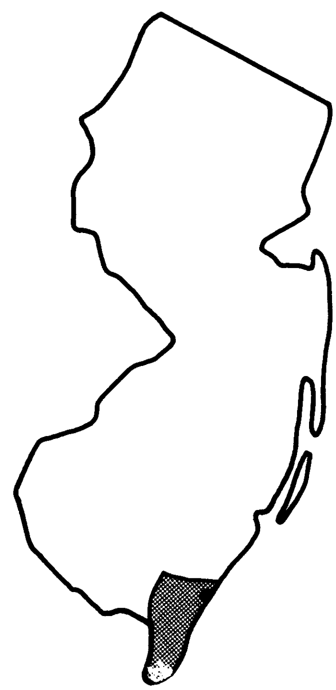
FLOOD INSURANCE STUDY

SUPPLEMENT-

WAVE HEIGHT ANALYSIS

CITY OF OCEAN CITY, NEW JERSEY
CAPE MAY COUNTY



MARCH 5, 1984

Federal Emergency Management Agency

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1.0 INTRODUCTION

1.1 Background and Purpose

The Federal Emergency Management Agency (FEMA) recently adopted recommendations by the National Academy of Sciences to include prediction of wave heights in Flood Insurance Studies for coastal communities subject to storm surge flooding, and to report the estimated wave crest elevations as the base flood elevations on Flood Insurance Rate Maps (FIRMs).

Previously, FIRMs were produced showing only the stillwater elevations due to the lack of a suitable and generally applicable methodology for estimating the wave crest elevations associated with storm surges. These stillwater elevations were subsequently stipulated in community flood plain management ordinances as the minimum elevation of the lowest floor including basement of new construction. Communities and individuals had to consider the additional hazards of velocity waters and wave action on an ad hoc basis. Because there has been a pronounced tendency for buildings to be constructed only to meet minimum standards, without consideration of the additional hazard due to wave height, increasing numbers of people could unknowingly be accepting a high degree of flood-related personal and property risk in coastal areas subject to wave action. Therefore, the FEMA has pursued the development of a suitable methodology for estimating the wave crest elevations associated with storm surges. The recent development of such a methodology by the National Academy of Sciences has led to the adoption of wave crest elevations for use as the base flood elevations in coastal communities (Reference 1).

The City of Ocean City is subject to flooding from tropical storms, extratropical cyclones, and, to a lesser extent, severe thunderstorm activity. Most serious tidal flooding problems are attributed to hurricanes which occur during the late summer and early autumn. In addition to heavy precipitation, hurricanes produce high tides and strong waves which can result in severe damage to coastal areas. Although extratropical cyclones, referred to as northeasters, can develop at almost any time of the year, they are more likely to occur during the winter and spring. Thunderstorms are a common occurrence during the summer months.

In recent years, the storms of September 1944, November 1950, and March 1962 caused damage to the New Jersey coast (References 2 and 3). The hurricane of September 14, 1944, struck the shoreline of New Jersey with wind velocities ranging from 90 miles per hour (mph) at Atlantic City to over 100 mph at New York City. During the passage of the storm, many communities reported extreme high tides. A strong northeaster struck the New Jersey shoreline on November 25, 1950, causing gale-force winds and more than 3 inches of rainfall.

The northeaster of March 6-8, 1962, struck the coastline of New Jersey with gale-force winds, extreme high tides, and heavy precipitation in the form of wet snow. Generating winds of 70 mph, the storm remained in the study area for 60 hours. The unusually long duration coincided with five successive high spring tides. Severe flooding conditions, not only in the study area but along the entire shoreline of New Jersey, resulted from the high stormwaters, waves, and gale-force winds.

Ocean City occupies the entire Peck Beach barrier island. During the March 1962 storm, tidal flooding reached depths of up to 2 feet over many sections of the city. Bulkheads failed during the storm, with many homes being damaged or destroyed by the combined effects of wave action and erosion. Damage to oceanfront structures, including boardwalks, was particularly severe along the southern half of the city, which is primarily occupied by residences protected by bulkheads. Beach and dune damage was extensive. A total of 6,195 residences and 392 commercial establishments were damaged, of which 1,961 were structurally damaged or destroyed (Reference 4).

The purpose of this study is to revise the FIRM for the City of Ocean City to include the effects of wave action for the following flooding sources: the Atlantic Ocean and Egg Harbor.

The wave height analysis for this study was prepared by Dewberry & Davis for the FEMA, under Contract No. EMW-C-0543. This work was completed in November 1983.

2.0 INVESTIGATIONS

2.1 Previous Investigations

Stillwater elevations used in this analysis for the Atlantic Ocean were taken from a set of tidal flood profiles for the open coast of New Jersey as developed by Dewberry & Davis (Reference 5). In the vicinity of Ocean City, the elevations for the Atlantic Ocean were determined by combining an analysis of the Atlantic City tidal gage performed by the Philadelphia District of the U. S. Army Corps of Engineers (COE), and ESSA Technical Memorandum WBTM Hydro II (References 6 and 7). The elevations for Egg Harbor were taken from the Flood Insurance Study for the Township of Egg Harbor (Reference 8). This study supersedes the previous Flood Insurance Study for the City of Ocean City (Reference 9).

2.2 Data Collection and Review

All available source data applicable for the wave height analysis were collected and reviewed. Because wave height calculations are based on such parameters as the size and density of vegetation, natural barriers (sand dunes), buildings, and other manmade structures, it was necessary to obtain detailed information on the physical and cultural features of the study area.

During the course of this analysis, the City of Ocean City, Keystone Aerial Surveys Incorporated, the New Jersey Department of Environmental Protection, the New Jersey Highway Authority, the New Jersey Department of Geology, the Cape May County Planning Department, and the COE were contacted for data.

The principal source materials used for the wave height analysis are described below.

1. Aerial photographs and glass aerial plotting plates (stereoscopic coverage) of Ocean City were obtained from Keystone Aerial Surveys of Philadelphia, Pennsylvania (Reference 10). The aerial plotting plates generated the topographic maps used in this analysis. The aerial photographs were used to determine the type, size, and density of vegetation and physical features. An updated photo mosaic was obtained from Aerial Data Reduction Associates for the New Jersey Department of Environmental Protection in March 1984 to update any changes of physical features or building and vegetation density (Reference 11).

2. Topographic maps for the shoreline areas of Ocean City at a scale of 1:2,400 and a contour interval of 4 feet were developed by Dewberry & Davis (Reference 12). These maps were used for adjusting the base maps, for work maps to calculate wave heights, and for plotting elevations and boundaries of the Flood Hazard Zones (Section 3.1). These maps were revised in October 1983 using bulkhead elevation information submitted by the community and in March 1984 using spot elevations supplied by the New Jersey Department of Environmental Protection. The spot elevations were taken from a field survey conducted in January through March 1984 (Reference 13).

3. U. S. Geological Survey (USGS) quadrangles of Mamora, Ocean City, and Sea Isle City were used to supplement the base and work maps, for fetch calculations, and for the placement of transects (Reference 14).

4. Stillwater elevations for the Atlantic Ocean were obtained from a profile developed by Dewberry & Davis (Reference 5). Stillwater elevations for Egg Harbor were taken from the Flood Insurance Study for the Township of Egg Harbor (Reference 8).

2.3 Wave Height Analysis

The methodology for analyzing the effects of wave heights associated with coastal storm surge flooding is described in the National Academy of Sciences report (Reference 1). This method is based on three major concepts. First, depth-limited waves in shallow water reach a maximum breaking height that is equal to 0.78 times the stillwater depth. The wave crest is 70 percent of the total wave height above the stillwater level. The second major concept is that wave height may be diminished by dissipation of energy due to the presence of obstructions such as sand dunes, dikes and seawalls, buildings, and vegetation. The amount of energy dissipation is a function of the physical characteristics of the obstruction and is determined by procedures described in Reference 1. The third major concept is that wave height can be regenerated in open fetch areas due to the transfer of wind energy to the water. This added energy is related to fetch length and depth.

Wave heights were computed along transects (cross section lines) that were located along the coastal areas, as illustrated in Figure 1, in accordance with the Users Manual for Wave Height Analysis (Reference 15). The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, they were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects.

Each transect was taken perpendicular to the shoreline and extended inland to a point where wave action ceased. Along each transect, wave heights and elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. The stillwater elevations for the 100-year flood were used as the starting elevations for these computations. Wave heights were calculated to the nearest 0.1 foot, and wave elevations were determined at whole-foot increments along the transects. The location of the 3-foot breaking wave for determining the terminus of the V Zone (area with velocity wave action) was also computed at each transect. Table 1 provides a listing of the transect location and stillwater starting elevations, as well as maximum wave crest elevations. It was assumed that the dunes and beach area would erode during a major storm, thus reducing their effectiveness in decreasing wave heights.

Figure 2 is a profile for a typical transect illustrating the effects of energy dissipation and regeneration on a wave as it moves inland. This figure shows the wave elevations being decreased by obstructions, such as buildings, vegetation, and rising ground elevations, and being increased by open, unobstructed wind fetches. Actual wave conditions in the City of Ocean City may not include all the situations illustrated in Figure 2.

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF OCEAN CITY, NJ

(CAPE MAY CO.)

APPROXIMATE SCALE

4000 0 4000 8000 12000 FEET

TRANSECT LOCATION MAP

FIGURE 1

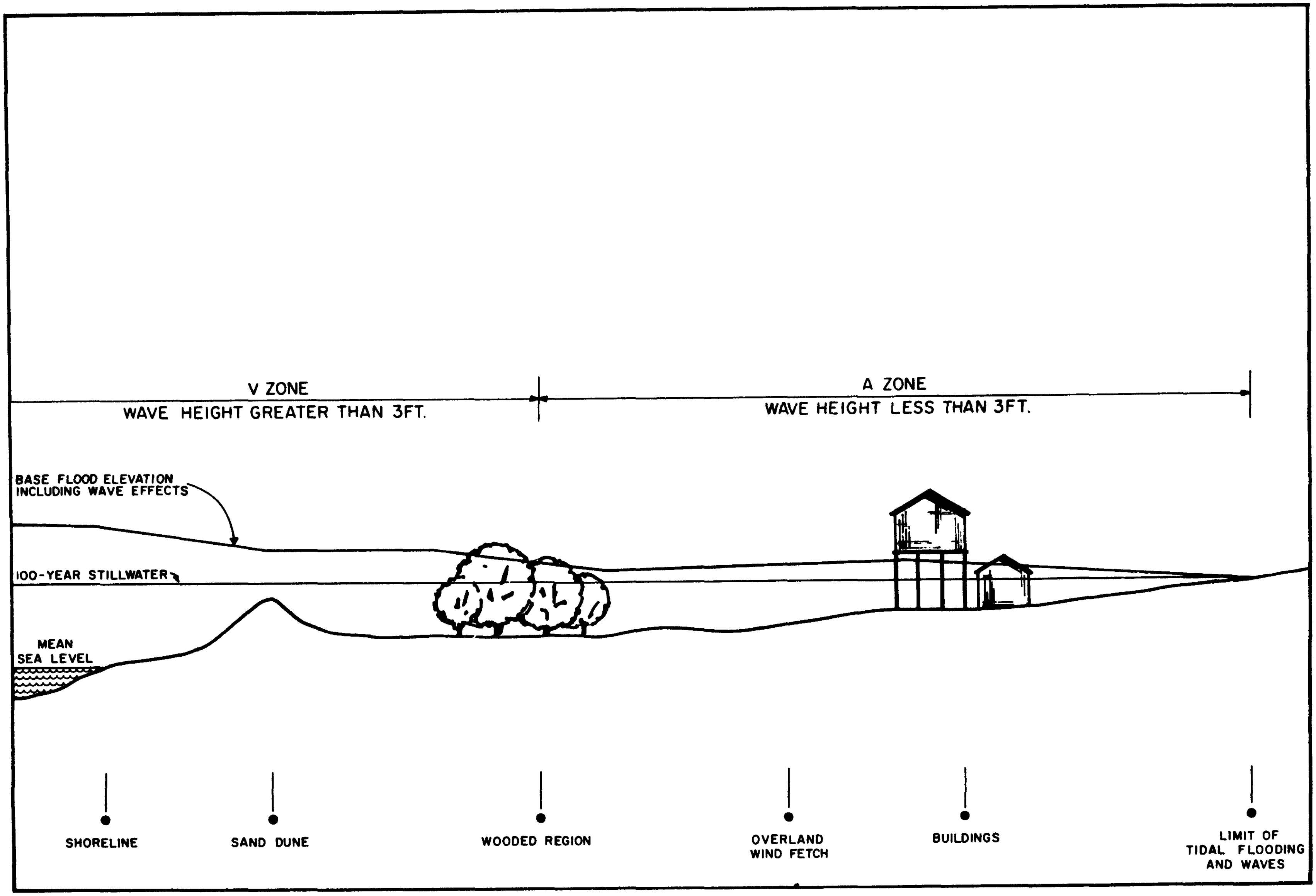

FIGURE 2
TYPICAL TRANSECT SCHEMATIC

TABLE 1 - TRANSECT DESCRIPTIONS

Transect	Location	Elevation (feet) Stillwater 100-year	Elevation (feet) Maximum Wave Crest 100-year
No. 1	Southern corporate limits to 59th Street, extended	Varies 9.2-9.8	15
No. 2	59th Street, extended, to 53rd Street, extended	Varies 9.2-9.8	15
No. 3	53rd Street, extended, to 44th Street, extended	Varies 9.2-9.8	15
No. 4	44th Street, extended, to 35th Street, extended	Varies 9.2-9.7	15
No. 5	35th Street, extended, to 23rd Street, extended	Varies 9.2-9.7	15
No. 6	23rd Street, extended, to 10th Street, extended	Varies 9.2-9.7	15
No. 7	10th Street, extended, to Seaview Road, extended	Varies 9.2-9.6	15
No. 8	Seaview Road, extended, to northern corporate limits	Varies 9.2-9.6	15

After analyzing wave heights along each transect, wave elevations were interpolated between transects. Various source data were used in the interpolation, including the topographic work maps, aerial photographs, notes and photographs taken during field inspection, and engineering judgment. Controlling features affecting the elevations were identified and considered in relation to their positions at a particular transect and their variation between transects.

2.4 Results

Computed wave heights and elevations associated with the 100-year storm surge are summarized below for various reaches in the study area.

Atlantic Ocean and Egg Harbor (Transects 1-8)

The maximum wave crest elevation affecting the Atlantic Ocean shoreline of Ocean City is 15 feet. South of 59th Street, waves greater than 3 feet propagate inland 500 to 1,000 feet. North of 59th Street and south of the jetty northeast of Surf Road, waves greater than 3 feet propagate up to 400 feet inland. Waves greater than 3 feet are diminished by rising ground elevations, development, and bulkheads. The jetty north and northeast of Surf Road protects the area behind it from waves greater than 3 feet. Waves less than 3 feet continue across the community into Egg Harbor, where waves are generated to greater than 3 feet.

On April 5, 1983, the results of the study were reviewed at a final Consultation and Coordination Officer's (CCO) meeting attended by representatives of the FEMA, the City of Ocean City, and Dewberry & Davis.

3.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

A prime purpose of the National Flood Insurance Program is to encourage local governments to adopt sound flood plain management programs designed to reduce future flood losses. The FIRM for the City of Ocean City has been revised to incorporate the latest available information, including wave height data, to assist these communities in developing the most appropriate and effective flood plain management measures.

3.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the FEMA as the base flood for purposes of flood plain management. This flood has a 1 percent chance of being equalled or exceeded each year and is expected to be exceeded once on the average during any 100-year period. The risk of having a flood of this magnitude or greater increases when periods longer than 1 year are considered. For example, over a 30-year period, there is a 26 percent chance of experiencing a flood equal to or greater than the 100-year flood. The 500-year flood plain is also shown on the FIRM to indicate areas of moderate flood hazards.

Areas inundated by the 100-year flood are shown as A and V Zones on the community's FIRM. It is in these areas that the FEMA requires local communities to exercise flood plain management measures as a condition for participation in the National Flood Insurance Program.

3.2 Base Flood Elevations

Areas within the communities studied by detailed engineering methods have base flood elevations established in A and V Zones. These are the elevations of the base (100-year) flood relative to the National Geodetic Vertical Datum (mean sea level) of 1929. In coastal areas affected by wave action, base flood elevations are generally maximum at the normal open shoreline. These elevations generally decrease in a landward direction at a rate dependent on the presence of obstructions capable of dissipating the wave energy. Where possible, changes in base flood elevations have been shown in 1-foot increments on the FIRMs. However, where the scale did not permit, 2- or 3-foot increments were sometimes used. Base flood elevations shown in the wave action areas represent the average elevation within the zone. Current program regulations generally require that all new construction be elevated such that the first floor, including basement, is above the base flood elevation in A and V Zones.

3.3 Velocity Zones

The U. S. Army Corps of Engineers has established the 3-foot breaking wave as the criterion for identifying coastal high hazard zones (Reference 16). This was based on a study of wave action effects on structures. This criterion has been adopted by the FEMA for the determination of V Zones. Because of the additional hazards associated with high-energy waves, the National Flood Insurance Program regulations require much more stringent flood plain management measures in these areas, such as elevating structures on piles or piers. In addition, insurance rates in V Zones are higher than those in A Zones with similar numerical designations.

The location of the V Zone is determined by the 3-foot breaking wave as discussed previously. The detailed analysis of wave heights performed in this study allowed a much more accurate location of the V Zone to be established. The V Zone generally extends inland to the point where the 100-year flood depth is insufficient to support a 3-foot breaking wave.

4.0 INSURANCE APPLICATIONS

The assignment of proper actuarial insurance rates requires that frequency and depth of flooding be estimated as accurately as possible. Because waves can add considerably to expected flood depths, it is important that insurance rates consider this additional hazard. The FEMA has developed a process to transform the data from this study into flood insurance criteria. This process includes the determination of Flood Hazard Factors and the designation of flood insurance zones.

4.1 Flood Hazard Factors

The Flood Hazard Factor (FHF) is the device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables.

The FHF is shown as a three-digit code that expresses the difference between the 10- and 100-year flood elevations to the nearest 0.5 foot. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, the FHF is computed to the nearest foot.

4.2 Flood Insurance Zones

After wave elevations for the 100-year storm surge were determined and mapped, the study areas were divided into zones, each having a specific flood potential and FHF. Each zone was assigned one of the following flood insurance zone designations:

Zones V8 and V11:	Special Flood Hazard Areas along coasts inundated by the 100-year flood as determined by detailed methods, and that have additional hazards due to velocity (wave action); base flood elevations shown, and zones subdivided according to FHFs.
Zone A7:	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to FHF.
Zone B:	Areas between the Special Flood Hazard Area and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; also, areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flooding.

Table 2, "Flood Insurance Zone Data," summarizes the FHFs, flood insurance zones, and base flood elevations for each flooding source in the study area.

4.3 Flood Insurance Rate Map

After flood insurance zones were established for the study area, the FIRM for the City of Ocean City was revised to incorporate the new zone information. This map contains the official delineation of flood insurance zones and base flood elevations. The base map was adjusted using the more accurate topographic maps developed for this analysis (Reference 11).

5.0 OTHER STUDIES

Flood Insurance Rate Maps for the adjacent Borough of Longport and Township of Upper are being revised concurrently with the Ocean City study to include wave height analyses (References 17 and 18). The revised studies for Longport and Upper will be in exact agreement with this study.

TABLE 2 - FLOOD INSURANCE ZONE DATA

Flooding Source	Stillwater Elevation 10-Year	50-Year	100-Year	500-Year	FHF	Zone	Base Flood Elevation (Feet NGVD)*
Atlantic Ocean and Egg Harbor							
Transects 1-3	6.3	8.5	9.8	13.1	055	V11	12-15
	6.3	8.5	9.8	13.1	035	A7	10-12
	6.7	8.3	9.2	14.0	040	V8	11
	6.7	8.3	9.2	14.0	035	A7	9-11
Transects 4-5	6.3	8.5	9.7	12.7	055	V11	12-15
	6.3	8.5	9.7	12.7	035	A7	10-12
	6.7	8.3	9.2	14.0	035	A7	9-11
Transect 6	6.3	8.5	9.7	12.7	055	V11	12-15
	6.3	8.5	9.7	12.7	035	A7	10-12
	6.7	8.3	9.2	14.0	040	V8	11-12
	6.7	8.3	9.2	14.0	035	A7	9-11
Transects 7-8	6.3	8.5	9.6	12.4	055	V11	12-15
	6.3	8.5	9.6	12.4	035	A7	10-12
	6.7	8.3	9.2	14.0	040	V8	11-13
	6.7	8.3	9.2	14.0	035	A7	9-11

*Due to map scale limitations, base flood elevations shown on the FIRM represent average elevations for the zones depicted.

No wave height analyses for the adjacent Township of Egg Harbor and City of Somers Point are being conducted at this time (References 8 and 19). Therefore, the Flood Insurance Rate Maps for those studies will not agree with the map in the Ocean City study.

6.0 REFERENCES

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3. U. S. Army Corps of Engineers, Philadelphia District, Tidal Flood Plain Information, Toms River Area, Ocean County, New Jersey, Philadelphia, Pennsylvania, June 1972.

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9. U. S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, City of Ocean City, Cape May County, New Jersey, Washington, D. C., January 1976.

10. Keystone Aerial Surveys of Philadelphia, Pennsylvania, Aerial Photographs and Aerial Plotting Plates, Scale 1:12,000: Ocean City, New Jersey, March 1979.

11. Aerial Data Reduction Associates, prepared for the New Jersey Department of Environmental Protection and Department of Law and Public Safety, Aerial Mosaic, Scale 1:400: Ocean City, New Jersey, March 1983.

12. Dewberry & Davis of Fairfax, Virginia, prepared for the Federal Emergency Management Agency, Topographic Maps, Scale 1:2,400, Contour Interval 4 Feet: City of Ocean City, New Jersey, Developed in October 1982, Revised October 1983 (Unpublished).

13. State of New Jersey, Department of Environmental Protection, Field Survey, Trenton, New Jersey, January through March 1984.

14. U. S. Department of the Interior, Geological Survey, 7.5-Minute Series Topographic Maps, Scale 1:24,000, Contour Interval 10 Feet: Mamora, New Jersey, 1952, Photorevised 1972; Ocean City, New Jersey, 1952, Photo-revised 1972; Sea Isle City, New Jersey, 1957, Photorevised 1971.

15. Federal Emergency Management Agency, Users Manual for Wave Height Analysis, Washington, D. C., Revised February 1981.

16. U. S. Army Corps of Engineers, Galveston District, Guidelines for Identifying Coastal High Hazard Zones, Galveston, Texas, June 1975.

17. Federal Emergency Management Agency, Flood Insurance Study, Supplement Wave Height Analysis, Borough of Longport, Atlantic County, New Jersey (Unpublished).

18. Federal Emergency Management Agency, Flood Insurance Study, Supplement Wave Height Analysis, Township of Upper, Atlantic County, New Jersey (Unpublished).

19. U. S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, Township of Somers Point, Atlantic County, New Jersey, Washington, D. C., January 9, 1974.