**Storm Impact Risk Assessment**

**Phipps Ocean Park Beach Restoration Project**

**Palm Beach County, Florida**

December 2003

# Storm Impact Risk Assessment
# Phipps Ocean Park Beach Restoration Project
# Palm Beach County, Florida

Prepared for
Town of Palm Beach, Florida

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## 1.0 INTRODUCTION

The Town of Palm Beach contracted Taylor Engineering to apply the SBEACH (Storm-Induced Beach Change) cross-shore transport numerical model (Larson and Kraus, 1989) to simulate storm erosion at the Phipps Ocean Park Beach Restoration Project area. Modeling results will help quantify storm damage prevention benefits in the project area, which lies between Lake Worth Inlet and South Lake Worth Inlet in Palm Beach County, Florida (or between Florida Department of Environmental Protection [FDEP] monuments R-116 and R-126). This study estimates the number of structures in the project area impacted by various return period storms for existing (no action) and project (with beach fill) conditions. The difference between the two estimates represents the storm damage prevention benefits of the proposed beach fill project.

## 2.0 CROSS-SHORE EROSION MODELING

SBEACH, a two-dimensional cross-shore model, uses input parameters describing the physical characteristics of a particular storm event to predict the adjustment of a pre-storm to a post-storm beach profile. SBEACH simulates wave-induced erosion as well as formation and movement of offshore bars and troughs and accounts for hardbottom or seawall effects on dune and beach erosion. The model accommodates variable grid spaces, time-dependent surge levels and wave characteristics, wave refraction and runup, water level setup due to breaking waves and wind, and sediment overwash. As SBEACH only simulates beach erosion due to short-term events (storms), model results provide no indication of long-term trends of cross-shore sediment transport. The model does not simulate the effects of any longshore processes; during a storm, such processes are generally of secondary importance relative to cross-shore processes.

### 2.1 SBEACH Model Technical Overview

The SBEACH model incorporates an extension of a breaking wave model (Dally et al., 1985) to compute wave height and energy flux distributions across the subaqueous beach profile. The model identifies four distinct zones with different sediment transport expressions across the active nearshore zone. These zones correspond to

Zone 1: Pre-breaking zone
Zone 2: Transition zone
Zone 3: Broken wave zone
Zone 4: Swash zone

Zone 1 extends offshore from the break point, with the sediment transport rate assumed to decay exponentially with distance from the break point. Zone 2, a narrow region between the break point and the plunge point, exhibits a transport relation similar to that in Zone 1. The width of this transition zone is taken as three times the breaking wave height. Zone 3 extends from the plunge point to the landward end of the surf zone; sediment transport in this region controls the sediment transport of the other zones. The sediment transport rate is proportional to the excess of the actual dissipation of wave energy per unit volume over the equilibrium dissipation of wave energy per unit volume, with an additional term to account for the local beach slope. Sediment transport in Zone 4 is assumed to decay linearly up to the active subaerial height (runup limit).

The SBEACH model allows for calibration of four parameters: the transport rate parameter (K), the slope-related sand transport rate parameter (ε), the special decay coefficient (λ), and the angle of advent of avalanching (Φ). Table 2.1 presents the permissible ranges for the SBEACH calibration parameters. The transport rate parameter, K, governs the magnitude of sediment transport directly and influences the response time of the beach profile. Smaller values of K lead to longer time scales for equilibrium, whereas larger K values result in faster response times. The slope-related transport rate parameter, ε, mainly influences the bar volume, with larger values of ε resulting in more subdued bars. The spatial decay factor, λ, influences the rate of decay of transport seaward of the break point, with smaller values of λ resulting in slower rates of decay. The angle of advent of avalanching, Φ, influences the steepness of the eroded profile with larger values causing steeper profiles.

**Table 2.1** Permissible Calibration Ranges for the SBEACH Model Parameters

| Parameter | Range |
|---|---|
| K | $0.5 \times 10^{-6} - 2.5 \times 10^{-6}$ $m^4/N$ |
| ε | $0.001 - 0.003$ $m^2/s$ |
| λ | $0.1 - 0.5$ $m^{-1}$ |
| Φ | 15º – 45º |

SBEACH also models the effects of hardbottom on beach profile evolution by allowing locations of the beach profile with exposed hardbottom to get covered with sand but restricting such locations from eroding below the hardbottom elevation. Thus, during any time step, hardbottom in deposition zones (with negative potential sediment transport gradients) does not affect profile evolution. However, hardbottom in erosive zones (with positive potential sediment transport gradients) may affect profile evolution depending on a variety of factors, for example, actual sand transport is constant over exposed hardbottom since it cannot erode any more. Details of the hardbottom algorithm implemented in SBEACH are presented in Larson and Kraus (1996).

## 2.2 SBEACH Model Input and Calibration

The SBEACH model input data include a pre-storm beach profile, storm information for the duration of a particular storm event, and sediment transport parameters. The pre-storm beach profile input requirements include a measured pre-storm beach profile, cross-shore location of any existing hardbottom, cross-shore location of any existing seawalls, and sediment grain size. The storm input requirements include a wave height and period and water level time series for the duration of the storm event.

Model calibration, the process of determining values of the sediment transport parameters that most accurately replicate the changes from a measured pre-storm to a measured post-storm beach profile, generally requires many parameters. These parameters include 1) pre-storm profile, 2) post-storm profile, 3) site sediment characteristics, 4) time-dependent storm wave characteristics (heights, periods, and directions), and 5) time-dependent water level history. Therefore, calibrating the model requires pre-storm and post-storm measured beach profile data as well as measured storm data from the corresponding storm event.

This study obtained measured beach profile data for the Phipps Park Ocean Park beach area (FDEP monuments R-116 to R-126 in Palm Beach County) from all known sources: Coastal Technology Corporation (Coastal Tech), the FDEP, Morgan & Eklund, and Palm Beach County. These sources produced a compilation of measured beach profile data for the years 1974, 1978, 1986, 1990, 1991, 1995, 1997, 1999, 2000, 2001, 2002, and 2003. Unfortunately, examination of the beach profile data set failed to identify an appropriate time period during which the project area experienced extensive erosion attributable to a storm event along a majority of its length.

In lieu of measured pre- and post-storm beach profile data, this study adopted two methods developed in other studies to determine the storm induced erosion anticipated along the Phipps Ocean Park project area for 10-, 20-, 50-, and 100-year return period storms. Note that, by definition, the probabilities of occurrence, in any given year, of 10-, 20-, 50-, and 100-year return period storms are 0.1, 0.05, 0.02, and 0.01, respectively. The following section documents the details and results of the two methods used in this study to compute storm-related beach recessions.

### 2.3 SBEACH Derived Recession Estimates

Storm recession distance equals the distance from the pre-storm MHW location to the landward limit of storm-induced erosion. Figure 2.1 presents an illustration of storm recession as defined in this study. The figure also schematically displays the definition of the structure to MHW shoreline distance — a concept used later to investigate storm impacts on structures.

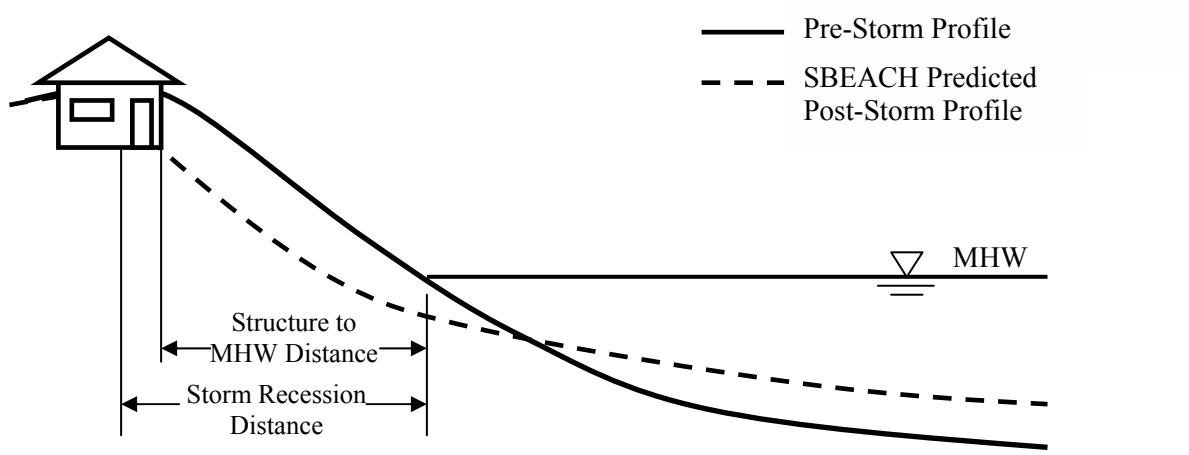



**Figure 2.1** Structure to MHW Distance and Storm-Induced Recession Definition Sketch

### *2.3.1 Method 1*

Method 1 applied the recession versus storm return period curve reported in Coast of Florida Erosion and Storm Effects Study (USACE, 1996) for the stretch of beach between Lake Worth Inlet and South Lake Worth Inlet in Palm Beach County (location of the Phipps Ocean Park Project area).

Similar to this study, the Coast of Florida Study concluded that little appropriate storm and profile change data exist for Palm Beach County for storm erosion modeling calibration. Given the absence of measured storm and beach profile change data for Palm Beach County, the Coast of Florida Study used beach and storm data from Broward and Dade Counties (the counties directly south of Palm Beach County). Based on storm conditions and beach similarities between Palm Beach County and Broward and Dade Counties, the Coast of Florida Study assumed similar calibration coefficients for Palm Beach County between Lake Worth Inlet and South Lake Worth Inlet and Broward and Dade Counties. Figure 2.2 presents the recession-storm return period relationship for the beach segment between Lake Worth and South Lake Worth Inlets as reported in the Coast of Florida Study. This relationship is directly applicable to the Phipps Ocean Park project area, which lies between Lake Worth and South Lake Worth Inlets.

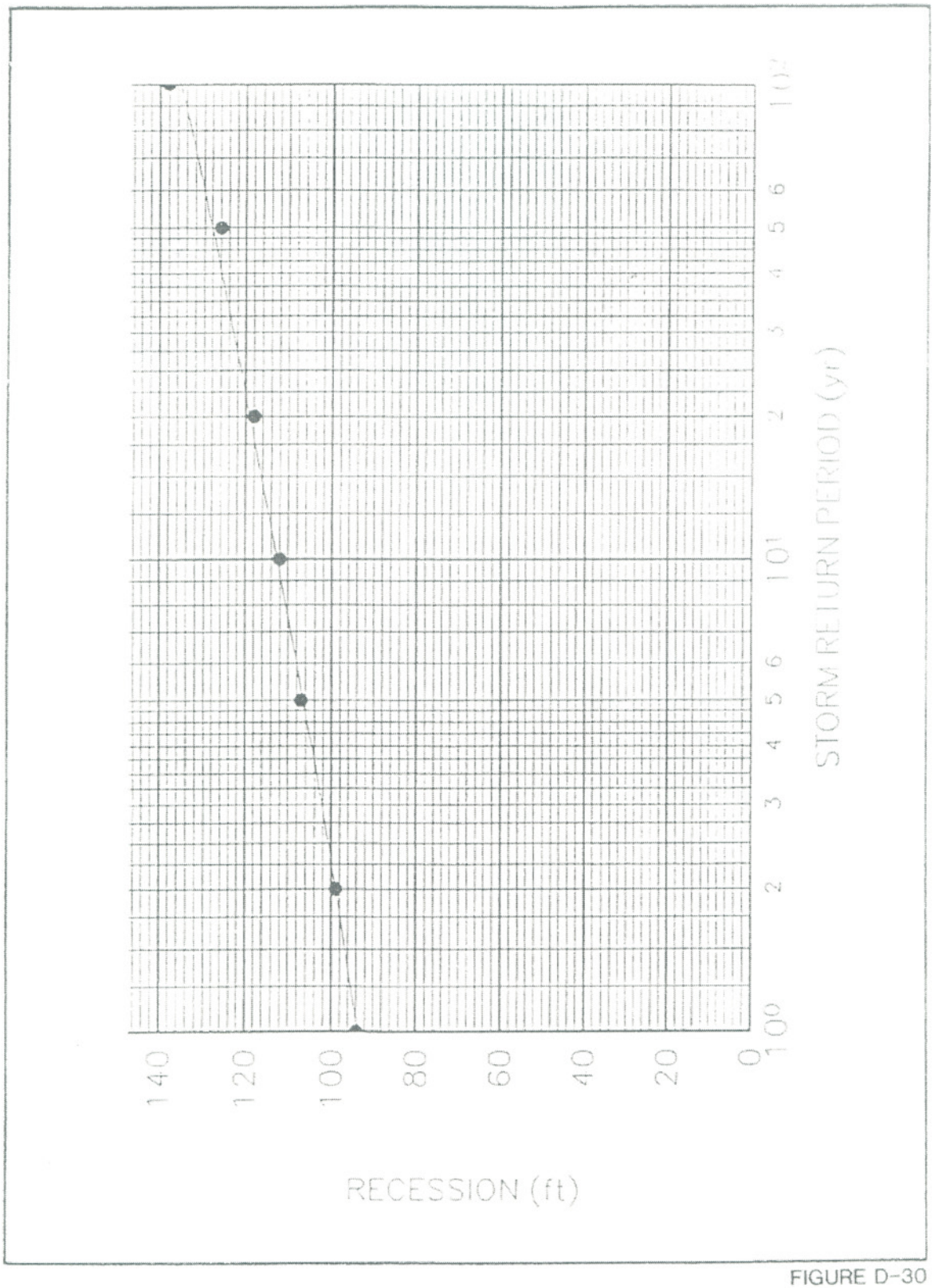



FIGURE D-30

PROFILE R 129, PALM BEACH, FLORIDA
RECESSION vs. STORM RETURN PERIOD CURVE

**Figure 2.2** Recession vs. Storm Return Period Curve, Palm Beach, Florida (USACE, 1996)

### *2.3.2 Method 2*

Method 2 applied the SBEACH storm erosion model with the calibration coefficients derived in the General Design Memorandum Addendum for the Ocean Ridge Segment in Palm Beach County (Olsen Associates, Inc., 1996). The Ocean Ridge segment of Palm Beach County lies approximately six miles south of the Phipps Ocean Park Project area.

Olsen Associates suggested the unavailability of pre- and post-storm data for this section of shoreline, and therefore, excluded formal SBEACH model calibration. Instead, Olsen Associates performed a sensitivity analysis of calibration coefficient sets applied in previous studies of Martin County, Broward County, and Palm Beach County (based on calibration results in Broward and Dade Counties) to determine their applicability for the Ocean Ridge segment. Olsen Associates concluded that the storm-induced recession exhibited little sensitivity to the various calibration coefficient sets and thus applied the calibration coefficient set estimated for Palm Beach County for Ocean Ridge Segment project justification. This study applied the calibration coefficients determined by Olsen Associates, Inc. (1996) for the Ocean Ridge segment of Palm Beach County to the Phipps Ocean Park Project area (Table 2.2). Knowledge of the SBEACH calibration coefficients permits us to model future storm effects on a profile-by-profile basis to reflect the local beach, hardbottom, and seawall conditions. This facet is an advantage over Method 1 described earlier which depended on a global analysis to predict, for a given storm, uniform recession throughout the project area.

**Table 2.2** Calibrated SBEACH Parameters

| Parameter | Value |
|---|---|
| K | $1.35 \times 10^{-6}$ $m^4/N$ |
| $\varepsilon$ | 0.001 $m^2/s$ |
| $\lambda$ | 0.4 $m^{-1}$ |
| $\Phi$ | 28º |

This study developed 10-, 20-, 50-, and 100-year storm characteristics for use in the calibrated SBEACH model. Dean et al. (1992) provided the 10-, 20-, 50- and 100-year return period peak storm surge elevations and the 100-year storm surge hydrograph for Palm Beach County. Development of the storm surge hydrographs for storms with return periods less than 100 years required multiplying the 100-year storm surge hydrograph by the ratio of the peak storm surge elevation of the storm under consideration to that of a 100-year storm.

Consistent with the State of Florida's methodology, the study applied a breaking wave height of 10 ft for the 50- and 100-year return period storms and a breaking wave height of 8 ft for the 10- and 20-year return period storms. The study applied wave periods of 12 sec and 10 sec, representative of the wave climate offshore of the study site, for the 50- and 100-year return period storms and the 10- and 20-year return period storms.

The pre-storm profile consisted of the 2001 profile because it represented the most recent and extensive data. Morgan & Eklund took jet probes in November 2003 to determine submerged hardbottom along the profiles. Incorporating this recent 2003 hardbottom information with the 1999 hardbottom information from Coastal Tech revealed the hardbottom locations along each beach profile. Per Coastal Tech (Stephen Boehning, personal communication, 2003), the mean sediment grain size at the site equals 0.43 mm.

Inputting the above parameters into the SBEACH model yielded recession distance versus storm return period at each monument in the Phipps Ocean Park Project area for 10-, 20-, 50-, and 100-year return period storms. Figure 2.3 presents a typical pre-storm and post-storm profile as well as the hardbottom location for one profile in the study area (FDEP monument R-123). Notably, the post-storm profile lies above the pre-storm profile in the dune area (above +15 ft-NGVD) where wave run-up deposited sand during the storm event (overwash). As indicated by the figure, there is significant erosion of the upper beach face with the 50- and 100-year return period storms at monument R-123. Appendix A presents the pre-storm and post-storm profile as well as the hardbottom location for each profile in the study area. Notably, given its configuration, hardbottom has negligible influence on profile evolution in the Phipps Ocean Park Project area.

### *2.3.3 Storm Recession Results*

As mentioned before, storm recession distance equals the distance from the measured pre-storm MHW location to the landward limit of storm-induced erosion. Morgan & Eklund took wading depth beach profile surveys at each profile in November 2003 to determine the most recent measured MHW location.

Table 2.3 presents the storm recession distances derived from Methods 1 and 2 for 10-, 20- 50-, and 100-year return period storms. As mentioned earlier, Method 1 predicts, for a given storm, uniform recession along the entire length of the Phipps Ocean Park project area. In contrast, Method 2 generates, for a given storm, non-uniform recessions along the length of the project area. Therefore, Table 2.3 lists

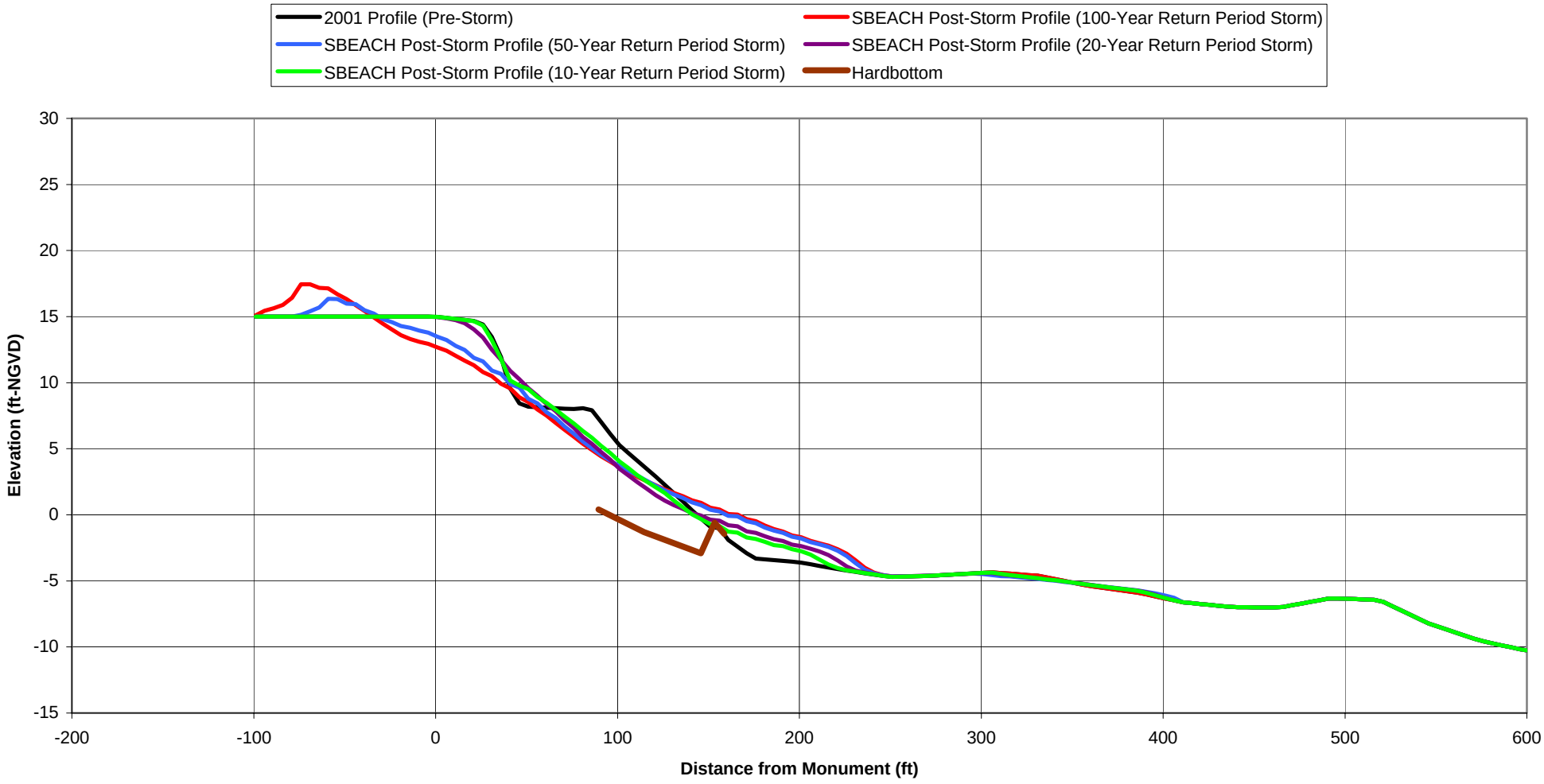



**Figure 2.3** Pre-Storm and Post-Storm Profiles at FDEP Profile R-123

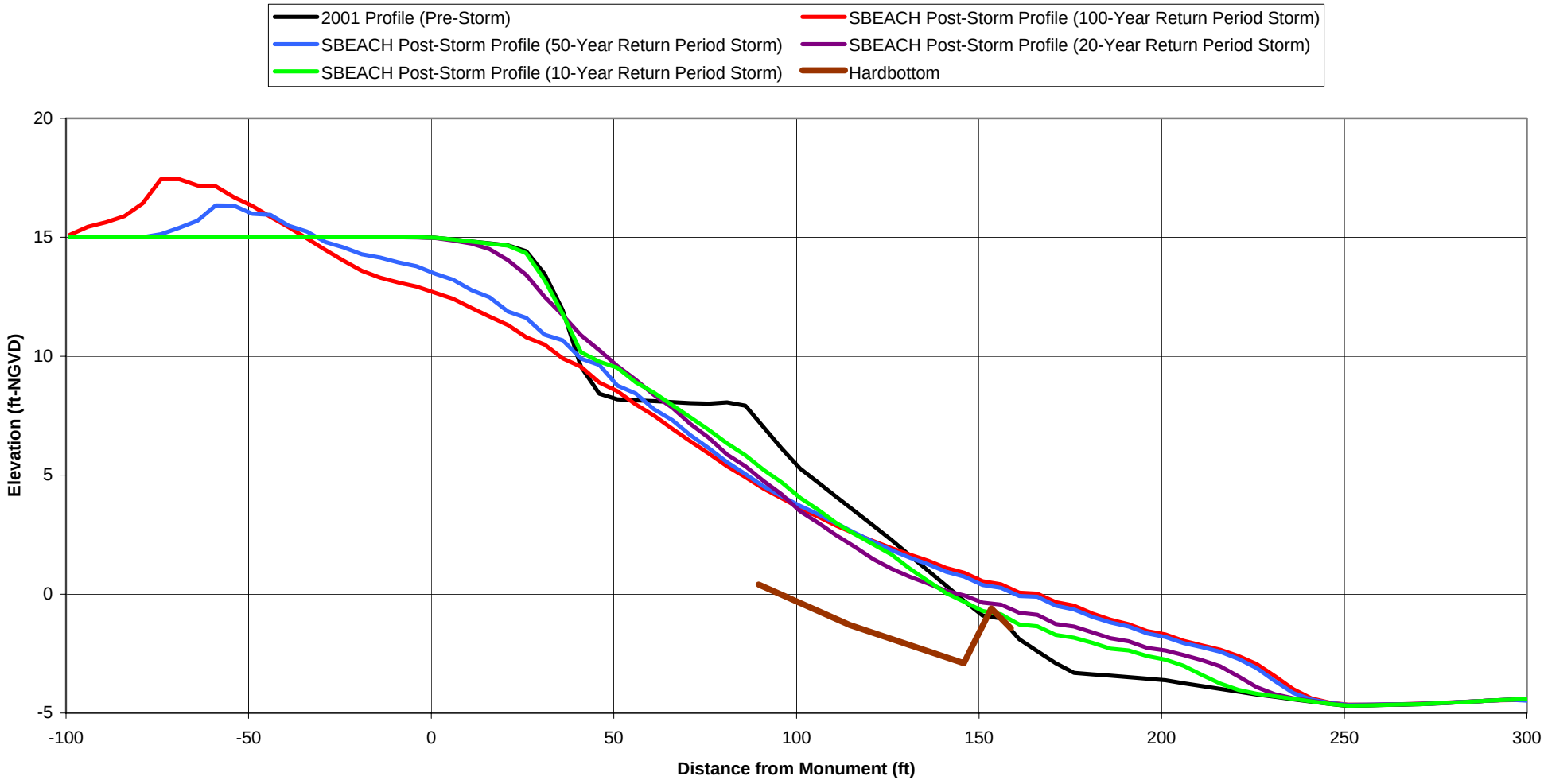



**Figure 2.4** Upland Pre-Storm and Post-Storm Profiles at FDEP Profile R-123

one set of recession distances for Method 1 and another set of recession distances per monument for Method 2.

**Table 2.3** Storm Recession (ft from MHW) As A Function of Return Period (years)

| **Method 1** | | | | |
|---|---|---|---|---|
| | Return Period Storm (years) | | | |
| Storm Recession | 10 | 20 | 50 | 100 |
| R-116 to R-126 | 112 | 118 | 126 | 138 |
| **Method 2** | | | | |
| | Return Period Storm (years) | | | |
| Storm Recession | 10 | 20 | 50 | 100 |
| R-116 | 70 | 80 | 100 | 105 |
| R-117 | 111 | 121 | 146 | 166 |
| R-118 | 108 | 118 | 148 | 158 |
| R-119 | 97 | 127 | 137 | 142 |
| R-120 | 122 | 142 | 162 | 167 |
| R-121 | 123 | 128 | 173 | 183 |
| R-122 | 117 | 142 | 162 | 167 |
| R-123 | 113 | 138 | 158 | 163 |
| R-124 | 106 | 161 | 181 | 186 |
| R-125 | 110 | 135 | 155 | 165 |
| R-126 | 122 | 147 | 162 | 172 |

## 3.0 STRUCTURAL IMPACTS

This study applied the recession distances developed in Methods 1 and 2 to estimate the percent of structures impacted by the various return period storms for with and without beach nourishment project conditions. Determining structural impacts required overlaying the storm recession distances derived from Methods 1 and 2 on June 2003 aerial photographs from Aerial Cartographics of America. This analysis assumed structural impacts if the storm-induced recession (measured from the 2003 MHW line) met or exceeded the distance from the seaward limit of the oceanfront upland structure to the 2003 MHW line. Note that actual property damage — dependent on the severity of beach erosion and the type of shorefront structure — may or may not occur during such an event. Additionally, wave overtopping may cause damage even if storms do not affect the property according to the above definition.

### 3.1 Existing (No Beach Nourishment) Conditions

Table 3.1 presents the number of structures and the specific structures impacted by 10-, 20-, 50-, and 100-year return period storms for Methods 1 and 2 for existing conditions in the absence of a beach nourishment project. Appendix B contains two sets of full size plan view drawings (Figures B1 and B2) illustrating the 2003 MHW shoreline, oceanfront structure number, and the storm recession limit for 10-, 20-, 50-, and 100-year return period storms for Methods 1 and 2. Adopting Method 1 derived the recession limit lines for the 10-, 20-, 50-, and 100-year return period storms by uniformly applying the recession distances presented in Table 2.3 to the 2003 MHW shoreline along the entire Phipps Ocean Park Project area. Adopting Method 2 derived the recession limit lines for the 10-, 20-, 50-, and 100-year return period storms by applying the recession distances presented in Table 2.3 to the 2003 MHW shoreline at each monument location. Notably, straight lines connect adjacent monument recession distances. The figures in Appendix C present the 2003 beach profile and hardbottom data, the 100-year return period storm recession distance developed in Method 2, and the average structure location at each monument in the project area.

This analysis assumed that the rock revetment located along the most northern portion of the project area (from FDEP monument R-116 south approximately 500 ft) and the approximate 350-ft long seawall located at approximately FDEP monument R-120 would prevent any storm recession landward of these structures. The full size plan view drawings depict this landward limit of recession in these areas.

**Table 3.1** Number of Structures Impacted with No Action Conditions

| Structure # | Description | Nearest Monument | Return Period Storm Impact | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 10-Year | | 20-Year | | 50-Year | | 100-Year | |
| | | | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 |
| Total Number of Structures Impacted | | | 0 | 2 | 3 | 7 | 5 | 15 | 5 | 19 |
| 1 | Sloans Curve Townhouses | R-117 | | | | | ■ | ■ | ■ | ■ |
| 2 | 2000 Condo Sloans Curve | R-117 | | | | | | ■ | | ■ |
| 3 | 2000 Condo Sloans Curve | R-118 | | | | | | ■ | | ■ |
| 4 | 2100 Condo Sloans Curve | R-118 | | | | | | | | ■ |
| 5 | 2100 Condo Sloans Curve | R-118 | | | | | | | | ■ |
| 6 | 2275 South Ocean The Reef Condo | R-120 | | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 7 | 2275 South Ocean The Reef Condo | R-120 | | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 8 | 2295 South Ocean Harbor House | R-120 | | | | | | | | |
| 9 | 2295 South Ocean Harbor House | R-120 | | | | | | | | |
| 10 | 2295 South Ocean Harbor House | R-120 | | | | | | | | |
| 11 | 2320 South Ocean | R-121 | | | | | | ■ | | ■ |
| 12 | 2330 South Ocean | R-121 | | | | | | ■ | | ■ |
| 13 | 2340 South Ocean | R-121 | | | | | | ■ | | ■ |
| 14 | 2500 South Ocean Condo | R-123 | | | | | | | | |
| 15 | 2500 South Ocean Condo | R-124 | | | | ■ | | ■ | | ■ |
| 16 | 2545 South Ocean Palm Beach White House | R-124 | | | ■ | ■ | ■ | ■ | ■ | ■ |
| 17 | 2565 South Ocean Palm Beach White House | R-124 | | | | ■ | ■ | ■ | ■ | ■ |
| 18 | 2580 South Ocean Stratford | R-124 | | | | ■ | | ■ | | ■ |
| 19 | 2600 South Ocean The 2600 | R-124 | | | | ■ | | ■ | | ■ |
| 20 | 2600 South Ocean The 2600 | R-124 | | | | | | ■ | | ■ |
| 21 | 2660 South Ocean Beach Point | R-125 | | | | | | ■ | | ■ |
| 22 | 2660 South Ocean Beach Point | R-125 | | | | | | | | |
| 23 | 2660 South Ocean Beach Point | R-125 | | | | | | | | |
| 24 | 2730 South Ocean Ambassador Hotel | R-125 | | | | | | | | |
| 25 | 2770 South Ocean | R-125 | | | | | | | | |
| 26 | 2770 South Ocean | R-125 | | | | | | | | |
| 27 | 2774 South Ocean Ambassador South Cooperative | R-126 | | | | | | | | ■ |
| 28 | 2780 South Ocean Ambassador II Cooperative | R-126 | | | | | | | | ■ |

■ shaded box indicates storm impact

As indicated in Table 3.1 and the plan view drawings, the number of impacted structures increases with the severity of the storm, that is, with increasing storm return periods. Lower frequency, high intensity storms affect several of the oceanfront structures in the absence of a beach nourishment project. Of the 28 structures along the Phipps Ocean Park Project area, a 100-year return period storm would affect between 5 (Method 1) and 19 structures (Method 2).

### 3.2 With Beach Nourishment Project Conditions

The locations of upland structures, the locations of the with-project MHW shoreline, and SBEACH-derived recession estimates help determine the impacts of various storms on shorefront development in the presence of the proposed beach restoration project.

In this context, the storm recession distances developed in Methods 1 and 2 were applied to the with-project MHW locations in the Phipps Ocean Park area. Per Coastal Tech (Stephen Boehning, personal communication, 2003), the renourishment interval for the Phipps Ocean Park Beach Restoration Project equals eight years. Theoretically, the with-project MHW contour will be at its most landward location just prior to renourishment (eight years after initial construction); therefore, this study utilizes this MHW location to apply the storm recession distances developed for the existing conditions. This method estimates the structural impacts in the project area for the condition where the 10-, 20-, 50-, or 100-year return period storms occur immediately prior to the scheduled renourishment; thus, this method gives the most conservative (smallest) estimate of storm damage benefit for with-project conditions. In practice, a greater level of storm damage protection than that estimated by this method should prevail for the duration of the project.

Table 3.2 presents the number of structures and the specific structures impacted by 10-, 20-, 50-, and 100-year return period storms for Methods 1 and 2 for with beach nourishment project conditions. Appendix B contains two sets of full size plan view drawings (Figures B1 and B2) illustrating the 2003 MHW shoreline, oceanfront structure number, and the storm recession limit for 10-, 20-, 50-, and 100-year return period storms for Methods 1 and 2. As indicated in the two sets of full size plan view drawings, eight years after construction of the beach restoration project and just prior to renourishment, the 10-, 20-, and 50-year return period storms do not impact any structures. A 100-year return period storm would impact between one (Method 1) and three (Method 2) structures. These structures lie in the extreme northern section of the project area where the erosion of the beach fill over eight years is expected to be the most extensive compared to the rest of the project area.

**Table 3.2** Number of Structures Impacted with Beach Nourishment Project Conditions

| Structure # | Description | Nearest Monument | Return Period Storm Impact | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 10-Year | | 20-Year | | 50-Year | | 100-Year | |
| | | | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 |
| Total Number of Structures Impacted | | | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| 1 | Sloans Curve Townhouses | R-117 | | | | | | | | |
| 2 | 2000 Condo Sloans Curve | R-117 | | | | | | | | |
| 3 | 2000 Condo Sloans Curve | R-118 | | | | | | | | |
| 4 | 2100 Condo Sloans Curve | R-118 | | | | | | | | |
| 5 | 2100 Condo Sloans Curve | R-118 | | | | | | | | |
| 6 | 2275 South Ocean The Reef Condo | R-120 | | | | | | | | |
| 7 | 2275 South Ocean The Reef Condo | R-120 | | | | | | | | |
| 8 | 2295 South Ocean Harbor House | R-120 | | | | | | | | |
| 9 | 2295 South Ocean Harbor House | R-120 | | | | | | | | |
| 10 | 2295 South Ocean Harbor House | R-120 | | | | | | | | |
| 11 | 2320 South Ocean | R-121 | | | | | | | | |
| 12 | 2330 South Ocean | R-121 | | | | | | | | |
| 13 | 2340 South Ocean | R-121 | | | | | | | | |
| 14 | 2500 South Ocean Condo | R-123 | | | | | | | | |
| 15 | 2500 South Ocean Condo | R-124 | | | | | | | | |
| 16 | 2545 South Ocean Palm Beach White House | R-124 | | | | | | | | |
| 17 | 2565 South Ocean Palm Beach White House | R-124 | | | | | | | | |
| 18 | 2580 South Ocean Stratford | R-124 | | | | | | | | |
| 19 | 2600 South Ocean The 2600 | R-124 | | | | | | | | |
| 20 | 2600 South Ocean The 2600 | R-124 | | | | | | | | |
| 21 | 2660 South Ocean Beach Point | R-125 | | | | | | | | |
| 22 | 2660 South Ocean Beach Point | R-125 | | | | | | | | |
| 23 | 2660 South Ocean Beach Point | R-125 | | | | | | | | |
| 24 | 2730 South Ocean Ambassador Hotel | R-125 | | | | | | | | |
| 25 | 2770 South Ocean | R-125 | | | | | | | | |
| 26 | 2770 South Ocean | R-125 | | | | | | | | |
| 27 | 2774 South Ocean Ambassador South Cooperative | R-126 | | | | | | | | |
| 28 | 2780 South Ocean Ambassador II Cooperative | R-126 | | | | | | | | |

shaded box indicates storm impact

## 4.0 OTHER CONSIDERATIONS RELATED TO STORM SURGE

Notably, the Federal Emergency Management Agency (FEMA) (FEMA, 1982) also provides estimates of the peak storm surge associated with storms of different return periods for Palm Beach County. FEMA storm surge estimates typically produce more modest results than those of the FDEP, possibly because the FDEP storm surge numerical model explicitly includes static and dynamic wave setup. As stated above, the SBEACH model also calculates static wave setup. Therefore, the Method 2 results may overestimate the recession distances by possibly accounting for static wave setup twice. To investigate the sensitivity of the wave setup effects for the 100-year storm requires removing the static wave setup component from FDEP's 100-year storm hydrograph. Given a breaking wave height of 10 ft, the maximum static setdown equals -0.5 ft while the maximum static wave setup equals 2.3 ft. Assuming no wave reformation and monotonic breaker height decay within the breaker zone gives an average wave setup of 0.9 ft in the surf zone. Subtracting this value from each time step in the FDEP's 100-year hydrograph produces a new storm tide hydrograph, absent static wave setup. Note that static wave setup occurs only within the surf zone; because the FDEP storm surge hydrograph represents offshore conditions, this approach will likely underestimate storm recession. Nonetheless, running the SBEACH model with the adjusted 100-year hydrograph produces less severe recession distances; on average, this hydrograph generates about 6 fewer feet of shoreline recession over the entire project area. For comparison purposes, the adjusted 100-year hydrograph (absent static wave setup) reduces the number of storm-impacted structures in Method 2 from 19 to 14, or by about 25%. The analysis outlined above provides another estimate of the potential storm impacts along the Phipps Ocean Park project area.

## 5.0 SUMMARY AND CONCLUSIONS

Taylor Engineering applied the SBEACH (Storm-Induced Beach Change) cross-shore transport numerical model (Larson and Kraus, 1989) to simulate storm erosion at the Phipps Ocean Park Beach Restoration Project area with and without beach nourishment project construction. Lack of measured pre- and post-storm profile data led Taylor Engineering to utilize two previous studies on SBEACH modeling for this area. Therefore, the study developed two methods of estimating storm erosion.

Method 1 applied the recession versus storm return period curve from the Coast of Florida Erosion and Storm Effects Study (USACE, 1996), while Method 2 applied the SBEACH storm erosion model with the calibration coefficients derived in the General Design Memorandum Addendum for the Ocean Ridge Segment in Palm Beach County (Olsen Associates, Inc., 1996). Note that the Method 2 approach, consistent with the typical approach employed when appropriate storm data for calibration are available, is generally superior to the Method 1 approach.

The study presented the storm recession distances in the Phipps Ocean Park Project area derived from Methods 1 and 2 for 10-, 20- 50-, and 100-year return period storms. The study then applied the recession distances developed in Methods 1 and 2 to estimate the number of structures impacted by the various return period storms for with and without (existing) beach nourishment project conditions. Low frequency, high intensity storms affect several of the oceanfront structures in the absence of a beach nourishment project while only the 100-year return period storm would impact a few structures with construction of the beach nourishment project. For example, for existing conditions in the absence of a beach nourishment project, a 100-year return period storm would affect between 5 (Method 1) and 19 structures (Method 2) of the 28 structures located along the Phipps Ocean Park Project area. For with-beach nourishment project conditions, a 100-year return period storm would affect between 1 (Method 1) and 3 structures (Method 2) along the Phipps Ocean Park Project area.

In addition to structural impacts, low frequency storms cause erosion landward of the dune crest. Dunes play an important role in the health of the nearshore beach — by acting as a sand repository; the dune provides sacrificial sand to satisfy the erosion potential of a storm. Erosion of the crest of the dune greatly diminishes its storm protection capability. First, such dune conditions increase the vulnerability of upland structures to flooding from future storms. Second, the dune recovery process takes longer time. Following a storm, recovery processes (long period swell and aeolian transport) start building back the dune from its lowest contours. However, the time scales of recovery of the dune's upper contours are very slow — of the order of multiple years to decades. In a qualitative sense, storms, which impact an area

with damaged dunes, can cause aggravated erosion to upland property because the dune, being only partially recovered from the previous storm, has lesser sand to sacrifice.

In conclusion, many upland structures and the dune system are currently vulnerable to storm impacts. The presence of the beach restoration project should have the immediate effect of increasing the level of storm protection to both upland properties and the dune system.

## References


Applied Technology and Management, Inc. *Comprehensive Coastal Management Plan Update, Palm Beach Island, Florida*. Applied Technology and Management, Inc. West Palm Beach, FL.

Dally, W.R., Dean, R.G., and Dalrymple, R.A. 1985. Wave Height Variation Across Beaches of Arbitrary Profile. *Journal of Geophysical Research*, 90(C6): 11917–11927.

Dean, R.G., Chiu, T.Y., and Wang, S.Y. 1992. *Combined Total Storm Tide Frequency Analysis for Palm Beach County, Florida.* Beaches and Shores Resource Center, Florida State University, Tallahassee, FL.

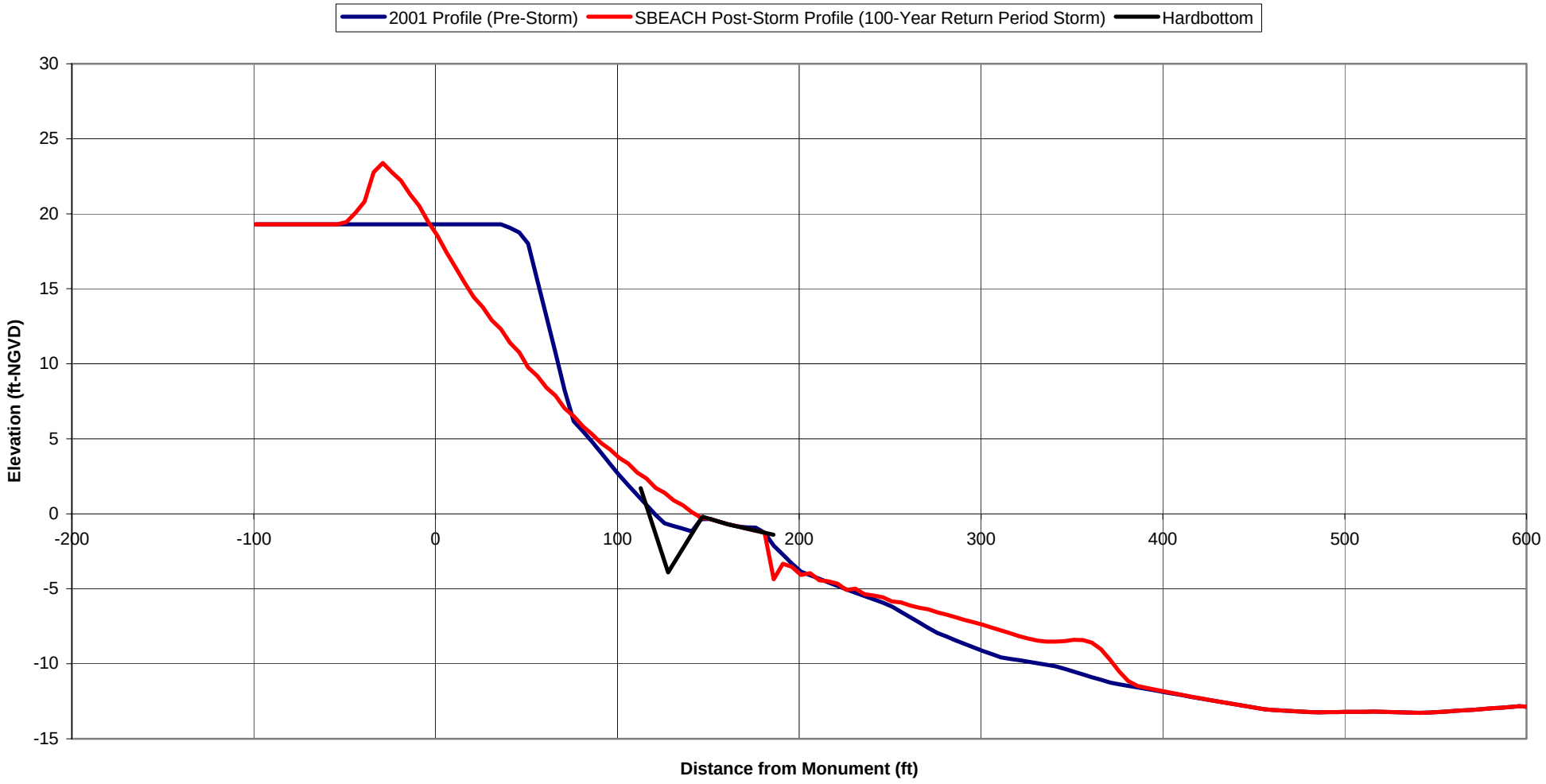
Federal Emergency Management Agency. 1982. *Flood Insurance Study: Wave Height Analysis, Palm Beach County, Florida, Unincorporated Areas.*

Olsen Associates, Inc. 1996. *Palm Beach County, Florida Shore Protection Project (From Martin County Line to Lake Worth Inlet and from South Lake Worth Inlet to Broward County Line), General Design Memorandum Addendum for the Ocean Ridge Segment with Supplement to the Environmental Impact Statement.* Olsen Associates, Inc., Jacksonville, FL.

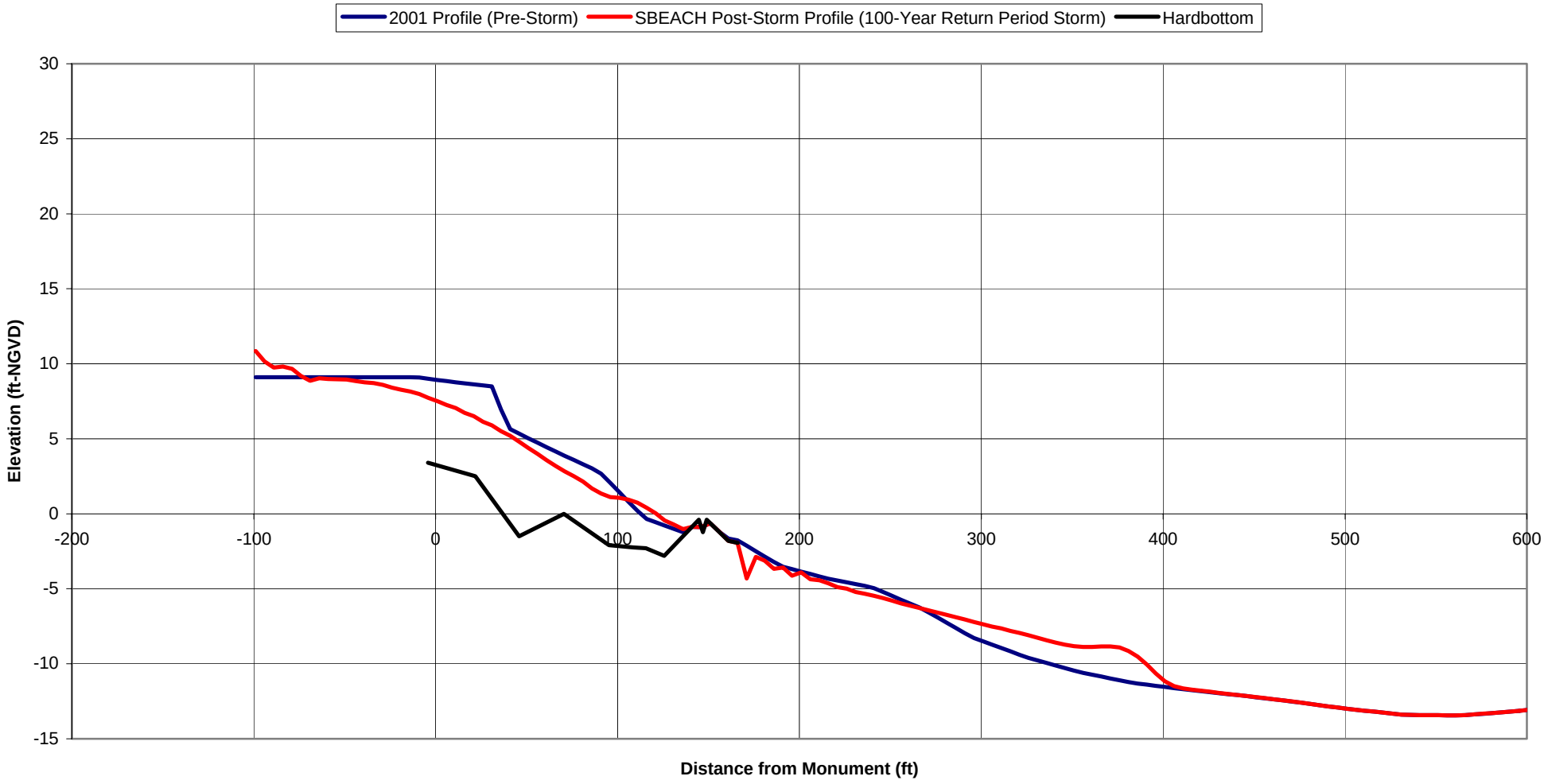
U.S. Army Corps of Engineers (USACE) 1996. *Coast of Florida Erosion and Storm Effects Study Region III, Appendix D Engineering Design and Cost Estimates, May 1995, revised April 1996, revised July 1996.* Jacksonville District, Jacksonville, FL.

# APPENDIX A

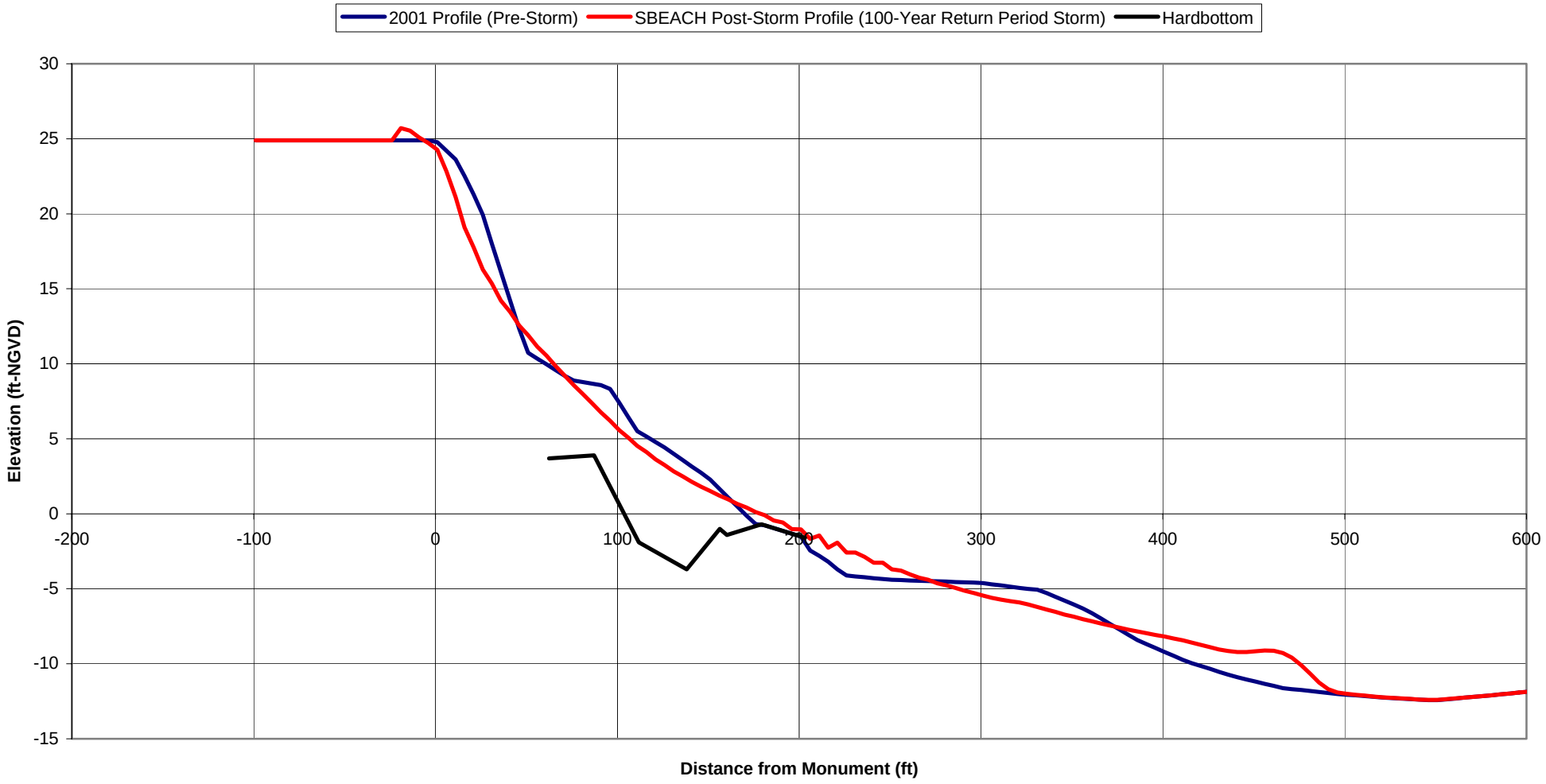
Pre-Storm and Post-100-Year Storm Profiles at Each FDEP Monument



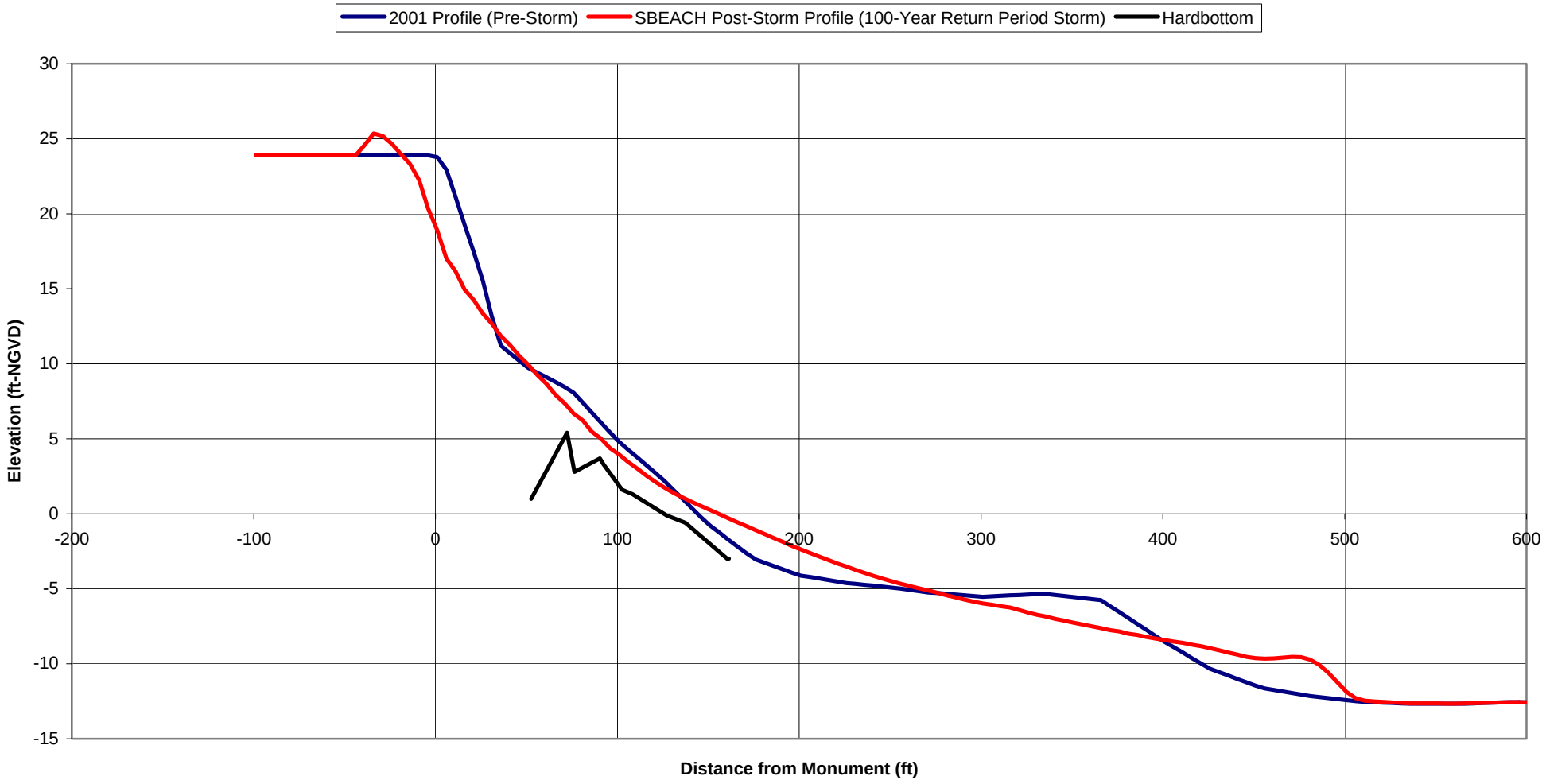

Pre-Storm and Post-Storm Profile at FDEP Profile R-116



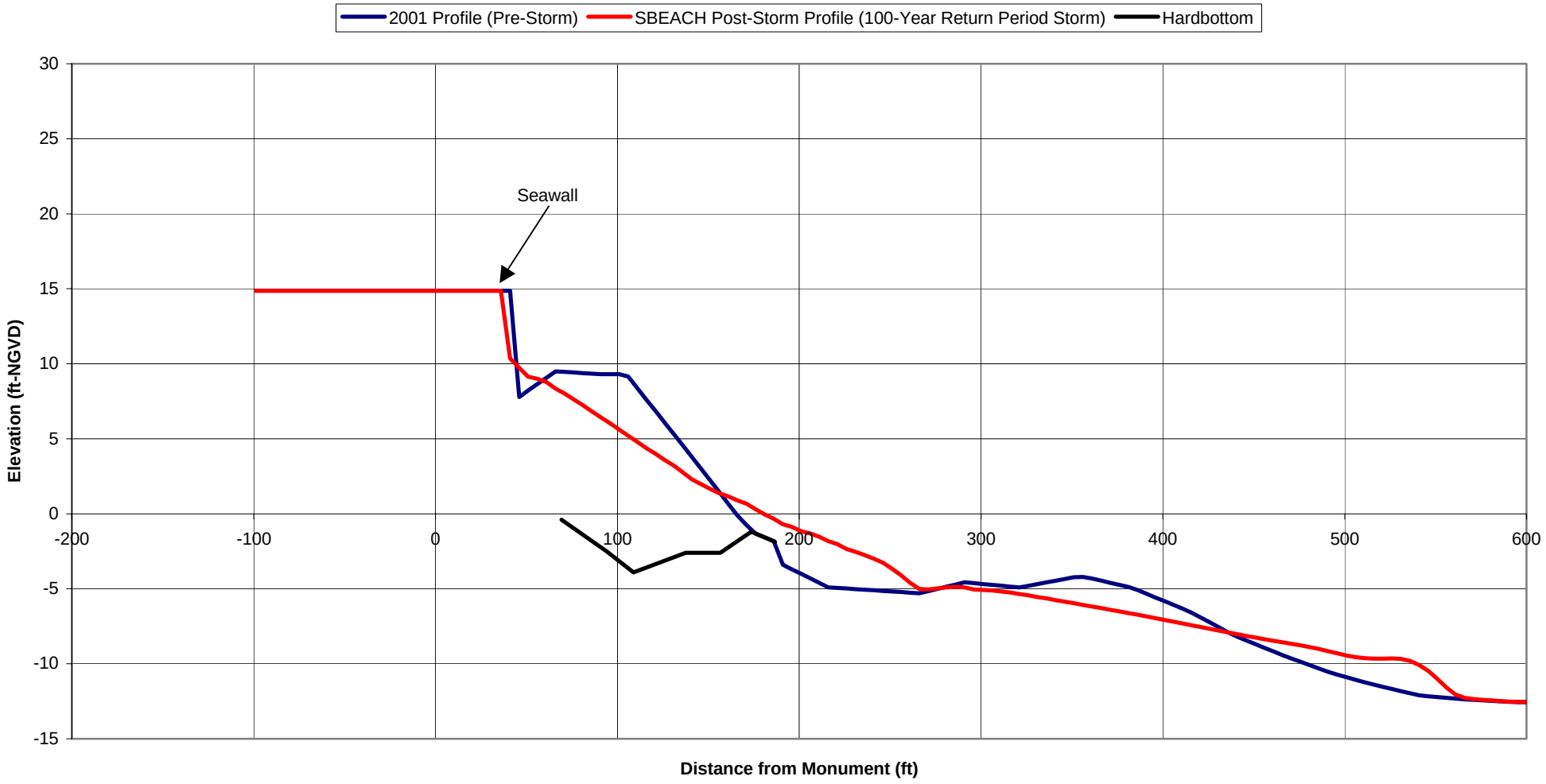

Pre-Storm and Post-Storm Profile at FDEP Profile R-117




Pre-Storm and Post-Storm Profile at FDEP Profile R-118




Pre-Storm and Post-Storm Profile at FDEP Profile R-119

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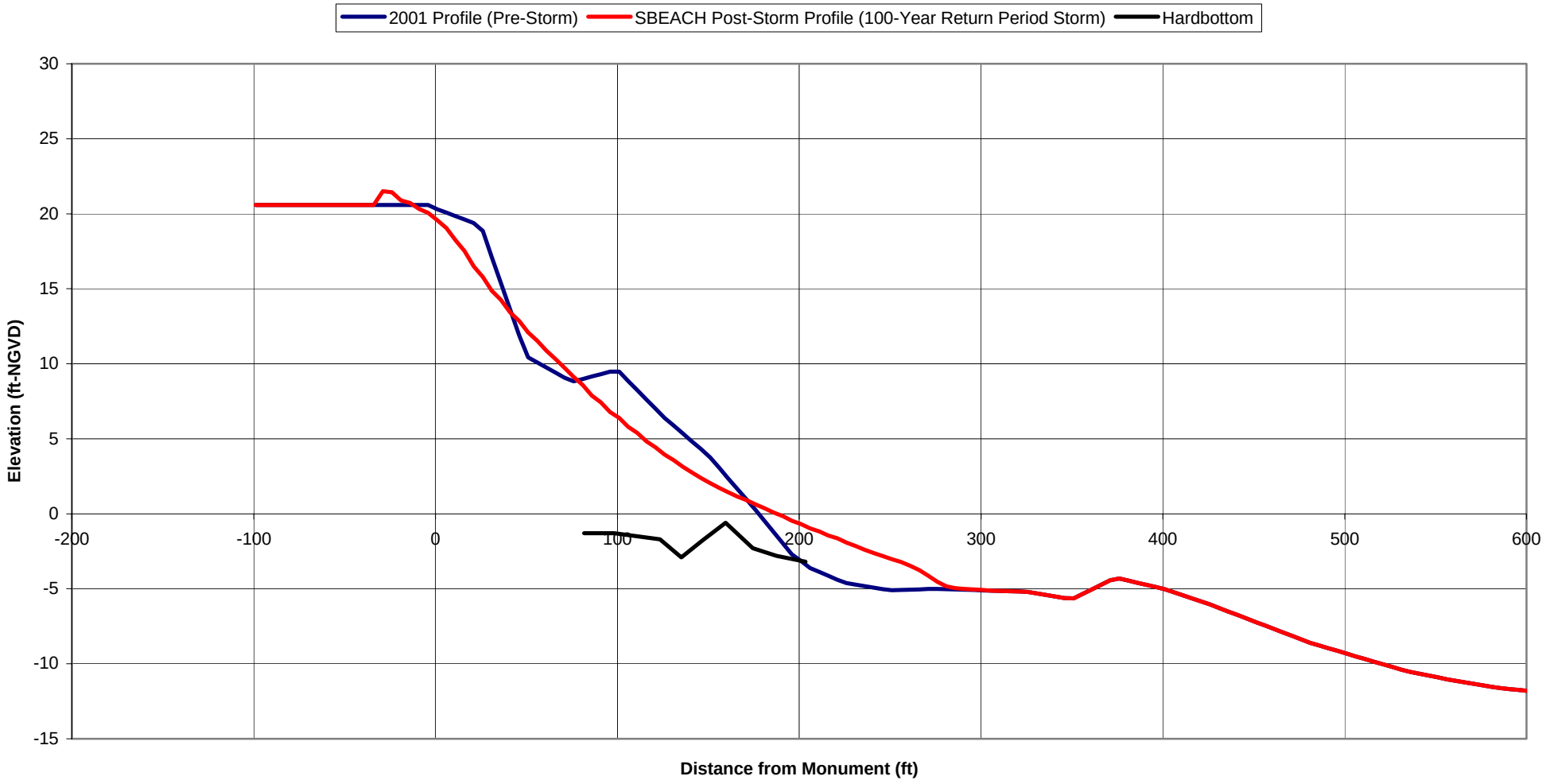
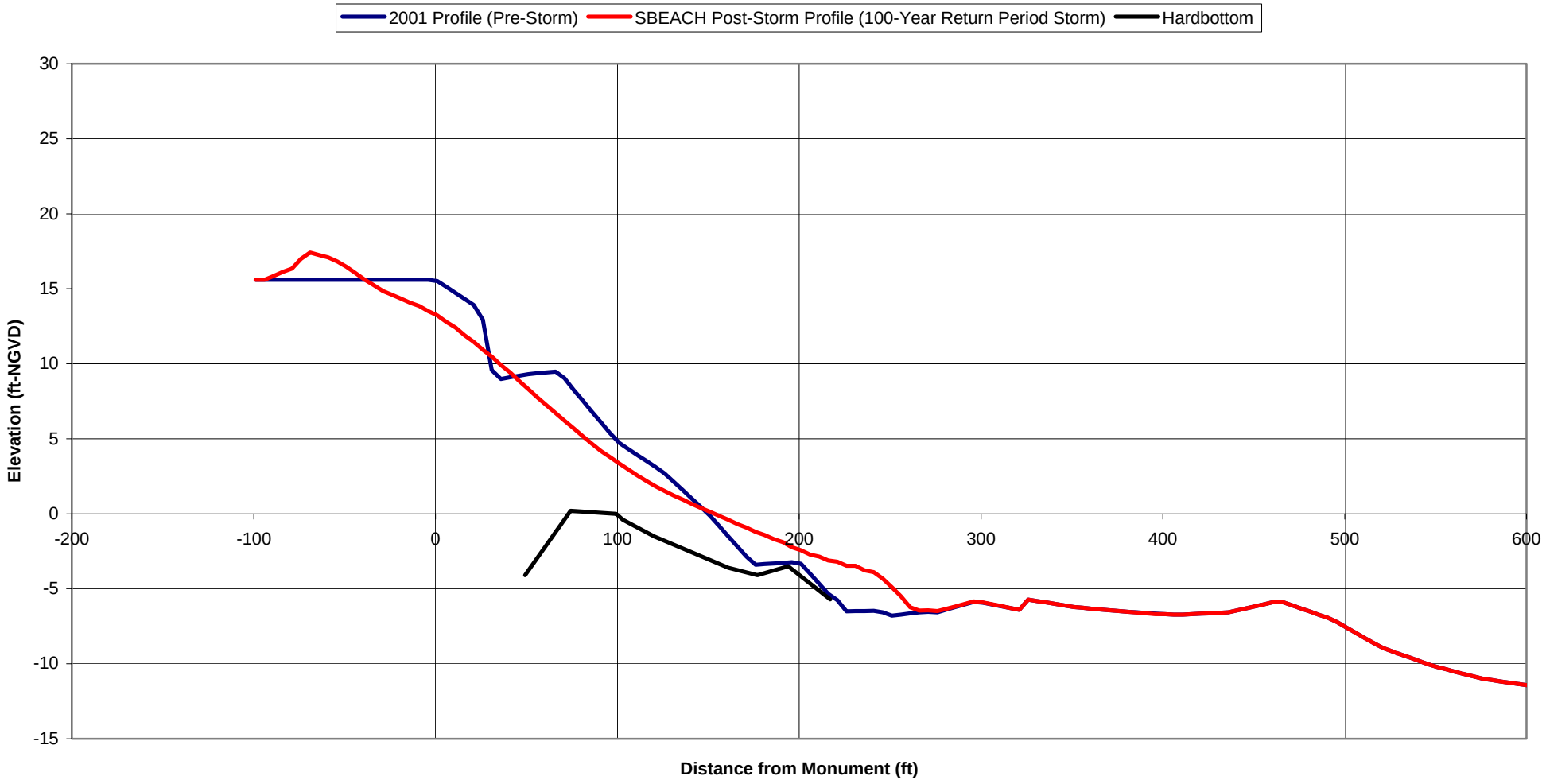
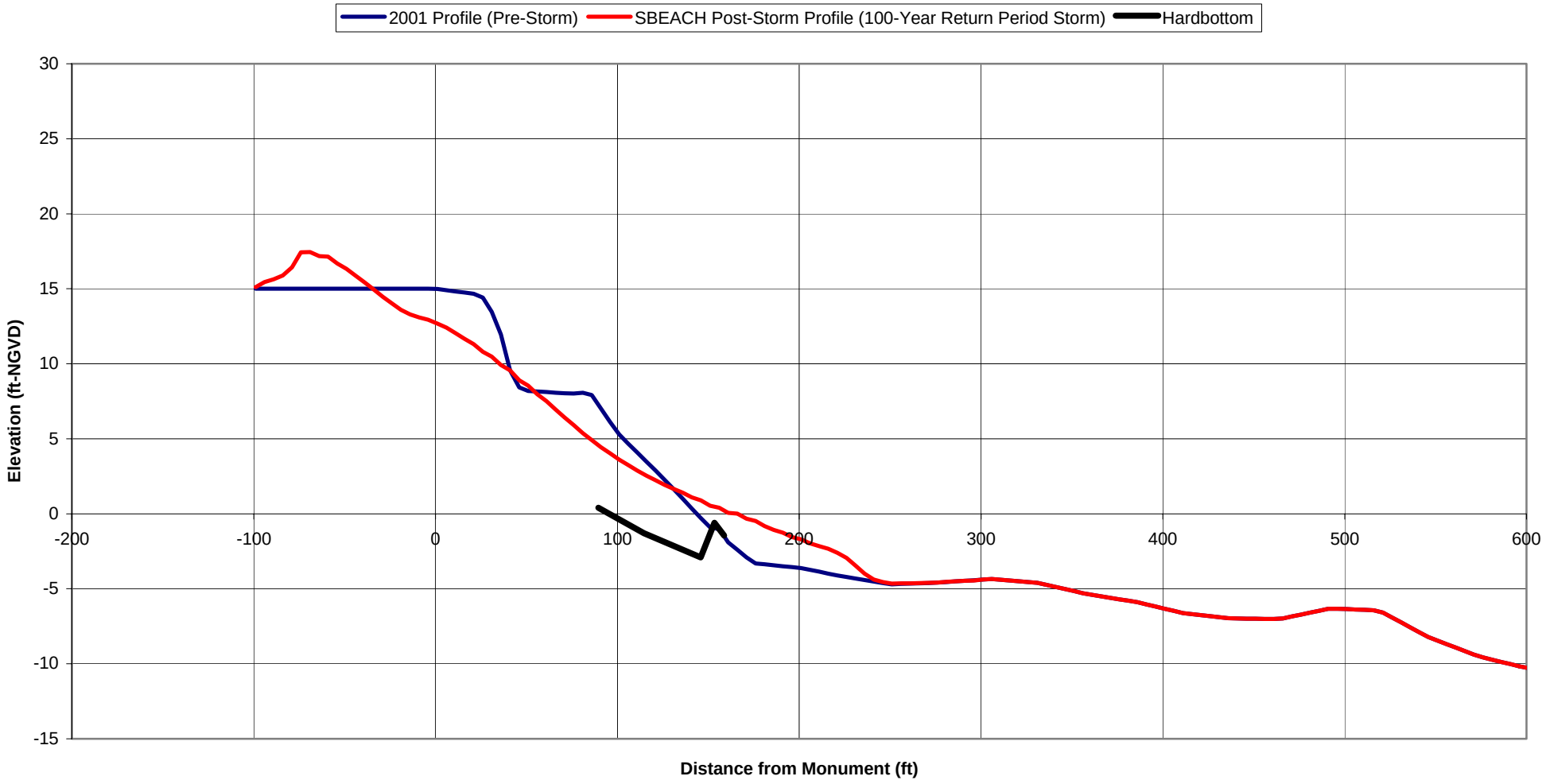


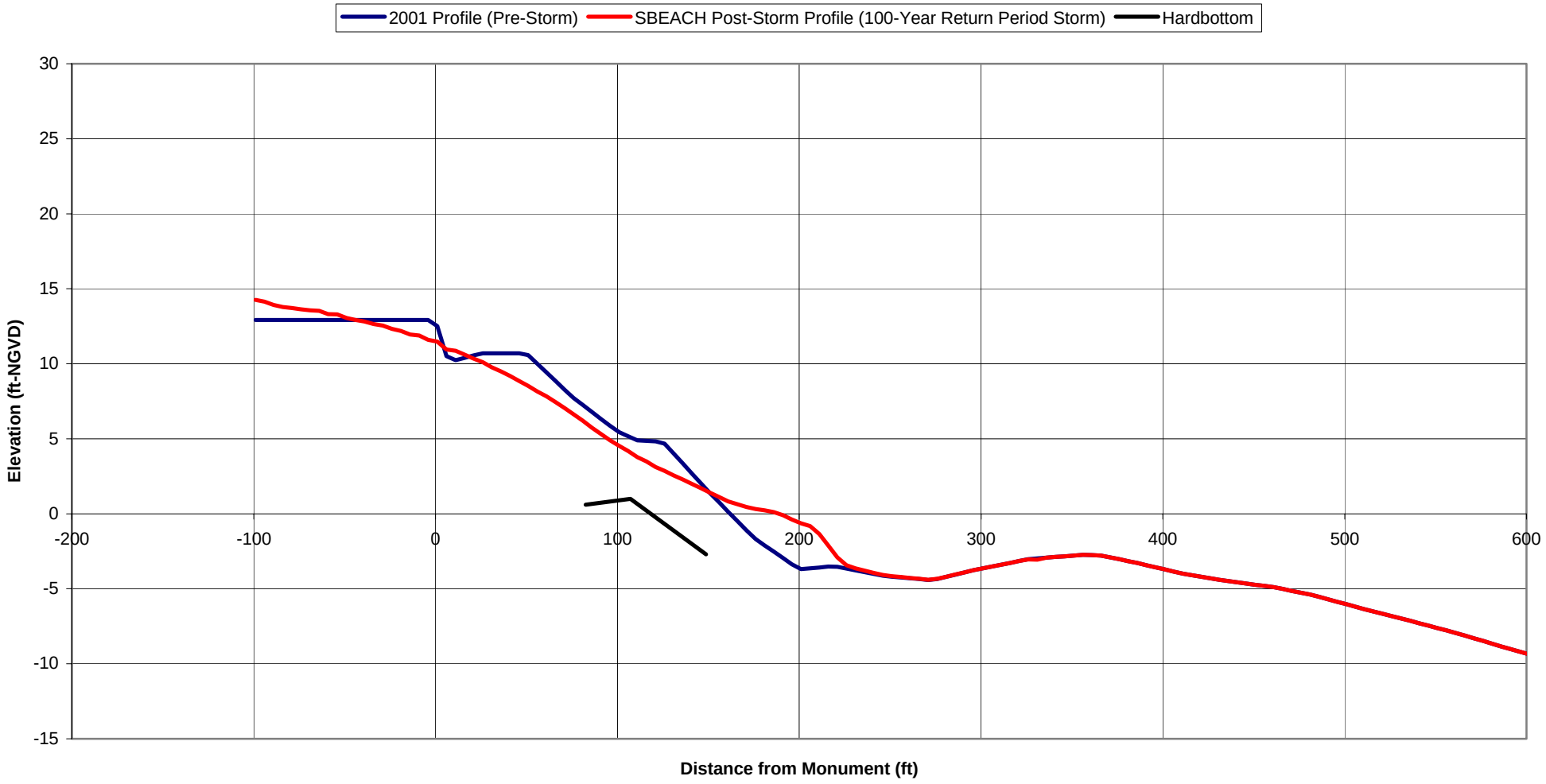

Pre-Storm and Post-Storm Profile at FDEP Profile R-121




Pre-Storm and Post-Storm Profile at FDEP Profile R-122




Pre-Storm and Post-Storm Profile at FDEP Profile R-123

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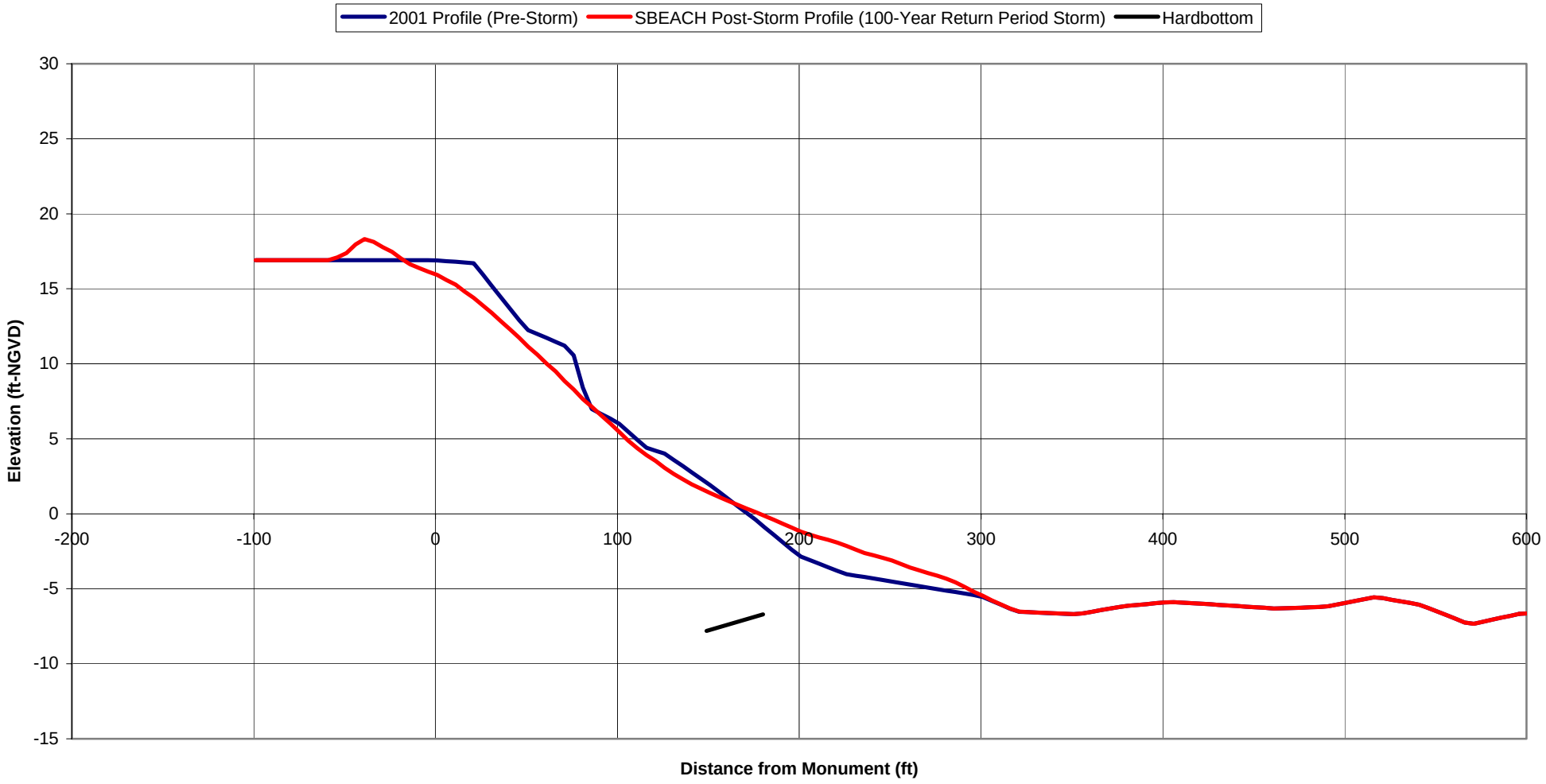
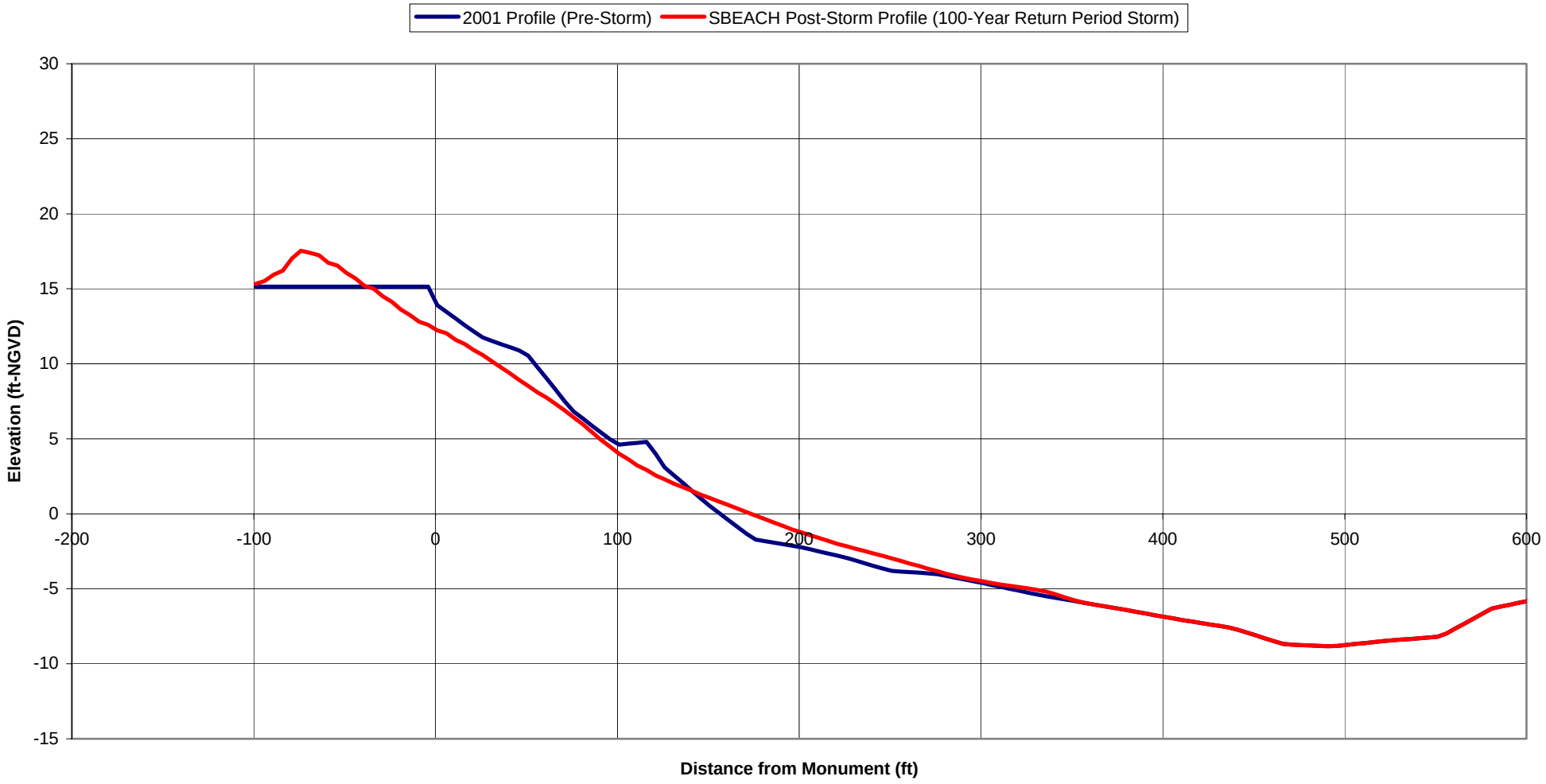



Pre-Storm and Post-Storm Profile at FDEP Profile R-125




Pre-Storm and Post-Storm Profile at FDEP Profile R-126

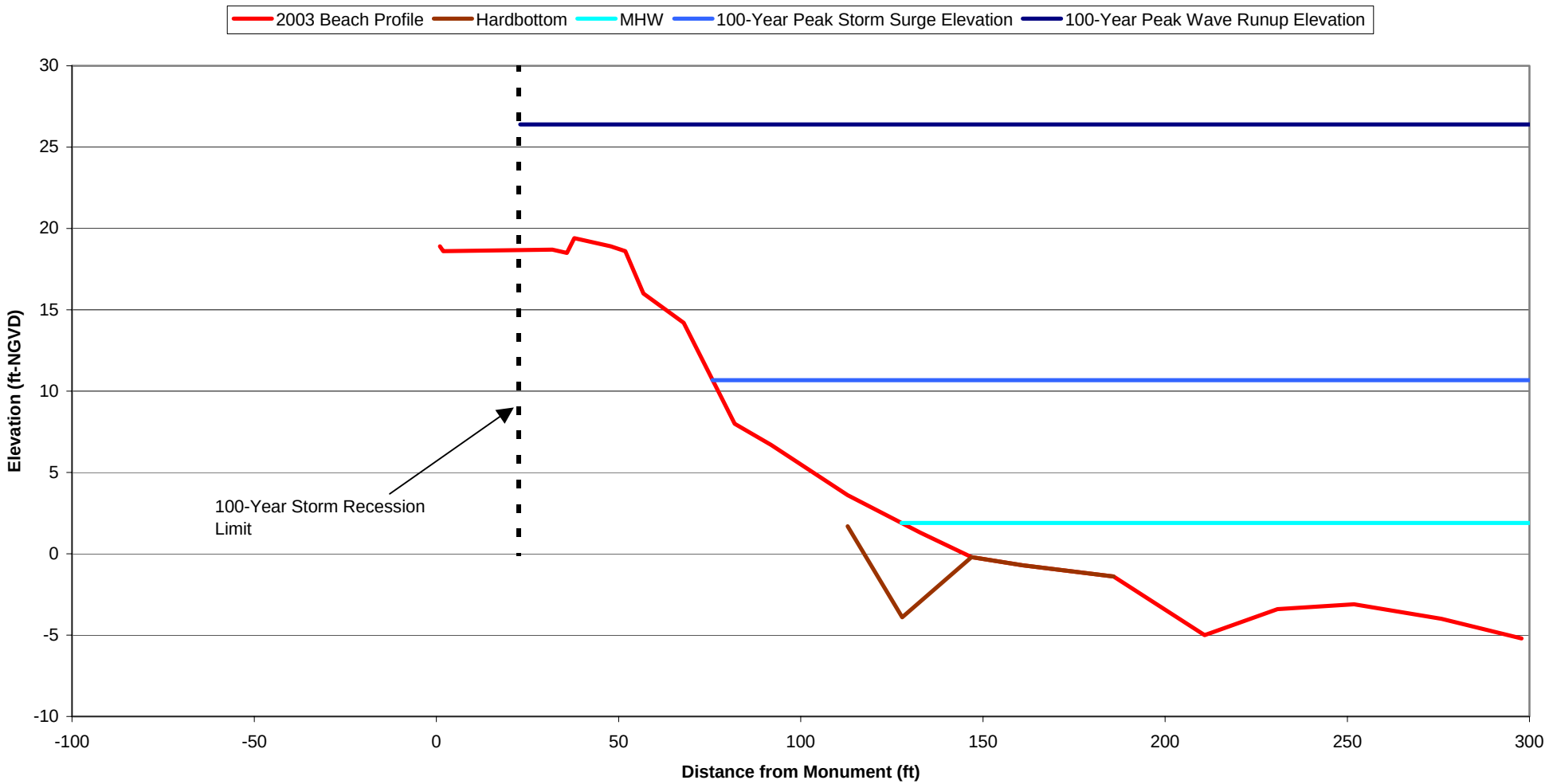
# APPENDIX B

SBEACH Predicted Storm Recession in the Phipps Ocean Park Beach Restoration Project Area

# APPENDIX C

2003 Beach Profile and Hardbottom Data with Method 2 100-Year Storm Recession Distance and Average Structure Location

The following figures present the 100-year storm recession distance developed in Method 2 and the average structure location at each monument in the project area. The figures show MHW (+1.9 ft-NGVD) and the peak storm surge associated with the 100-year return period storm (+10.7 ft-NGVD). However, wave runup, the uprush of water up a slope from the breaking of a wave, will exceed the peak storm surge elevation. The figures also show the maximum wave runup elevation specific for each profile location. The average seaward limit of the structure is a weighted average calculated with respect to the width of the structure.

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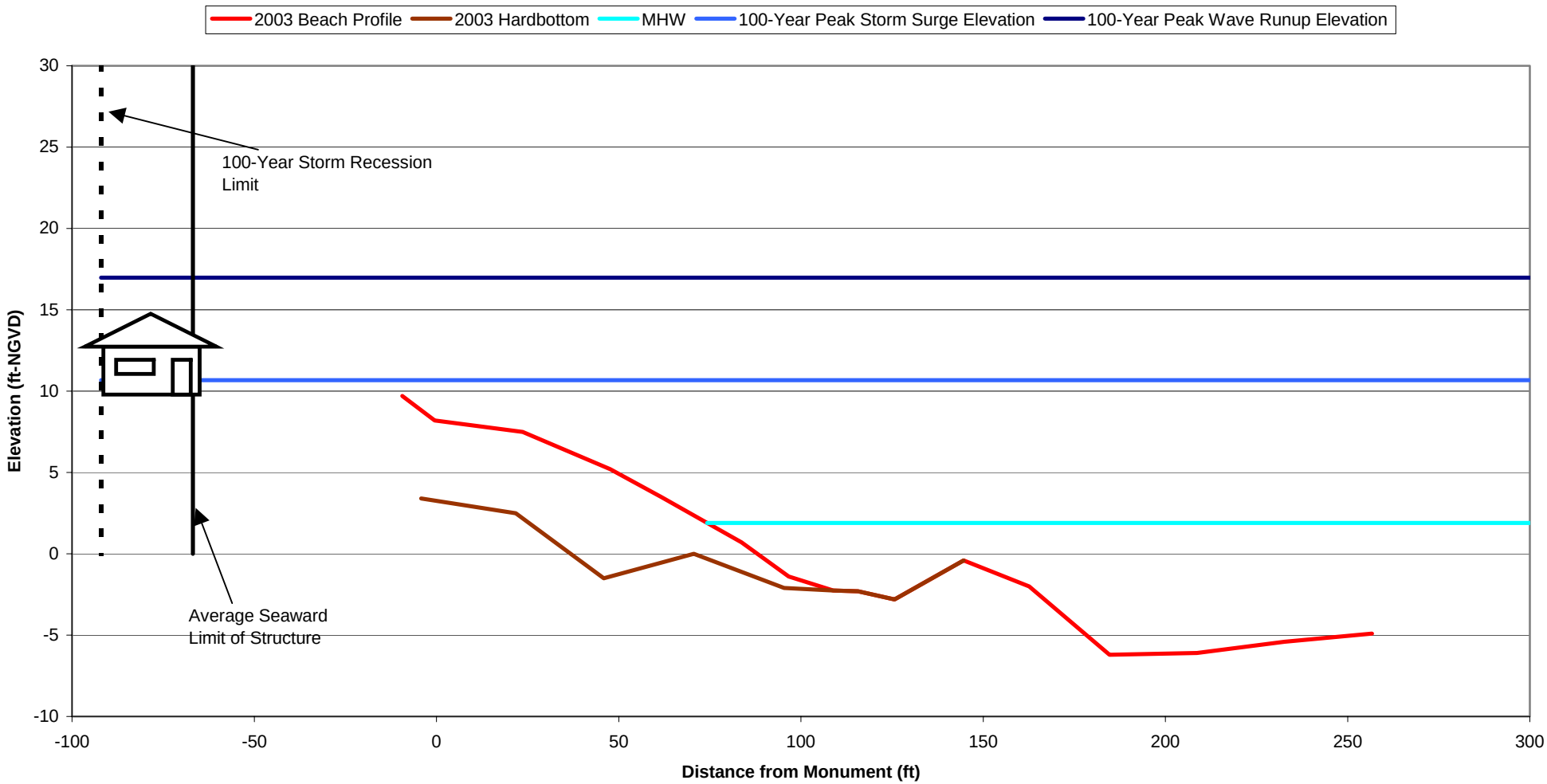


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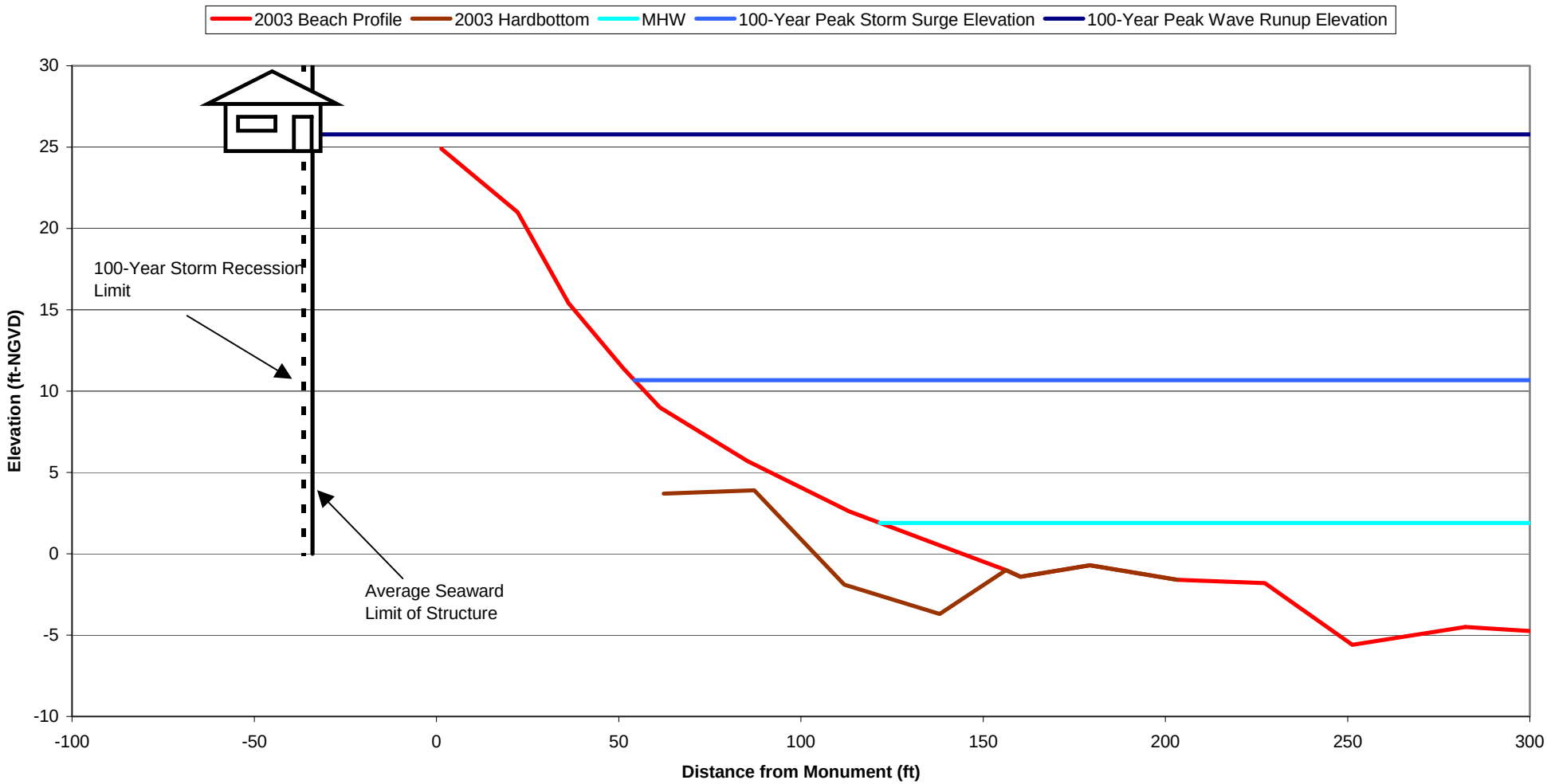


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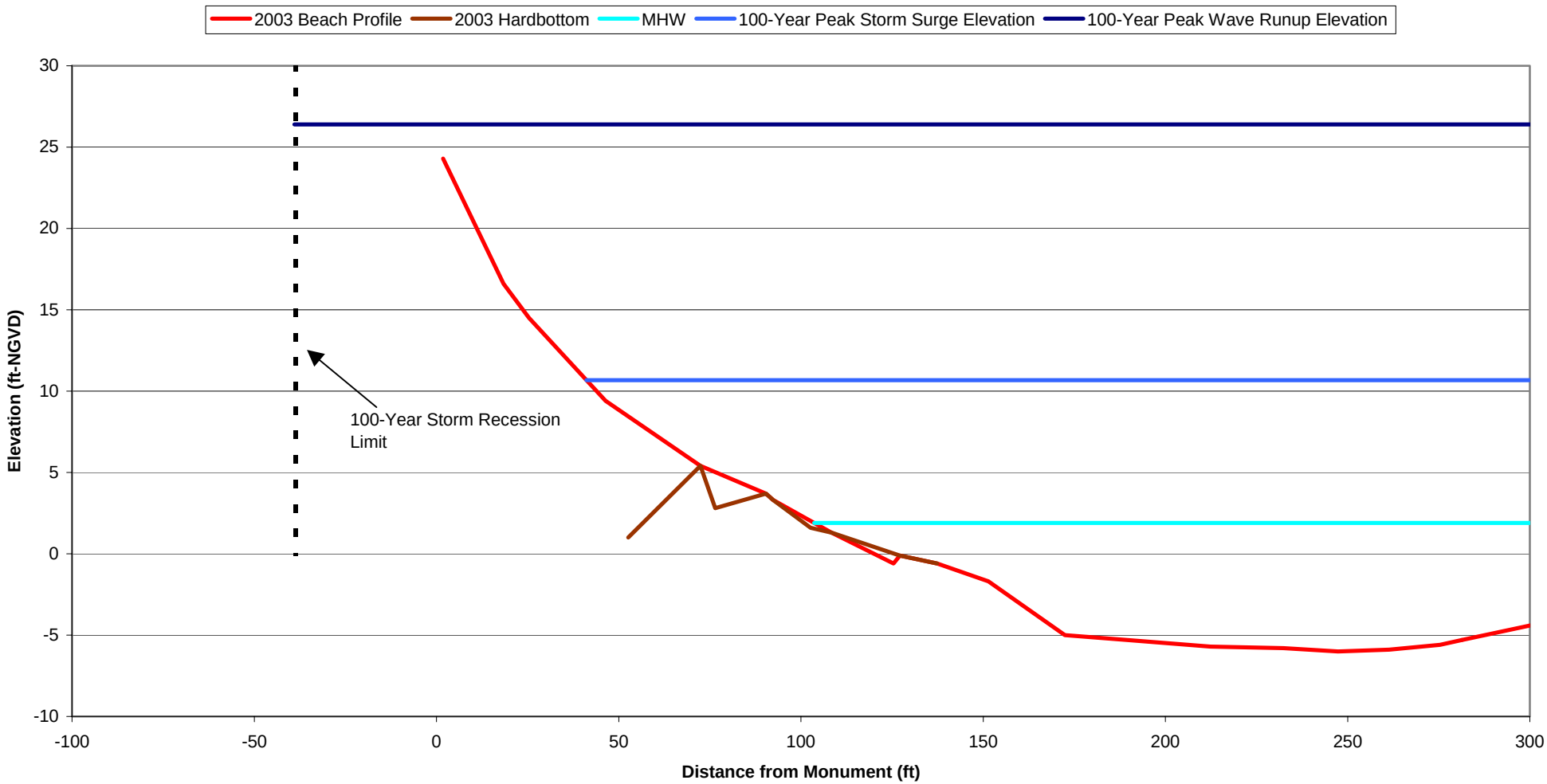


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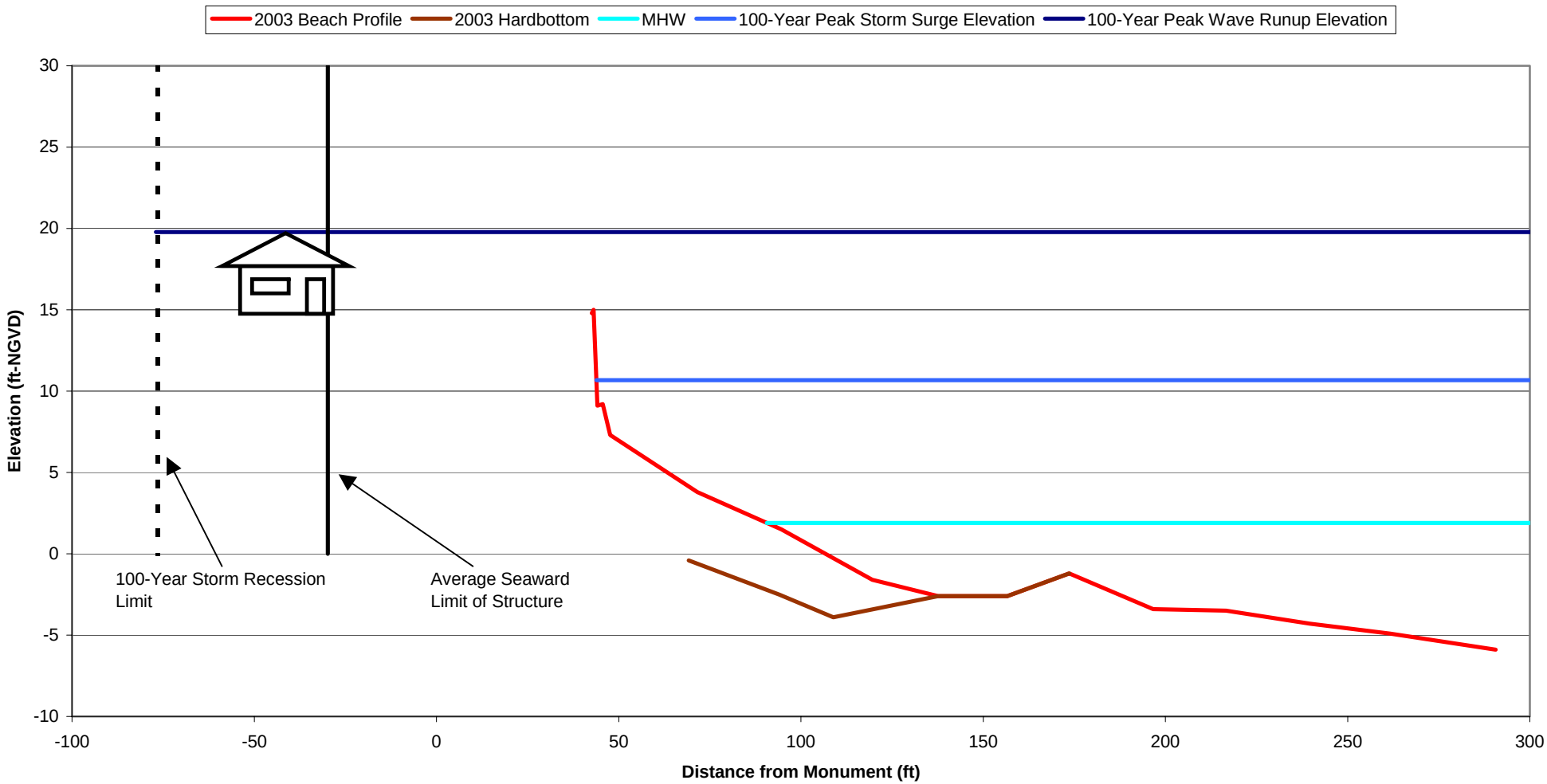


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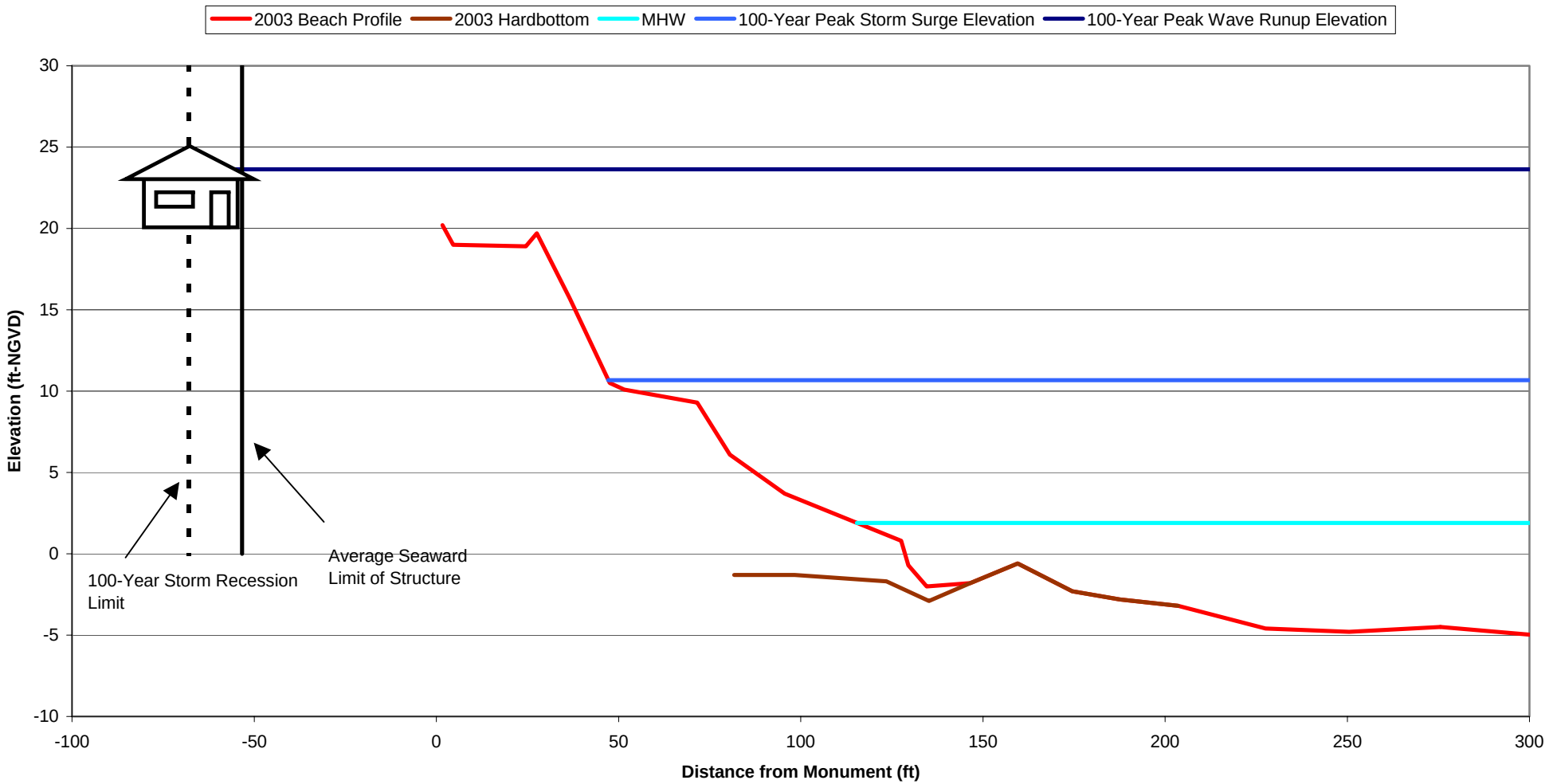


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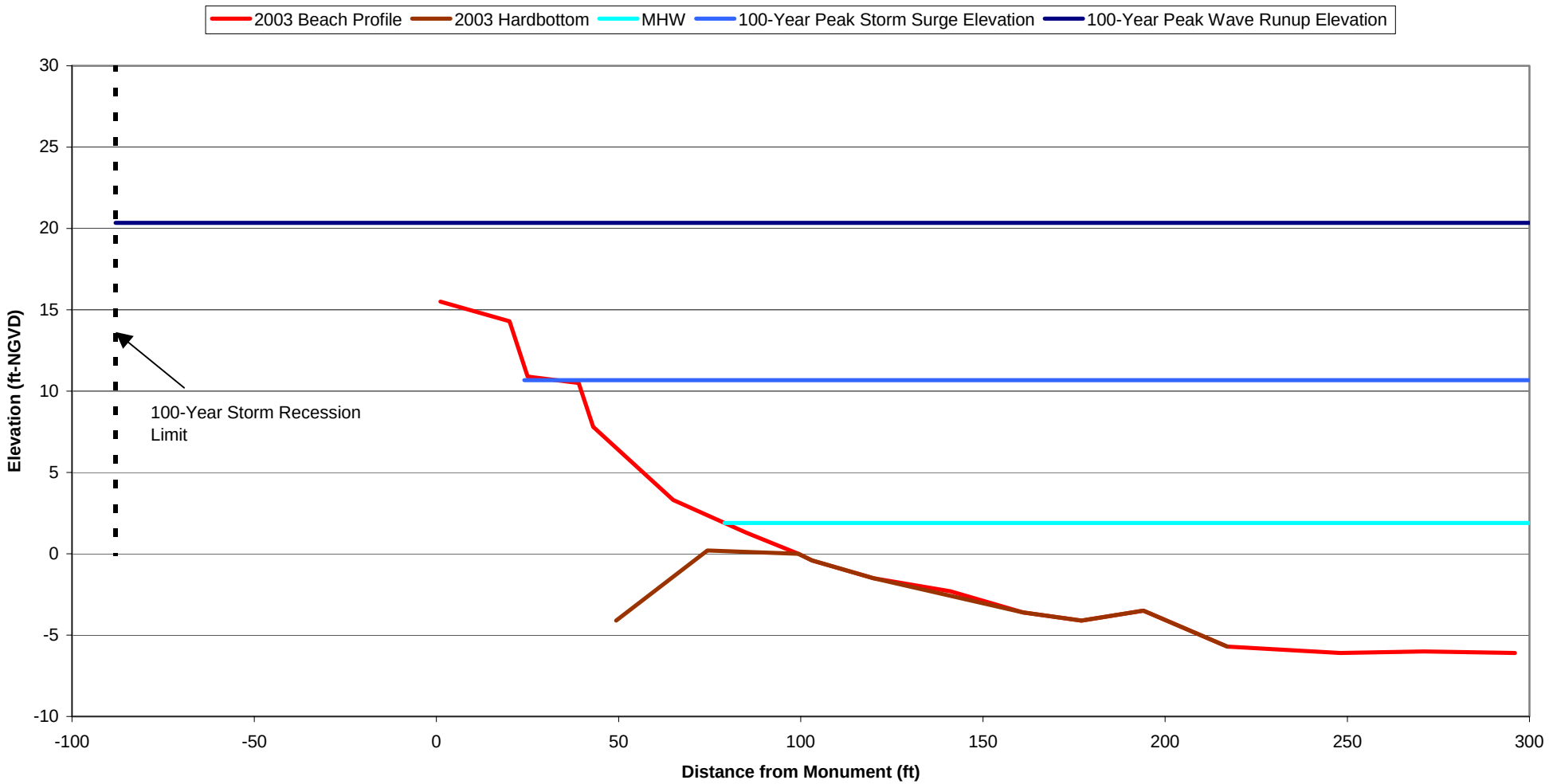


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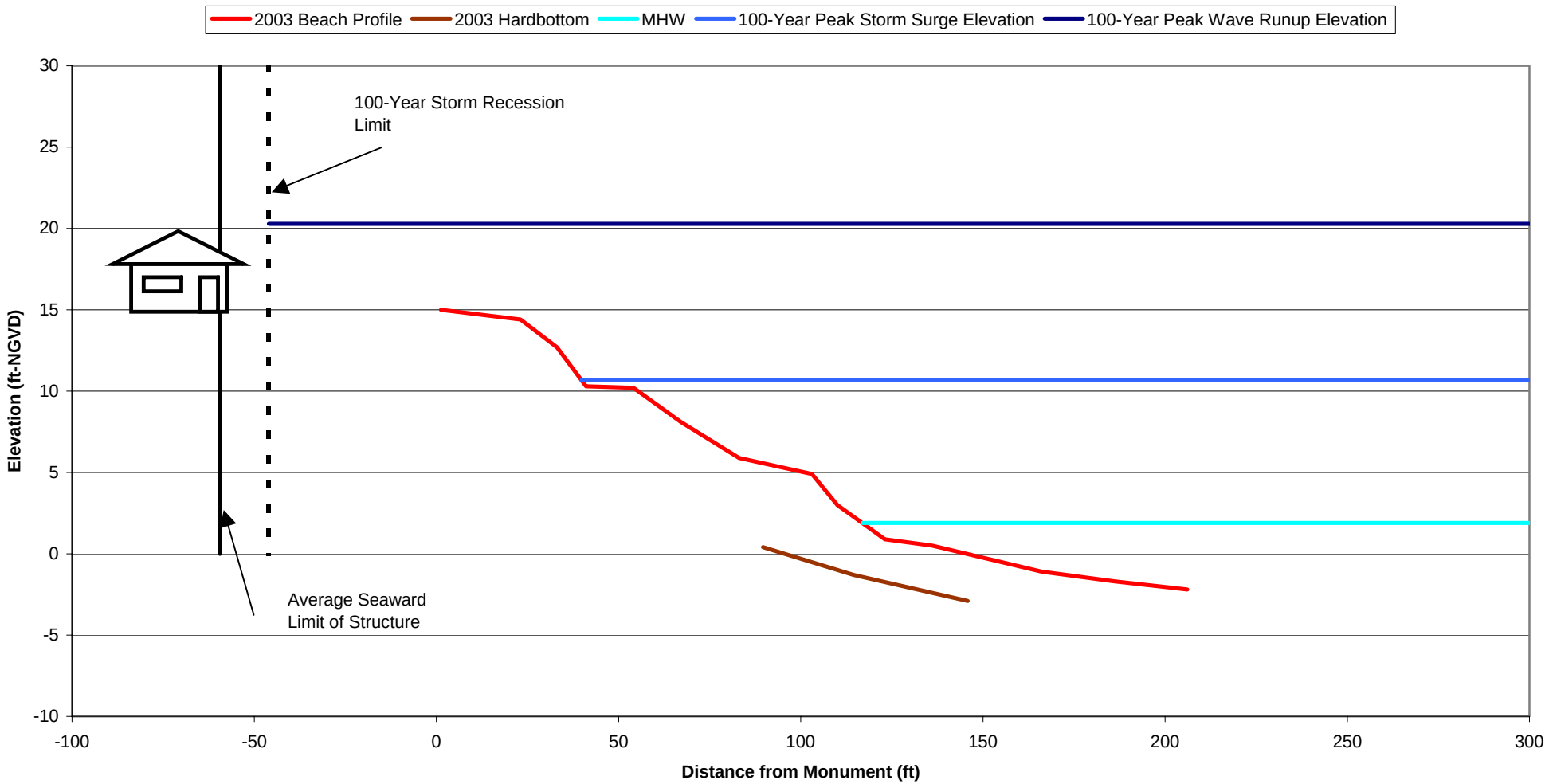


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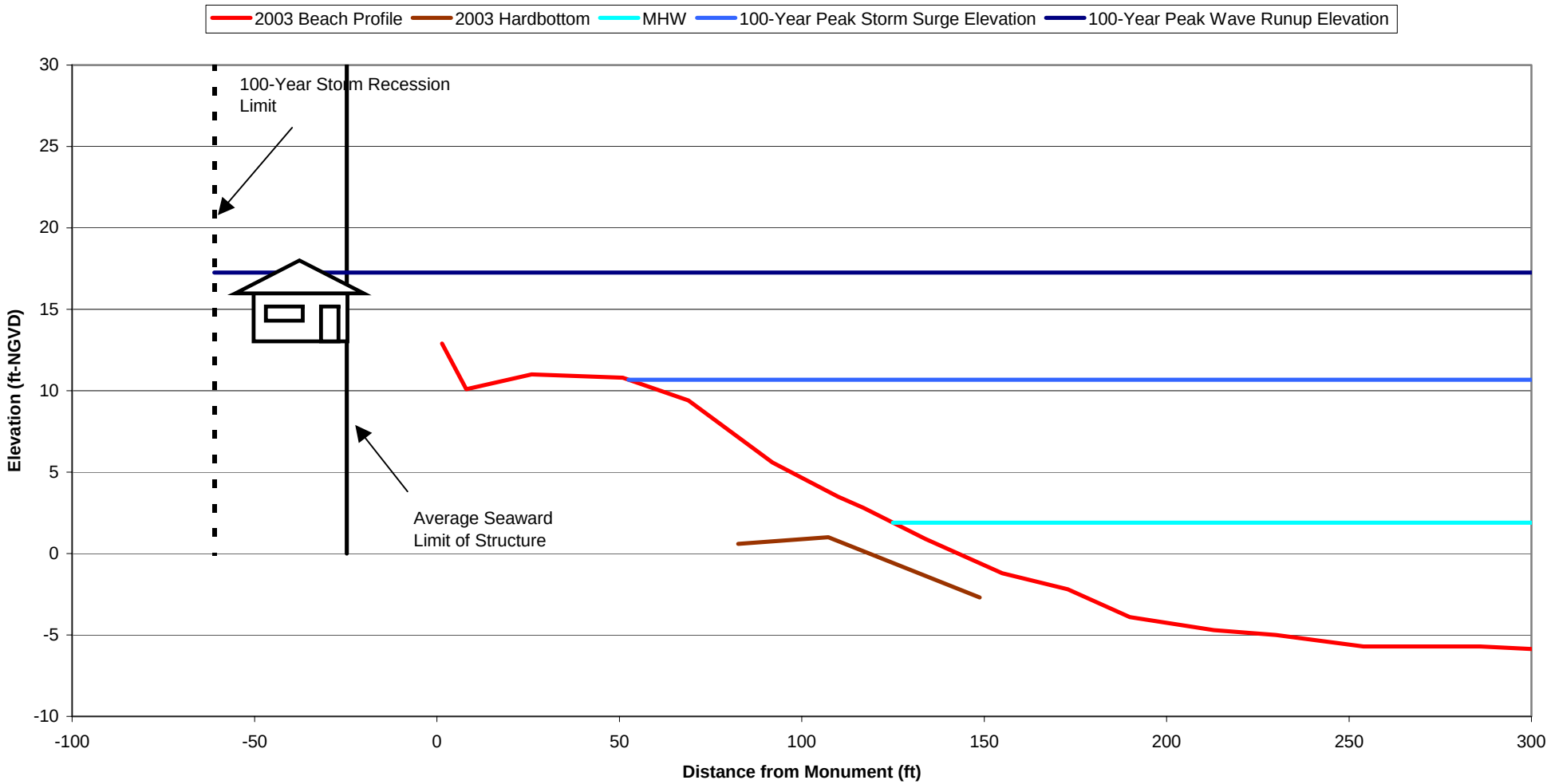


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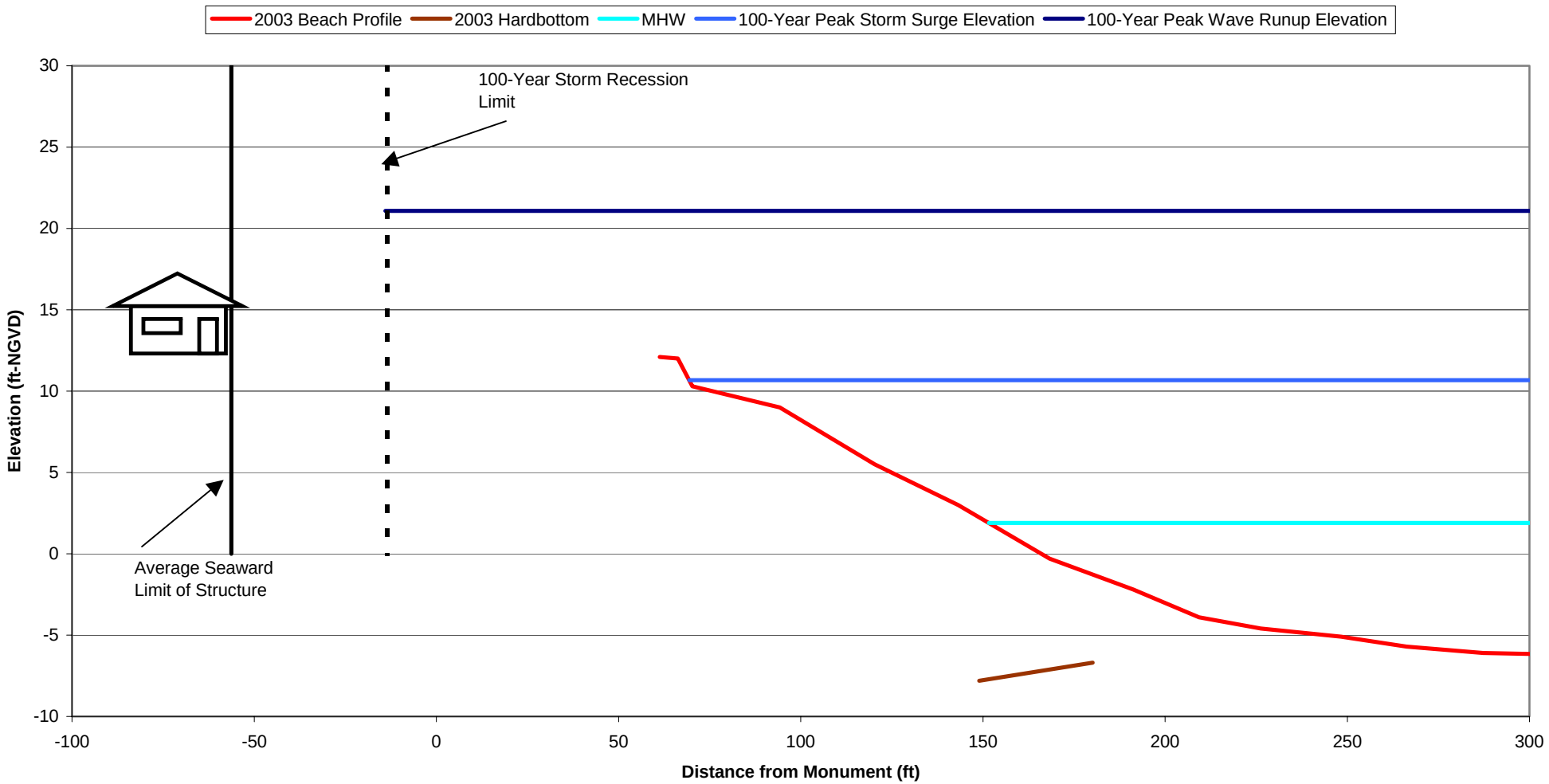


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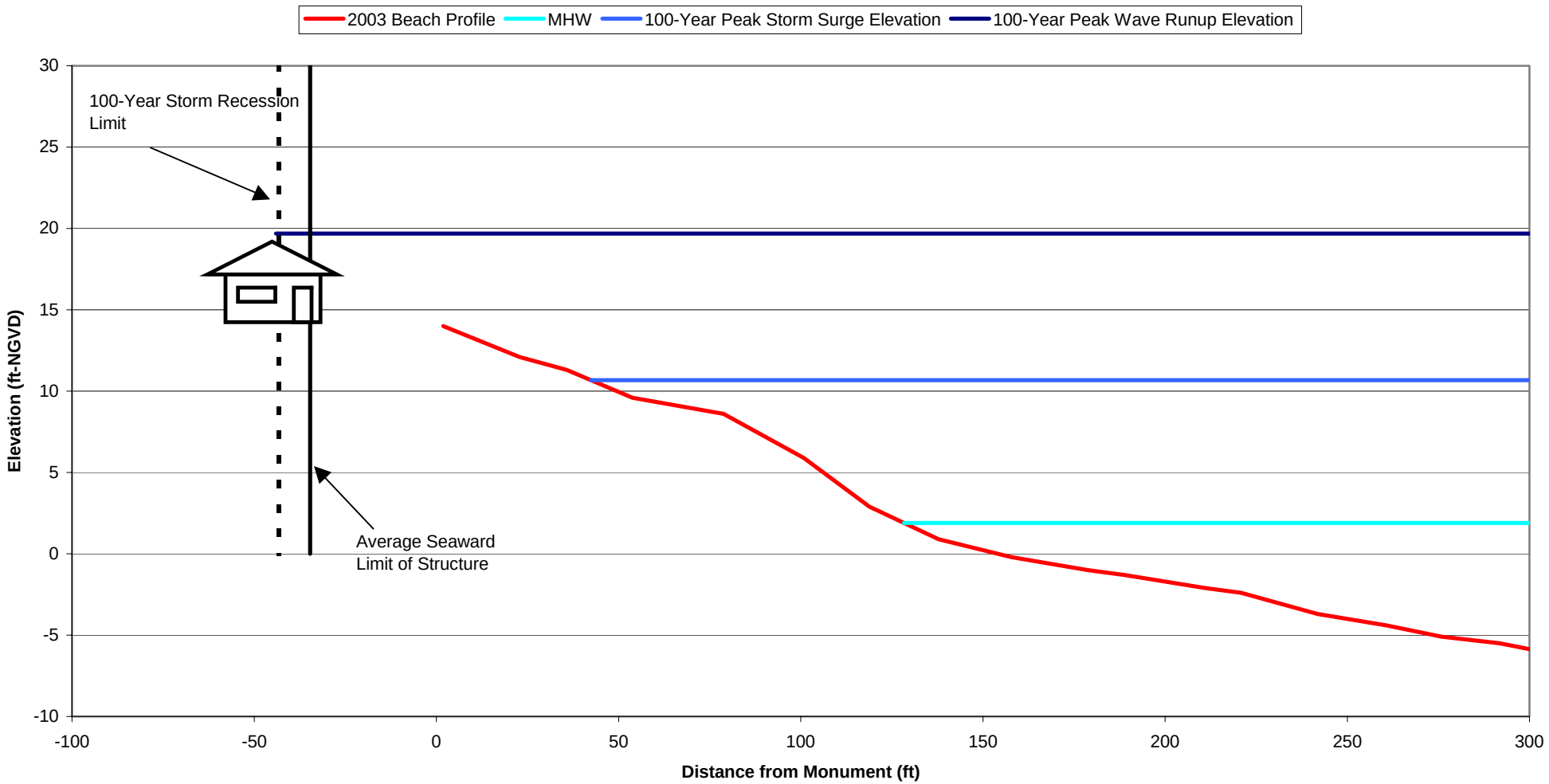


FDEP Profile R-126