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November 28, 2014

To: Fay Rubin, NH GRANIT Project Director
CC: John Grace, U.S. Department of Homeland Security;
Peter Rowell, Town of Rye Building Inspector

Subject: Appeal to the April 9, 2014 Preliminary FIRM for Rockingham County.

Woods Hole Group, Inc. is submitting an appeal for a portion of the Federal Emergency Management Agency (FEMA) Preliminary Flood Insurance Rate Map (FIRM) for Rockingham County, New Hampshire. This appeal is being filed after evaluating the preliminary FIRMs (#33015C0432F), Flood Insurance Study (FIS), and associated coastal backup data for Rockingham County that were released on the April 9, 2014. A revised coastal analysis was conducted to support this appeal that is focused at the reach for FIRM Transect TR-39 in the Town of Rye. This appeal has been filed with the Town of Rye Building inspector and in accordance with the FEMA Appeals Guidance.

1 INTRODUCTION

The Preliminary flood hazards zone delineations along Jenress State Beach in the Town of Rye are shown in Figure 1. Woods Hole Group, Inc. was contacted by Edward O'Meara to review the preliminary FIRMs and associated data for the FIRM reach that includes his property at 2220 Ocean Boulevard in Rye, New Hampshire. The property is located within the reach for transect TR-39, and his property located roughly 150 feet north of the actual FIRM Transect itself. Note that Transect TR-39 was designated TR-42 for the FEMA modeling runs. The properties along this stretch of beach terminate in a concrete/stone seawall roughly 4 feet high above the beach. Figure 1 shows that TR-39 and adjacent properties, including 2220 Ocean Boulevard, in a VE Elevation 15 feet (El. 15) Zone, which transitions into an AO Zone (Depth 3 feet) that extends across Ocean Boulevard and up the cross streets. The effective FEMA FIRM #33015C0432E dated May 17, 2005 designated a VE (El. 15) with a landward extent at the seawall and then transitioning into an AO Zone (Depth 1 ft). Therefore, the overall extent and severity of the SFHA has been expanded for the subject area.

With the appeal period for the preliminary Rockingham Country FIRMs open between November 2 and December 1, 2014, this appeal is being filed to amend the preliminary base flood zone elevations and delineations in the vicinity of FIRM Transect TR-39. The revised analyses presented in this report determined that the base flood zone elevation (BFE) could be lowered based on a reduced wave setup value and that the overall extent of the Special Flood Hazard Area (SFHA) could be reduced based upon the removal the Primary Frontal Dune (PFD) classification for the subject area.

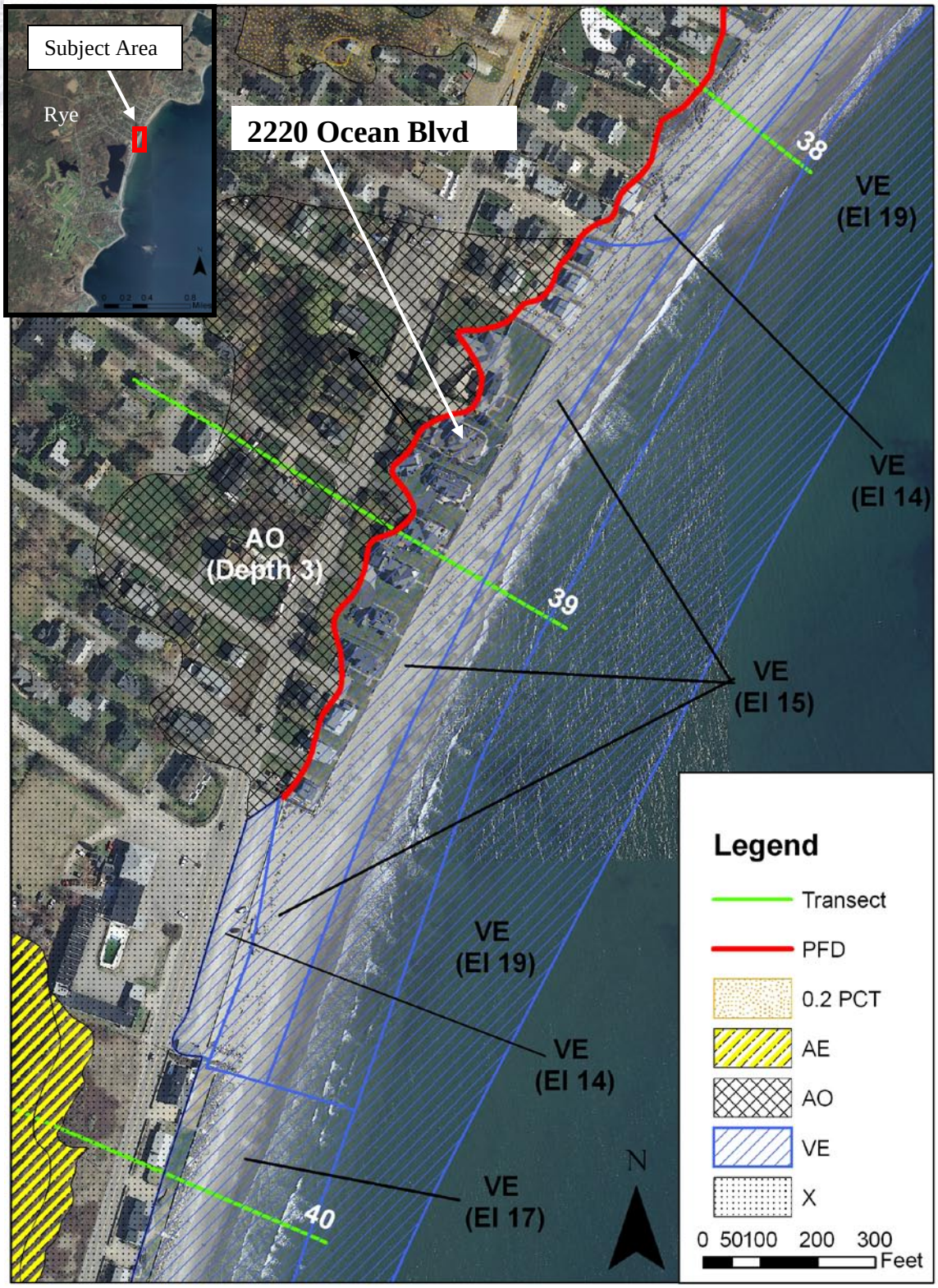

Figure 1. Preliminary April 9, 2014 FEMA FIRM (#33015C0432F).

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2 REVISED WAVE SETUP

Wave setup is an elevation of the water surface above the still water level in the surf zone due to the action of breaking waves and is an important component when analyzing storm flooding. Wave setup values from the April 9, 2014 FIS were computed using the empirically based Direct Integration Method (DIM), which was developed to address wave setup along the Pacific Coast. While FEMA has approved DIM for the Atlantic and Gulf coasts, it has been demonstrated that the DIM can overestimate wave setup for these regions (Kelly, 2013). Therefore, Woods Hole Group computed a revised computation of wave setup using the numerical model Simulating Waves Nearshore (SWAN). SWAN is a third-generation wave model, approved by FEMA, for obtaining realistic estimates of wave parameters in coastal areas from given wind, bottom, and current conditions. SWAN includes wave generation, dissipation, non-linear interactions, and transformations. It also includes bottom friction, currents, shoaling, refraction, diffraction, depth induced breaking, and wave setup. SWAN represents a model based approach that accounts for the physics of the waves, and was therefore selected as an improved alternate to the empirically based Direct Integration Method (DIM) for computing wave setup.

SWAN was operated in 1-D mode to compute wave setup. The 1-D model approach was considered to be more conservative for wave setup, since the 2-D model accounts for effects of the surrounding bathymetry and shoreline configuration on the wave form as it travels towards the coastline. The 1-D model is also consistent with FEMA's transect based analyses and readily allows representation of rapidly changing shoreline conditions at a high resolution.

Woods Hole Group, Inc. computed wave setup using SWAN 1-D for TR-39 (TR-42 in CHAMP). Woods Hole Group reviewed the April 9, 2014 CHAMP input data, including the offshore wave conditions and the 100-yr Still Water Elevation (1% SWEL), and deemed these input criteria to be valid. Therefore, the input data for CHAMP was used as input to SWAN to calculate a revised wave setup value for Firm Transect TR-39 as shown in Table 1. Bathymetric and topographic conditions were also taken directly from the April 9, 2014 FEMA CHAMP database for Transect TR-39. Waves were assumed to conservatively approach normal to the shoreline (along the axis of the transect i.e. 90 degrees) and spectral spreading was turned off in the model (to ensure that the peak energy was not muted). This represents a conservation assumption where the model computed wave setup using peak wave conditions, rather than a spectral spread of the waves.

Table 1. FEMA April 9, 2014 CHAMP input values utilized at input for the SWAN 1-D calculation of Wave Setup.

FIRM Transect No.	1% SWEL (ft)	Significant Wave Height (ft)	Peak Period (sec)	Angle (deg)
TR-39*	8.36	25.1	11.66	90

*Transect TR-39 on the preliminary FIRM is modeled Transect TR-42 in CHAMP data base

The results from the SWAN 1-D simulation for wave setup at transect TR-39 are shown in Table 2 and Figure 2. For comparison, the wave setup values utilized by FEMA in the April 9, 2014 FIS is also shown. The wave set-up dynamically computed by the SWAN model is 1.21 ft lower (38% reduction) than the DIM result for the April 9, 2014 FIS. Electronic files containing the SWAN 1-D input and output files are provided in the *SWAN1D_WaveSetup* folder of the attached CD.

Table 2. Comparison of Revised and FEMA April 9, 2014 FIS Wave Setup Values.

Transect No.	April 9, 2014 Wave Setup (ft)	Revised Wave Setup (ft)	% Reduction
TR-39*	3.20	1.99	38%

*Transect TR-39 on the preliminary FIRM is modeled Transect TR-42 in CHAMP data base

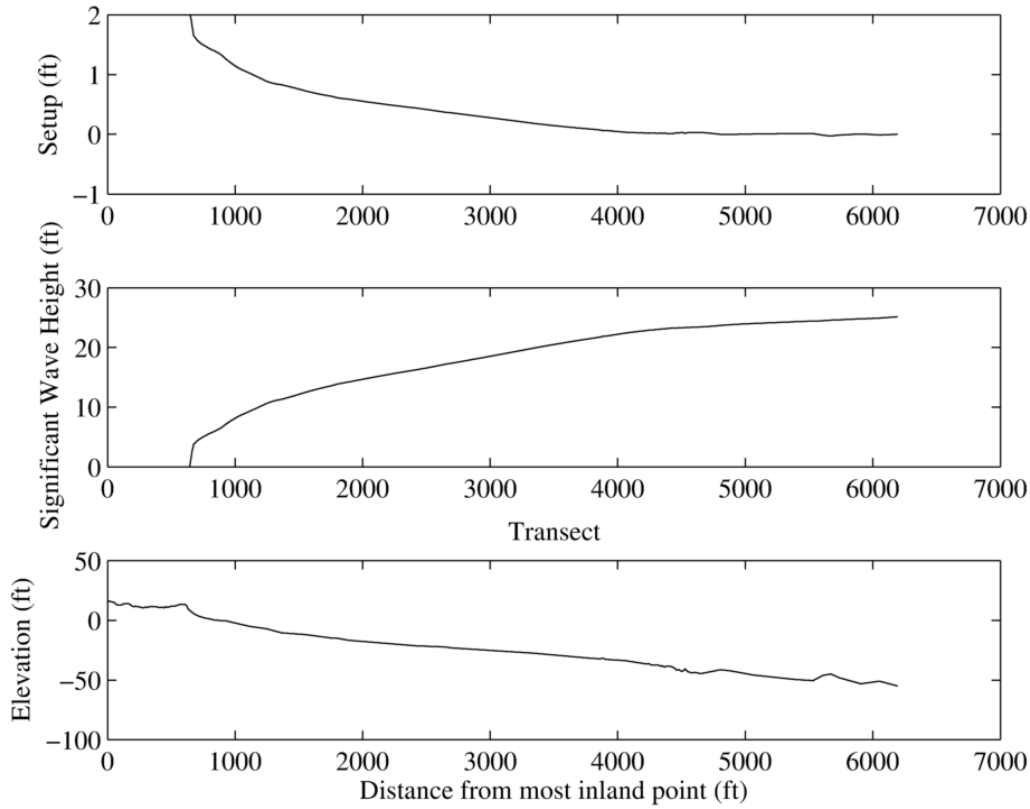

Figure 2. SWAN 1-D modeling results for wave setup (top), wave height (middle), along Transect TR-39 (bottom).

3 REVISED BASE FLOOD ELEVATION (BFE) DETERMINATION USING CHAMP

In an effort to understand how the reduced wave setup would change the Base Flood Elevation (BFE) and delineation for Transect TR-39, the CHAMP modules WHAFIS and Runup 2.0 were implemented using the reduced wave setup value. The preliminary

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FIRMs mapped a VE Zone with a BFE of 15 feet NAVD88 based on runup results since they were more conservation than the WHAFIS results. All other input to CHAMP including offshore wave conditions, water levels, and topographic profile data remained unchanged from the April 9, 2014 backup data. The revised BFE for Transect TR-39 would be determined by using the more conservative estimate of BFE from WHAFIS and Runup 2.0 as per FEMA guidance.

WHAFIS is a nearshore wave transformation model that delineates the BFE along a transect based on where it is subject to wave activity. Except for the reduced wave setup, the WHAFIS input from the April 9, 2014 backup data remained unchanged as shown in Table 3. For transect TR-39, the total water level (TWL) was computed by WHAFIS based on values input for the 1% SWEL and the wave setup (TWL = 1% SWEL + wave setup). The revised WHAFIS results for TR-39 indicate that the BFE for the final VE Zone reduces from 15 ft NAVD88 in the preliminary FIRM to 12 ft NAVD88. The resulting VE (El. 12) is limited to the beach as shown in Figure 3 and a small AE (El. 12-11) zone is delineated between the VE Zone and seawall.

Table 3. FEMA April 9, 2014 CHAMP Input Values.

FIRM Transect No.	1% SWEL (ft)	Significant Wave Height (ft)	Peak Period (sec)	Revised Wave Setup (ft)	Revised TWL (ft)	Revised BFE (ft)
TR-39*	8.36	25.1	11.66	1.99	10.35	12

*Transect TR-39 on the preliminary FIRM is modeled Transect TR-42 in CHAMP data base

Wave runup was calculated using the methodologies described in the FEMA Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update (FEMA, 2007). Transect TR-39 is represented by a natural sloping sand beach in front of a 4-foot vertical stone/concrete wall. For the April 9, 2014 FIS, FEMA had treated runup using two methods: the CHAMP Module Runup 2.0 for natural sloping beaches and the TAW Method for runup on a sea wall (as failed structure). The more conservative estimate for the BFE was then used to delineate the preliminary FIRM. However, the revised TWL of 10.35 ft NAVD88 is below the toe of the structure, 10.4 ft NAVD88, which would make the TAW method not applicable since the toe of the structure is not inundated. Also, since the transect is characterized by a natural sloping beach in front of the structure, there is no secondary toe further seaward where the TAW composite slope method could be applied. Therefore, Runup 2.0 was solely used to model runup since the profile is represented by a natural sloping beach. All other Runup 2.0 input from the April 9, 2014 FIS remained unchanged including mean wave conditions (height and period), 100-year SWEL, and profile data for Transect TR-39.

The revised Runup 2.0 results for the mean runup, R_{mean}, and 2% runup, $R_{2\%}$, are shown in Table 4. The 2% runup is the value exceeded by 2% of the runup events and is the current value that the National Flood Insurance Program (NFIP) uses for runup. The resulting $R_{2\%}$ of 3.48 feet is then added to the 1% SWEL of 8.36 feet without wave setup (based upon the 2007 FEMA guidance) to obtain the total wave runup elevation of 11.84 feet. This runup elevation is rounded up to resulting delineation is a VE (El. 12) Zone

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limited to the beach as shown in Figure 3. Significant wave overtopping is not expected to occur since the toe of the structure is not inundated using the revised TWL and the revised $R_{2\%}$ elevation is below the crest of the structure. The revised Runup 2.0 results for TR-39 indicate that the VE Zone BFE reduces from 15 ft NAVD88 in the preliminary FIRM to 12 ft NAVD88 and encompassing the entire beach to the seawall.

Table 4. Revised Runup 2.0 input and output (NAVD88).

FIRM Transect	Revised TWL (ft)	Structure Toe Elevation (ft)	Structure Crest Elevation (ft)	Revised R_{mean} (ft)	Revised $R_{2\%}$ (ft)	Revised Runup Elevation (ft)
TR-39*	10.35	10.4	12.7	1.56	3.48	11.84

*Transect TR-39 on the preliminary FIRM is modeled Transect TR-42 in CHAMP data base

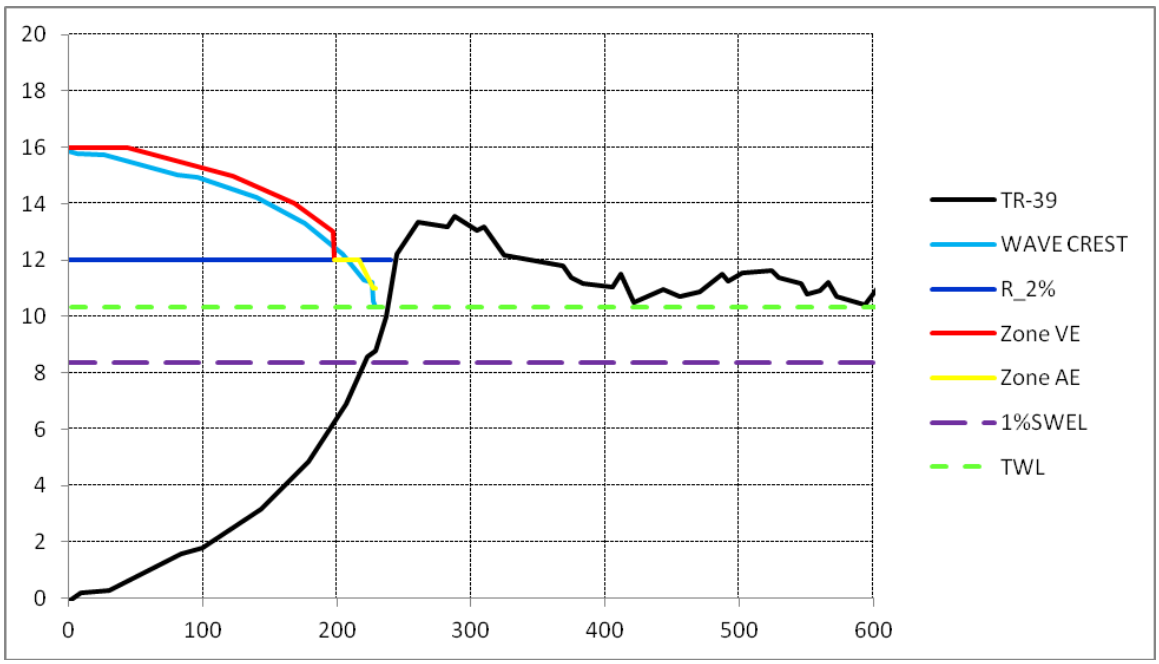

Figure 3. Revised WHAFIS and Runup 2.0 results for transect TR-39.

The revised WHAFIS and Runup 2.0 results both computed a BFE of 12 ft NAVD88 for the final VE Zone at Transect TR-39. An elevation of 12 feet NAVD88 would put the runup on the seawall below the crest of the structure. WHAFIS also delineated an AE (El. 11) zone for a short section of beach in front seawall; however, Runup 2.0 delineated the VE (El. 12) zone to the seawall. Therefore, the more conservation delineation, the Runup 2.0 results, are used to map the VE (El. 12) Zone across the beach to the seawall at Transect TR-39. Electronic files containing the CHAMP database and associated model files are provided in the *CHAMP_Modeling* folder of the attached CD.

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Table 5. Comparison of revised WHAFIS and Runup 2.0 results to preliminary FIS results.

FIRM Transect	BFE Delineation*		
	Preliminary FIRM (ft)	Revised WHAFIS (ft)	Revised Runup 2.0 (ft)
TR-39*	VE (El. 15)	VE (El. 12)	VE (El. 12)

*Transect TR-39 on the preliminary FIRM is modeled Transect TR-42 in CHAMP data base

4.0 PRIMARY FRONTAL DUNE DELINEATION

A review of the April 9, 2014 backup data indicated that the landward extent of the VE (El. 15) Zone for TR-39 was not mapped based on the WHAFIS or runup results. Instead, the landward limit of the VE (El. 15) Zone was mapped to the landward toe of the Primary Frontal Dune (PFD), which was a more conservative mapping decision. Woods Hole Group, Inc. investigated the delineation of a PFD in this location to determine whether the revised flood hazard zones delineations determined by WHAFIS and Runup 2.0 in Section 3.0 would need to be adjusted accordingly. The definition of a Primary Frontal Dune (PFD) from the National Flood Insurance Program (NFIP) is:

> *"Primary frontal dune means a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during major coastal storms. The inland limit of the primary frontal dune occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope."*

Figure 4 shows the FEMA GIS layers for the PFD and transects plotted over an aerial image of the town of Rye. The figure indicates that a PFD was delineated between transects TR-37 and TR-39. It should be noted that a PFD was not delineated at this location in effective 2005 FIRM. Also shown in Figure 4 is a GIS layer provided by the New Hampshire Department of Environmental Sciences (NHDES) that delineates coastal sand dune resources along this stretch of coast. The figure indicates that NHDES delineated a dune in front of the parking lot at Jenress State Park, but not between Transects TR-37 and TR-39 where a PFD was delineated by FEMA. Therefore, NHDES does not consider the area between TR-37 and to TR-39 to be classified as a dune resource.

Additionally, the Field Reconnaissance Report associated with this preliminary mapping entitled *Coastal Flood Insurance Study performed December 12-14, 2011* (AECOM, 2012) did not document a PFD between TR-37 and to TR-39, meaning that the PFD delineation was never 'ground truthed'. However, the same AECOM field report documented PFDs at other nearby locations including Wallis Sands State Park (Transects TR-23 to TR-25) and North Hampton State Park (Transects TR-55 to TR-58).

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Figure 4. Delineation of the PFD for the Town of Rye along with

Topographic data between Transects TR-37 to TR-39 was evaluated to determine the presence of a primary frontal dune. Topographic data was derived from the 2011 LiDAR dataset for the Northeast that was downloaded from the NOAA Coastal Services Center (CSC) website. The LiDAR data was referenced to the New Hampshire State Plane coordinate system (NAD83, ft) and the vertical datum of NAVD88 (ft). The LIDAR data set was used to developed color contour image of the project area using the Surface-Water Modeling System (SMS) as shown in Figure 5. The image indicates that there does not appear to continuous mound or ridge of sand that would constitute a dune along this stretch of coast. The land is highly developed with extensive impervious surfaces including roads, driveways, and houses with solid foundations and is not a dune resource. A concrete/stone sea wall both defines and protects the oceanfront properties at their

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seaward property limit. While the seaward portion of these properties (abutting the seawall) is at a higher elevation (1-3 feet) than the landward portion that abuts the road, these building footprints are primarily built on fill that artificially raises the elevation of the land relatively to the rest of the property. In addition there does not appear to be a distinct change from a relatively steep slope to relatively mild slope that would define the landward toe or heel of the PFD. Historically there may have been a dune in this location, however, this stretch of coast has been significantly altered and a PFD delineation cannot be definitively made from this landform.

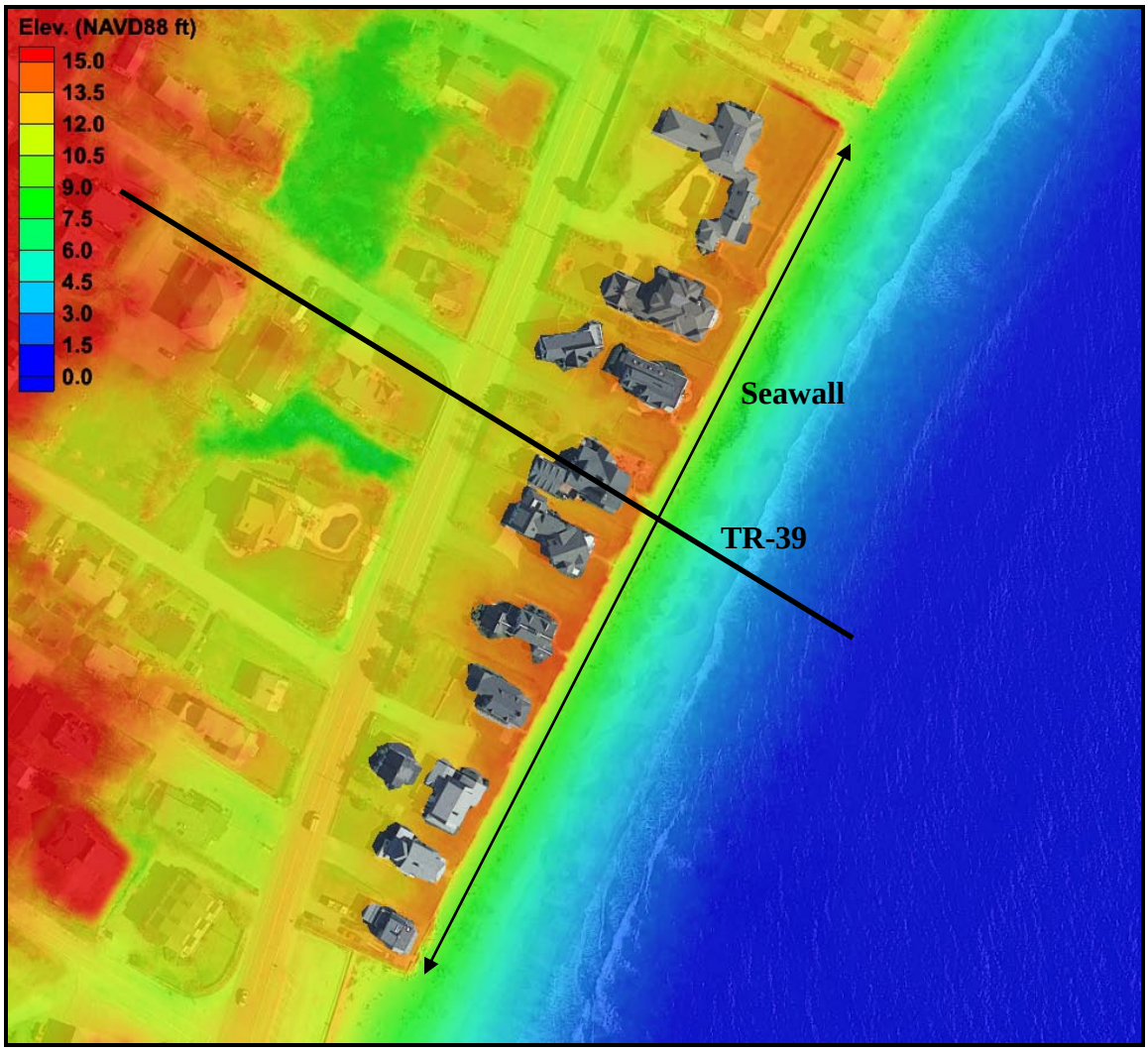

Figure 5. Topographic contours based on 2011* LIDAR (NAVD88 feet).

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5 WOODS HOLE GROUP FIELD RECONNAISSANCE

After reviewing the preliminary April 9, 2014 FIS and associated data, it remained unclear how the PFD delineation was made between Transects TR-37 and TR-39. The PFD delineation was never 'ground truthed' since it was not documented between Transects TR-37 and TR-39 the AECOM 2012 field report. Therefore, Woods Hole Group, Inc. conducted a supplemental field investigation to confirm the presence of a PFD on November 13, 2014. This section presents the photographs and evidence gathered during this field investigation.

Figures 6 and 7 show photographs taken on the beach in front of the seawall at TR-39. The figures show a natural sloping beach leading to the seawall. Some small sand piles and vegetation occurs at the base of the wall, but this is not unexpected in the coastal environment and it does not consistent a PFD. Figures 8 and 9 shows the grade of the land between the sea wall and Ocean Boulevard at TR-39. The land between the seawall and road has a layer of fill (~1 foot thick) and gently slopes back towards the road from the seawall. Additionally, there are a number of impervious surfaces along TR-39 including paved driveways, roads, and houses built with solid foundations. There is no evidence of the landward toe for a PFD.

Figure 6. Photo showing the beach facing south at Transect TR-39.

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Figure 7. Photo showing the beach facing north at Transect TR-39.

Figure 8. Photo showing the land between the seawall and the Ocean Blvd. at Transect TR-39 (facing west).

Figure 9. Photo showing the land between Ocean Blvd and the seawall at Transect TR-39 (facing east).

For comparison, Woods Hole Group also investigated the PFD delineations at two nearby locations: Wallis Sands State Beach (WSSB), Transects TR-23 to TR-25, and North Hampton State Park (NHSP), Transects TR-55 to TR-58. The photos in Figures 10 and 11 were taken at Wallis Sands State Beach, and show how the houses in this location are built upon large continuous mound/ridge of sand that extends along the length of the beach. The face of the PFD is heavily vegetated and there is an obvious seaward and landward toe on either side of the dune crest. Therefore, the PFD at Wallis Sands State Beach (Transects TR-23 to TR-25) appears to be delineated correctly.

The photos in Figures 12 and 13 were taken at North Hampton State Park, where an active dune field extends well landward past the first row of houses off Northeast Lane. Figure 12 shows a heavily vegetated dune with dune grass. Figure 13 shows the large slope break on the backside of Northeast Lane where the landward toe of the PFD was delineated on the preliminary FIRMs. Therefore, the PFD at Wallis Sands State Beach (Transects TR-55 to TR-58) appears to be delineated correctly.

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Figure 10. Photo from WSSB showing the seaward toe of the PFD.

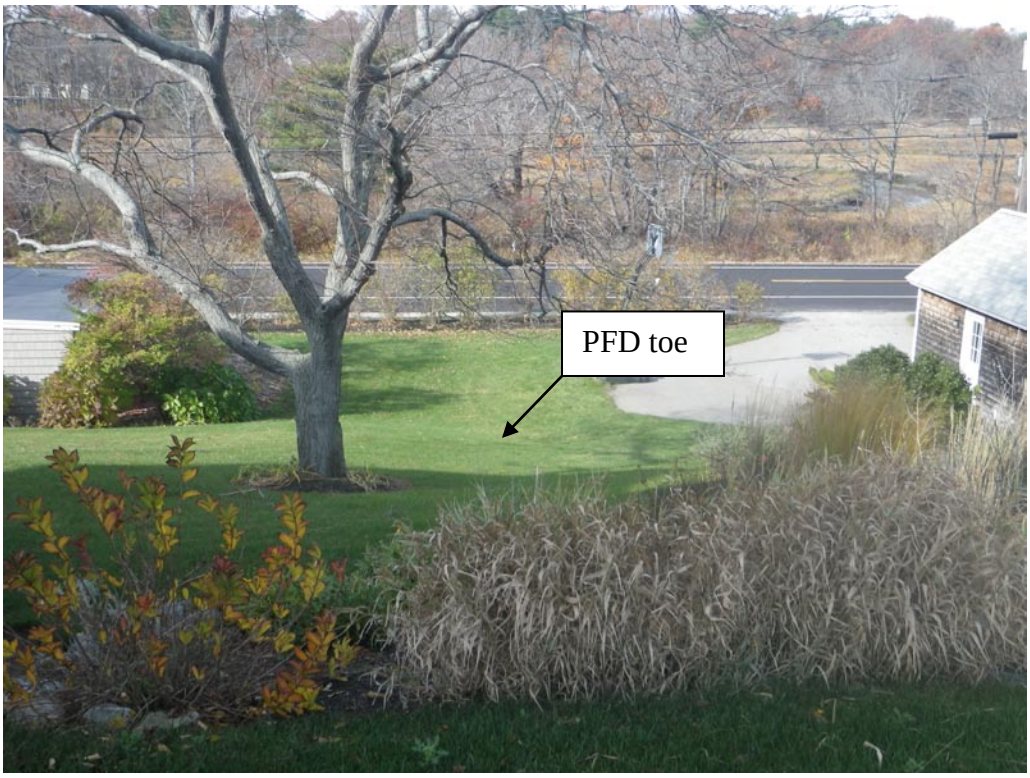

Figure 11. Photo from WSSB showing the landward toe of the PFD.

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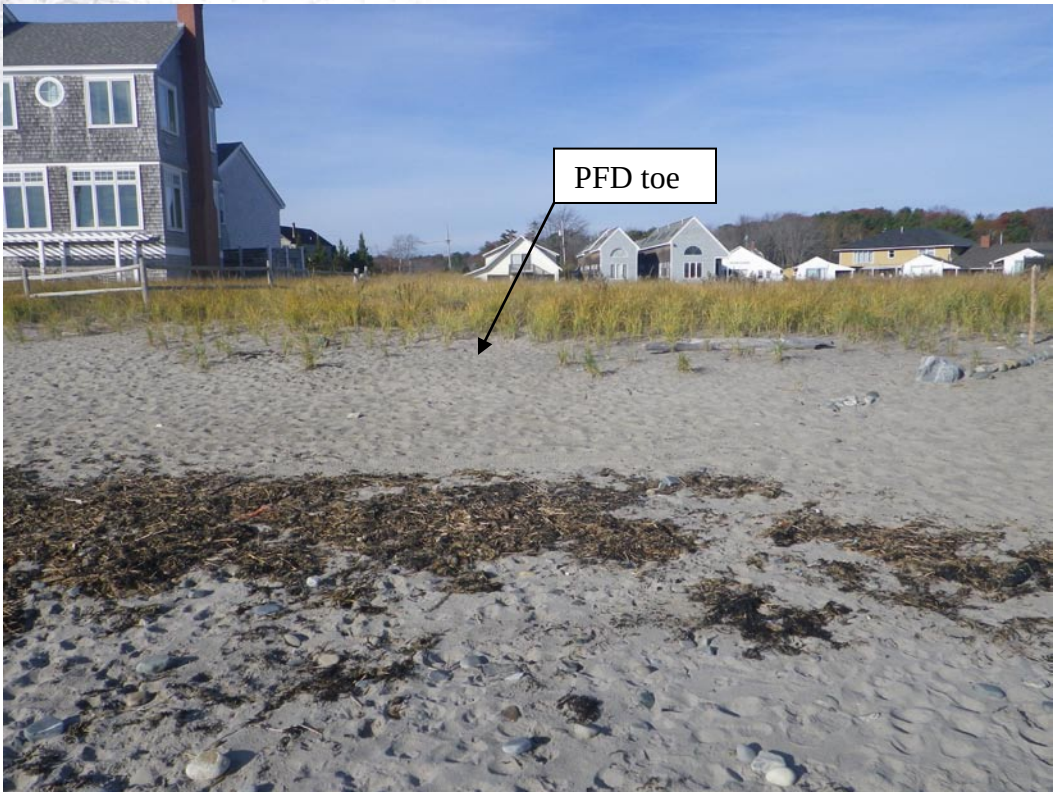

Figure 12. Photo from NHSP showing the seaward toe of the PFD.

Figure 13. Photo from NHSP showing the landward toe of the PFD.

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6.0 RESULTS SUMMARY AND REVISED FIRM MAPPING

Woods Hole Group reviewed the preliminary April 9, 2014 FIRM, FIS, and associated backup data for accuracy and completeness and then performed a revised coastal analysis. The first part of coastal analysis involved revising the Base Flood Elevation (BFD) for Transect TR-39 by using SWAN 1-D to compute a reduced wave setup value. This reduction (38%) in wave setup resulted in a corresponding reduction in the BFE from 15 feet to 12 feet NAVD88 using both WHAFIS and Runup 2.0. While Woods Hole Group, Inc. only evaluated wave setup using SWAN 1-D for transect TR-39 due to the limited scope of the project, it is anticipated that other transect reaches along this stretch of coast would experience a similar reduction in wave setup due to the similarity of the natural sloping beach profiles and model input data.

The second part of the coastal analysis involved re-delineating the extents of the Special Flood Hazard Area (SFHA). The April 9, 2014 preliminary FIRM had delineated the landward edge of the VE (El. 15) Zone based upon the landward toe of the PFD since it was a more conservative estimate than either the WHAFIS or runup results. However, no information could be found on how the PFD was delineated between Transects TR-37 and TR-39 and it was not documented in the 2012 AECOM field report or April 9, 2014 FIS. Woods Hole Group, Inc. conducted a follow-up field investigation to determine whether a PFD was present at the subject area on November 13, 2014. The investigation could not find evidence of a PFD nor a distinct change from a relatively steep slope to relatively mild slope that would define its landward toe. The landform in this vicinity does not appear to be comprised of a long, continuous mound or ridge of sand that would constitute a PFD. PFD delineation is used to a management tool in many cases protect the dune resources along a stretch of open coast. However, the subject area is not an active dune resource nor is it subject to coastal processes during the base flood (erosion, wave height, wave runup, and overtopping) using the updated CHAMP results. In addition, a sharp transition from a steep to shallow slope that would indicate the landward toe of the dune could not be located. Therefore, Woods Hole Group determined that a PFD could not be delineated along the reach for TR-39 and that the landward limit of the VE (El. 12) Zone should be mapped using the revised CHAMP (Runup 2.0) results. The PFD delineation was not amended for abutting Transects TR-37 and TR-38 since they were outside of the scope of work of the project; however, it is recommended that they also be evaluated further.

The revised flood zone and BFE mapping was performed according to the procedures outlined in the FEMA Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update (FEMA, 2007). Topographic data for the Town of Rye was obtained from the 2011 LiDAR dataset for the Northeast. The LiDAR data were downloaded from the NOAA Coastal Services Center (CSC) website and referenced to the New Hampshire State Plane coordinate system (NAD83, ft) and the vertical datum of NAVD88 (ft). Figure 14 shows the revised preliminary FIRM based upon the revised flood hazard zones and BFEs for the Transect TR-39 reach. The figure shows that, overall the extent of the Special Flood Hazard Area (SFHA) has decreased and that the BFEs have been reduced for the Transect TR-39 reach. The most significant change is that the BFE was reduced from 15 ft to 12 ft NAVD and the landward edges of the SFHA were revised to follow the corresponding,

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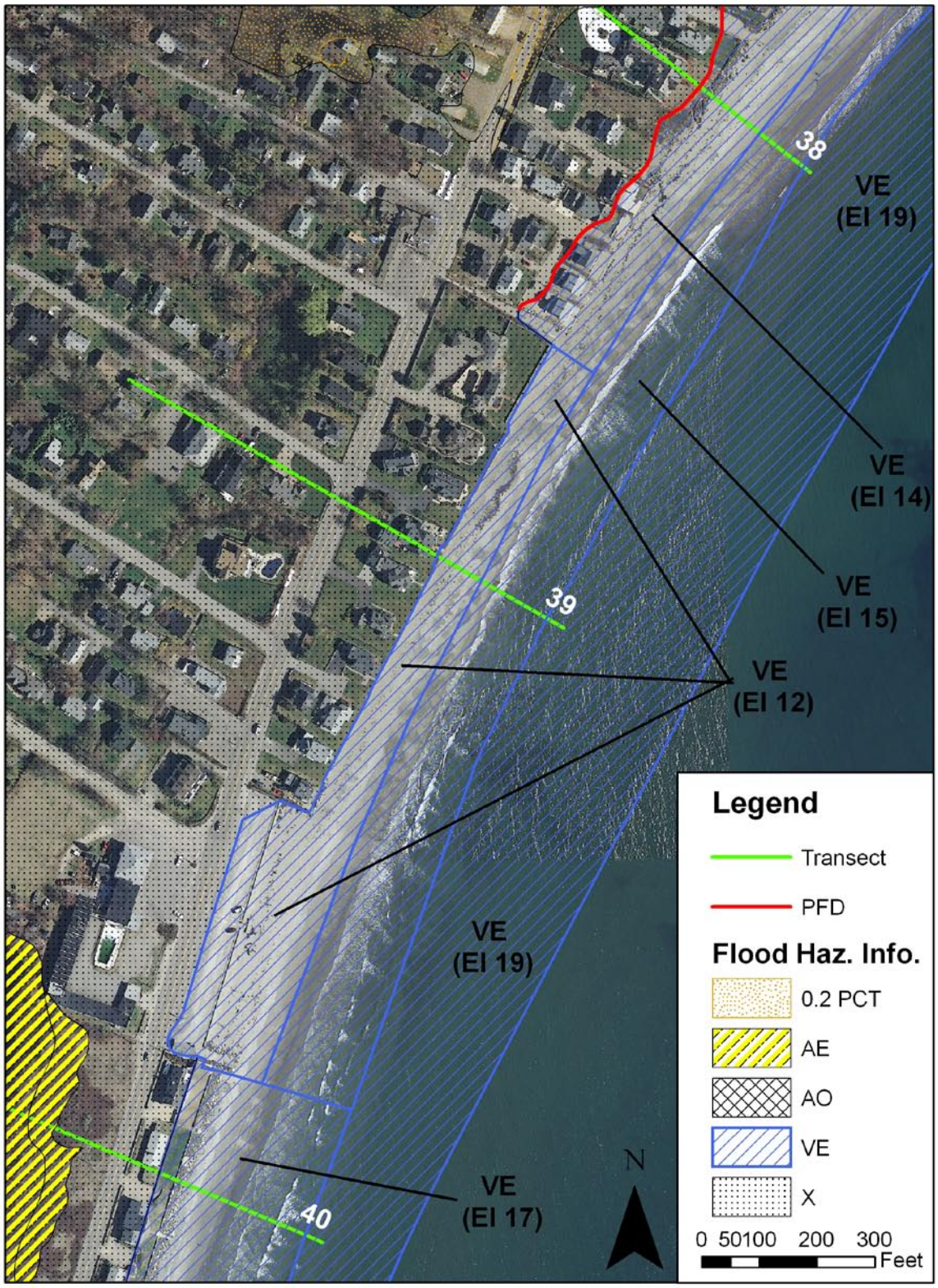

Figure 14. Revised BFE and Flood Hazards Zone Map.

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lower topographic contours that occurred along the seawall since the PFD was removed. The VE (El. 12) Zone now terminates at the seawall. The AO (3 foot depth) Zone on the preliminary FIRM along Ocean Blvd was removed since runup was below the crest of the structure and there was no significant overtopping. The shapefiles included with this appeal provide greater detail on the exact flood zone boundaries and can be used to compare with the effective flood zones and associated BFEs.

Woods Hole Group, Inc. appreciates the opportunity for your consideration of this appeal. Please contact me by phone (508-495-6210) or email (mbuck@whgrp.com) if there are any questions or requirements for additional information.

Sincerely,

Mitchell Buck, P.E.
Coastal Engineer
81 Technology Park Dr.
East Falmouth, MA 02536

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REFERENCES

AECOM (2012). The Field Reconnaissance Report for a Coastal Flood Insurance Study. December 12-14, 2011.

Kelly, S.W. (2013). Town of Rockport, MA, Essex County FEMA Flood Map Appeal. Technical Memorandum. Applied Coastal Research and Engineering, Inc., Mashpee, MA.

Federal Emergency Management Agency (2014), Flood Insurance Study, Rockingham County, New Hampshire (All Jurisdictions), April 9, 2014.

Federal Emergency Management Agency (2007). Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update , Final Draft, Washington, D.C.

US Army Corps of Engineers (2003). Coastal Engineering Manual.