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December 17, 2013
Via e-mail & 1st Class Mail

Mr. Robert J. Schaefer
Hazard Mitigation, DR-4086-NJ
307-309 Middletown Lincroft Road
Lincroft, NJ 07738

RE: FEMA Flood Map Revisions
Bay Side V-Zones
Borough of Mantoloking, Ocean County

Dear Mr. Schaefer:

On behalf of our client, the Borough of Mantoloking, Hatch Mott MacDonald (HMM) conducted an analysis of the extent of the bay side V-Zones, using FEMA-approved methods, in order to confirm the landward extent of the V-Zones depicted on the Preliminary Work Maps. This analysis was conducted in conjunction with the coastal engineering firm of Moffatt & Nichol (M&N), and is described, along with supplemental comment, herein for FEMA's consideration in revising the V-Zones accordingly.

With the objective of verifying the validity of the preliminary V-Zone extent, M&N performed an analysis to calculate wave heights for the 100-year return period or 1% annual exceedance probability case along the target area. The analysis was carried out for seven (7) transects which were dedicated in the FIS for wave hazard analysis in the direction from Barnegat Bay to the Atlantic Ocean (Figure 1). The analysis included:

1) Computations of wind-generated waves at the transect start point with the Wave Height Analysis for Flood Insurance Study (WHAFIS) Version 4.0 software using a prescribed fetch.

2) Calculation of wind-generated waves at the transect start point with the Automated Coastal Engineering System (ACES) using a prescribed fetch.

This letter summarizes the methods used and results obtained from the review.

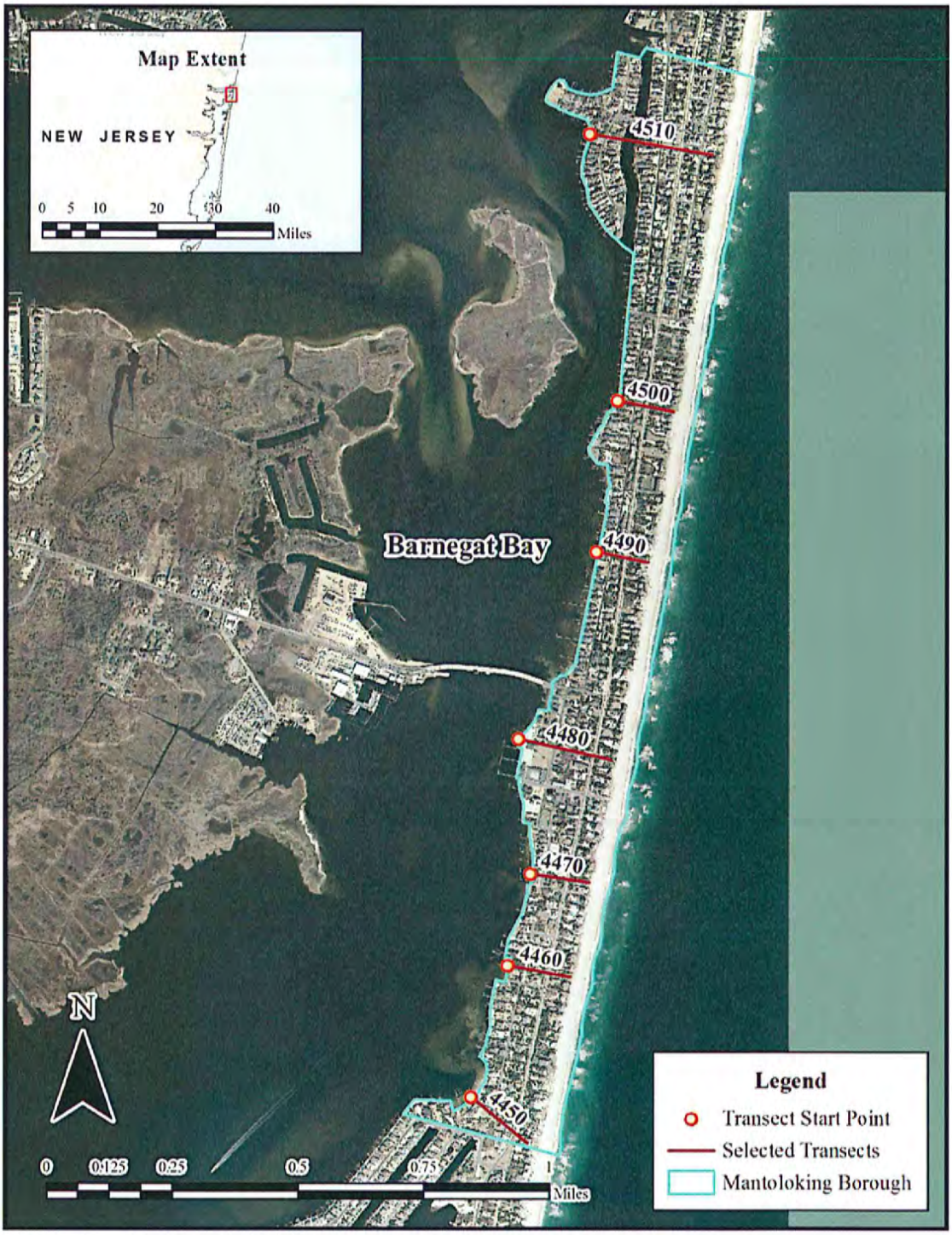

Figure 1: Review target area and transects contemplated in the analysis

1.0 INPUT DATA

Via an FTP site, a number of datasets were provided to M&N by FEMA's coastal analysis contractor, URS, through HMM. Table 1 summarizes those that were utilized in the review.

Table 1: Provided input datasets used in the review

Dataset	Format	Other info
Transect layout	ESRI polyline shapefile	
Digital Elevation Map	10 x 10 ft Resolution raster	Includes ground elevations and Barnegat Bay depths
Still-water elevations	25 x 25 ft Resolution raster	Return periods included: 10, 50, 100, and 500 year
WHAFIS Input	ESRI point shapefile	Includes WHAFIS card, station, and elevation along transect
	.DAT file	Includes all relevant input data along transects
WHAFIS output	.OUT file	Includes all relevant output along transects

In addition, M&N obtained other publicly available datasets, including 2007 aerial imagery of the area from the New Jersey Geographic Information Network website and 2007 land use/land cover for the State of New Jersey from the New Jersey Department of Environmental Protection website.

Although they were requested by M&N, the methodology and/or models used to derive initial wave conditions used at the transect start points were not provided. URS pointed out that the methodology used in generating these initial wave conditions would be released with the Technical Support Data Notebook for Ocean County. It is our understanding, based on a November 7, 2013 conversation with Mr. Tolga Yilmaz of URS, that this information will be released at the time of the publication of the Preliminary FIRMS in early 2014.

2.0 FETCH DEVELOPMENT

Given the proximity to the shoreline of the V-Zones in question, the starting wave conditions were the primary focus of the review. A fetch analysis across Barnegat Bay to determine the starting wave conditions was deemed applicable, given the sheltered configuration of the bay. The fetch is defined as the unobstructed distance over which the wind acts on the water surface in a constant direction (Rohweder et al., 2008). Therefore, a fetch length, a water depth, a wind speed, and a wind direction are needed to perform a fetch analysis.

In the context of storm conditions, the determination of a fetch is primarily a function of the extent of inundation and the water depth. In order to visualize the inundation under the 100-year conditions, ground elevations were subtracted from the still-water elevations. Figure 2 shows the resulting surface which essentially represents the available water depth for wave growth. Using this surface, fetches were estimated for each transect along the transect direction (WHAFIS analysis) and at angles from the transect direction (ACES analysis). The use of inundation depths alone does not account for developed areas that fall along the fetch, where buildings and other structures would have a significant attenuating effect on the wave. Therefore, where developed areas exist along the fetch (Transects 4480 and 4510), an adjusted fetch is provided, limiting the fetch to the leeward side of the development. Figures 3 and 5 show the fetch adjustment for these transects.

It is noted that the transect layout and fetches used for analysis were based on what was provided by FEMA. The transects are based on an assumption that the winds blow in a generally easterly direction co-incident with the peak storm surge. The viability of this assumption has previously been challenged by HMM in a formal letter issued to FEMA dated April 29, 2013 (attached for easy reference).

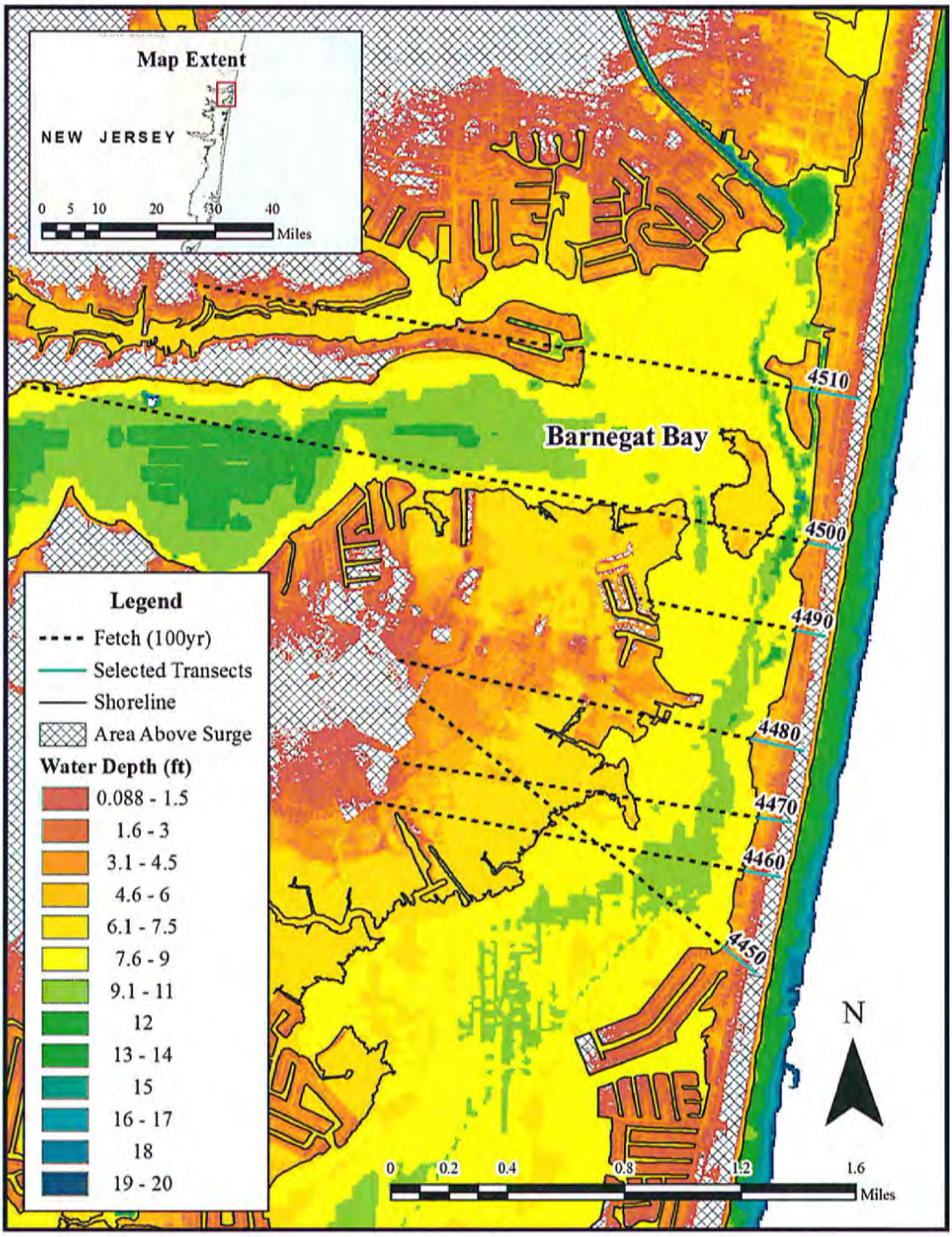

Figure 2: Extent of inundation for 1% annual exceedance probability still water elevation and WHAFIS fetch

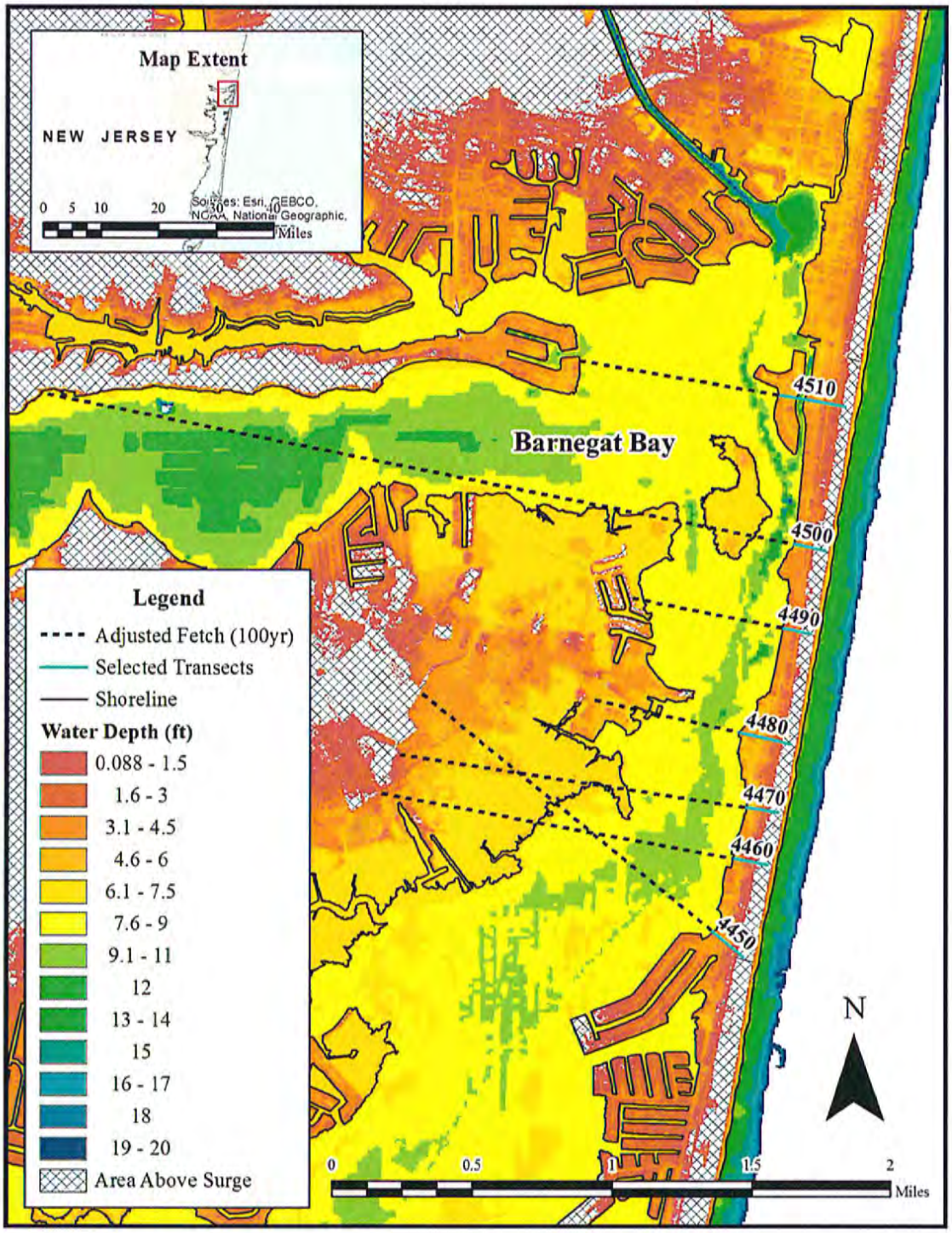

Figure 3: Extent of inundation for 1% annual exceedance probability still water elevation and WHAFIS adjusted fetch for transects 4480 and 4510

3.0 WHAFIS ANALYSIS

WHAFIS is the software utilized by FEMA to conduct wave hazard analysis along transects. In terms of starting wave conditions, WHAFIS offers the following options:

- Internal calculation based on depth-limited criteria
- User-specified wave conditions
- User-specified fetch length from which wave conditions are internally calculated based on a default or user-specified wind speed

Using the last option, starting wave conditions were computed. The WHAFIS input files from URS were simply modified to insert the fetch in the IE (Initial Elevations) line. In addition, an average water depth along the fetch was calculated and inserted in the IE line as the 100-year elevation. Table 2 summarizes the fetch and average water depth for each transect.

Table 2: Fetch characteristics for WHAFIS analysis

Transect	Fetch (miles)	Average Water Depth (ft)	Adjusted Fetch (miles)	Adjusted Average Water Depth (ft)
4450	1.34	7.2	-	-
4460	1.29	7.5	-	-
4470	1.25	6.82	-	-
4480	1.23	5.58	0.55	7.4
4490	0.55	7.98	-	-
4500	2.74	8.92	-	-
4510	2.07	6.24	0.72	8.3

To define the wind speed, the WHAFIS default values were utilized. The default, sustained wind speed for overwater fetch (OF, i.e. water depths greater than 10 ft) is 80 mph and that for inland fetch (IF, i.e. water depths equal to or less than 10 ft) is 60 mph (FEMA 2007). As shown in Table 2, the calculated average water depths suggest the use of an inland fetch wind speed. Therefore, the analysis was carried out for the 60 mph scenario, with winds assumed to blow in the direction of the transect.

The results of the WHAFIS analysis are presented in Table 3. H_c is the controlling wave height, which is 1.6 times the significant wave height (H_s), and T_p is the peak wave period. These are the wave parameters that would be utilized to start the analysis along each transect and determine the flooding zones.

Table 3: Starting wave conditions calculated with WHAFIS

Transect	IF (60 mph wind)		IF Adjusted Fetch (60 mph wind)		FEMA	
	H_c (ft)	T_p (s)	H_c (ft)	T_p (s)	H_c (ft)	T_p (s)
4450	3.95	2.66	-	-	4.6	3.35
4460	3.99	2.63	-	-	4.72	3.4
4470	3.76	2.61	-	-	4.63	3.38
4480	3.3	2.59	2.82	2.01	4.74	3.41
4490	2.86	2.01	-	-	4.4	3.16
4500	5.31	3.31	-	-	4.2	2.99
4510	3.92	3.04	3.31	2.19	4.1	2.75

The results indicate that wave heights in excess of 3ft can develop across the prescribed fetches under 60-mph sustained winds. In all but one case, the wave heights computed by M&N are lower than the values produced by FEMA.

Using the WHAFIS output part that defines the location of the V-Zones, the inland extent of the V-Zone was found for each transect. This information is presented in Table 4.

Table 4: V-Zone inland extent along transect (WHAFIS initial conditions)

Transect	IF (60 mph wind), ft	IF Adjusted Fetch (60 mph wind), ft	FEMA, ft
4450	20.36	-	29.64
4460	11.98	-	17.56
4470	23.77	-	83.65
4480	32.11	0	54.68
4490	0	-	17.99
4500	76.94	-	72.73
4510	32.97	4.17	9.49

Using the results of the M&N modeling, Table 4 shows that the extent of the V-Zone can be significantly reduced for all but one (1) transect by using WHAFIS to generate initial wave conditions.

A comparison between the M&N and FEMA results indicates an average reduction in the inland extent of the V-Zone of over 50%. The corresponding correction of the Borough-wide V-Zone would result in a significant number of structures that are currently shown (on the Preliminary Work Map) in the V-Zone falling within the expanded A-Zone. Furthermore, minor variances of shoreline elevation can further

reduce the extent of wave penetration, a condition that is predominant along the bay where a significant number of docks, piles, and bulkheads would obviously interrupt the developing wave form – a factor that is not accounted for in the model.

4.0 ACES ANALYSIS

Developed by the United States Army Corps of Engineers (USACE), the Automated Coastal Engineering System (ACES) software estimates wave growth over open-water and restricted fetches in deep and shallow water. It is one of the numerical models accepted by the National Flood Insurance Program (FEMA website).

For the case of Barnegat Bay with 100-year water levels, the shallow restricted fetch approach was deemed applicable. When using the restricted fetch option in ACES, multiple radial fetches can be defined for each location where the waves are to be computed. Using the fetches developed for the WHAFIS analysis, additional fetches were measured for each transect at 5° sectors (Figure 4). In total, each transect has five (5) fetches covering a 20° sector. As with the WHAFIS analysis, an adjusted fetch was considered for transects 4480 and 4510. Figure 5 shows the fetch adjustment for these transects. Internally, ACES computes a weighted fetch which is utilized in the calculations. Table 5 shows the fetch characteristics for each transect. The average water depth is the same as in the WHAFIS analysis.

Table 5: Fetch characteristics for ACES analysis

Transect	Weighted Fetch (miles)	Average Water Depth (ft)
4450	1.34	7.2
4460	1.31	7.5
4470	1.24	6.82
4480	1.17	5.58
4490	0.58	7.98
4500	2.04	8.92
4510	1.84	6.24

As with the WHAFIS analysis, 60-mph winds were contemplated, since the water depths warrant an inland fetch. As part of the input to ACES, the duration of the observed wind must be specified. From the glossary of the National Oceanic and Atmospheric Administration (NOAA) National Weather Service, a sustained wind speed is a 2-minute average wind speed. Using these input parameters, the final wind duration was adjusted, via an iterative method, to match the duration for full wave development for each wind speed (SPM 1984). Table 6 summarizes the results of the analysis.

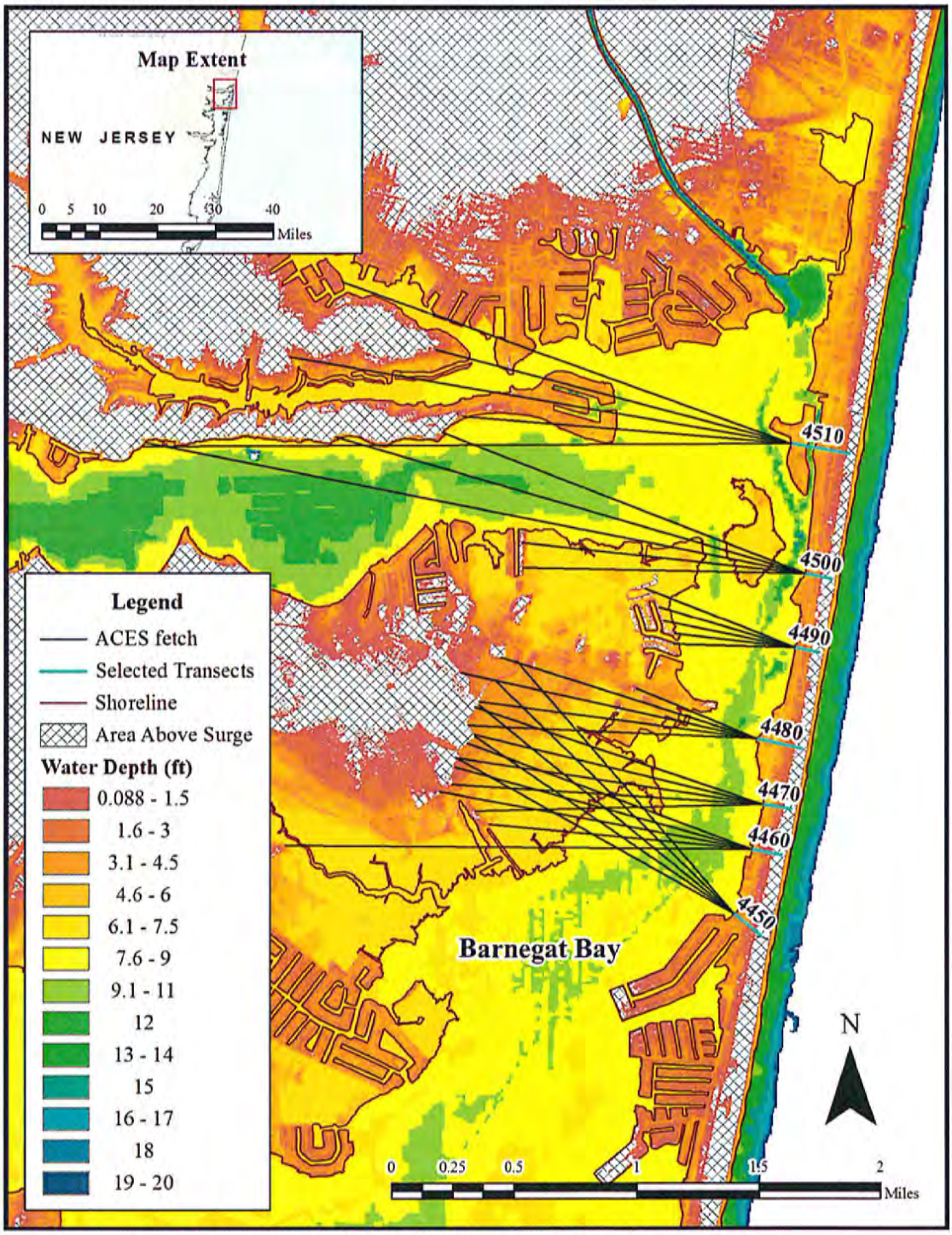

Figure 4: Extent of inundation for 1% annual exceedance probability still water elevation and ACES fetch

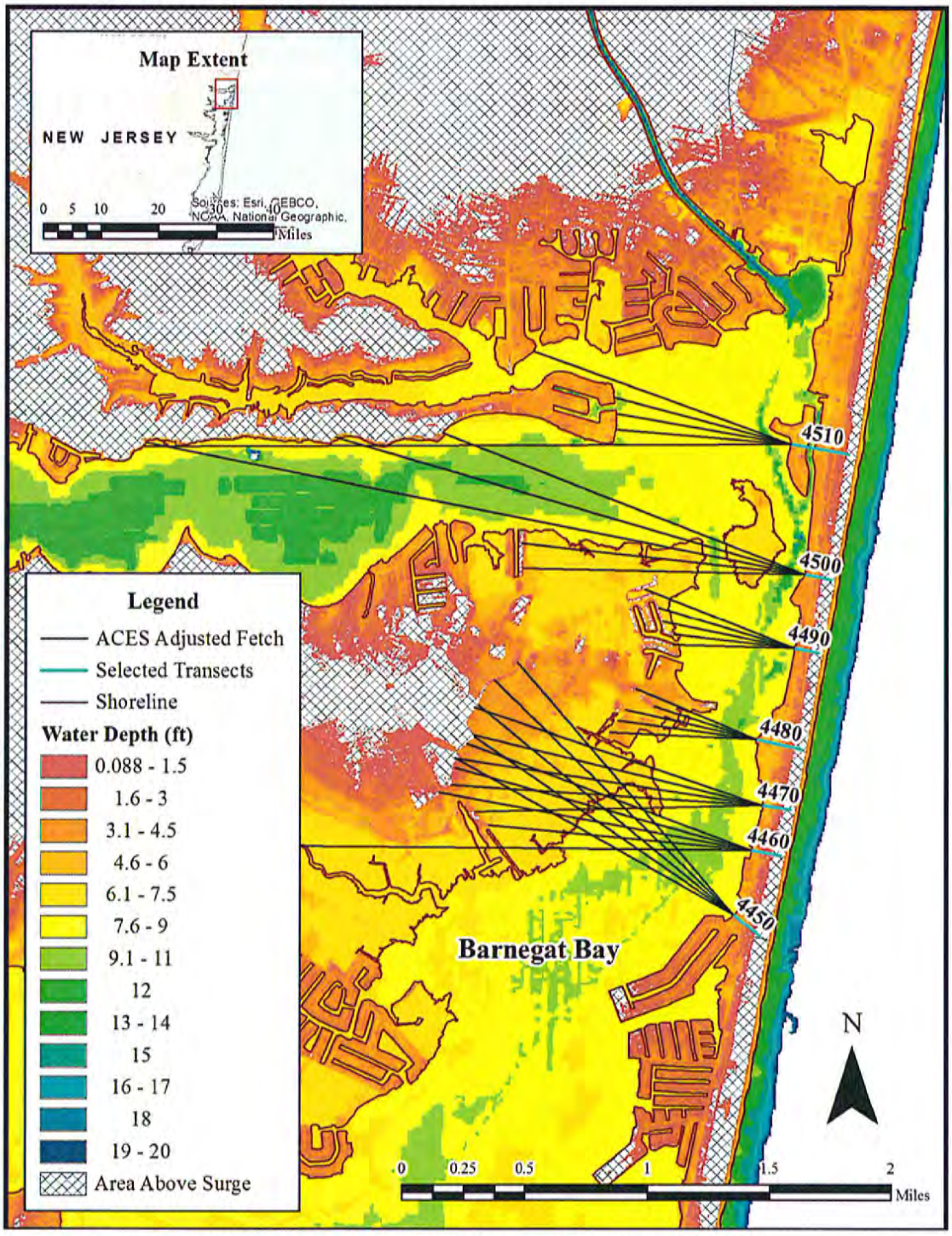

Figure 5: Extent of inundation for 1% annual exceedance probability still water elevation and ACES adjusted fetch for transects 4480 and 4510

Table 6: Starting wave conditions calculated with ACES

Transect	ACES (60 mph wind)		ACES Adjusted Fetch (60 mph wind)		FEMA	
	H_c (ft)	T_p (ft)	H_c (ft)	T_p (ft)	H_c (ft)	T_p (s)
4450	3.02	2.51	-	-	4.6	3.35
4460	3.02	2.51	-	-	4.72	3.4
4470	2.91	2.46	-	-	4.63	3.38
4480	2.70	2.39	2.21	2.06	4.74	3.41
4490	2.27	2.09	-	-	4.4	3.16
4500	3.63	2.79	-	-	4.2	2.99
4510	3.17	2.65	2.90	2.42	4.1	2.75

The results show that waves exceed 3 ft in height at four out of the seven transects. As expected, the transects with wave heights below 3 ft are those with the shortest fetch. Conversely, transect 4500 has the longest fetch and, therefore, resulted in the largest waves. The ACES wave heights are lower than the WHAFIS wave heights and are also lower than the initial conditions used by FEMA.

The inland extent of the V-Zone resulting from the ACES analysis was also tabulated (Table 7).

Table 7: V-Zone inland extent along transect (ACES initial conditions)

Transect	ACES (60 mph wind), ft	ACES Adjusted Fetch (60 mph wind)	FEMA, ft
4450	9.07	-	29.64
4460	1.28	-	17.56
4470	0	-	83.65
4480	0	0	54.68
4490	0	-	17.99
4500	68.99	-	72.73
4510	6.11	0	9.49

Table 7 shows that the extent of the V-Zone is significantly reduced for most transects. The V-Zones are eliminated entirely at Transects 4470, 4480, 4490 and 4510. At Transects 4450 and 4460 – based on the WHAFIS elevation data and the Digital Elevation Model – the V-Zone boundary is located at significantly lower elevations than FEMA calculated at Transects 4450 and 4460. Therefore, the correct location of the V-Zones based on the ACES analysis would result in a significant number of structures falling within the A-Zone.

5.0 CONCLUSIONS

The results of the analysis/review lead to the following conclusions.

- Average water depths calculated for the fetch of selected transects were less than 10 ft. According to FEMA guidelines (FEMA 2007), water depths less than 10 ft correspond to inland fetch areas on which a 60-mph sustained wind should be applied. In this context, the starting wave conditions computed with WHAFIS and ACES using the 60 mph sustained wind are applicable.

- The transect layout and fetches used for analysis were based on underlying information provided by FEMA. The actual initial wave conditions and fetches were requested from FEMA; however, we were advised that this data would not be publicly available until such time as FEMA releases the Preliminary Maps. Also, the transects are based on an assumption that the winds blow in a generally easterly direction co-incident with the peak storm surge. This assumption was challenged by HMM in a letter from HMM to FEMA dated April 29, 2013.

- Waves generated by WHAFIS at the transect start point, with a fetch length as input and assuming the wind blows in the direction of the transect, are, on average, significantly smaller than those computed by FEMA.

- The inland extent of the V-Zone calculated using WHAFIS to compute initial wave conditions is significantly less than that resulting from the FEMA analysis (an average of 55% reduction). For most transects the reduction is significant.

- Waves generated by ACES at the transect start point, with a weighted fetch length as input and assuming the wind blows in the direction of the transect, are significantly smaller than those computed by FEMA. ACES-predicted wave heights and periods are of lower magnitude than the WHAFIS-calculated waves.

- The inland extent of the V-Zone calculated using ACES to compute initial wave conditions is significantly less than that resulting from the FEMA analysis (an average of 81% reduction). At four of the seven transects analyzed the inland extent was zero.

- The method used to determine the starting wave conditions for both WHAFIS and ACES used the average depth.

- The Preliminary Work Map appears to have failed to account for the presence of attenuating structures, including bulkheads, around the westerly peninsula at the north end of the Borough (Channel Lane, immediately north of Transect 4510) which is shown as completely within the V-Zone. Furthermore, it is our understanding that the delineation of the V-Zone between transects is based on LIDAR and other topographical information to

derive the location of the V-Zone boundary. The correct application of this method would result in the V-Zone working its way around the peninsula, not cutting directly across it as the Preliminary Work Map shows.

— Finally, we have not received a technical response to our November 7, 2013 letter challenging FEMA's assumption that sustained westerly winds capable of producing sizable waves impacting the bay side shoreline would occur coincident with the peak of the storm surge. We look forward to FEMA's detailed response.

6.0 REFERENCES

Moffatt & Nichol Memorandum, Santiago Alfageme, PE and Arturo Jimenez (Moffat & Nichol) to Robert Mainberger (HMM), December 13, 2013.

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Federal Emergency Management Agency (FEMA). (2007). "Guidelines and Specifications for Flood Hazard Mapping Partners." Section D.2.7 Overland Wave Propagation.

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Rohweder, Jason, Rogala, James T., Johnson, Barry L., Anderson, Dennis, Clark, Steve, Chamberlin, Ferris, and Runyon, Kip. (2008). "Application of wind fetch and wave models for habitat rehabilitation and enhancement projects." U.S. Geological Survey Open-File Report 2008–1200, 43 p.

Shore Protection Manual (SPM) Volume One. (1984). U.S. Army Coastal Engineering Research Center. P 3-66.

Hatch Mott MacDonald

As the above analysis indicates, the V-Zones along the bay side of the Borough of Mantoloking, delineated by FEMA and depicted on the Preliminary Work Maps, appear to encroach further inland than warranted. We look forward to discussing this matter with you in further detail, and would also request that a formal response be provided to both this letter and our April 29, 2013 letter regarding the validity of FEMA's assumption of sustained westerly winds during the storm surge.

Thank you for your attention to this matter. Should you have any questions, please do not hesitate to contact our office.

Very truly yours,

Hatch Mott MacDonald

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