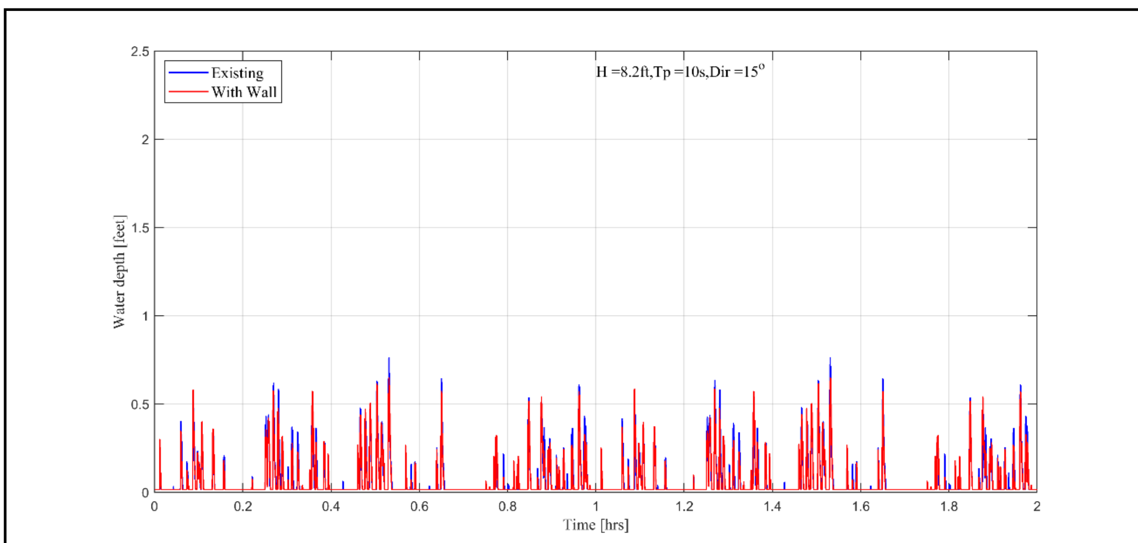
A24. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 6.6 ft, wave period = 8s, and wave direction = 150° from North.



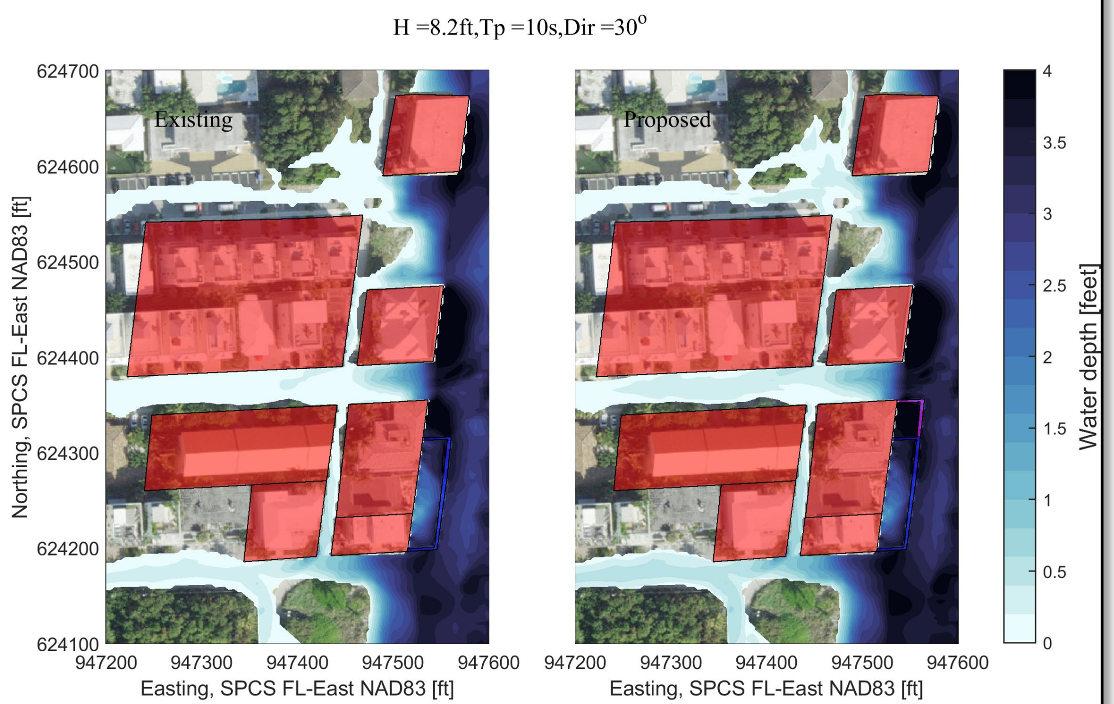
A25. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 6.6 ft, wave period = 8s, and wave direction = 150° from North.



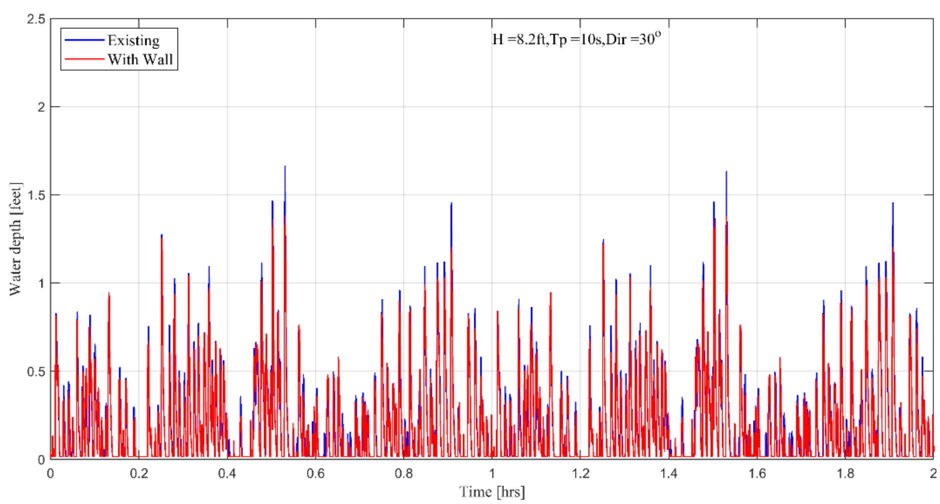
A26. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 8.2 ft, wave period = 10s, and wave direction = 15° from North.



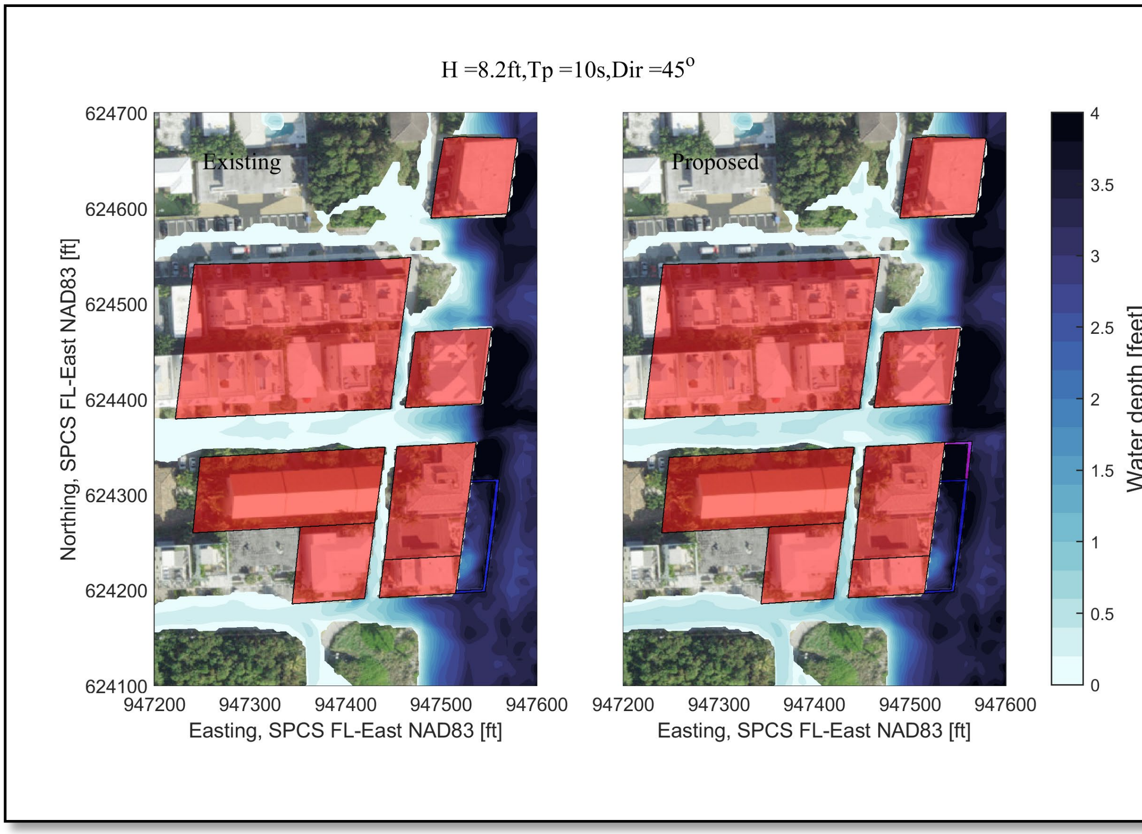
A27. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 8.2 ft, wave period = 10s, and wave direction = 15° from North.



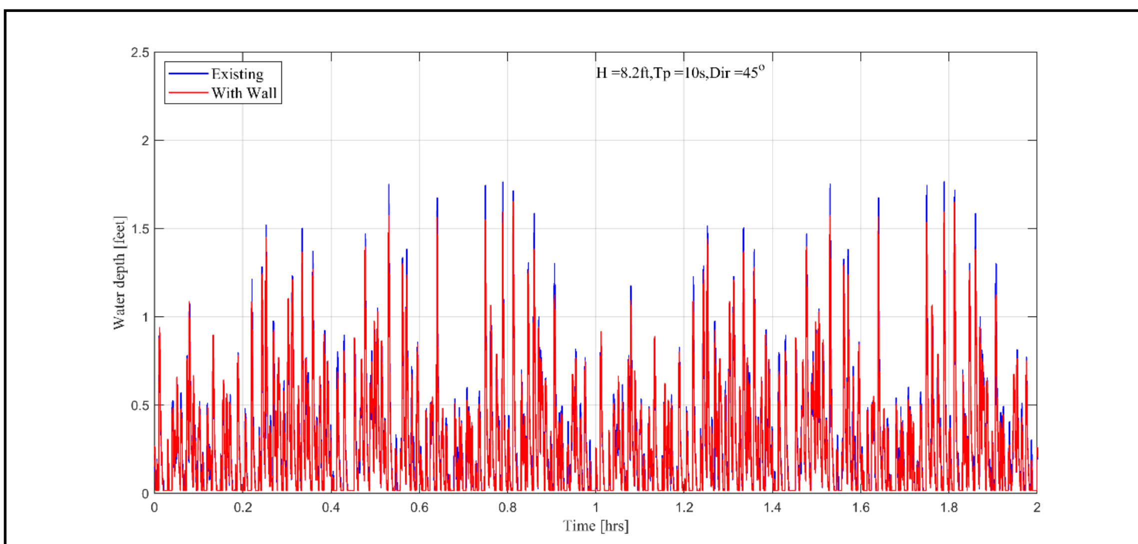
A28. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 8.2 ft, wave period = 10s, and wave direction = 30° from North.



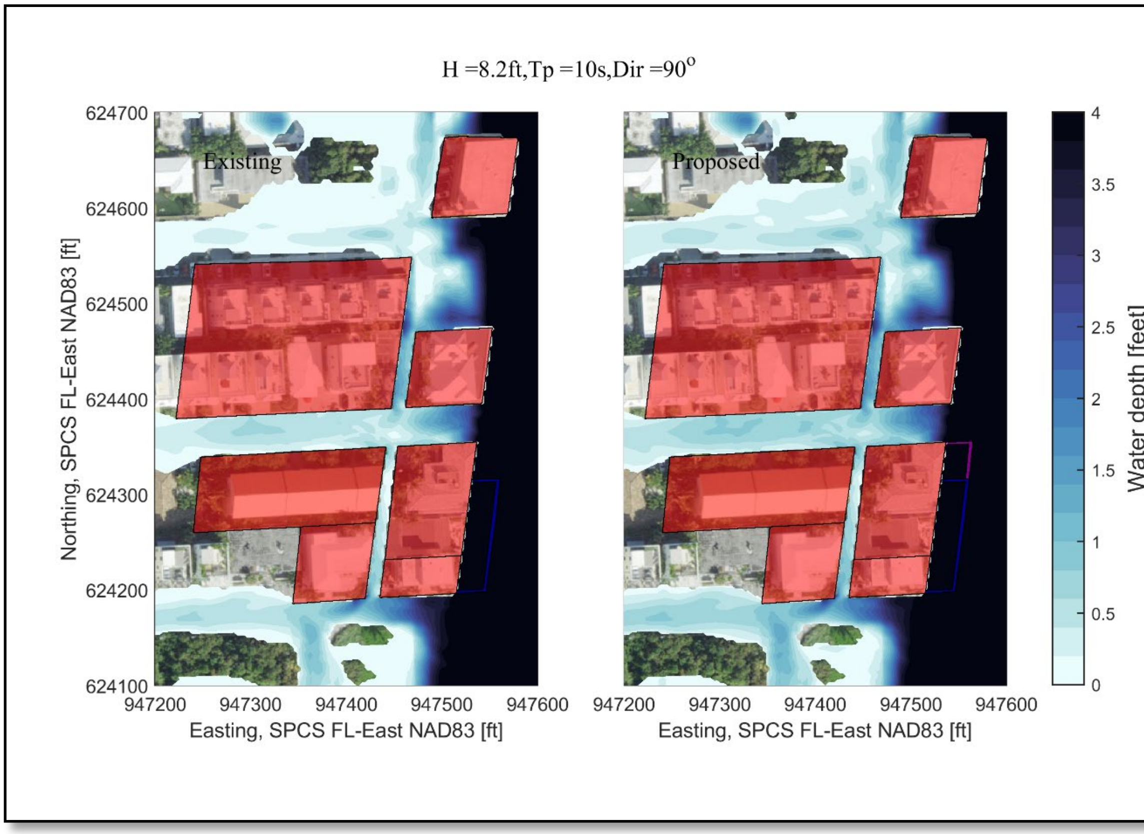
A29. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 8.2 ft, wave period = 10s, and wave direction = 30° from North.



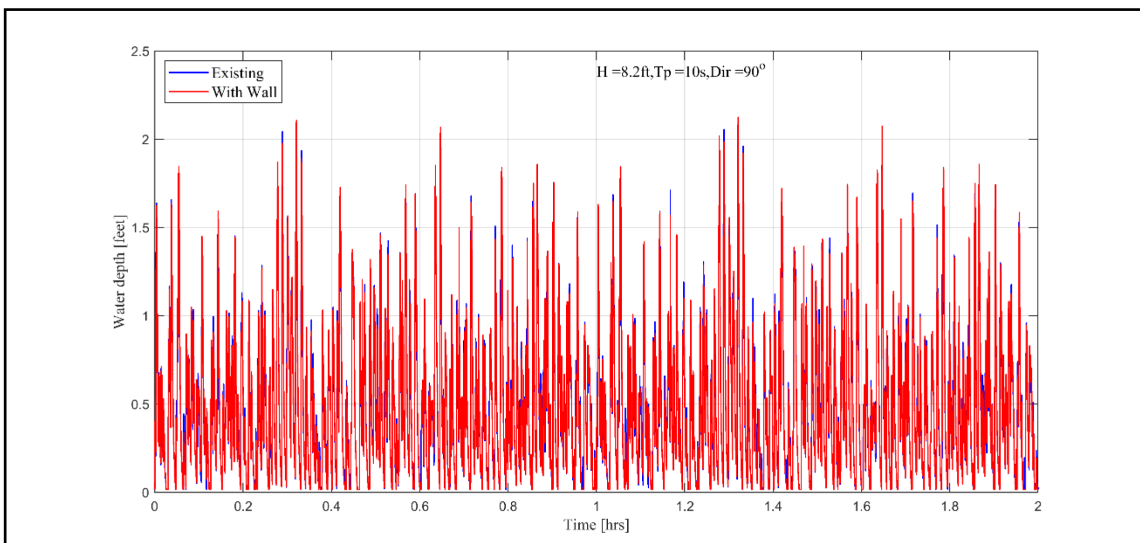
A30. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 8.2 ft, wave period = 10s, and wave direction = 45° from North.



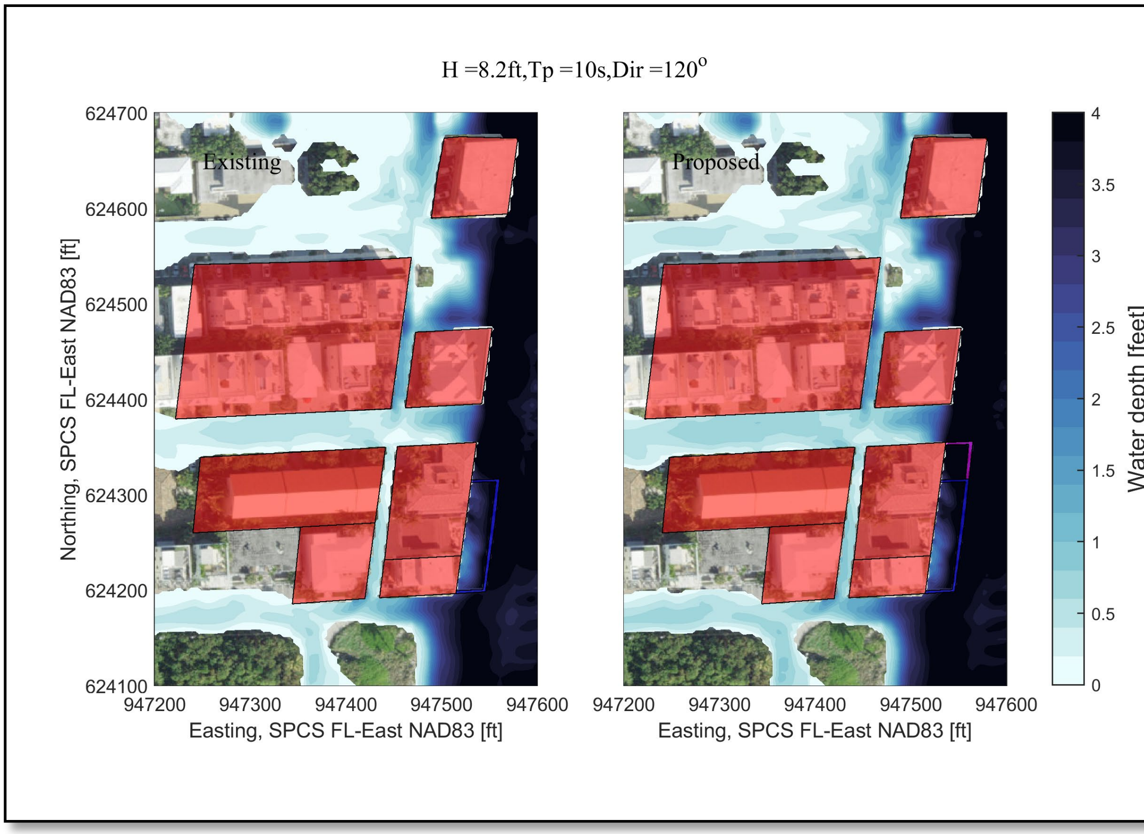
A31. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 8.2 ft, wave period = 10s, and wave direction = 45° from North.



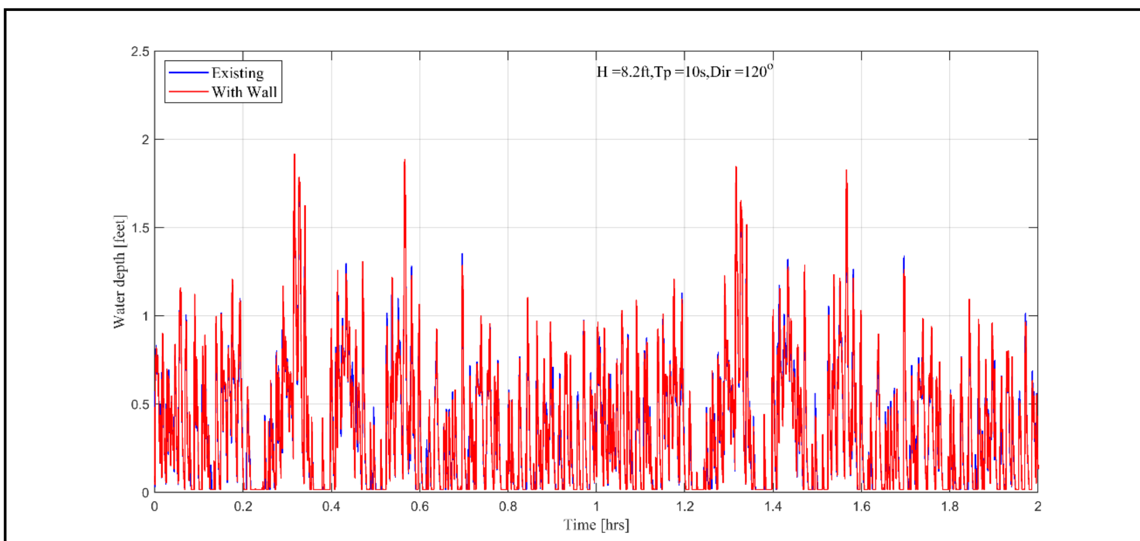
A32. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 8.2 ft, wave period = 10s, and wave direction = 90° from North.



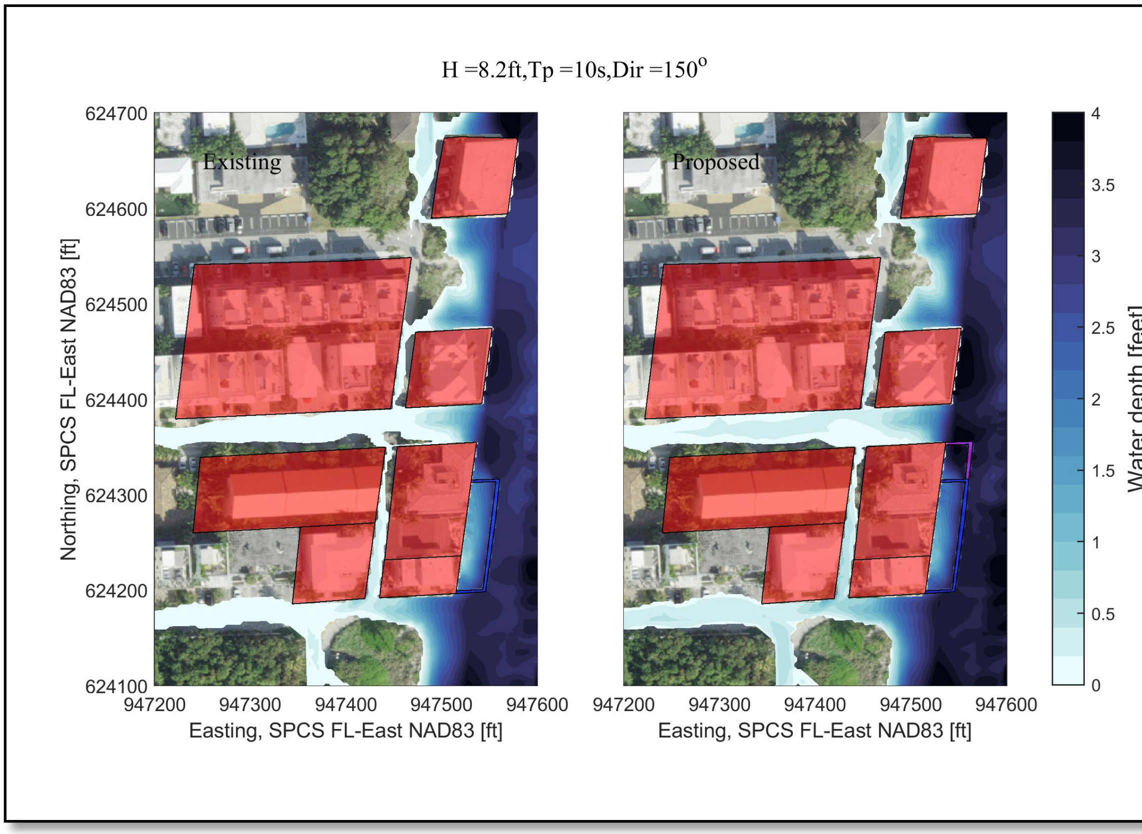
A33. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 8.2 ft, wave period = 10s, and wave direction = 90° from North.



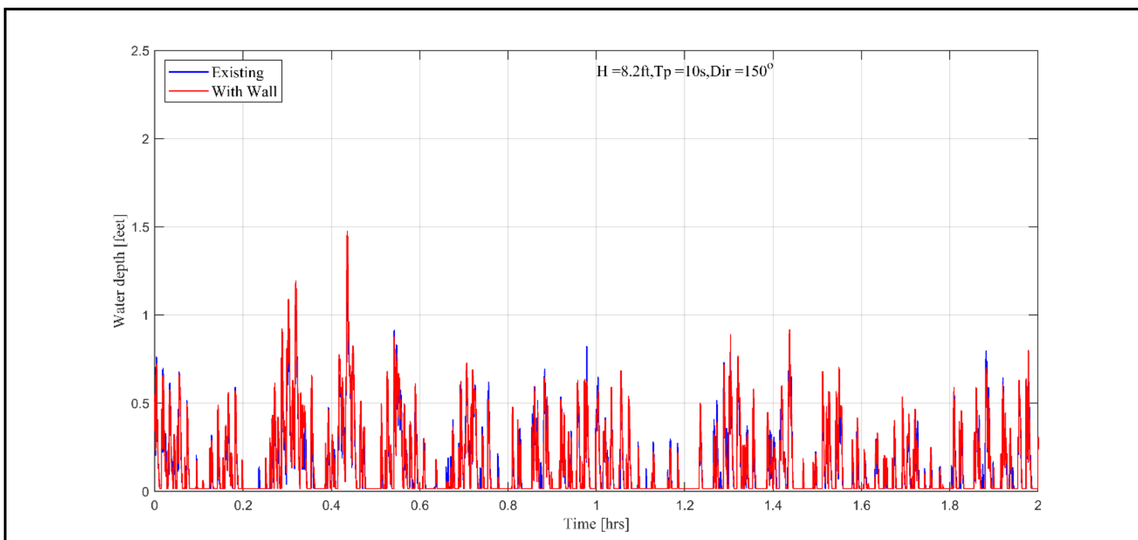
A34. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 8.2 ft, wave period = 10s, and wave direction = 120° from North.



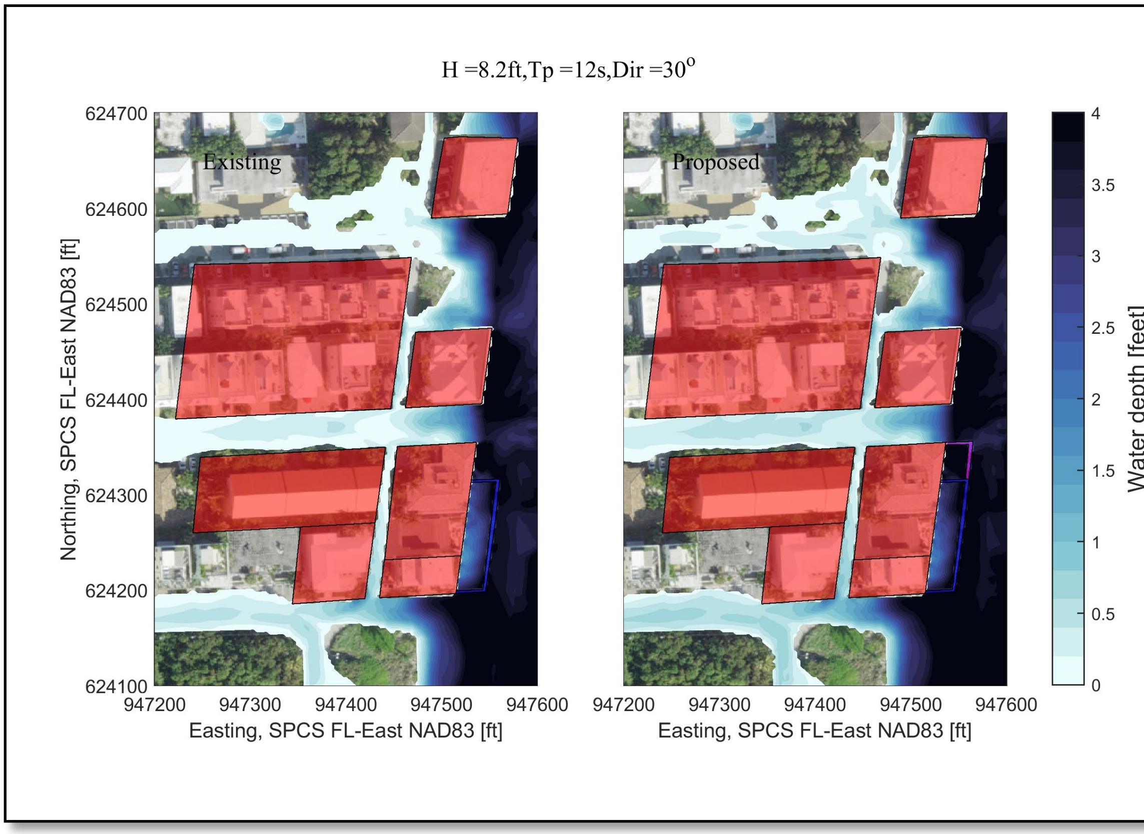
A35. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 8.2 ft, wave period = 10s, and wave direction = 120° from North.



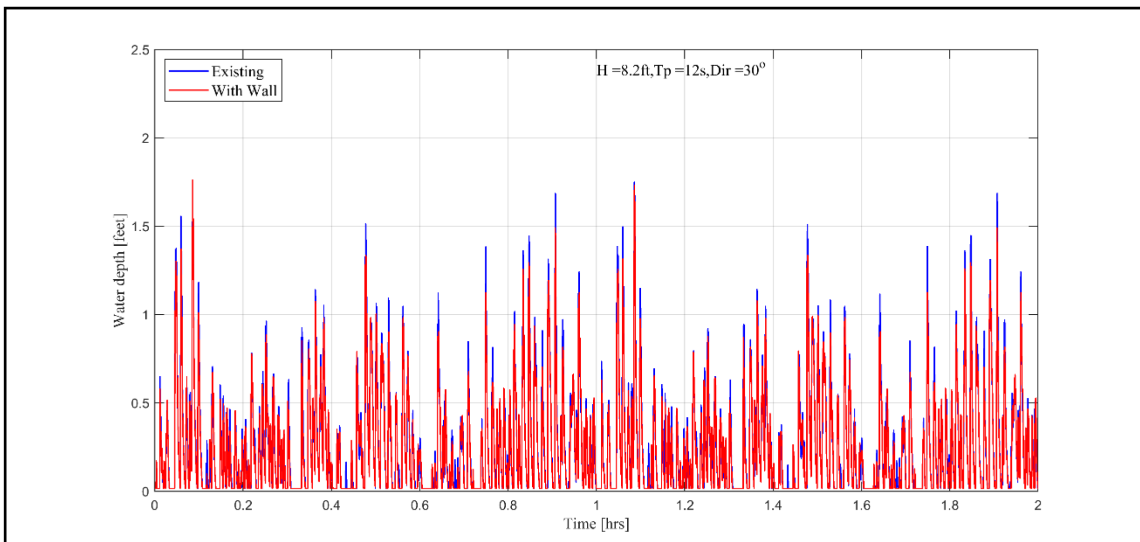
A36. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 8.2 ft, wave period = 10s, and wave direction = 150^{o} from North.



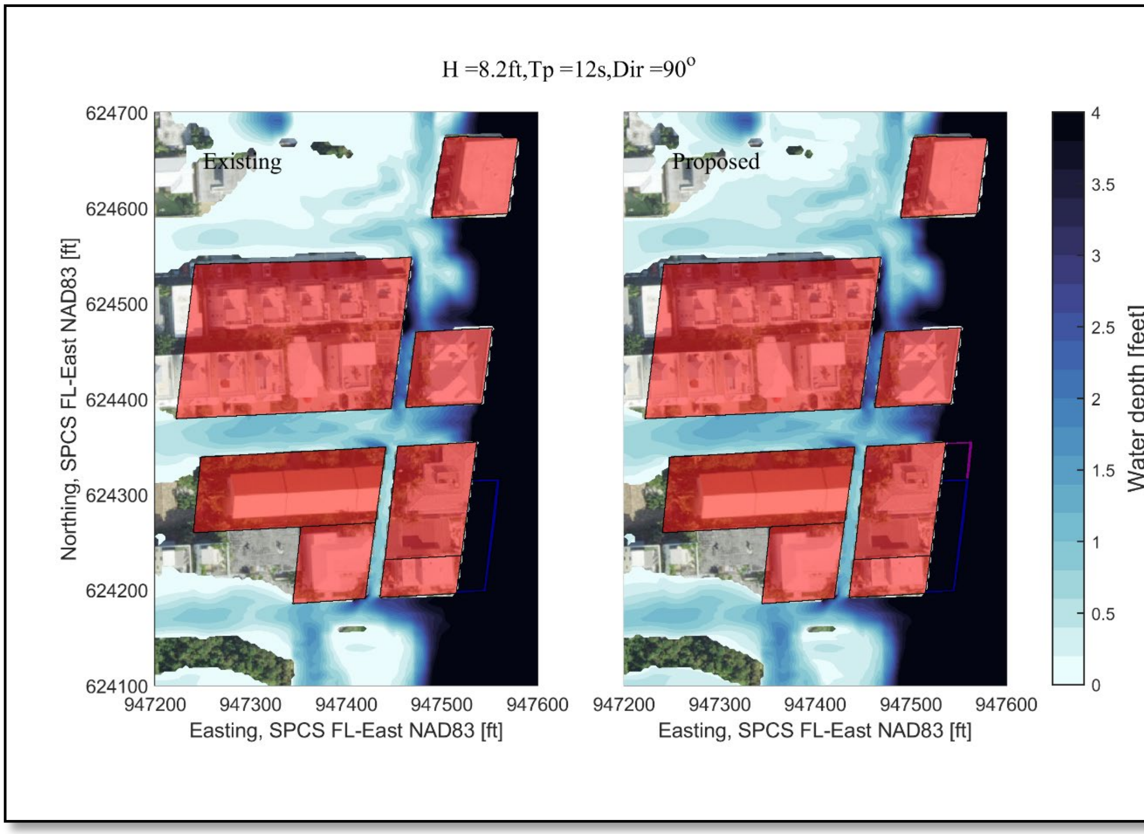
A37. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 8.2 ft, wave period = 10s, and wave direction = 150^{o} from North.



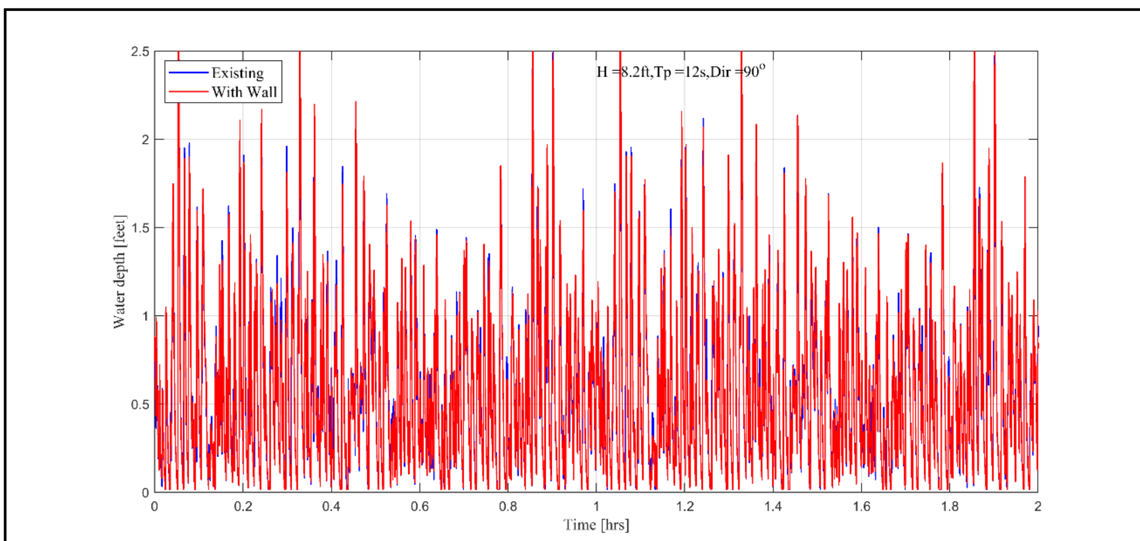
A38. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 8.2 ft, wave period = 12s, and wave direction = 30° from North.



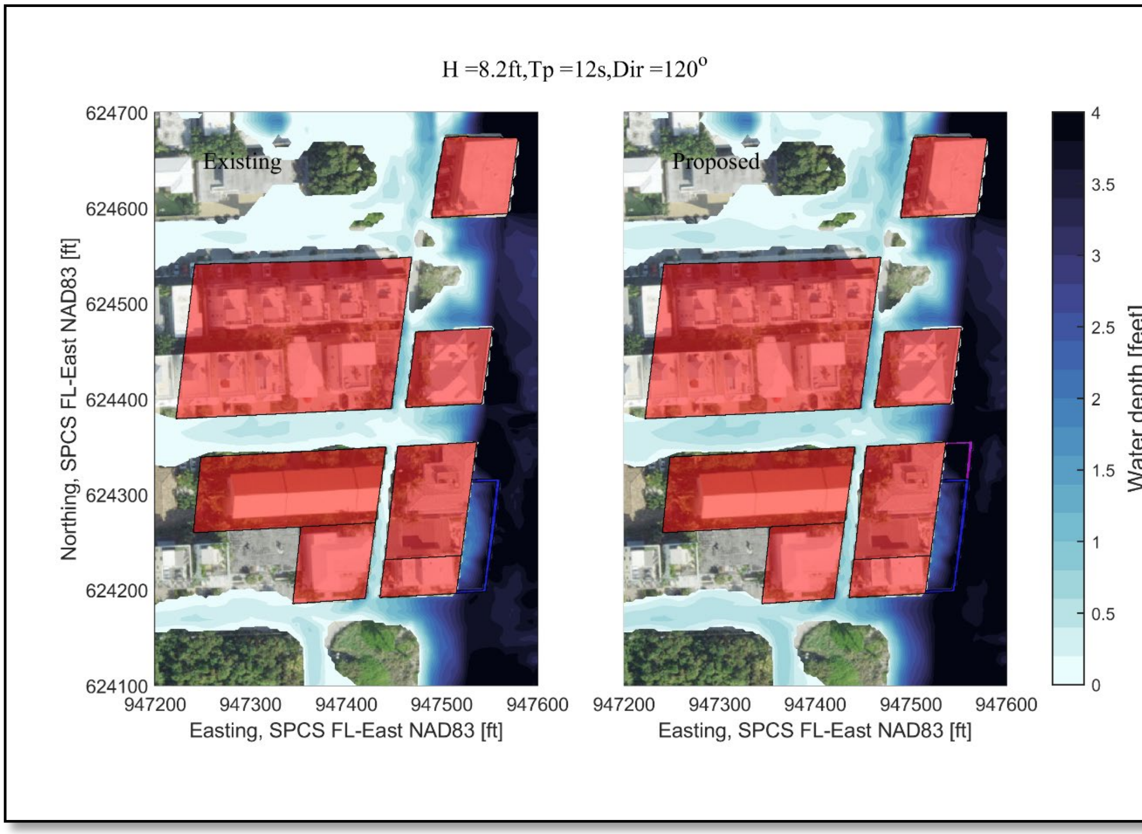
A39. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 8.2 ft, wave period = 12s, and wave direction = 30° from North.



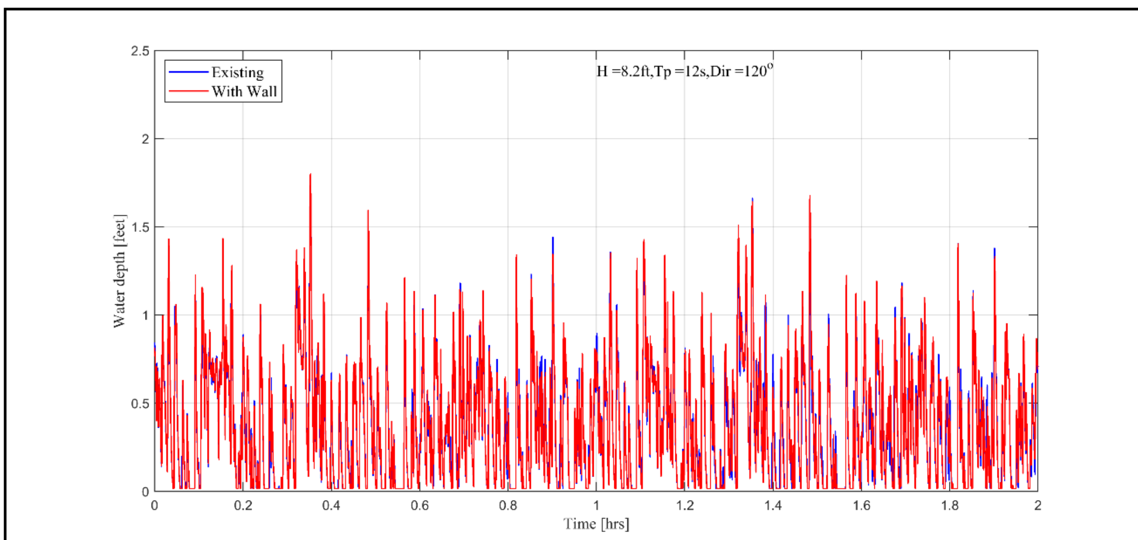
A40. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 8.2 ft, wave period = 12s, and wave direction = 90° from North.



A41. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 8.2 ft, wave period = 12s, and wave direction = 90° from North.



A42. XBeach model results for both the existing beach condition (left) and the beach with the proposed seawall (right with the proposed wall in pink) for the following wave condition: wave height = 8.2 ft, wave period = 12s, and wave direction = 120° from North.



A43. Time-series of water depth calculated on the Oak Street right-of-way for the existing beach condition (blue), and with the proposed seawall (red) for the following wave condition: wave height = 8.2 ft, wave period = 12s, and wave direction = 120° from North.