# Appendix E – Metocean Report

# METOCEAN CRITERIA FOR VIRGINIA OFFSHORE WIND TECHNOLOGY ADVANCEMENT PROJECT (VOWTAP)

**Report Number: C56462/7907/R3**
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**This report is not to be used for contractual or engineering purposes unless described as 'Final' in the approval box below**

Prepared for: Dominion Resources Services, Inc
Alternative Energy Solutions

| | | | | | |
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# 1 INTRODUCTION

Fugro GEOS are pleased to provide this metocean criteria to support the Client's Virginia Offshore Wind Technology Advancement Project (VOWTAP). The VOWTAP project would be located approximately 24 miles off the coast of Virginia Beach (in the blue aliquots), as shown in Figure 1-1 below. The latitude and longitude coordinates for the two turbine sites are as followed; (36.885$^{o}$N, 75.4875$^{o}$W) and (36.8925$^{o}$N, 75.486667$^{o}$W). This Metocean criteria is applicable to these offshore locations.

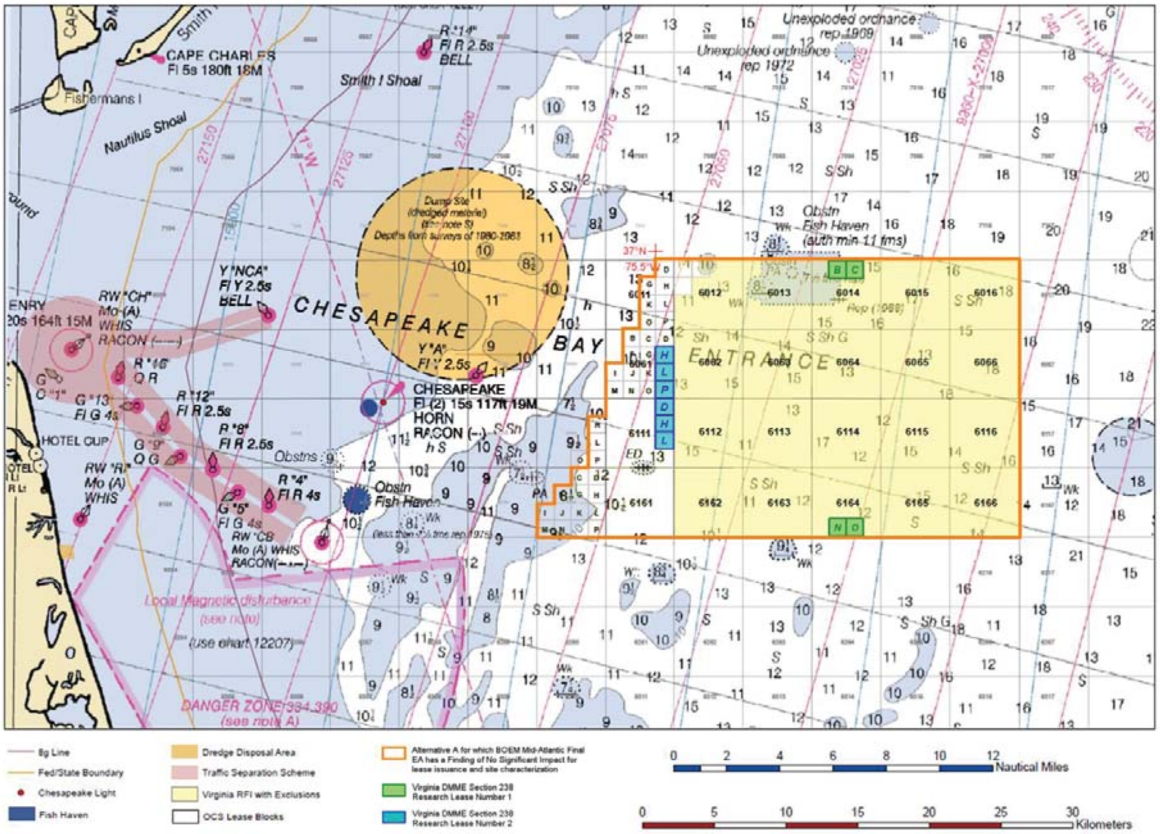


**Figure 1-1 Study Area and VOMTAP Proposed Location**

The major metocean processes that are expected to influence the study area are hurricanes and strong Northeasters winds and associated wave and currents, tides and tidal currents, and river discharge.

## 1.1 Units and Conventions

Unless explicitly stated otherwise, the following list outlines the units and conventions adopted in this report.

- Wind speeds are expressed in meter per second (m/s).
- Wind direction is expressed in compass points or degrees, relative to true North, and describes the direction from which the winds were blowing.
- Wave heights are expressed in meters (m).
- Wave periods are expressed in seconds (s).
- Wave direction is expressed in compass points or degrees, relative to true North, and describes the direction from which the waves were travelling.
- Current speed is expressed in meter per second (m/s).
- Current direction is expressed in degrees clockwise from true North and describes the directions towards which the current was flowing.

**Table 1-1 Directional Sectors**

| DIRECTIONAL SECTOR | N | NE | E | SE | S | SW | W | NW |
|---|---|---|---|---|---|---|---|---|
| RANGE (° T) | 337.5 -< 22.5 | 22.5 -< 67.5 | 67.5 -< 112.5 | 112.5 -< 157.5 | 157.5 -< 202.5 | 202.5 -< 247.5 | 247.5 -< 292.5 | 292.5 -< 337.5 |

## 1.2 Abbreviations

The following list outline the abbreviations adopted in this report.

| | |
|---|---|
| ECMWF | European Center for Medium-Range Weather Forecasts |
| GEOS | Global Environmental & Ocean Sciences |
| MSL | Mean Sea Level |
| TMD | Tide Model Driver |

### 1.3 Parameter Descriptions

The following table provides summary descriptions of the primary metocean parameters.

| Parameter | Abbreviation | Comments | Units |
|---|---|---|---|
| Wind Speed | Ws | Mean wind speed at 10m above sea level. By default 1 hour average unless otherwise stated. | m/s |
| Significant Wave Height | Hs | Estimated from the wave energy spectrum, Hs = 4√m$_0$. Equivalent to the mean height (from wave crest to trough) of the highest one-third of the waves in a sea-state. | m |
| Peak Period | Tp | The period associated with the peak in the wave energy spectrum. | s |
| Mean zero crossing Wave Period | Tz |  | s |
| Current Speed | Cs | Current speed | m/s |
| Crest Height | Hc | Height difference between maximum wave crest and succeeding trough. | m |
| Maximum Wave Height | Hmax | Height difference between the wave crest and trough of the largest wave in a sea-state. | m |
| Storm Surge Height | Hsur | Height of strom surges. Defined as the water level elevation due to sea surface pressure. | m |

**Table 1-2 Parameter Descriptions**

# 2 METOCEAN CRITERIA

## 2.1 Wind Criteria

Extreme value analysis was carried out on a subset of peak wind speed events from the Oceanweather hindcast data. The analysis only considered winter storm events from 1957 to 2003 and hurricane storm events from 1924 to 2005. The 1-year criteria are derive from 26-years (1980 to 2005) Oceanweather operational hindcast data.

Hub height is 100 m above MSL.

### 2.1.1 Omni-Directional 1-Year Extreme Wind Values

| Omnidirectional Wind Speeds at 10m ASL and at Hub Height 100 m Above MSL | | | | | | |
|---|---|---|---|---|---|---|
| | 1-hr (m/s) | 10-min (m/s) | 1-min (m/s) | 15-sec (m/s) | 5-sec (m/s) | 3-sec (m/s) |
| **1-year (ASL)** | 22.16 | 24.07 | 26.52 | 28.00 | 29.17 | 29.72 |
| **1-year (Hub)** | 37.22 | 29.71 | 31.59 | 32.73 | 33.63 | 34.04 |

Table 2-1 Omni-Directional 1-Year Extreme Wind Speed at 10 m ASL and Hub Heigh

### 2.1.2 Directional 1-Year Extreme Wind Values

| Winter Storm Wind Speeds by Direction at 10 m ASL and at Hub Height 100 m Above MSL | | | | | | |
|---|---|---|---|---|---|---|
| **1-year (ASL)** | 1-hr (m/s) | 10-min (m/s) | 1-min (m/s) | 15-sec (m/s) | 5-sec (m/s) | 3-sec (m/s) |
| North | 20.78 | 22.52 | 24.74 | 26.09 | 27.15 | 27.64 |
| Northeast | 21.85 | 23.72 | 26.12 | 27.56 | 28.71 | 29.24 |
| East | 18.77 | 20.26 | 22.18 | 23.34 | 24.26 | 24.68 |
| Southeast | 22.16 | 24.07 | 26.52 | 28.00 | 29.17 | 29.72 |
| South | 16.31 | 17.53 | 19.10 | 20.05 | 20.80 | 21.15 |
| Southwest | 19.55 | 21.14 | 23.18 | 24.40 | 25.38 | 25.83 |
| West | 15.02 | 16.11 | 17.51 | 18.35 | 19.02 | 19.33 |
| Northwest | 16.32 | 17.55 | 19.12 | 20.07 | 20.82 | 21.17 |
| **1-year (Hub)** | | | | | | |
| North | 34.89 | 27.67 | 29.37 | 30.40 | 31.21 | 31.59 |
| Northeast | 36.69 | 29.24 | 31.09 | 32.19 | 33.07 | 33.48 |
| East | 31.51 | 24.74 | 26.19 | 27.07 | 27.76 | 28.09 |
| Southeast | 37.22 | 29.71 | 31.59 | 32.73 | 33.63 | 34.04 |
| South | 27.38 | 21.22 | 22.40 | 23.11 | 23.67 | 23.93 |
| Southwest | 32.83 | 25.87 | 27.42 | 28.35 | 29.09 | 29.44 |
| West | 25.22 | 19.40 | 20.45 | 21.08 | 21.58 | 21.81 |
| Northwest | 27.40 | 21.24 | 22.42 | 23.13 | 23.69 | 23.95 |

Table 2-2 Directional 1-Year Extreme Wind Speeds at 10 m ASL and Hub Height

### 2.1.3 1-Year Wind Fitting Parameters

The independent omni-directional 1-hr wind cases are given in Table 2-1 and detailed descriptions of the calculations are given below. The analysis considered 26-years (1980 to 2005) Oceanweather operational hindcast data.

Cumulative frequency extrapolation involves grouping all the parameter values in the data set using specified class intervals and then forming a cumulative frequency distribution (cfd) by summing the number of observations greater than or equal to the lower bound of the class interval. This method was then employed to derive the 1-year criteria.

The Exponential (EXP), Fisher-Tippett 1 (FT1), Fisher-Tippett 2 (FT2), Fisher-Tippett 3 (FT3), Weibull 2 (W2) and Weibull 3 (W3) distributions were tested for goodness-of-fit to the OceanWeather data using the method of least squares (LS). The best fits for the 1-year wind speed are summarised in Table 2-3.

| | **Distribution** | **Fit** | **Threshold** | **# Peaks** | **Extreme Values** |
|---|---|---|---|---|---|
| | | | | | **1-yr** |
| **Ws (m/s)** | FT2 | LS | 5.00 | 10707 | 22.10 |
| | FT2 | LS | 5.00 | 10707 | 22.13 |
| | FT2 | LS | 5.00 | 10707 | 22.09 |
| | FT2 | LS | 10.00 | 21217 | 22.23 |
| | FT2 | LS | 10.00 | 17079 | 22.22 |
| | FT2 | LS | 10.00 | 21217 | 22.22 |
| | **AVERAGE** | | | | 22.16 |

**Table 2-3 Extreme Omni-directional Wind Speed Fitting Parameters for 1-year Extreme**

### 2.1.4 Omni-Directional Winter Storm Extreme Wind Values

| **Winter Storm Omnidirectional Wind Speeds at 10m ASL** | | | | | | |
|---|---|---|---|---|---|---|
| | 1-hr (m/s) | 10-min (m/s) | 1-min (m/s) | 15-sec (m/s) | 5-sec (m/s) | 3-sec (m/s) |
| 50-years | 24.55 | 26.77 | 29.63 | 31.35 | 32.71 | 33.35 |
| 100-years | 26.45 | 28.95 | 32.15 | 34.08 | 35.61 | 36.32 |
| 500-years | 30.88 | 34.04 | 38.12 | 40.57 | 42.51 | 43.41 |
| 1000-years | 32.78 | 36.26 | 40.74 | 43.43 | 45.56 | 46.56 |
| 10000-years | 39.10 | 43.72 | 49.66 | 53.23 | 56.07 | 57.38 |

**Table 2-4 Omni-Directional Winter Storm Extreme Wind Speeds 10 m ASL**

### 2.1.5 Directional Winter Storm Extreme Wind Values

| **Winter Storm Wind Speeds by Direction at 10 m ASL** | | | | | | |
|---|---|---|---|---|---|---|
| **50-years** | 1-hr (m/s) | 10-min (m/s) | 1-min (m/s) | 15-sec (m/s) | 5-sec (m/s) | 3-sec (m/s) |
| North | 24.55 | 26.77 | 29.63 | 31.35 | 32.71 | 33.35 |
| Northeast | 19.71 | 21.32 | 23.38 | 24.62 | 25.61 | 26.06 |
| East | 23.38 | 25.44 | 28.10 | 29.70 | 30.97 | 31.55 |
| Southeast | 23.25 | 25.30 | 27.93 | 29.51 | 30.77 | 31.35 |
| South | 22.62 | 24.58 | 27.11 | 28.63 | 29.84 | 30.40 |
| Southwest | 21.85 | 23.72 | 26.12 | 27.57 | 28.72 | 29.25 |
| West | 19.56 | 21.15 | 23.19 | 24.41 | 25.39 | 25.84 |
| Northwest | 20.28 | 21.95 | 24.10 | 25.40 | 26.43 | 26.90 |
| **100-years** | | | | | | |
| North | 26.45 | 28.95 | 32.15 | 34.08 | 35.61 | 36.32 |
| Northeast | 21.24 | 23.04 | 25.34 | 26.73 | 27.82 | 28.34 |
| East | 25.20 | 27.51 | 30.48 | 32.27 | 33.69 | 34.35 |
| Southeast | 25.05 | 27.35 | 30.30 | 32.07 | 33.48 | 34.13 |

| | | | | | | |
|---|---|---|---|---|---|---|
| South | 24.38 | 26.58 | 29.40 | 31.11 | 32.46 | 33.08 |
| Southwest | 23.55 | 25.64 | 28.33 | 29.95 | 31.23 | 31.82 |
| West | 21.08 | 22.85 | 25.13 | 26.50 | 27.59 | 28.09 |
| Northwest | 21.86 | 23.73 | 26.13 | 27.57 | 28.72 | 29.25 |
| **500-years** | | | | | | |
| North | 30.88 | 34.04 | 38.12 | 40.57 | 42.51 | 43.41 |
| Northeast | 24.80 | 27.05 | 29.96 | 31.70 | 33.09 | 33.73 |
| East | 29.41 | 32.34 | 36.12 | 38.39 | 40.19 | 41.02 |
| Southeast | 29.24 | 32.15 | 35.89 | 38.14 | 39.93 | 40.75 |
| South | 28.45 | 31.24 | 34.82 | 36.98 | 38.69 | 39.48 |
| Southwest | 27.49 | 30.14 | 33.53 | 35.58 | 37.20 | 37.95 |
| West | 24.60 | 26.84 | 29.70 | 31.43 | 32.80 | 33.44 |
| Northwest | 25.51 | 27.87 | 30.90 | 32.72 | 34.17 | 34.84 |
| **1000-years** | | | | | | |
| North | 32.78 | 36.26 | 40.74 | 43.43 | 45.56 | 46.56 |
| Northeast | 26.32 | 28.80 | 31.98 | 33.89 | 35.41 | 36.11 |
| East | 31.22 | 34.44 | 38.59 | 41.08 | 43.06 | 43.98 |
| Southeast | 31.04 | 34.24 | 38.34 | 40.82 | 42.78 | 43.69 |
| South | 30.20 | 33.26 | 37.20 | 39.56 | 41.44 | 42.31 |
| Southwest | 29.19 | 32.09 | 35.81 | 38.06 | 39.84 | 40.66 |
| West | 26.12 | 28.57 | 31.71 | 33.60 | 35.10 | 35.79 |
| Northwest | 27.08 | 29.67 | 32.99 | 34.99 | 36.57 | 37.31 |
| **10000-years** | | | | | | |
| North | 39.10 | 43.72 | 49.66 | 53.23 | 56.07 | 57.38 |
| Northeast | 31.40 | 34.65 | 38.83 | 41.35 | 43.34 | 44.27 |
| East | 37.24 | 41.51 | 47.00 | 50.30 | 52.92 | 54.13 |
| Southeast | 37.03 | 41.26 | 46.70 | 49.97 | 52.56 | 53.77 |
| South | 36.03 | 40.07 | 45.28 | 48.41 | 50.89 | 52.04 |
| Southwest | 34.81 | 38.64 | 43.57 | 46.53 | 48.88 | 49.97 |
| West | 31.16 | 34.37 | 38.50 | 40.99 | 42.96 | 43.87 |
| Northwest | 32.31 | 35.71 | 40.08 | 42.71 | 44.80 | 45.77 |

**Table 2-5 Directional Winter Storm Extreme Wind Speeds 10 m ASL**

### 2.1.6 Omni-Directional Winter Storm Extreme Wind Values at Hub Height

| **Winter Storm Omnidirectional Wind Speeds at Hub Height 100 m Above MSL** | | | | | | |
|---|---|---|---|---|---|---|
| | 1-hr (m/s) | 10-min (m/s) | 1-min (m/s) | 15-sec (m/s) | 5-sec (m/s) | 3-sec (m/s) |
| 50-years | 31.55 | 34.41 | 38.09 | 40.30 | 42.05 | 42.87 |
| 100-years | 34.23 | 37.46 | 41.61 | 44.10 | 46.08 | 47.00 |
| 500-years | 40.54 | 44.70 | 50.05 | 53.27 | 55.82 | 57.01 |
| 1000-years | 43.30 | 47.90 | 53.81 | 57.37 | 60.19 | 61.50 |
| 10000-years | 52.62 | 58.83 | 66.83 | 71.64 | 75.45 | 77.22 |

**Table 2-6 Omni-Directional Winter Storm Extreme Wind Speeds at Hub height**

### 2.1.7 Directional Winter Storm Extreme Wind Values at Hub Height

| Winter Storm Wind Speeds by Direction at Hub Height 100 m Above MSL | | | | | | |
|---|---|---|---|---|---|---|
| **50-years** | 1-hr (m/s) | 10-min (m/s) | 1-min (m/s) | 15-sec (m/s) | 5-sec (m/s) | 3-sec (m/s) |
| North | 31.55 | 33.28 | 35.49 | 36.82 | 37.88 | 38.37 |
| Northeast | 25.34 | 26.11 | 27.68 | 28.62 | 29.37 | 29.72 |
| East | 30.05 | 31.52 | 33.57 | 34.80 | 35.78 | 36.23 |
| Southeast | 29.88 | 31.32 | 33.35 | 34.57 | 35.54 | 35.99 |
| South | 29.07 | 30.38 | 32.33 | 33.50 | 34.42 | 34.86 |
| Southwest | 28.09 | 29.25 | 31.09 | 32.20 | 33.08 | 33.49 |
| West | 25.14 | 25.89 | 27.44 | 28.37 | 29.11 | 29.45 |
| Northwest | 26.07 | 26.94 | 28.58 | 29.56 | 30.35 | 30.71 |
| **100-years** | | | | | | |
| North | 34.23 | 36.18 | 38.68 | 40.18 | 41.37 | 41.93 |
| Northeast | 27.49 | 28.35 | 30.11 | 31.17 | 32.02 | 32.41 |
| East | 32.61 | 34.26 | 36.57 | 37.96 | 39.06 | 39.57 |
| Southeast | 32.42 | 34.04 | 36.33 | 37.71 | 38.80 | 39.31 |
| South | 31.54 | 33.02 | 35.21 | 36.53 | 37.57 | 38.06 |
| Southwest | 30.48 | 31.78 | 33.86 | 35.10 | 36.09 | 36.55 |
| West | 27.28 | 28.11 | 29.85 | 30.90 | 31.73 | 32.12 |
| Northwest | 28.29 | 29.26 | 31.10 | 32.21 | 33.09 | 33.50 |
| **500-years** | | | | | | |
| North | 40.54 | 43.05 | 46.27 | 48.21 | 49.75 | 50.46 |
| Northeast | 32.56 | 33.65 | 35.90 | 37.26 | 38.33 | 38.83 |
| East | 38.62 | 40.74 | 43.72 | 45.50 | 46.92 | 47.58 |
| Southeast | 38.40 | 40.49 | 43.43 | 45.20 | 46.60 | 47.26 |
| South | 37.36 | 39.25 | 42.07 | 43.76 | 45.10 | 45.73 |
| Southwest | 36.10 | 37.77 | 40.43 | 42.03 | 43.30 | 43.89 |
| West | 32.31 | 33.36 | 35.59 | 36.92 | 37.98 | 38.48 |
| Northwest | 33.50 | 34.74 | 37.09 | 38.51 | 39.64 | 40.16 |
| **1000-years** | | | | | | |
| North | 43.30 | 46.07 | 49.63 | 51.78 | 53.48 | 54.27 |
| Northeast | 34.77 | 35.98 | 38.46 | 39.95 | 41.13 | 41.68 |
| East | 41.24 | 43.59 | 46.87 | 48.85 | 50.42 | 51.14 |
| Southeast | 41.01 | 43.31 | 46.56 | 48.52 | 50.07 | 50.79 |
| South | 39.90 | 41.99 | 45.10 | 46.96 | 48.45 | 49.13 |
| Southwest | 38.55 | 40.40 | 43.33 | 45.10 | 46.50 | 47.15 |
| West | 34.50 | 35.67 | 38.11 | 39.59 | 40.75 | 41.30 |
| Northwest | 35.78 | 37.14 | 39.74 | 41.30 | 42.54 | 43.11 |
| **10000-years** | | | | | | |
| North | 52.62 | 56.36 | 61.18 | 64.08 | 66.37 | 67.44 |
| Northeast | 42.25 | 43.88 | 47.19 | 49.18 | 50.76 | 51.50 |
| East | 50.11 | 53.29 | 57.72 | 60.38 | 62.49 | 63.48 |
| Southeast | 49.83 | 52.95 | 57.33 | 59.97 | 62.06 | 63.03 |
| South | 48.48 | 51.31 | 55.49 | 58.01 | 60.00 | 60.93 |
| Southwest | 46.85 | 49.34 | 53.28 | 55.66 | 57.54 | 58.41 |
| West | 41.93 | 43.49 | 46.76 | 48.73 | 50.29 | 51.02 |
| Northwest | 43.47 | 45.31 | 48.79 | 50.88 | 52.54 | 53.31 |

**Table 2-7 Directional Winter Storm Extreme Wind Speeds at Hub Height**

### 2.1.8 Wind Fitting Parameters for Winter Storm

The independent omni-directional 1-hr wind cases are given in Table 2-4 and detailed descriptions of the calculations are given below.

Extreme value analysis was carried out on a subset of peak wave heights from the OceanWeather data. The analysis only considered winter storm events from 1957 to 2003.

The Peaks Over Threshold (POT) method consisted of declustering the data by selecting peak events to produce a set of independent and identically distributed observations. This method was then employed to derive the 50-, 100-, 500-, 1000-, and 10000-year criteria. The number of peaks exceeding a given level, divided by the number of years of record, gave the rate of exceedance which could then be used to find the expected number of occurrences in a specified period of time.

The Exponential (EXP), Fisher-Tippett 1 (FT1), Fisher-Tippett 2 (FT2), Fisher-Tippett 3 (FT3), Generalised Pareto (GP), Weibull 2 (W2) and Weibull 3 (W3) distributions were tested for goodness-of-fit to the OceanWeather data using the method of least squares (LS), maximum likelihood (MLE), and the method of moments (MoM). The best fits for 50-, 100-, 500-, 1000-, and 10000-year wind speed are summarised in Table 2-8.

| | **Distribution** | **Fit** | **Threshold** | **# Peaks** | **Extreme Values** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **50-yr** | **100-yr** | **500-yr** | **1000-yr** | **10000-yr** |
| **Ws (m/s)** | EXP | MoM | 9.91 | 72 | 25.54 | 27.83 | 33.15 | 35.44 | 43.05 |
| | EXP | MoM | 10.20 | 70 | 25.44 | 27.70 | 32.95 | 35.21 | 42.73 |
| | EXP | MoM | 10.53 | 64 | 25.13 | 27.31 | 32.36 | 34.54 | 41.77 |
| | FT1 | LS | 9.91 | 72 | 25.05 | 27.00 | 31.51 | 33.45 | 39.89 |
| | FT1 | LS | 10.20 | 70 | 24.99 | 26.91 | 31.37 | 33.29 | 39.66 |
| | FT1 | LS | 10.53 | 64 | 24.79 | 26.65 | 30.96 | 32.81 | 38.97 |
| | FT1 | MLE | 9.91 | 72 | 23.97 | 25.73 | 29.82 | 31.58 | 37.43 |
| | FT1 | MLE | 10.20 | 70 | 23.88 | 25.62 | 29.65 | 31.38 | 37.13 |
| | FT1 | MLE | 10.53 | 64 | 23.62 | 25.28 | 29.13 | 30.78 | 36.28 |
| | FT1 | MoM | 9.91 | 72 | 24.16 | 25.95 | 30.10 | 31.89 | 37.82 |
| | FT1 | MoM | 10.20 | 70 | 24.09 | 25.86 | 29.96 | 31.73 | 37.59 |
| | FT1 | MoM | 10.53 | 64 | 23.90 | 25.60 | 29.55 | 31.25 | 36.88 |
| | **AVERAGE** | | | | 24.55 | 26.45 | 30.88 | 32.78 | 39.10 |

**Table 2-8 Extreme Omni-directional Wind Speed Fitting Parameters for Winter Storm**

### 2.1.9 Omni-Directional Hurricane Extreme Wind Values

| **Hurricane Omnidirectional Wind Speeds at 10m ASL** | | | | | | |
|---|---|---|---|---|---|---|
| | 1-hr (m/s) | 10-min (m/s) | 1-min (m/s) | 15-sec (m/s) | 5-sec (m/s) | 3-sec (m/s) |
| 50-years | 33.02 | 36.54 | 41.06 | 43.79 | 45.95 | 46.95 |
| 100-years | 36.47 | 40.60 | 45.91 | 49.10 | 51.63 | 52.81 |
| 500-years | 44.47 | 50.18 | 57.52 | 61.93 | 65.43 | 67.06 |
| 1000-years | 47.91 | 54.38 | 62.68 | 67.68 | 71.65 | 73.49 |
| 10000-years | 59.35 | 68.64 | 80.58 | 87.76 | 93.46 | 96.11 |

**Table 2-9 Omni-Directional Hurricane Extreme Wind Speeds 10 m ASL**

### 2.1.10 Directional Hurricane Extreme Wind Values

| Hurricane Wind Speeds by Direction at 10 m ASL | | | | | | |
|---|---|---|---|---|---|---|
| **50-years** | 1-hr (m/s) | 10-min (m/s) | 1-min (m/s) | 15-sec (m/s) | 5-sec (m/s) | 3-sec (m/s) |
| North | 29.39 | 32.32 | 36.09 | 38.36 | 40.15 | 40.99 |
| Northeast | 31.22 | 34.44 | 38.58 | 41.07 | 43.05 | 43.97 |
| East | 33.02 | 36.54 | 41.06 | 43.79 | 45.95 | 46.95 |
| Southeast | 28.83 | 31.67 | 35.33 | 37.53 | 39.27 | 40.09 |
| South | 27.13 | 29.72 | 33.05 | 35.06 | 36.64 | 37.38 |
| Southwest | 25.43 | 27.77 | 30.79 | 32.60 | 34.04 | 34.71 |
| West | 20.88 | 22.63 | 24.88 | 26.23 | 27.30 | 27.80 |
| Northwest | 26.23 | 28.69 | 31.85 | 33.75 | 35.26 | 35.96 |
| **100-years** | | | | | | |
| North | 32.46 | 35.89 | 40.30 | 42.95 | 45.05 | 46.03 |
| Northeast | 34.48 | 38.26 | 43.11 | 46.03 | 48.34 | 49.41 |
| East | 36.47 | 40.60 | 45.91 | 49.10 | 51.63 | 52.81 |
| Southeast | 31.84 | 35.17 | 39.44 | 42.01 | 44.05 | 45.00 |
| South | 29.97 | 32.99 | 36.88 | 39.22 | 41.07 | 41.93 |
| Southwest | 28.09 | 30.82 | 34.33 | 36.45 | 38.12 | 38.90 |
| West | 23.07 | 25.09 | 27.70 | 29.26 | 30.51 | 31.08 |
| Northwest | 28.97 | 31.84 | 35.52 | 37.74 | 39.50 | 40.32 |
| **500-years** | | | | | | |
| North | 39.58 | 44.30 | 50.36 | 54.01 | 56.90 | 58.24 |
| Northeast | 42.05 | 47.25 | 53.94 | 57.97 | 61.16 | 62.64 |
| East | 44.47 | 50.18 | 57.52 | 61.93 | 65.43 | 67.06 |
| Southeast | 38.83 | 43.40 | 49.27 | 52.80 | 55.60 | 56.91 |
| South | 36.54 | 40.69 | 46.01 | 49.21 | 51.75 | 52.93 |
| Southwest | 34.25 | 37.98 | 42.78 | 45.67 | 47.95 | 49.02 |
| West | 28.13 | 30.87 | 34.39 | 36.51 | 38.19 | 38.97 |
| Northwest | 35.33 | 39.25 | 44.29 | 47.32 | 49.73 | 50.85 |
| **1000-years** | | | | | | |
| North | 42.65 | 47.98 | 54.82 | 58.94 | 62.21 | 63.73 |
| Northeast | 45.30 | 51.19 | 58.75 | 63.31 | 66.92 | 68.60 |
| East | 47.91 | 54.38 | 62.68 | 67.68 | 71.65 | 73.49 |
| Southeast | 41.83 | 46.99 | 53.63 | 57.62 | 60.78 | 62.25 |
| South | 39.37 | 44.05 | 50.05 | 53.67 | 56.53 | 57.87 |
| Southwest | 36.90 | 41.11 | 46.51 | 49.77 | 52.35 | 53.55 |
| West | 30.31 | 33.38 | 37.34 | 39.72 | 41.60 | 42.48 |
| Northwest | 38.06 | 42.48 | 48.17 | 51.59 | 54.30 | 55.56 |
| **10000-years** | | | | | | |
| North | 52.82 | 60.44 | 70.23 | 76.12 | 80.79 | 82.96 |
| Northeast | 56.11 | 64.55 | 75.40 | 81.93 | 87.10 | 89.51 |
| East | 59.35 | 68.64 | 80.58 | 87.76 | 93.46 | 96.11 |
| Southeast | 51.81 | 59.19 | 68.66 | 74.36 | 78.88 | 80.99 |
| South | 48.77 | 55.42 | 63.98 | 69.13 | 73.21 | 75.11 |
| Southwest | 45.70 | 51.68 | 59.35 | 63.97 | 67.64 | 69.34 |
| West | 37.54 | 41.86 | 47.42 | 50.77 | 53.42 | 54.65 |
| Northwest | 47.14 | 53.43 | 61.51 | 66.38 | 70.24 | 72.03 |

**Table 2-10 Directional Hurricane Extreme Wind Speeds 10 m ASL**

### 2.1.11 Omni-Directional Hurricane Extreme Wind Values at Hub Height

| Hurricane Omnidirectional Wind Speeds at Hub Height 100 m Above MSL | | | | | | |
|---|---|---|---|---|---|---|
| | 1-hr (m/s) | 10-min (m/s) | 1-min (m/s) | 15-sec (m/s) | 5-sec (m/s) | 3-sec (m/s) |
| 50-years | 43.64 | 46.45 | 50.05 | 52.22 | 53.94 | 54.74 |
| 100-years | 48.71 | 52.03 | 56.30 | 58.87 | 60.91 | 61.86 |
| 500-years | 60.72 | 65.42 | 71.45 | 75.09 | 77.97 | 79.31 |
| 1000-years | 66.00 | 71.37 | 78.26 | 82.41 | 85.70 | 87.23 |
| 10000-years | 83.98 | 91.91 | 102.09 | 108.22 | 113.08 | 115.33 |

**Table 2-11 Omni-Directional Hurricane Extreme Wind Speeds at Hub height**

### 2.1.12 Directional Hurricane Extreme Wind Values at Hub Height

| Hurricane Wind Speeds by Direction at Hub Height 100 m Above MSL | | | | | | |
|---|---|---|---|---|---|---|
| **50-years** | 1-hr (m/s) | 10-min (m/s) | 1-min (m/s) | 15-sec (m/s) | 5-sec (m/s) | 3-sec (m/s) |
| North | 38.85 | 40.71 | 43.68 | 45.47 | 46.88 | 47.54 |
| Northeast | 41.26 | 43.59 | 46.87 | 48.84 | 50.41 | 51.14 |
| East | 43.64 | 46.45 | 50.05 | 52.22 | 53.94 | 54.74 |
| Southeast | 38.10 | 39.84 | 42.71 | 44.44 | 45.81 | 46.45 |
| South | 35.86 | 37.22 | 39.82 | 41.38 | 42.63 | 43.20 |
| Southwest | 33.61 | 34.61 | 36.95 | 38.36 | 39.48 | 40.00 |
| West | 27.61 | 27.82 | 29.54 | 30.57 | 31.39 | 31.77 |
| Northwest | 34.67 | 35.83 | 38.29 | 39.77 | 40.95 | 41.50 |
| **100-years** | | | | | | |
| North | 43.36 | 45.57 | 49.07 | 51.18 | 52.85 | 53.63 |
| Northeast | 46.06 | 48.81 | 52.68 | 55.02 | 56.87 | 57.73 |
| East | 48.71 | 52.03 | 56.30 | 58.87 | 60.91 | 61.86 |
| Southeast | 42.53 | 44.58 | 47.97 | 50.01 | 51.63 | 52.38 |
| South | 40.03 | 41.62 | 44.69 | 46.54 | 48.00 | 48.68 |
| Southwest | 37.51 | 38.69 | 41.44 | 43.10 | 44.42 | 45.03 |
| West | 30.81 | 31.06 | 33.06 | 34.27 | 35.23 | 35.67 |
| Northwest | 38.69 | 40.06 | 42.96 | 44.71 | 46.09 | 46.73 |
| **500-years** | | | | | | |
| North | 54.05 | 57.17 | 62.09 | 65.05 | 67.40 | 68.49 |
| Northeast | 57.41 | 61.30 | 66.76 | 70.06 | 72.66 | 73.88 |
| East | 60.72 | 65.42 | 71.45 | 75.09 | 77.97 | 79.31 |
| Southeast | 53.02 | 55.91 | 60.67 | 63.53 | 65.80 | 66.86 |
| South | 49.90 | 52.15 | 56.44 | 59.02 | 61.06 | 62.01 |
| Southwest | 46.76 | 48.43 | 52.26 | 54.57 | 56.40 | 57.25 |
| West | 38.41 | 38.76 | 41.52 | 43.18 | 44.50 | 45.11 |
| Northwest | 48.23 | 50.17 | 54.21 | 56.65 | 58.58 | 59.47 |
| **1000-years** | | | | | | |
| North | 58.75 | 62.31 | 67.92 | 71.29 | 73.97 | 75.21 |
| Northeast | 62.40 | 66.84 | 73.08 | 76.84 | 79.81 | 81.20 |
| East | 66.00 | 71.37 | 78.26 | 82.41 | 85.70 | 87.23 |
| Southeast | 57.63 | 60.94 | 66.35 | 69.62 | 72.20 | 73.40 |
| South | 54.24 | 56.82 | 61.69 | 64.63 | 66.95 | 68.03 |
| Southwest | 50.83 | 52.73 | 57.09 | 59.71 | 61.79 | 62.76 |
| West | 41.75 | 42.15 | 45.28 | 47.16 | 48.65 | 49.34 |
| Northwest | 52.43 | 54.64 | 59.24 | 62.01 | 64.20 | 65.22 |

| **10000-years** | | | | | | |
|---|---|---|---|---|---|---|
| North | 74.75 | 80.04 | 88.26 | 93.22 | 97.14 | 98.96 |
| Northeast | 79.41 | 85.97 | 95.15 | 100.68 | 105.06 | 107.10 |
| East | 83.98 | 91.91 | 102.09 | 108.22 | 113.08 | 115.33 |
| Southeast | 73.33 | 78.24 | 86.18 | 90.96 | 94.75 | 96.51 |
| South | 69.01 | 72.86 | 79.97 | 84.26 | 87.65 | 89.23 |
| Southwest | 64.68 | 67.53 | 73.87 | 77.68 | 80.71 | 82.11 |
| West | 53.12 | 53.78 | 58.27 | 60.97 | 63.11 | 64.11 |
| Northwest | 66.71 | 70.02 | 76.72 | 80.75 | 83.94 | 85.43 |

**Table 2-12 Directional Hurricane Extreme Wind Speeds at Hub Height**

### 2.1.13 Wind Fitting Parameters for Hurricanes

The independent omni-directional 1-hr wind cases are given in Table 2-9 and detailed descriptions of the calculations are given below.

Extreme value analysis was carried out on a subset of peak wave heights from the OceanWeather data. The analysis only considered hurricane storm events from 1924 to 2005.

The Peaks Over Threshold (POT) method consisted of declustering the data by selecting peak events to produce a set of independent and identically distributed observations. This method was then employed to derive the 50-, 100-, 500-, 1000-, and 10000-year criteria. The number of peaks exceeding a given level, divided by the number of years of record, gave the rate of exceedance which could then be used to find the expected number of occurrences in a specified period of time.

The Exponential (EXP), Fisher-Tippett 1 (FT1), Fisher-Tippett 2 (FT2), Fisher-Tippett 3 (FT3), Generalised Pareto (GP), Weibull 2 (W2) and Weibull 3 (W3) distributions were tested for goodness-of-fit to the OceanWeather data using the method of least squares (LS), maximum likelihood (MLE), and the method of moments (MoM). The best fits for 50-, 100-, 500-, 1000-, and 10000-year wind speed are summarised in Table 2-13.

| | **Distribution** | **Fit** | **Threshold** | **# Peaks** | **Extreme Values** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **50-yr** | **100-yr** | **500-yr** | **1000-yr** | **10000-yr** |
| **Ws (m/s)** | EXP | MLE | 10.55 | 99 | 33.40 | 37.25 | 46.20 | 50.05 | 62.85 |
| | FT1 | LS | 10.01 | 103 | 34.05 | 37.59 | 45.76 | 49.28 | 60.96 |
| | FT1 | MoM | 10.01 | 103 | 32.33 | 35.54 | 42.98 | 46.18 | 56.81 |
| | FT1 | MoM | 9.80 | 106 | 32.29 | 35.51 | 42.95 | 46.15 | 56.77 |
| | **AVERAGE** | | | | 33.02 | 36.47 | 44.47 | 47.91 | 59.35 |

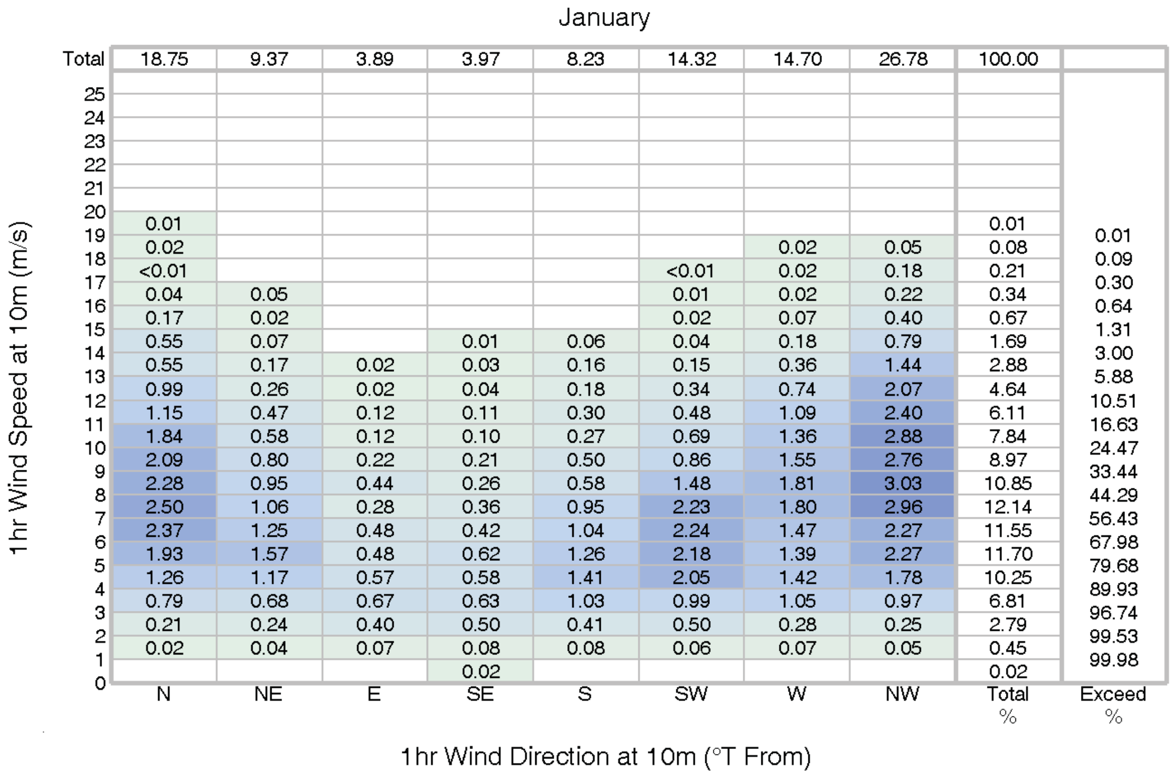
**Table 2-13 Extreme Omni-directional Wind Speed Fitting Parameters for Hurricanes**

### 2.1.14 Omni-Directional Monthly Average and Maximum Wind Speed Excluding Hurricanes

| COMBINED PERIOD (1980 to 2005) | 1hr Wind Speed at 10m (m/s) | | MAIN DIRECTION(S) |
|---|---|---|---|
| | MEAN | MAX | |
| January | 7.81 | 19.33 | NW |
| February | 7.33 | 20.06 | N NW |
| March | 6.97 | 23.02 | N NW |
| April | 5.98 | 19.64 | S |
| May | 4.93 | 17.06 | S SW |
| June | 4.46 | 15.09 | S SW |
| July | 4.49 | 18.72 | SW |
| August | 4.67 | 25.63 | S SW |
| September | 5.35 | 24.51 | NE |
| October | 6.31 | 23.21 | N NE |
| November | 6.96 | 19.18 | N NW |
| December | 7.73 | 21.13 | N NW |
| All Year | 6.09 | 25.63 | N S SW NW |

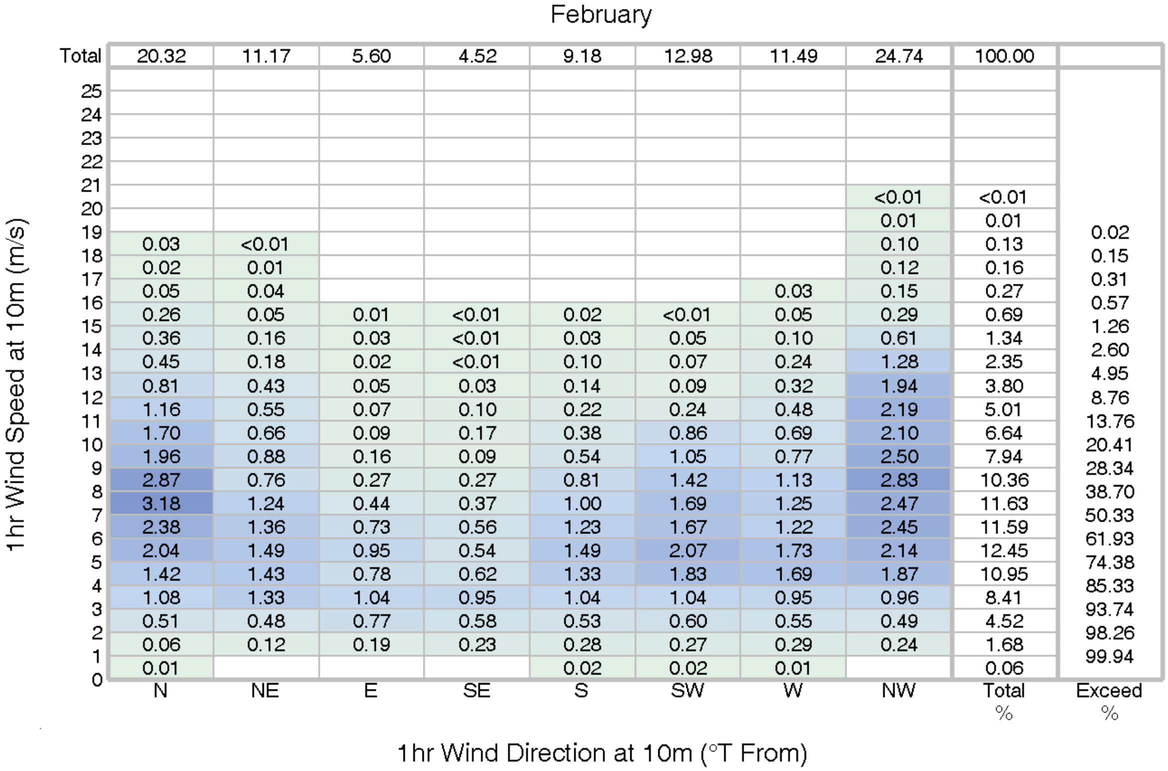
Table 2-14 Omni-Directional Month Average and Maximum Wind Speed Excluding Hurricanes

### 2.1.15 Joint Frequency of Wind Speed by Direction Excluding Hurricanes



| | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 18.75 | 9.37 | 3.89 | 3.97 | 8.23 | 14.32 | 14.70 | 26.78 | 100.00 | |
| 25 | | | | | | | | | | |
| 24 | | | | | | | | | | |
| 23 | | | | | | | | | | |
| 22 | | | | | | | | | | |
| 21 | | | | | | | | | | |
| 20 | | | | | | | | | | |
| 19 | 0.01 | | | | | | | | 0.01 | 0.01 |
| 18 | | | | | | | 0.02 | 0.05 | 0.08 | 0.09 |
| 17 | <0.01 | | | | | <0.01 | 0.02 | 0.18 | 0.21 | 0.30 |
| 16 | 0.04 | 0.05 | | | | 0.01 | 0.02 | 0.22 | 0.34 | 0.64 |
| 15 | 0.17 | 0.02 | | | | 0.02 | 0.07 | 0.40 | 0.67 | 1.31 |
| 14 | 0.55 | 0.07 | | 0.01 | 0.06 | 0.04 | 0.18 | 0.79 | 1.69 | 3.00 |
| 13 | 0.55 | 0.17 | 0.02 | 0.03 | 0.16 | 0.15 | 0.36 | 1.44 | 2.88 | 5.88 |
| 12 | 0.99 | 0.26 | 0.02 | 0.04 | 0.18 | 0.34 | 0.74 | 2.07 | 4.64 | 10.51 |
| 11 | 1.15 | 0.47 | 0.12 | 0.11 | 0.30 | 0.48 | 1.09 | 2.40 | 6.11 | 16.63 |
| 10 | 1.84 | 0.58 | 0.12 | 0.10 | 0.27 | 0.69 | 1.36 | 2.88 | 7.84 | 24.47 |
| 9 | 2.09 | 0.80 | 0.22 | 0.21 | 0.50 | 0.86 | 1.55 | 2.76 | 8.97 | 33.44 |
| 8 | 2.28 | 0.95 | 0.44 | 0.26 | 0.58 | 1.48 | 1.81 | 3.03 | 10.85 | 44.29 |
| 7 | 2.50 | 1.06 | 0.28 | 0.36 | 0.95 | 2.23 | 1.80 | 2.96 | 12.14 | 56.43 |
| 6 | 2.37 | 1.25 | 0.48 | 0.42 | 1.04 | 2.24 | 1.47 | 2.27 | 11.55 | 67.98 |
| 5 | 1.93 | 1.57 | 0.48 | 0.62 | 1.26 | 2.18 | 1.39 | 2.27 | 11.70 | 79.68 |
| 4 | 1.26 | 1.17 | 0.57 | 0.58 | 1.41 | 2.05 | 1.42 | 1.78 | 10.25 | 89.93 |
| 3 | 0.79 | 0.68 | 0.67 | 0.63 | 1.03 | 0.99 | 1.05 | 0.97 | 6.81 | 96.74 |
| 2 | 0.21 | 0.24 | 0.40 | 0.50 | 0.41 | 0.50 | 0.28 | 0.25 | 2.79 | 99.53 |
| 1 | 0.02 | 0.04 | 0.07 | 0.08 | 0.08 | 0.06 | 0.07 | 0.05 | 0.45 | 99.98 |
| 0 | | | | 0.02 | | | | | 0.02 | |

Figure 2-1 Percentage Occurrence of Wind Speed and Direction Excluding Hurricanes – January

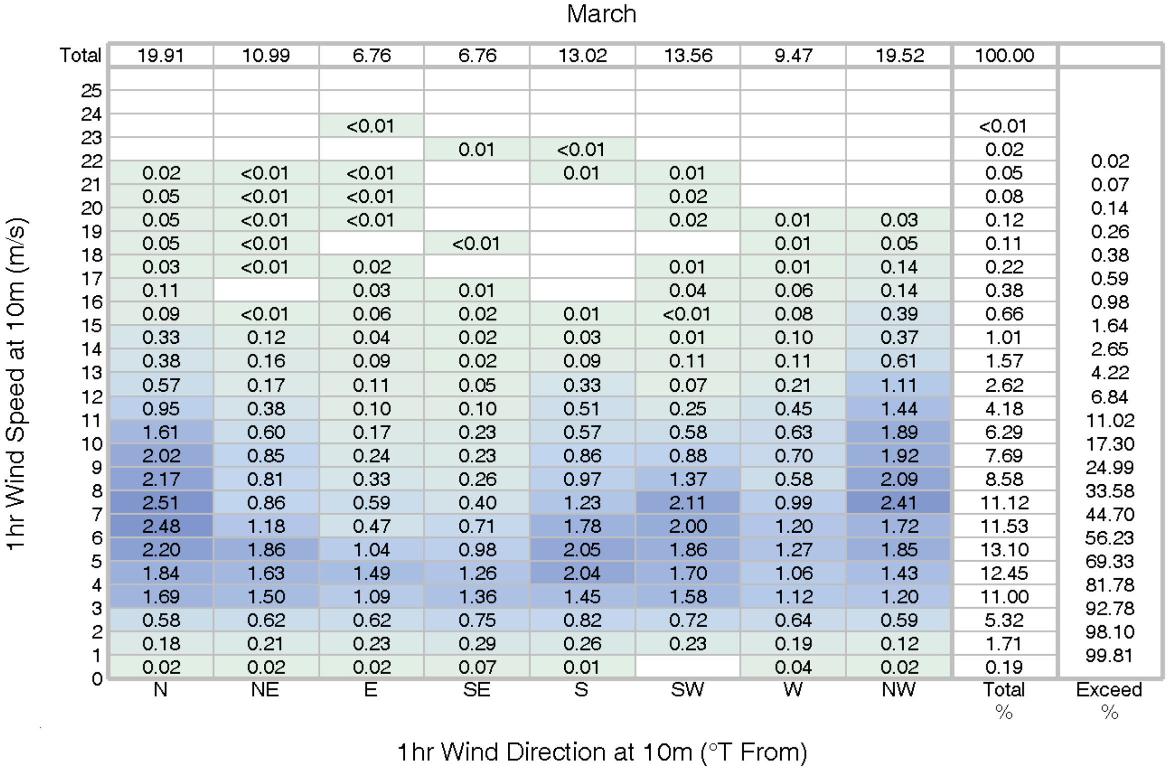


February

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 20.32 | 11.17 | 5.60 | 4.52 | 9.18 | 12.98 | 11.49 | 24.74 | 100.00 | |
| 24–25 | | | | | | | | | | |
| 23–24 | | | | | | | | | | |
| 22–23 | | | | | | | | | | |
| 21–22 | | | | | | | | | | |
| 20–21 | | | | | | | | <0.01 | <0.01 | |
| 19–20 | | | | | | | | 0.01 | 0.01 | 0.02 |
| 18–19 | 0.03 | <0.01 | | | | | | 0.10 | 0.13 | 0.15 |
| 17–18 | 0.02 | 0.01 | | | | | | 0.12 | 0.16 | 0.31 |
| 16–17 | 0.05 | 0.04 | | | | | 0.03 | 0.15 | 0.27 | 0.57 |
| 15–16 | 0.26 | 0.05 | 0.01 | <0.01 | 0.02 | <0.01 | 0.05 | 0.29 | 0.69 | 1.26 |
| 14–15 | 0.36 | 0.16 | 0.03 | <0.01 | 0.03 | 0.05 | 0.10 | 0.61 | 1.34 | 2.60 |
| 13–14 | 0.45 | 0.18 | 0.02 | <0.01 | 0.10 | 0.07 | 0.24 | 1.28 | 2.35 | 4.95 |
| 12–13 | 0.81 | 0.43 | 0.05 | 0.03 | 0.14 | 0.09 | 0.32 | 1.94 | 3.80 | 8.76 |
| 11–12 | 1.16 | 0.55 | 0.07 | 0.10 | 0.22 | 0.24 | 0.48 | 2.19 | 5.01 | 13.76 |
| 10–11 | 1.70 | 0.66 | 0.09 | 0.17 | 0.38 | 0.86 | 0.69 | 2.10 | 6.64 | 20.41 |
| 9–10 | 1.96 | 0.88 | 0.16 | 0.09 | 0.54 | 1.05 | 0.77 | 2.50 | 7.94 | 28.34 |
| 8–9 | 2.87 | 0.76 | 0.27 | 0.27 | 0.81 | 1.42 | 1.13 | 2.83 | 10.36 | 38.70 |
| 7–8 | 3.18 | 1.24 | 0.44 | 0.37 | 1.00 | 1.69 | 1.25 | 2.47 | 11.63 | 50.33 |
| 6–7 | 2.38 | 1.36 | 0.73 | 0.56 | 1.23 | 1.67 | 1.22 | 2.45 | 11.59 | 61.93 |
| 5–6 | 2.04 | 1.49 | 0.95 | 0.54 | 1.49 | 2.07 | 1.73 | 2.14 | 12.45 | 74.38 |
| 4–5 | 1.42 | 1.43 | 0.78 | 0.62 | 1.33 | 1.83 | 1.69 | 1.87 | 10.95 | 85.33 |
| 3–4 | 1.08 | 1.33 | 1.04 | 0.95 | 1.04 | 1.04 | 0.95 | 0.96 | 8.41 | 93.74 |
| 2–3 | 0.51 | 0.48 | 0.77 | 0.58 | 0.53 | 0.60 | 0.55 | 0.49 | 4.52 | 98.26 |
| 1–2 | 0.06 | 0.12 | 0.19 | 0.23 | 0.28 | 0.27 | 0.29 | 0.24 | 1.68 | 99.94 |
| 0–1 | 0.01 | | | | 0.02 | 0.02 | 0.01 | | 0.06 | |

1hr Wind Direction at 10m (°T From)

Figure 2-2 Percentage Occurrence of Wind Speed and Direction Excluding Hurricanes – February

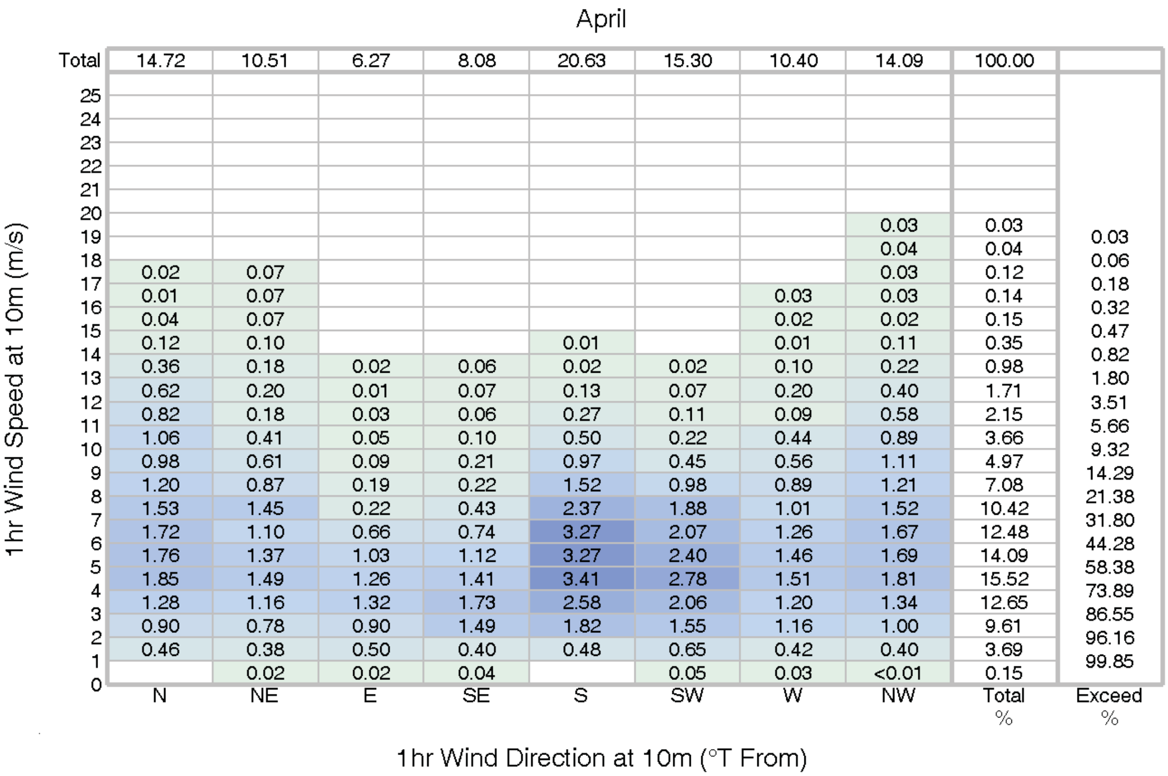


March

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 19.91 | 10.99 | 6.76 | 6.76 | 13.02 | 13.56 | 9.47 | 19.52 | 100.00 | |
| 24–25 | | | | | | | | | | |
| 23–24 | | | <0.01 | | | | | | <0.01 | |
| 22–23 | | | | 0.01 | <0.01 | | | | 0.02 | 0.02 |
| 21–22 | 0.02 | <0.01 | <0.01 | | 0.01 | 0.01 | | | 0.05 | 0.07 |
| 20–21 | 0.05 | <0.01 | <0.01 | | | 0.02 | | | 0.08 | 0.14 |
| 19–20 | 0.05 | <0.01 | <0.01 | | | 0.02 | 0.01 | 0.03 | 0.12 | 0.26 |
| 18–19 | 0.05 | <0.01 | | <0.01 | | | 0.01 | 0.05 | 0.11 | 0.38 |
| 17–18 | 0.03 | <0.01 | 0.02 | | | 0.01 | 0.01 | 0.14 | 0.22 | 0.59 |
| 16–17 | 0.11 | | 0.03 | 0.01 | | 0.04 | 0.06 | 0.14 | 0.38 | 0.98 |
| 15–16 | 0.09 | <0.01 | 0.06 | 0.02 | 0.01 | <0.01 | 0.08 | 0.39 | 0.66 | 1.64 |
| 14–15 | 0.33 | 0.12 | 0.04 | 0.02 | 0.03 | 0.01 | 0.10 | 0.37 | 1.01 | 2.65 |
| 13–14 | 0.38 | 0.16 | 0.09 | 0.02 | 0.09 | 0.11 | 0.11 | 0.61 | 1.57 | 4.22 |
| 12–13 | 0.57 | 0.17 | 0.11 | 0.05 | 0.33 | 0.07 | 0.21 | 1.11 | 2.62 | 6.84 |
| 11–12 | 0.95 | 0.38 | 0.10 | 0.10 | 0.51 | 0.25 | 0.45 | 1.44 | 4.18 | 11.02 |
| 10–11 | 1.61 | 0.60 | 0.17 | 0.23 | 0.57 | 0.58 | 0.63 | 1.89 | 6.29 | 17.30 |
| 9–10 | 2.02 | 0.85 | 0.24 | 0.23 | 0.86 | 0.88 | 0.70 | 1.92 | 7.69 | 24.99 |
| 8–9 | 2.17 | 0.81 | 0.33 | 0.26 | 0.97 | 1.37 | 0.58 | 2.09 | 8.58 | 33.58 |
| 7–8 | 2.51 | 0.86 | 0.59 | 0.40 | 1.23 | 2.11 | 0.99 | 2.41 | 11.12 | 44.70 |
| 6–7 | 2.48 | 1.18 | 0.47 | 0.71 | 1.78 | 2.00 | 1.20 | 1.72 | 11.53 | 56.23 |
| 5–6 | 2.20 | 1.86 | 1.04 | 0.98 | 2.05 | 1.86 | 1.27 | 1.85 | 13.10 | 69.33 |
| 4–5 | 1.84 | 1.63 | 1.49 | 1.26 | 2.04 | 1.70 | 1.06 | 1.43 | 12.45 | 81.78 |
| 3–4 | 1.69 | 1.50 | 1.09 | 1.36 | 1.45 | 1.58 | 1.12 | 1.20 | 11.00 | 92.78 |
| 2–3 | 0.58 | 0.62 | 0.62 | 0.75 | 0.82 | 0.72 | 0.64 | 0.59 | 5.32 | 98.10 |
| 1–2 | 0.18 | 0.21 | 0.23 | 0.29 | 0.26 | 0.23 | 0.19 | 0.12 | 1.71 | 99.81 |
| 0–1 | 0.02 | 0.02 | 0.02 | 0.07 | 0.01 | | 0.04 | 0.02 | 0.19 | |

1hr Wind Direction at 10m (°T From)

Figure 2-3 Percentage Occurrence of Wind Speed and Direction Excluding Hurricanes – March

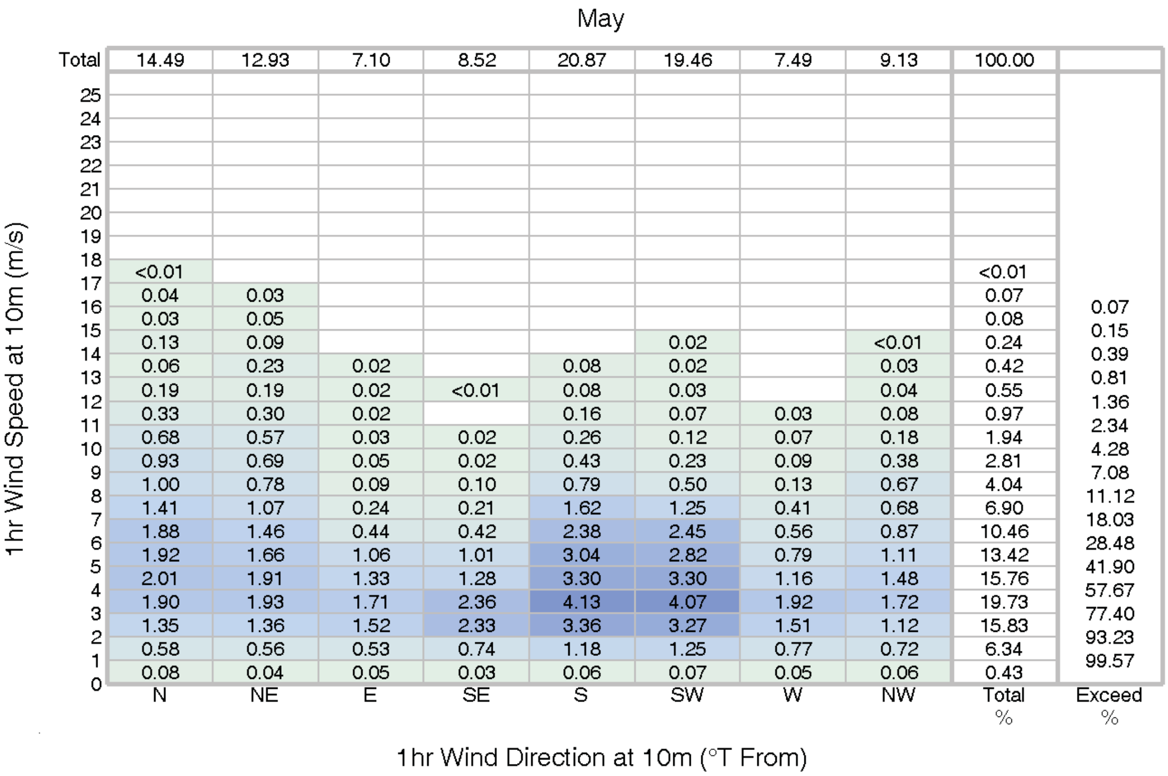


April

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 14.72 | 10.51 | 6.27 | 8.08 | 20.63 | 15.30 | 10.40 | 14.09 | 100.00 | |
| 25 | | | | | | | | | | |
| 24 | | | | | | | | | | |
| 23 | | | | | | | | | | |
| 22 | | | | | | | | | | |
| 21 | | | | | | | | | | |
| 20 | | | | | | | | | | |
| 19 | | | | | | | | 0.03 | 0.03 | 0.03 |
| 18 | | | | | | | | 0.04 | 0.04 | 0.06 |
| 17 | 0.02 | 0.07 | | | | | | 0.03 | 0.12 | 0.18 |
| 16 | 0.01 | 0.07 | | | | | 0.03 | 0.03 | 0.14 | 0.32 |
| 15 | 0.04 | 0.07 | | | | | 0.02 | 0.02 | 0.15 | 0.47 |
| 14 | 0.12 | 0.10 | | | 0.01 | | 0.01 | 0.11 | 0.35 | 0.82 |
| 13 | 0.36 | 0.18 | 0.02 | 0.06 | 0.02 | 0.02 | 0.10 | 0.22 | 0.98 | 1.80 |
| 12 | 0.62 | 0.20 | 0.01 | 0.07 | 0.13 | 0.07 | 0.20 | 0.40 | 1.71 | 3.51 |
| 11 | 0.82 | 0.18 | 0.03 | 0.06 | 0.27 | 0.11 | 0.09 | 0.58 | 2.15 | 5.66 |
| 10 | 1.06 | 0.41 | 0.05 | 0.10 | 0.50 | 0.22 | 0.44 | 0.89 | 3.66 | 9.32 |
| 9 | 0.98 | 0.61 | 0.09 | 0.21 | 0.97 | 0.45 | 0.56 | 1.11 | 4.97 | 14.29 |
| 8 | 1.20 | 0.87 | 0.19 | 0.22 | 1.52 | 0.98 | 0.89 | 1.21 | 7.08 | 21.38 |
| 7 | 1.53 | 1.45 | 0.22 | 0.43 | 2.37 | 1.88 | 1.01 | 1.52 | 10.42 | 31.80 |
| 6 | 1.72 | 1.10 | 0.66 | 0.74 | 3.27 | 2.07 | 1.26 | 1.67 | 12.48 | 44.28 |
| 5 | 1.76 | 1.37 | 1.03 | 1.12 | 3.27 | 2.40 | 1.46 | 1.69 | 14.09 | 58.38 |
| 4 | 1.85 | 1.49 | 1.26 | 1.41 | 3.41 | 2.78 | 1.51 | 1.81 | 15.52 | 73.89 |
| 3 | 1.28 | 1.16 | 1.32 | 1.73 | 2.58 | 2.06 | 1.20 | 1.34 | 12.65 | 86.55 |
| 2 | 0.90 | 0.78 | 0.90 | 1.49 | 1.82 | 1.55 | 1.16 | 1.00 | 9.61 | 96.16 |
| 1 | 0.46 | 0.38 | 0.50 | 0.40 | 0.48 | 0.65 | 0.42 | 0.40 | 3.69 | 99.85 |
| 0 | | 0.02 | 0.02 | 0.04 | | 0.05 | 0.03 | <0.01 | 0.15 | |

1hr Wind Direction at 10m (°T From)

**Figure 2-4 Percentage Occurrence of Wind Speed and Direction Excluding Hurricanes – April**

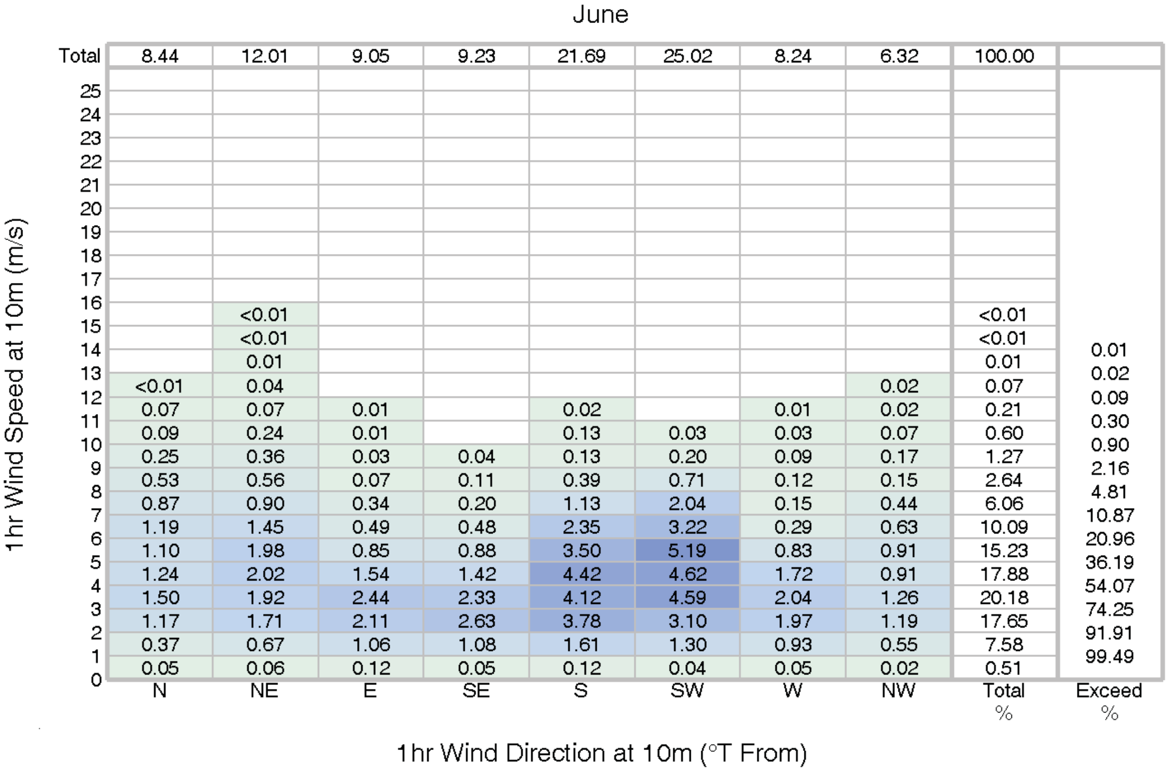


May

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 14.49 | 12.93 | 7.10 | 8.52 | 20.87 | 19.46 | 7.49 | 9.13 | 100.00 | |
| 25 | | | | | | | | | | |
| 24 | | | | | | | | | | |
| 23 | | | | | | | | | | |
| 22 | | | | | | | | | | |
| 21 | | | | | | | | | | |
| 20 | | | | | | | | | | |
| 19 | | | | | | | | | | |
| 18 | | | | | | | | | | |
| 17 | <0.01 | | | | | | | | <0.01 | |
| 16 | 0.04 | 0.03 | | | | | | | 0.07 | 0.07 |
| 15 | 0.03 | 0.05 | | | | | | | 0.08 | 0.15 |
| 14 | 0.13 | 0.09 | | | | 0.02 | | <0.01 | 0.24 | 0.39 |
| 13 | 0.06 | 0.23 | 0.02 | | 0.08 | 0.02 | | 0.03 | 0.42 | 0.81 |
| 12 | 0.19 | 0.19 | 0.02 | <0.01 | 0.08 | 0.03 | | 0.04 | 0.55 | 1.36 |
| 11 | 0.33 | 0.30 | 0.02 | | 0.16 | 0.07 | 0.03 | 0.08 | 0.97 | 2.34 |
| 10 | 0.68 | 0.57 | 0.03 | 0.02 | 0.26 | 0.12 | 0.07 | 0.18 | 1.94 | 4.28 |
| 9 | 0.93 | 0.69 | 0.05 | 0.02 | 0.43 | 0.23 | 0.09 | 0.38 | 2.81 | 7.08 |
| 8 | 1.00 | 0.78 | 0.09 | 0.10 | 0.79 | 0.50 | 0.13 | 0.67 | 4.04 | 11.12 |
| 7 | 1.41 | 1.07 | 0.24 | 0.21 | 1.62 | 1.25 | 0.41 | 0.68 | 6.90 | 18.03 |
| 6 | 1.88 | 1.46 | 0.44 | 0.42 | 2.38 | 2.45 | 0.56 | 0.87 | 10.46 | 28.48 |
| 5 | 1.92 | 1.66 | 1.06 | 1.01 | 3.04 | 2.82 | 0.79 | 1.11 | 13.42 | 41.90 |
| 4 | 2.01 | 1.91 | 1.33 | 1.28 | 3.30 | 3.30 | 1.16 | 1.48 | 15.76 | 57.67 |
| 3 | 1.90 | 1.93 | 1.71 | 2.36 | 4.13 | 4.07 | 1.92 | 1.72 | 19.73 | 77.40 |
| 2 | 1.35 | 1.36 | 1.52 | 2.33 | 3.36 | 3.27 | 1.51 | 1.12 | 15.83 | 93.23 |
| 1 | 0.58 | 0.56 | 0.53 | 0.74 | 1.18 | 1.25 | 0.77 | 0.72 | 6.34 | 99.57 |
| 0 | 0.08 | 0.04 | 0.05 | 0.03 | 0.06 | 0.07 | 0.05 | 0.06 | 0.43 | |

1hr Wind Direction at 10m (°T From)

**Figure 2-5 Percentage Occurrence of Wind Speed and Direction Excluding Hurricanes – May**

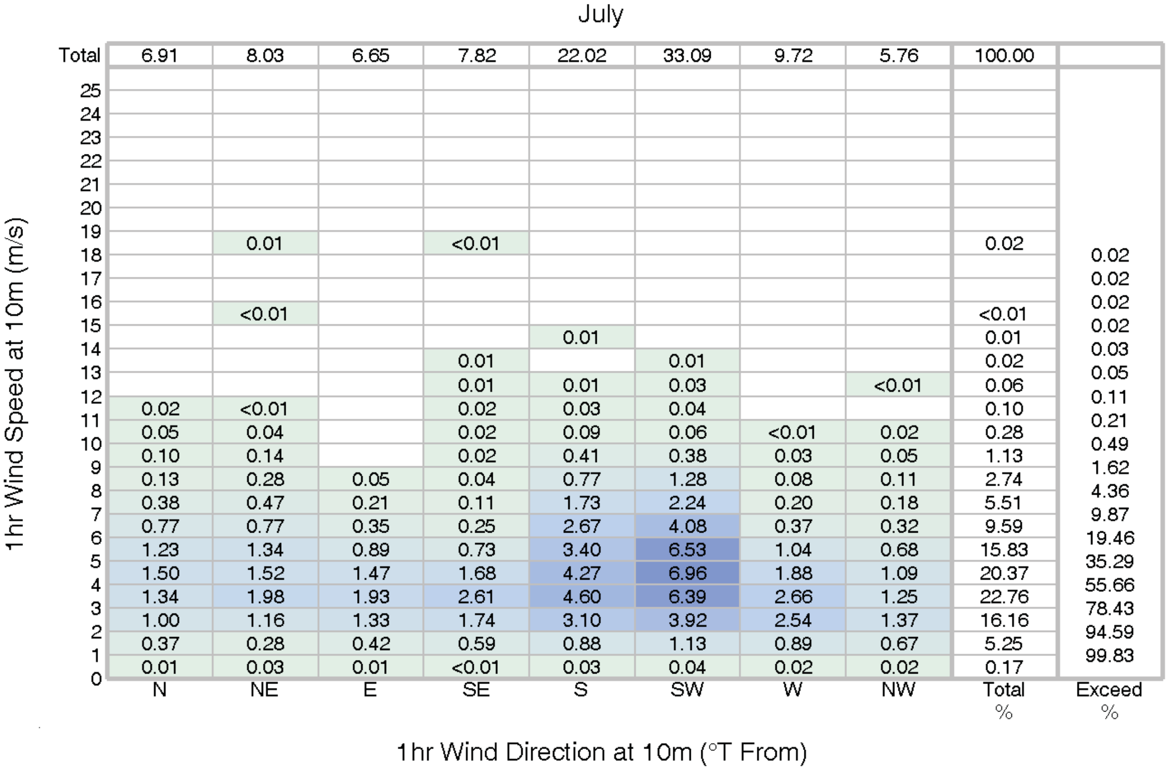


June

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 8.44 | 12.01 | 9.05 | 9.23 | 21.69 | 25.02 | 8.24 | 6.32 | 100.00 | |
| 24-25 | | | | | | | | | | |
| 23-24 | | | | | | | | | | |
| 22-23 | | | | | | | | | | |
| 21-22 | | | | | | | | | | |
| 20-21 | | | | | | | | | | |
| 19-20 | | | | | | | | | | |
| 18-19 | | | | | | | | | | |
| 17-18 | | | | | | | | | | |
| 16-17 | | | | | | | | | | |
| 15-16 | | <0.01 | | | | | | | <0.01 | |
| 14-15 | | <0.01 | | | | | | | <0.01 | 0.01 |
| 13-14 | | 0.01 | | | | | | | 0.01 | 0.02 |
| 12-13 | <0.01 | 0.04 | | | | | | 0.02 | 0.07 | 0.09 |
| 11-12 | 0.07 | 0.07 | 0.01 | | 0.02 | | 0.01 | 0.02 | 0.21 | 0.30 |
| 10-11 | 0.09 | 0.24 | 0.01 | | 0.13 | 0.03 | 0.03 | 0.07 | 0.60 | 0.90 |
| 9-10 | 0.25 | 0.36 | 0.03 | 0.04 | 0.13 | 0.20 | 0.09 | 0.17 | 1.27 | 2.16 |
| 8-9 | 0.53 | 0.56 | 0.07 | 0.11 | 0.39 | 0.71 | 0.12 | 0.15 | 2.64 | 4.81 |
| 7-8 | 0.87 | 0.90 | 0.34 | 0.20 | 1.13 | 2.04 | 0.15 | 0.44 | 6.06 | 10.87 |
| 6-7 | 1.19 | 1.45 | 0.49 | 0.48 | 2.35 | 3.22 | 0.29 | 0.63 | 10.09 | 20.96 |
| 5-6 | 1.10 | 1.98 | 0.85 | 0.88 | 3.50 | 5.19 | 0.83 | 0.91 | 15.23 | 36.19 |
| 4-5 | 1.24 | 2.02 | 1.54 | 1.42 | 4.42 | 4.62 | 1.72 | 0.91 | 17.88 | 54.07 |
| 3-4 | 1.50 | 1.92 | 2.44 | 2.33 | 4.12 | 4.59 | 2.04 | 1.26 | 20.18 | 74.25 |
| 2-3 | 1.17 | 1.71 | 2.11 | 2.63 | 3.78 | 3.10 | 1.97 | 1.19 | 17.65 | 91.91 |
| 1-2 | 0.37 | 0.67 | 1.06 | 1.08 | 1.61 | 1.30 | 0.93 | 0.55 | 7.58 | 99.49 |
| 0-1 | 0.05 | 0.06 | 0.12 | 0.05 | 0.12 | 0.04 | 0.05 | 0.02 | 0.51 | |

1hr Wind Direction at 10m (°T From)

**Figure 2-6 Percentage Occurrence of Wind Speed and Direction Excluding Hurricanes – June**

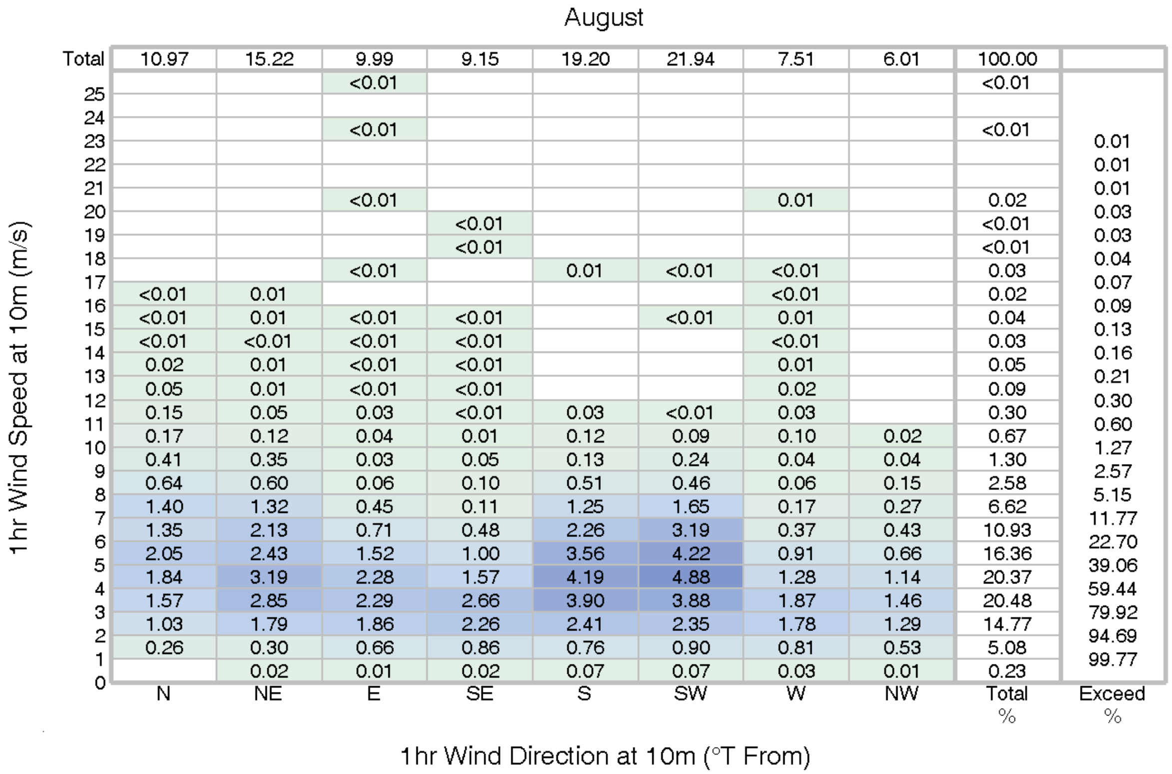


July

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 6.91 | 8.03 | 6.65 | 7.82 | 22.02 | 33.09 | 9.72 | 5.76 | 100.00 | |
| 24-25 | | | | | | | | | | |
| 23-24 | | | | | | | | | | |
| 22-23 | | | | | | | | | | |
| 21-22 | | | | | | | | | | |
| 20-21 | | | | | | | | | | |
| 19-20 | | | | | | | | | | |
| 18-19 | | 0.01 | | <0.01 | | | | | 0.02 | 0.02 |
| 17-18 | | | | | | | | | | 0.02 |
| 16-17 | | | | | | | | | | 0.02 |
| 15-16 | | <0.01 | | | | | | | <0.01 | 0.02 |
| 14-15 | | | | | 0.01 | | | | 0.01 | 0.03 |
| 13-14 | | | | 0.01 | | 0.01 | | | 0.02 | 0.05 |
| 12-13 | | | | 0.01 | 0.01 | 0.03 | | <0.01 | 0.06 | 0.11 |
| 11-12 | 0.02 | <0.01 | | 0.02 | 0.03 | 0.04 | | | 0.10 | 0.21 |
| 10-11 | 0.05 | 0.04 | | 0.02 | 0.09 | 0.06 | <0.01 | 0.02 | 0.28 | 0.49 |
| 9-10 | 0.10 | 0.14 | | 0.02 | 0.41 | 0.38 | 0.03 | 0.05 | 1.13 | 1.62 |
| 8-9 | 0.13 | 0.28 | 0.05 | 0.04 | 0.77 | 1.28 | 0.08 | 0.11 | 2.74 | 4.36 |
| 7-8 | 0.38 | 0.47 | 0.21 | 0.11 | 1.73 | 2.24 | 0.20 | 0.18 | 5.51 | 9.87 |
| 6-7 | 0.77 | 0.77 | 0.35 | 0.25 | 2.67 | 4.08 | 0.37 | 0.32 | 9.59 | 19.46 |
| 5-6 | 1.23 | 1.34 | 0.89 | 0.73 | 3.40 | 6.53 | 1.04 | 0.68 | 15.83 | 35.29 |
| 4-5 | 1.50 | 1.52 | 1.47 | 1.68 | 4.27 | 6.96 | 1.88 | 1.09 | 20.37 | 55.66 |
| 3-4 | 1.34 | 1.98 | 1.93 | 2.61 | 4.60 | 6.39 | 2.66 | 1.25 | 22.76 | 78.43 |
| 2-3 | 1.00 | 1.16 | 1.33 | 1.74 | 3.10 | 3.92 | 2.54 | 1.37 | 16.16 | 94.59 |
| 1-2 | 0.37 | 0.28 | 0.42 | 0.59 | 0.88 | 1.13 | 0.89 | 0.67 | 5.25 | 99.83 |
| 0-1 | 0.01 | 0.03 | 0.01 | <0.01 | 0.03 | 0.04 | 0.02 | 0.02 | 0.17 | |

1hr Wind Direction at 10m (°T From)

**Figure 2-7 Percentage Occurrence of Wind Speed and Direction Excluding Hurricanes – July**

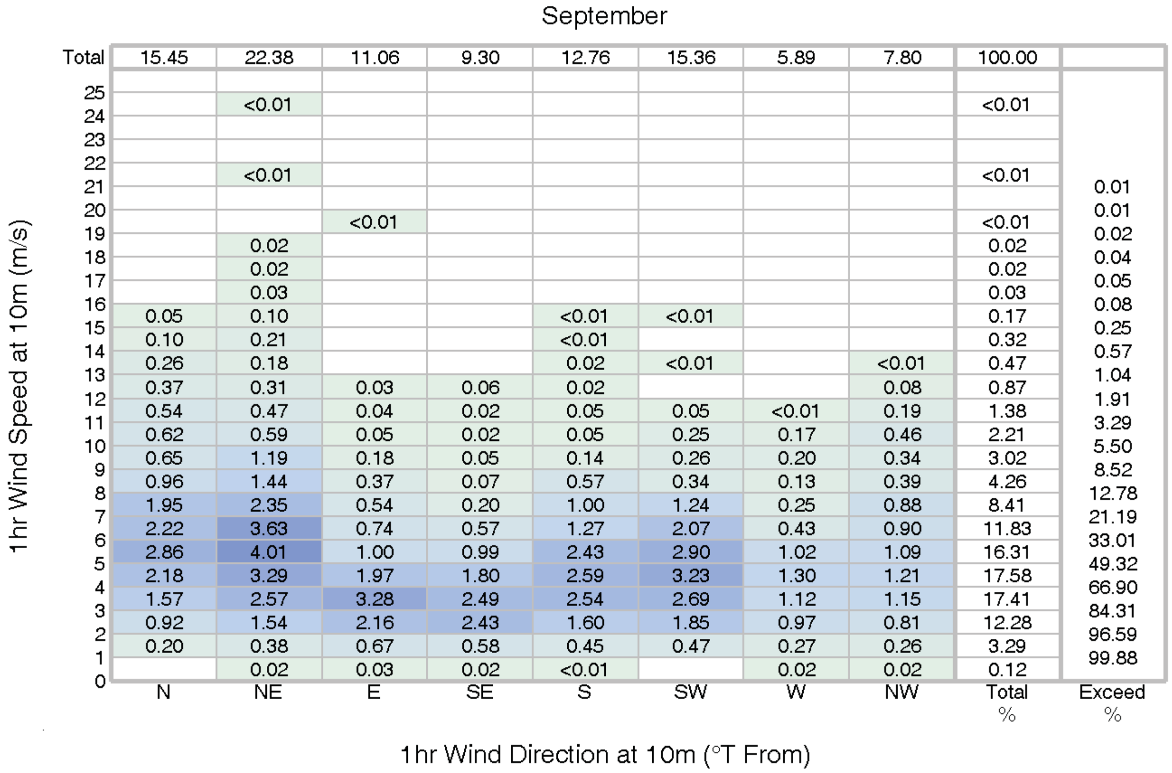


August

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 10.97 | 15.22 | 9.99 | 9.15 | 19.20 | 21.94 | 7.51 | 6.01 | 100.00 | |
| 25 | | | <0.01 | | | | | | <0.01 | |
| 24 | | | | | | | | | | |
| 23 | | | <0.01 | | | | | | <0.01 | 0.01 |
| 22 | | | | | | | | | | 0.01 |
| 21 | | | | | | | | | | 0.01 |
| 20 | | | <0.01 | | | | 0.01 | | 0.02 | 0.03 |
| 19 | | | | <0.01 | | | | | <0.01 | 0.03 |
| 18 | | | | <0.01 | | | | | <0.01 | 0.04 |
| 17 | | | <0.01 | | 0.01 | <0.01 | <0.01 | | 0.03 | 0.07 |
| 16 | <0.01 | 0.01 | | | | | <0.01 | | 0.02 | 0.09 |
| 15 | <0.01 | 0.01 | <0.01 | <0.01 | | <0.01 | 0.01 | | 0.04 | 0.13 |
| 14 | <0.01 | <0.01 | <0.01 | <0.01 | | | <0.01 | | 0.03 | 0.16 |
| 13 | 0.02 | 0.01 | <0.01 | <0.01 | | | 0.01 | | 0.05 | 0.21 |
| 12 | 0.05 | 0.01 | <0.01 | <0.01 | | | 0.02 | | 0.09 | 0.30 |
| 11 | 0.15 | 0.05 | 0.03 | <0.01 | 0.03 | <0.01 | 0.03 | | 0.30 | 0.60 |
| 10 | 0.17 | 0.12 | 0.04 | 0.01 | 0.12 | 0.09 | 0.10 | 0.02 | 0.67 | 1.27 |
| 9 | 0.41 | 0.35 | 0.03 | 0.05 | 0.13 | 0.24 | 0.04 | 0.04 | 1.30 | 2.57 |
| 8 | 0.64 | 0.60 | 0.06 | 0.10 | 0.51 | 0.46 | 0.06 | 0.15 | 2.58 | 5.15 |
| 7 | 1.40 | 1.32 | 0.45 | 0.11 | 1.25 | 1.65 | 0.17 | 0.27 | 6.62 | 11.77 |
| 6 | 1.35 | 2.13 | 0.71 | 0.48 | 2.26 | 3.19 | 0.37 | 0.43 | 10.93 | 22.70 |
| 5 | 2.05 | 2.43 | 1.52 | 1.00 | 3.56 | 4.22 | 0.91 | 0.66 | 16.36 | 39.06 |
| 4 | 1.84 | 3.19 | 2.28 | 1.57 | 4.19 | 4.88 | 1.28 | 1.14 | 20.37 | 59.44 |
| 3 | 1.57 | 2.85 | 2.29 | 2.66 | 3.90 | 3.88 | 1.87 | 1.46 | 20.48 | 79.92 |
| 2 | 1.03 | 1.79 | 1.86 | 2.26 | 2.41 | 2.35 | 1.78 | 1.29 | 14.77 | 94.69 |
| 1 | 0.26 | 0.30 | 0.66 | 0.86 | 0.76 | 0.90 | 0.81 | 0.53 | 5.08 | 99.77 |
| 0 | | 0.02 | 0.01 | 0.02 | 0.07 | 0.07 | 0.03 | 0.01 | 0.23 | |

1hr Wind Direction at 10m (°T From)

**Figure 2-8 Percentage Occurrence of Wind Speed and Direction Excluding Hurricanes – August**

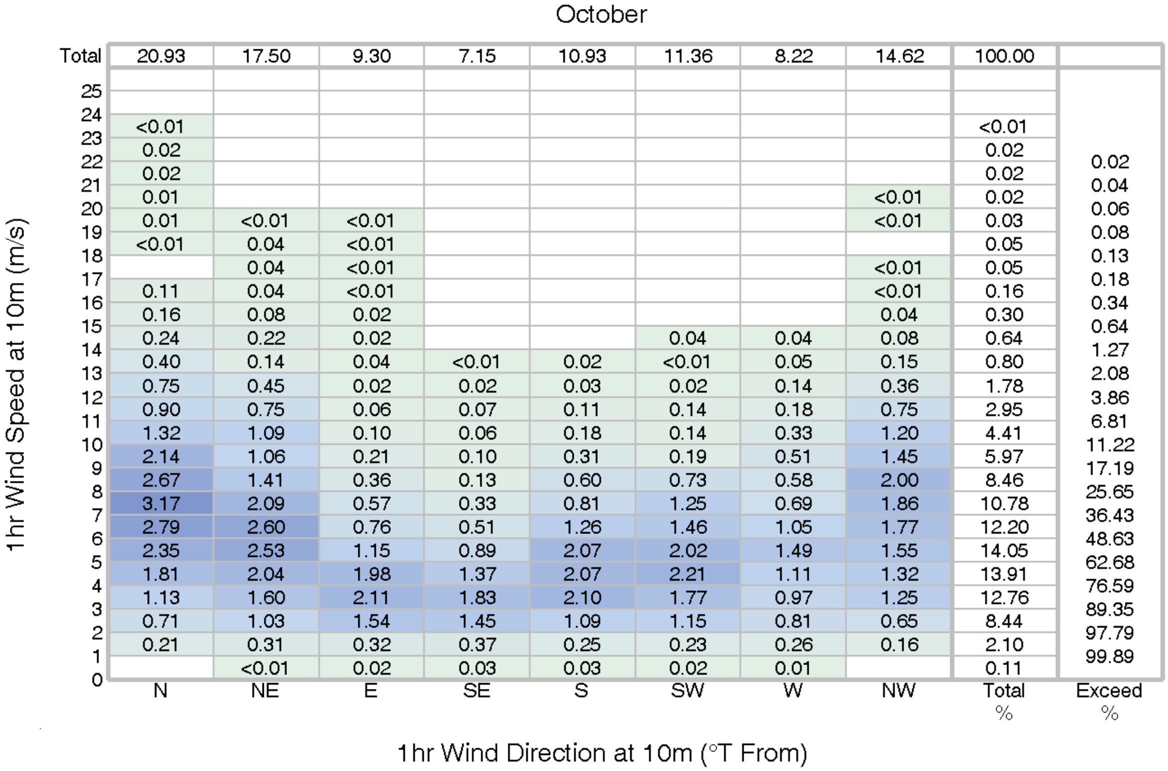


September

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 15.45 | 22.38 | 11.06 | 9.30 | 12.76 | 15.36 | 5.89 | 7.80 | 100.00 | |
| 25 | | | | | | | | | | |
| 24 | | <0.01 | | | | | | | <0.01 | |
| 23 | | | | | | | | | | |
| 22 | | | | | | | | | | |
| 21 | | <0.01 | | | | | | | <0.01 | 0.01 |
| 20 | | | | | | | | | | 0.01 |
| 19 | | | <0.01 | | | | | | <0.01 | 0.02 |
| 18 | | 0.02 | | | | | | | 0.02 | 0.04 |
| 17 | | 0.02 | | | | | | | 0.02 | 0.05 |
| 16 | | 0.03 | | | | | | | 0.03 | 0.08 |
| 15 | 0.05 | 0.10 | | | <0.01 | <0.01 | | | 0.17 | 0.25 |
| 14 | 0.10 | 0.21 | | | <0.01 | | | | 0.32 | 0.57 |
| 13 | 0.26 | 0.18 | | | 0.02 | <0.01 | | <0.01 | 0.47 | 1.04 |
| 12 | 0.37 | 0.31 | 0.03 | 0.06 | 0.02 | | | 0.08 | 0.87 | 1.91 |
| 11 | 0.54 | 0.47 | 0.04 | 0.02 | 0.05 | 0.05 | <0.01 | 0.19 | 1.38 | 3.29 |
| 10 | 0.62 | 0.59 | 0.05 | 0.02 | 0.05 | 0.25 | 0.17 | 0.46 | 2.21 | 5.50 |
| 9 | 0.65 | 1.19 | 0.18 | 0.05 | 0.14 | 0.26 | 0.20 | 0.34 | 3.02 | 8.52 |
| 8 | 0.96 | 1.44 | 0.37 | 0.07 | 0.57 | 0.34 | 0.13 | 0.39 | 4.26 | 12.78 |
| 7 | 1.95 | 2.35 | 0.54 | 0.20 | 1.00 | 1.24 | 0.25 | 0.88 | 8.41 | 21.19 |
| 6 | 2.22 | 3.63 | 0.74 | 0.57 | 1.27 | 2.07 | 0.43 | 0.90 | 11.83 | 33.01 |
| 5 | 2.86 | 4.01 | 1.00 | 0.99 | 2.43 | 2.90 | 1.02 | 1.09 | 16.31 | 49.32 |
| 4 | 2.18 | 3.29 | 1.97 | 1.80 | 2.59 | 3.23 | 1.30 | 1.21 | 17.58 | 66.90 |
| 3 | 1.57 | 2.57 | 3.28 | 2.49 | 2.54 | 2.69 | 1.12 | 1.15 | 17.41 | 84.31 |
| 2 | 0.92 | 1.54 | 2.16 | 2.43 | 1.60 | 1.85 | 0.97 | 0.81 | 12.28 | 96.59 |
| 1 | 0.20 | 0.38 | 0.67 | 0.58 | 0.45 | 0.47 | 0.27 | 0.26 | 3.29 | 99.88 |
| 0 | | 0.02 | 0.03 | 0.02 | <0.01 | | 0.02 | 0.02 | 0.12 | |

1hr Wind Direction at 10m (°T From)

**Figure 2-9 Percentage Occurrence of Wind Speed and Direction Excluding Hurricanes – September**



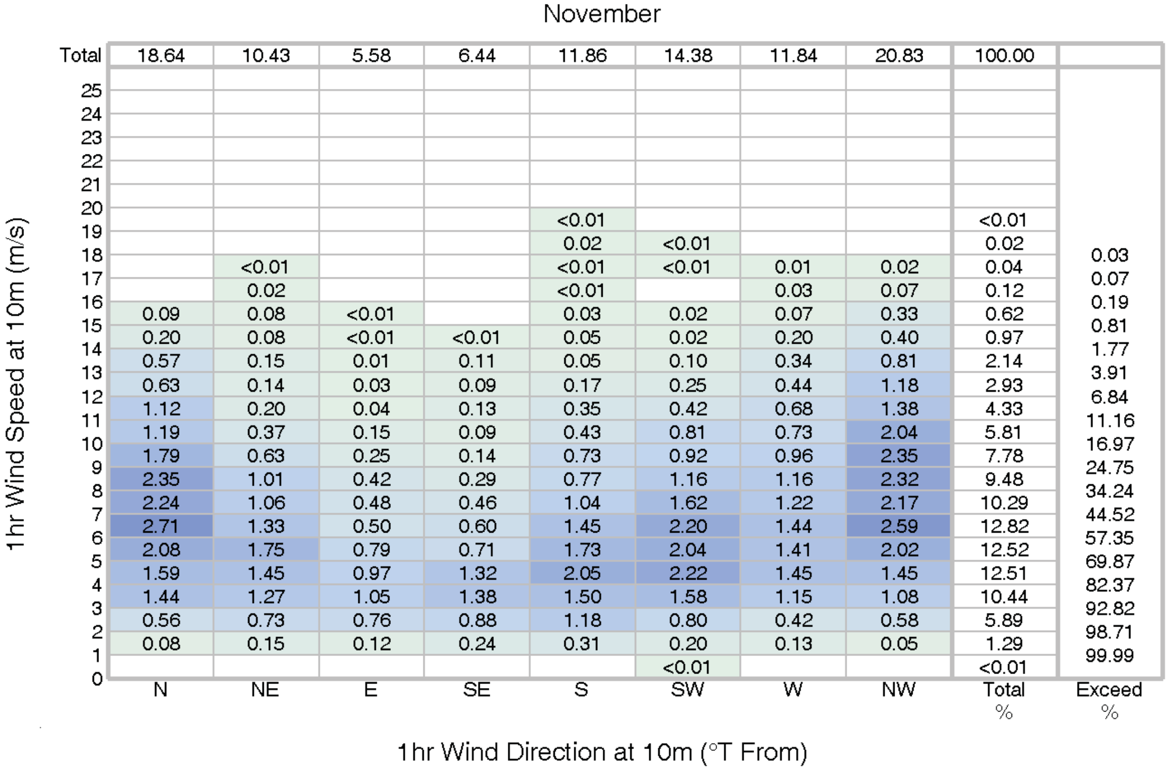
October

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % |
|---|---|---|---|---|---|---|---|---|---|
| Total | 20.93 | 17.50 | 9.30 | 7.15 | 10.93 | 11.36 | 8.22 | 14.62 | 100.00 |
| 24–25 | | | | | | | | | |
| 23–24 | <0.01 | | | | | | | | <0.01 |
| 22–23 | 0.02 | | | | | | | | 0.02 |
| 21–22 | 0.02 | | | | | | | | 0.02 |
| 20–21 | 0.01 | | | | | | | <0.01 | 0.02 |
| 19–20 | 0.01 | <0.01 | <0.01 | | | | | <0.01 | 0.03 |
| 18–19 | <0.01 | 0.04 | <0.01 | | | | | | 0.05 |
| 17–18 | | 0.04 | <0.01 | | | | | <0.01 | 0.05 |
| 16–17 | 0.11 | 0.04 | <0.01 | | | | | <0.01 | 0.16 |
| 15–16 | 0.16 | 0.08 | 0.02 | | | | | 0.04 | 0.30 |
| 14–15 | 0.24 | 0.22 | 0.02 | | | 0.04 | 0.04 | 0.08 | 0.64 |
| 13–14 | 0.40 | 0.14 | 0.04 | <0.01 | 0.02 | <0.01 | 0.05 | 0.15 | 0.80 |
| 12–13 | 0.75 | 0.45 | 0.02 | 0.02 | 0.03 | 0.02 | 0.14 | 0.36 | 1.78 |
| 11–12 | 0.90 | 0.75 | 0.06 | 0.07 | 0.11 | 0.14 | 0.18 | 0.75 | 2.95 |
| 10–11 | 1.32 | 1.09 | 0.10 | 0.06 | 0.18 | 0.14 | 0.33 | 1.20 | 4.41 |
| 9–10 | 2.14 | 1.06 | 0.21 | 0.10 | 0.31 | 0.19 | 0.51 | 1.45 | 5.97 |
| 8–9 | 2.67 | 1.41 | 0.36 | 0.13 | 0.60 | 0.73 | 0.58 | 2.00 | 8.46 |
| 7–8 | 3.17 | 2.09 | 0.57 | 0.33 | 0.81 | 1.25 | 0.69 | 1.86 | 10.78 |
| 6–7 | 2.79 | 2.60 | 0.76 | 0.51 | 1.26 | 1.46 | 1.05 | 1.77 | 12.20 |
| 5–6 | 2.35 | 2.53 | 1.15 | 0.89 | 2.07 | 2.02 | 1.49 | 1.55 | 14.05 |
| 4–5 | 1.81 | 2.04 | 1.98 | 1.37 | 2.07 | 2.21 | 1.11 | 1.32 | 13.91 |
| 3–4 | 1.13 | 1.60 | 2.11 | 1.83 | 2.10 | 1.77 | 0.97 | 1.25 | 12.76 |
| 2–3 | 0.71 | 1.03 | 1.54 | 1.45 | 1.09 | 1.15 | 0.81 | 0.65 | 8.44 |
| 1–2 | 0.21 | 0.31 | 0.32 | 0.37 | 0.25 | 0.23 | 0.26 | 0.16 | 2.10 |
| 0–1 | | <0.01 | 0.02 | 0.03 | 0.03 | 0.02 | 0.01 | | 0.11 |

| 1hr Wind Speed at 10m (m/s) | Exceed % |
|---|---|
| 22 | 0.02 |
| 21 | 0.04 |
| 20 | 0.06 |
| 19 | 0.08 |
| 18 | 0.13 |
| 17 | 0.18 |
| 16 | 0.34 |
| 15 | 0.64 |
| 14 | 1.27 |
| 13 | 2.08 |
| 12 | 3.86 |
| 11 | 6.81 |
| 10 | 11.22 |
| 9 | 17.19 |
| 8 | 25.65 |
| 7 | 36.43 |
| 6 | 48.63 |
| 5 | 62.68 |
| 4 | 76.59 |
| 3 | 89.35 |
| 2 | 97.79 |
| 1 | 99.89 |

1hr Wind Direction at 10m (°T From)

Figure 2-10 Percentage Occurrence of Wind Speed and Direction Excluding Hurricanes – October



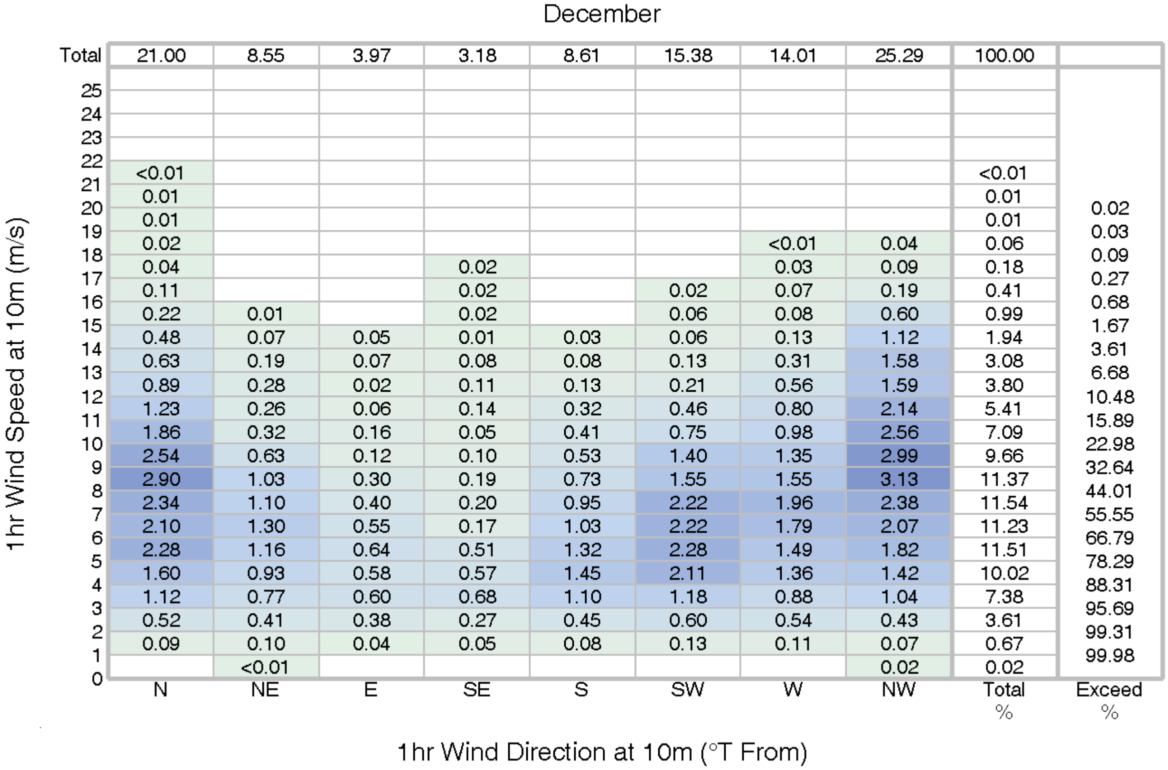
November

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % |
|---|---|---|---|---|---|---|---|---|---|
| Total | 18.64 | 10.43 | 5.58 | 6.44 | 11.86 | 14.38 | 11.84 | 20.83 | 100.00 |
| 24–25 | | | | | | | | | |
| 23–24 | | | | | | | | | |
| 22–23 | | | | | | | | | |
| 21–22 | | | | | | | | | |
| 20–21 | | | | | | | | | |
| 19–20 | | | | | <0.01 | | | | <0.01 |
| 18–19 | | | | | 0.02 | <0.01 | | | 0.02 |
| 17–18 | | <0.01 | | | <0.01 | <0.01 | 0.01 | 0.02 | 0.04 |
| 16–17 | | 0.02 | | | <0.01 | | 0.03 | 0.07 | 0.12 |
| 15–16 | 0.09 | 0.08 | <0.01 | | 0.03 | 0.02 | 0.07 | 0.33 | 0.62 |
| 14–15 | 0.20 | 0.08 | <0.01 | <0.01 | 0.05 | 0.02 | 0.20 | 0.40 | 0.97 |
| 13–14 | 0.57 | 0.15 | 0.01 | 0.11 | 0.05 | 0.10 | 0.34 | 0.81 | 2.14 |
| 12–13 | 0.63 | 0.14 | 0.03 | 0.09 | 0.17 | 0.25 | 0.44 | 1.18 | 2.93 |
| 11–12 | 1.12 | 0.20 | 0.04 | 0.13 | 0.35 | 0.42 | 0.68 | 1.38 | 4.33 |
| 10–11 | 1.19 | 0.37 | 0.15 | 0.09 | 0.43 | 0.81 | 0.73 | 2.04 | 5.81 |
| 9–10 | 1.79 | 0.63 | 0.25 | 0.14 | 0.73 | 0.92 | 0.96 | 2.35 | 7.78 |
| 8–9 | 2.35 | 1.01 | 0.42 | 0.29 | 0.77 | 1.16 | 1.16 | 2.32 | 9.48 |
| 7–8 | 2.24 | 1.06 | 0.48 | 0.46 | 1.04 | 1.62 | 1.22 | 2.17 | 10.29 |
| 6–7 | 2.71 | 1.33 | 0.50 | 0.60 | 1.45 | 2.20 | 1.44 | 2.59 | 12.82 |
| 5–6 | 2.08 | 1.75 | 0.79 | 0.71 | 1.73 | 2.04 | 1.41 | 2.02 | 12.52 |
| 4–5 | 1.59 | 1.45 | 0.97 | 1.32 | 2.05 | 2.22 | 1.45 | 1.45 | 12.51 |
| 3–4 | 1.44 | 1.27 | 1.05 | 1.38 | 1.50 | 1.58 | 1.15 | 1.08 | 10.44 |
| 2–3 | 0.56 | 0.73 | 0.76 | 0.88 | 1.18 | 0.80 | 0.42 | 0.58 | 5.89 |
| 1–2 | 0.08 | 0.15 | 0.12 | 0.24 | 0.31 | 0.20 | 0.13 | 0.05 | 1.29 |
| 0–1 | | | | | | <0.01 | | | <0.01 |

| 1hr Wind Speed at 10m (m/s) | Exceed % |
|---|---|
| 18 | 0.03 |
| 17 | 0.07 |
| 16 | 0.19 |
| 15 | 0.81 |
| 14 | 1.77 |
| 13 | 3.91 |
| 12 | 6.84 |
| 11 | 11.16 |
| 10 | 16.97 |
| 9 | 24.75 |
| 8 | 34.24 |
| 7 | 44.52 |
| 6 | 57.35 |
| 5 | 69.87 |
| 4 | 82.37 |
| 3 | 92.82 |
| 2 | 98.71 |
| 1 | 99.99 |

1hr Wind Direction at 10m (°T From)

Figure 2-11 Percentage Occurrence of Wind Speed and Direction Excluding Hurricanes – November



| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 21.00 | 8.55 | 3.97 | 3.18 | 8.61 | 15.38 | 14.01 | 25.29 | 100.00 | |
| 24–25 | | | | | | | | | | |
| 23–24 | | | | | | | | | | |
| 22–23 | | | | | | | | | | |
| 21–22 | <0.01 | | | | | | | | <0.01 | |
| 20–21 | 0.01 | | | | | | | | 0.01 | 0.02 |
| 19–20 | 0.01 | | | | | | | | 0.01 | 0.03 |
| 18–19 | 0.02 | | | | | | <0.01 | 0.04 | 0.06 | 0.09 |
| 17–18 | 0.04 | | | 0.02 | | | 0.03 | 0.09 | 0.18 | 0.27 |
| 16–17 | 0.11 | | | 0.02 | | 0.02 | 0.07 | 0.19 | 0.41 | 0.68 |
| 15–16 | 0.22 | 0.01 | | 0.02 | | 0.06 | 0.08 | 0.60 | 0.99 | 1.67 |
| 14–15 | 0.48 | 0.07 | 0.05 | 0.01 | 0.03 | 0.06 | 0.13 | 1.12 | 1.94 | 3.61 |
| 13–14 | 0.63 | 0.19 | 0.07 | 0.08 | 0.08 | 0.13 | 0.31 | 1.58 | 3.08 | 6.68 |
| 12–13 | 0.89 | 0.28 | 0.02 | 0.11 | 0.13 | 0.21 | 0.56 | 1.59 | 3.80 | 10.48 |
| 11–12 | 1.23 | 0.26 | 0.06 | 0.14 | 0.32 | 0.46 | 0.80 | 2.14 | 5.41 | 15.89 |
| 10–11 | 1.86 | 0.32 | 0.16 | 0.05 | 0.41 | 0.75 | 0.98 | 2.56 | 7.09 | 22.98 |
| 9–10 | 2.54 | 0.63 | 0.12 | 0.10 | 0.53 | 1.40 | 1.35 | 2.99 | 9.66 | 32.64 |
| 8–9 | 2.90 | 1.03 | 0.30 | 0.19 | 0.73 | 1.55 | 1.55 | 3.13 | 11.37 | 44.01 |
| 7–8 | 2.34 | 1.10 | 0.40 | 0.20 | 0.95 | 2.22 | 1.96 | 2.38 | 11.54 | 55.55 |
| 6–7 | 2.10 | 1.30 | 0.55 | 0.17 | 1.03 | 2.22 | 1.79 | 2.07 | 11.23 | 66.79 |
| 5–6 | 2.28 | 1.16 | 0.64 | 0.51 | 1.32 | 2.28 | 1.49 | 1.82 | 11.51 | 78.29 |
| 4–5 | 1.60 | 0.93 | 0.58 | 0.57 | 1.45 | 2.11 | 1.36 | 1.42 | 10.02 | 88.31 |
| 3–4 | 1.12 | 0.77 | 0.60 | 0.68 | 1.10 | 1.18 | 0.88 | 1.04 | 7.38 | 95.69 |
| 2–3 | 0.52 | 0.41 | 0.38 | 0.27 | 0.45 | 0.60 | 0.54 | 0.43 | 3.61 | 99.31 |
| 1–2 | 0.09 | 0.10 | 0.04 | 0.05 | 0.08 | 0.13 | 0.11 | 0.07 | 0.67 | 99.98 |
| 0–1 | | <0.01 | | | | | | 0.02 | 0.02 | |

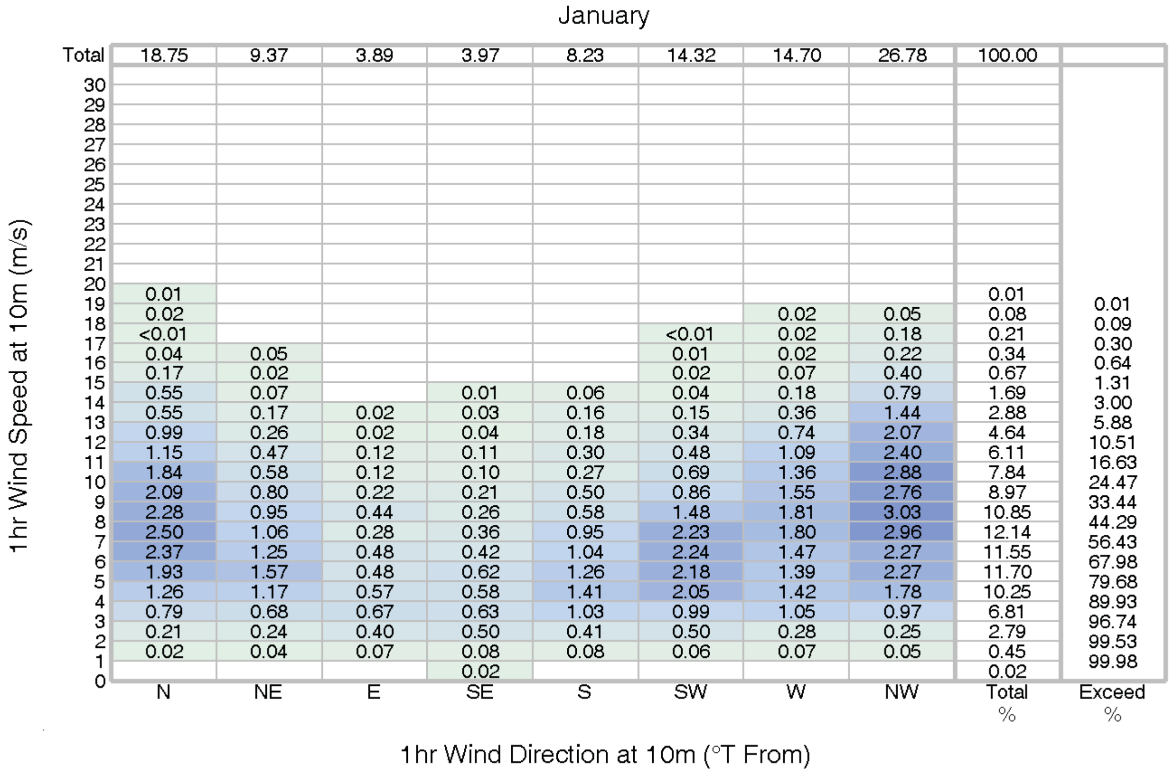
**Figure 2-12 Percentage Occurrence of Wind Speed and Direction Excluding Hurricanes – December**

### 2.1.16 Omni-Directional Monthly Average and Maximum Wind Speed Including Hurricanes

| COMBINED PERIOD (1980 to 2005) | 1hr Wind Speed at 10m (m/s) | | MAIN DIRECTION(S) |
|---|---|---|---|
| | MEAN | MAX | |
| January | 7.81 | 19.33 | NW |
| February | 7.33 | 20.06 | N NW |
| March | 6.97 | 23.02 | N NW |
| April | 5.98 | 19.64 | S |
| May | 4.93 | 17.06 | S SW |
| June | 4.46 | 15.09 | S SW |
| July | 4.52 | 21.82 | SW |
| August | 4.80 | 25.63 | S SW |
| September | 5.60 | 30.27 | NE |
| October | 6.34 | 23.21 | N NE |
| November | 6.96 | 19.18 | N NW |
| December | 7.73 | 21.13 | N NW |
| All Year | 6.11 | 30.27 | N NE S SW NW |

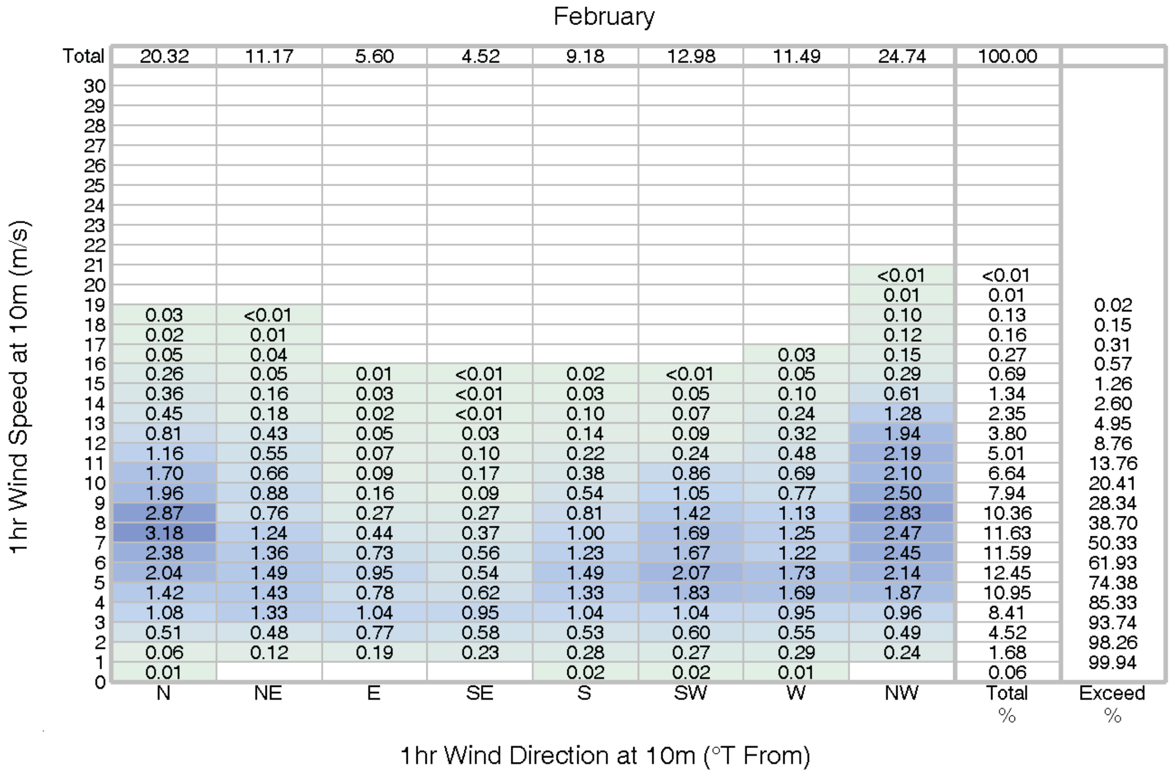
**Table 2-15 Omni-Directional Month Average and Maximum Wind Speed Including Hurricanes**

### 2.1.17 Joint Frequency of Wind Speed by Direction Including Hurricanes



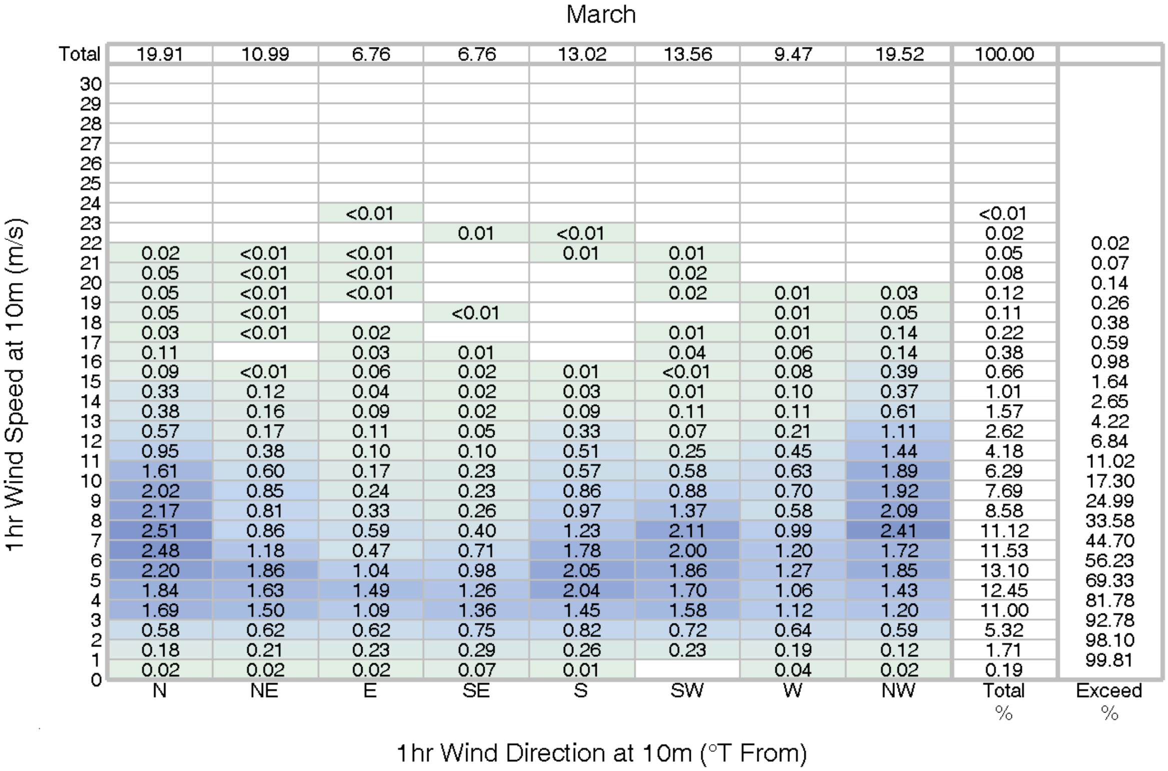
| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 18.75 | 9.37 | 3.89 | 3.97 | 8.23 | 14.32 | 14.70 | 26.78 | 100.00 | |
| 30 | | | | | | | | | | |
| 29 | | | | | | | | | | |
| 28 | | | | | | | | | | |
| 27 | | | | | | | | | | |
| 26 | | | | | | | | | | |
| 25 | | | | | | | | | | |
| 24 | | | | | | | | | | |
| 23 | | | | | | | | | | |
| 22 | | | | | | | | | | |
| 21 | | | | | | | | | | |
| 20 | | | | | | | | | | |
| 19 | 0.01 | | | | | | | | 0.01 | 0.01 |
| 18 | 0.02 | | | | | | 0.02 | 0.05 | 0.08 | 0.09 |
| 17 | <0.01 | | | | | <0.01 | 0.02 | 0.18 | 0.21 | 0.30 |
| 16 | 0.04 | 0.05 | | | | 0.01 | 0.02 | 0.22 | 0.34 | 0.64 |
| 15 | 0.17 | 0.02 | | | | 0.02 | 0.07 | 0.40 | 0.67 | 1.31 |
| 14 | 0.55 | 0.07 | | 0.01 | 0.06 | 0.04 | 0.18 | 0.79 | 1.69 | 3.00 |
| 13 | 0.55 | 0.17 | 0.02 | 0.03 | 0.16 | 0.15 | 0.36 | 1.44 | 2.88 | 5.88 |
| 12 | 0.99 | 0.26 | 0.02 | 0.04 | 0.18 | 0.34 | 0.74 | 2.07 | 4.64 | 10.51 |
| 11 | 1.15 | 0.47 | 0.12 | 0.11 | 0.30 | 0.48 | 1.09 | 2.40 | 6.11 | 16.63 |
| 10 | 1.84 | 0.58 | 0.12 | 0.10 | 0.27 | 0.69 | 1.36 | 2.88 | 7.84 | 24.47 |
| 9 | 2.09 | 0.80 | 0.22 | 0.21 | 0.50 | 0.86 | 1.55 | 2.76 | 8.97 | 33.44 |
| 8 | 2.28 | 0.95 | 0.44 | 0.26 | 0.58 | 1.48 | 1.81 | 3.03 | 10.85 | 44.29 |
| 7 | 2.50 | 1.06 | 0.28 | 0.36 | 0.95 | 2.23 | 1.80 | 2.96 | 12.14 | 56.43 |
| 6 | 2.37 | 1.25 | 0.48 | 0.42 | 1.04 | 2.24 | 1.47 | 2.27 | 11.55 | 67.98 |
| 5 | 1.93 | 1.57 | 0.48 | 0.62 | 1.26 | 2.18 | 1.39 | 2.27 | 11.70 | 79.68 |
| 4 | 1.26 | 1.17 | 0.57 | 0.58 | 1.41 | 2.05 | 1.42 | 1.78 | 10.25 | 89.93 |
| 3 | 0.79 | 0.68 | 0.67 | 0.63 | 1.03 | 0.99 | 1.05 | 0.97 | 6.81 | 96.74 |
| 2 | 0.21 | 0.24 | 0.40 | 0.50 | 0.41 | 0.50 | 0.28 | 0.25 | 2.79 | 99.53 |
| 1 | 0.02 | 0.04 | 0.07 | 0.08 | 0.08 | 0.06 | 0.07 | 0.05 | 0.45 | 99.98 |
| 0 | | | | 0.02 | | | | | 0.02 | |

**Figure 2-13 Percentage Occurrence of Wind Speed and Direction Including Hurricanes – January**



| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 20.32 | 11.17 | 5.60 | 4.52 | 9.18 | 12.98 | 11.49 | 24.74 | 100.00 | |
| 30 | | | | | | | | | | |
| 29 | | | | | | | | | | |
| 28 | | | | | | | | | | |
| 27 | | | | | | | | | | |
| 26 | | | | | | | | | | |
| 25 | | | | | | | | | | |
| 24 | | | | | | | | | | |
| 23 | | | | | | | | | | |
| 22 | | | | | | | | | | |
| 21 | | | | | | | | | | |
| 20 | | | | | | | | <0.01 | <0.01 | |
| 19 | | | | | | | | 0.01 | 0.01 | 0.02 |
| 18 | 0.03 | <0.01 | | | | | | 0.10 | 0.13 | 0.15 |
| 17 | 0.02 | 0.01 | | | | | | 0.12 | 0.16 | 0.31 |
| 16 | 0.05 | 0.04 | | | | | 0.03 | 0.15 | 0.27 | 0.57 |
| 15 | 0.26 | 0.05 | 0.01 | <0.01 | 0.02 | <0.01 | 0.05 | 0.29 | 0.69 | 1.26 |
| 14 | 0.36 | 0.16 | 0.03 | <0.01 | 0.03 | 0.05 | 0.10 | 0.61 | 1.34 | 2.60 |
| 13 | 0.45 | 0.18 | 0.02 | <0.01 | 0.10 | 0.07 | 0.24 | 1.28 | 2.35 | 4.95 |
| 12 | 0.81 | 0.43 | 0.05 | 0.03 | 0.14 | 0.09 | 0.32 | 1.94 | 3.80 | 8.76 |
| 11 | 1.16 | 0.55 | 0.07 | 0.10 | 0.22 | 0.24 | 0.48 | 2.19 | 5.01 | 13.76 |
| 10 | 1.70 | 0.66 | 0.09 | 0.17 | 0.38 | 0.86 | 0.69 | 2.10 | 6.64 | 20.41 |
| 9 | 1.96 | 0.88 | 0.16 | 0.09 | 0.54 | 1.05 | 0.77 | 2.50 | 7.94 | 28.34 |
| 8 | 2.87 | 0.76 | 0.27 | 0.27 | 0.81 | 1.42 | 1.13 | 2.83 | 10.36 | 38.70 |
| 7 | 3.18 | 1.24 | 0.44 | 0.37 | 1.00 | 1.69 | 1.25 | 2.47 | 11.63 | 50.33 |
| 6 | 2.38 | 1.36 | 0.73 | 0.56 | 1.23 | 1.67 | 1.22 | 2.45 | 11.59 | 61.93 |
| 5 | 2.04 | 1.49 | 0.95 | 0.54 | 1.49 | 2.07 | 1.73 | 2.14 | 12.45 | 74.38 |
| 4 | 1.42 | 1.43 | 0.78 | 0.62 | 1.33 | 1.83 | 1.69 | 1.87 | 10.95 | 85.33 |
| 3 | 1.08 | 1.33 | 1.04 | 0.95 | 1.04 | 1.04 | 0.95 | 0.96 | 8.41 | 93.74 |
| 2 | 0.51 | 0.48 | 0.77 | 0.58 | 0.53 | 0.60 | 0.55 | 0.49 | 4.52 | 98.26 |
| 1 | 0.06 | 0.12 | 0.19 | 0.23 | 0.28 | 0.27 | 0.29 | 0.24 | 1.68 | 99.94 |
| 0 | 0.01 | | | | 0.02 | 0.02 | 0.01 | | 0.06 | |

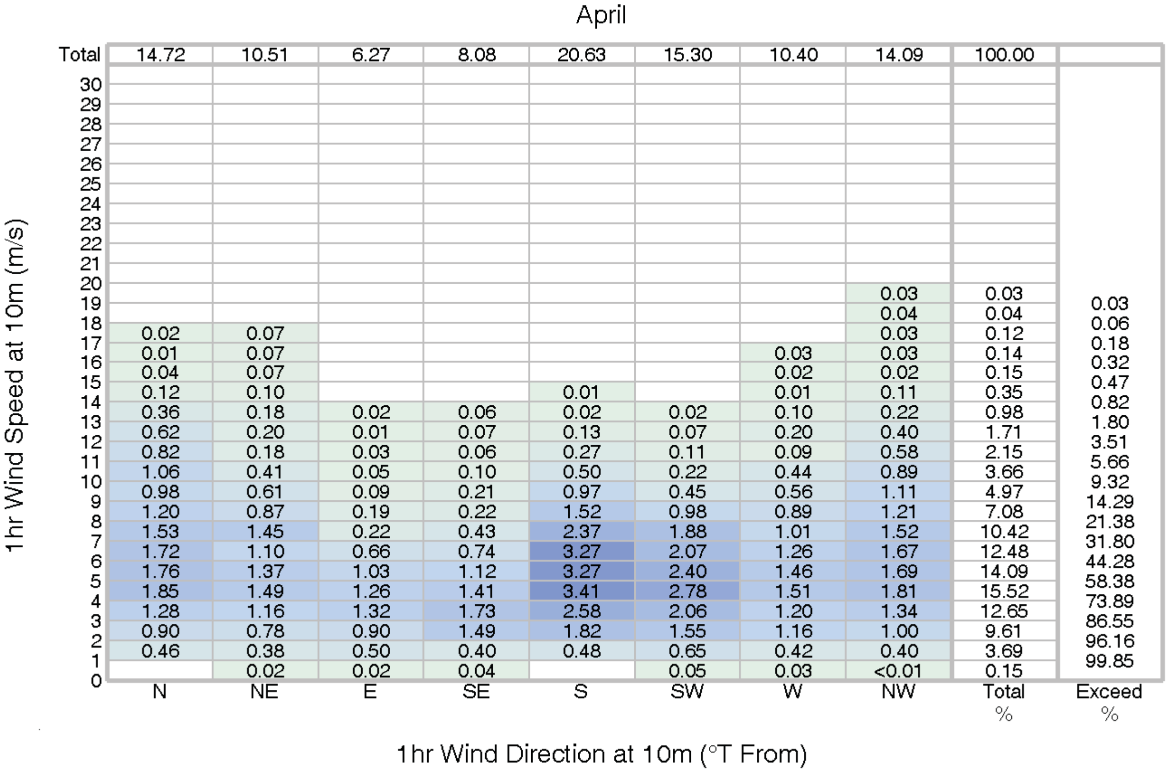
**Figure 2-14 Percentage Occurrence of Wind Speed and Direction Including Hurricanes – February**



March

| | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 19.91 | 10.99 | 6.76 | 6.76 | 13.02 | 13.56 | 9.47 | 19.52 | 100.00 | |
| 29–30 | | | | | | | | | | |
| 28–29 | | | | | | | | | | |
| 27–28 | | | | | | | | | | |
| 26–27 | | | | | | | | | | |
| 25–26 | | | | | | | | | | |
| 24–25 | | | | | | | | | | |
| 23–24 | | | <0.01 | | | | | | <0.01 | |
| 22–23 | | | | 0.01 | <0.01 | | | | 0.02 | 0.02 |
| 21–22 | 0.02 | <0.01 | <0.01 | | 0.01 | 0.01 | | | 0.05 | 0.07 |
| 20–21 | 0.05 | <0.01 | <0.01 | | | 0.02 | | | 0.08 | 0.14 |
| 19–20 | 0.05 | <0.01 | <0.01 | | | 0.02 | 0.01 | 0.03 | 0.12 | 0.26 |
| 18–19 | 0.05 | <0.01 | | <0.01 | | | 0.01 | 0.05 | 0.11 | 0.38 |
| 17–18 | 0.03 | <0.01 | 0.02 | | | 0.01 | 0.01 | 0.14 | 0.22 | 0.59 |
| 16–17 | 0.11 | | 0.03 | 0.01 | | 0.04 | 0.06 | 0.14 | 0.38 | 0.98 |
| 15–16 | 0.09 | <0.01 | 0.06 | 0.02 | 0.01 | <0.01 | 0.08 | 0.39 | 0.66 | 1.64 |
| 14–15 | 0.33 | 0.12 | 0.04 | 0.02 | 0.03 | 0.01 | 0.10 | 0.37 | 1.01 | 2.65 |
| 13–14 | 0.38 | 0.16 | 0.09 | 0.02 | 0.09 | 0.11 | 0.11 | 0.61 | 1.57 | 4.22 |
| 12–13 | 0.57 | 0.17 | 0.11 | 0.05 | 0.33 | 0.07 | 0.21 | 1.11 | 2.62 | 6.84 |
| 11–12 | 0.95 | 0.38 | 0.10 | 0.10 | 0.51 | 0.25 | 0.45 | 1.44 | 4.18 | 11.02 |
| 10–11 | 1.61 | 0.60 | 0.17 | 0.23 | 0.57 | 0.58 | 0.63 | 1.89 | 6.29 | 17.30 |
| 9–10 | 2.02 | 0.85 | 0.24 | 0.23 | 0.86 | 0.88 | 0.70 | 1.92 | 7.69 | 24.99 |
| 8–9 | 2.17 | 0.81 | 0.33 | 0.26 | 0.97 | 1.37 | 0.58 | 2.09 | 8.58 | 33.58 |
| 7–8 | 2.51 | 0.86 | 0.59 | 0.40 | 1.23 | 2.11 | 0.99 | 2.41 | 11.12 | 44.70 |
| 6–7 | 2.48 | 1.18 | 0.47 | 0.71 | 1.78 | 2.00 | 1.20 | 1.72 | 11.53 | 56.23 |
| 5–6 | 2.20 | 1.86 | 1.04 | 0.98 | 2.05 | 1.86 | 1.27 | 1.85 | 13.10 | 69.33 |
| 4–5 | 1.84 | 1.63 | 1.49 | 1.26 | 2.04 | 1.70 | 1.06 | 1.43 | 12.45 | 81.78 |
| 3–4 | 1.69 | 1.50 | 1.09 | 1.36 | 1.45 | 1.58 | 1.12 | 1.20 | 11.00 | 92.78 |
| 2–3 | 0.58 | 0.62 | 0.62 | 0.75 | 0.82 | 0.72 | 0.64 | 0.59 | 5.32 | 98.10 |
| 1–2 | 0.18 | 0.21 | 0.23 | 0.29 | 0.26 | 0.23 | 0.19 | 0.12 | 1.71 | 99.81 |
| 0–1 | 0.02 | 0.02 | 0.02 | 0.07 | 0.01 | | 0.04 | 0.02 | 0.19 | |

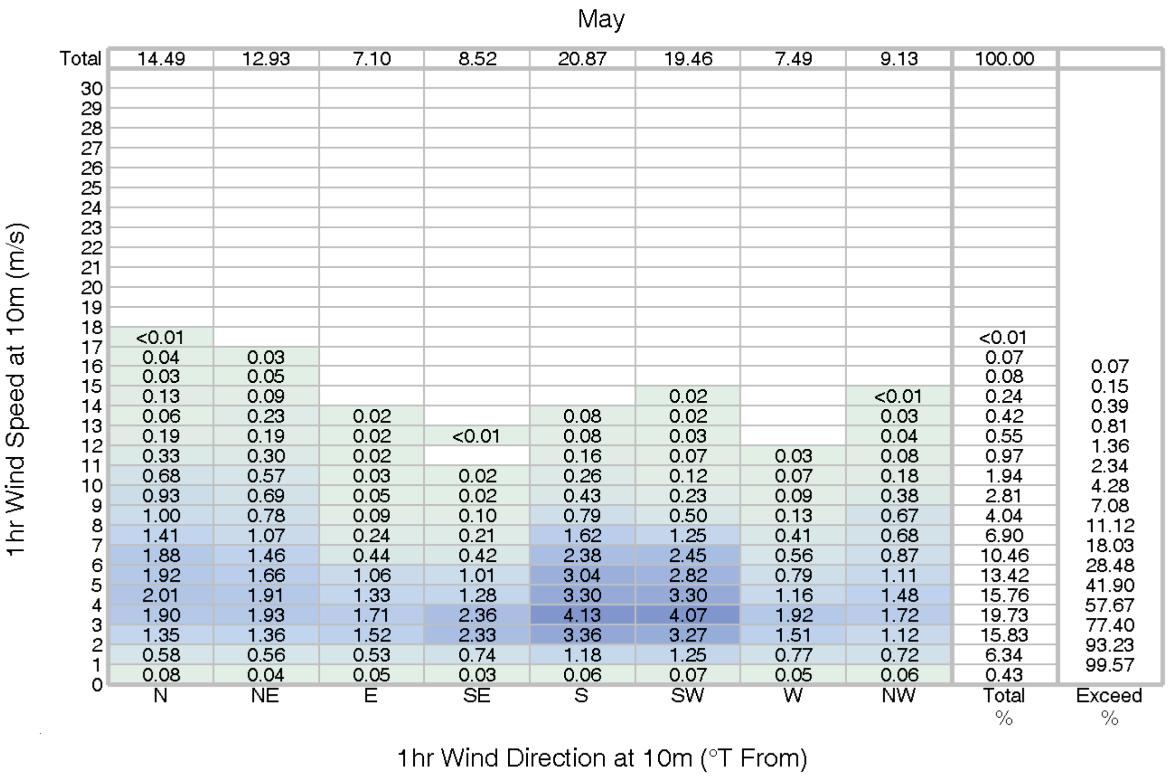
Figure 2-15 Percentage Occurrence of Wind Speed and Direction Including Hurricanes – March



April

| | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 14.72 | 10.51 | 6.27 | 8.08 | 20.63 | 15.30 | 10.40 | 14.09 | 100.00 | |
| 29–30 | | | | | | | | | | |
| 28–29 | | | | | | | | | | |
| 27–28 | | | | | | | | | | |
| 26–27 | | | | | | | | | | |
| 25–26 | | | | | | | | | | |
| 24–25 | | | | | | | | | | |
| 23–24 | | | | | | | | | | |
| 22–23 | | | | | | | | | | |
| 21–22 | | | | | | | | | | |
| 20–21 | | | | | | | | | | |
| 19–20 | | | | | | | | 0.03 | 0.03 | 0.03 |
| 18–19 | | | | | | | | 0.04 | 0.04 | 0.06 |
| 17–18 | 0.02 | 0.07 | | | | | | 0.03 | 0.12 | 0.18 |
| 16–17 | 0.01 | 0.07 | | | | | 0.03 | 0.03 | 0.14 | 0.32 |
| 15–16 | 0.04 | 0.07 | | | | | 0.02 | 0.02 | 0.15 | 0.47 |
| 14–15 | 0.12 | 0.10 | | | 0.01 | | 0.01 | 0.11 | 0.35 | 0.82 |
| 13–14 | 0.36 | 0.18 | 0.02 | 0.06 | 0.02 | 0.02 | 0.10 | 0.22 | 0.98 | 1.80 |
| 12–13 | 0.62 | 0.20 | 0.01 | 0.07 | 0.13 | 0.07 | 0.20 | 0.40 | 1.71 | 3.51 |
| 11–12 | 0.82 | 0.18 | 0.03 | 0.06 | 0.27 | 0.11 | 0.09 | 0.58 | 2.15 | 5.66 |
| 10–11 | 1.06 | 0.41 | 0.05 | 0.10 | 0.50 | 0.22 | 0.44 | 0.89 | 3.66 | 9.32 |
| 9–10 | 0.98 | 0.61 | 0.09 | 0.21 | 0.97 | 0.45 | 0.56 | 1.11 | 4.97 | 14.29 |
| 8–9 | 1.20 | 0.87 | 0.19 | 0.22 | 1.52 | 0.98 | 0.89 | 1.21 | 7.08 | 21.38 |
| 7–8 | 1.53 | 1.45 | 0.22 | 0.43 | 2.37 | 1.88 | 1.01 | 1.52 | 10.42 | 31.80 |
| 6–7 | 1.72 | 1.10 | 0.66 | 0.74 | 3.27 | 2.07 | 1.26 | 1.67 | 12.48 | 44.28 |
| 5–6 | 1.76 | 1.37 | 1.03 | 1.12 | 3.27 | 2.40 | 1.46 | 1.69 | 14.09 | 58.38 |
| 4–5 | 1.85 | 1.49 | 1.26 | 1.41 | 3.41 | 2.78 | 1.51 | 1.81 | 15.52 | 73.89 |
| 3–4 | 1.28 | 1.16 | 1.32 | 1.73 | 2.58 | 2.06 | 1.20 | 1.34 | 12.65 | 86.55 |
| 2–3 | 0.90 | 0.78 | 0.90 | 1.49 | 1.82 | 1.55 | 1.16 | 1.00 | 9.61 | 96.16 |
| 1–2 | 0.46 | 0.38 | 0.50 | 0.40 | 0.48 | 0.65 | 0.42 | 0.40 | 3.69 | 99.85 |
| 0–1 | | 0.02 | 0.02 | 0.04 | | 0.05 | 0.03 | <0.01 | 0.15 | |

Figure 2-16 Percentage Occurrence of Wind Speed and Direction Including Hurricanes – April

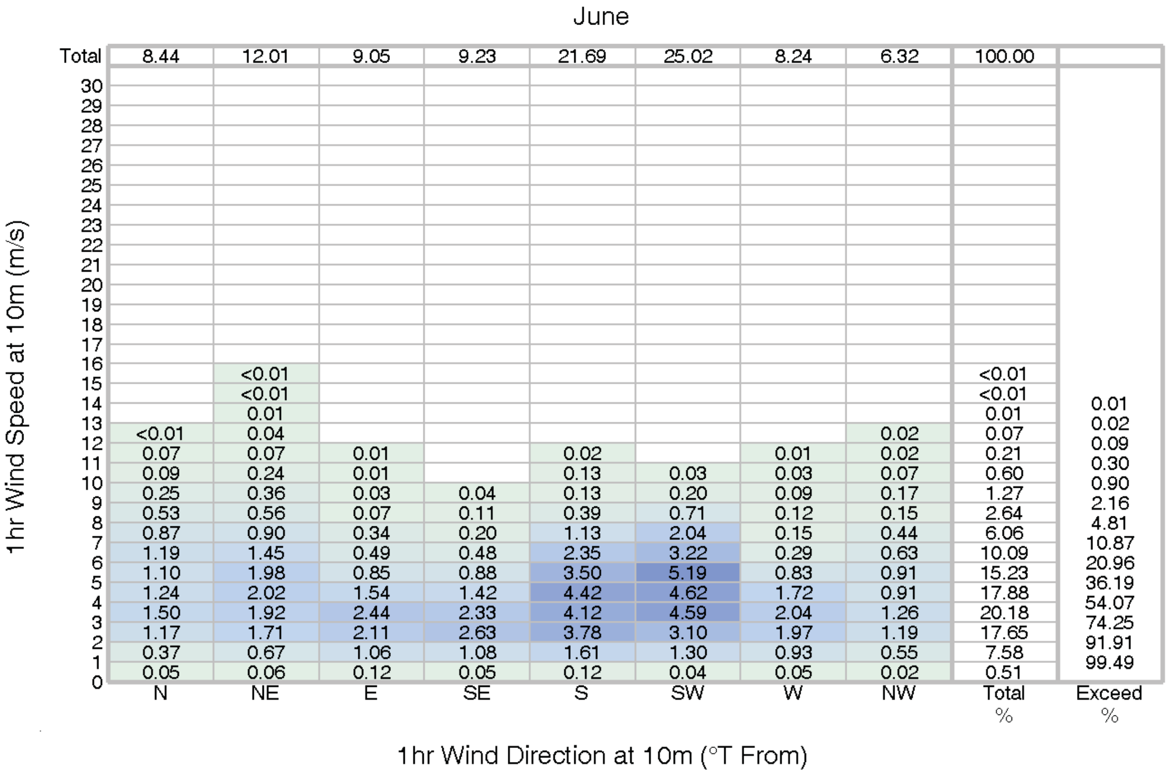


May

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 14.49 | 12.93 | 7.10 | 8.52 | 20.87 | 19.46 | 7.49 | 9.13 | 100.00 | |
| 29–30 | | | | | | | | | | |
| 28–29 | | | | | | | | | | |
| 27–28 | | | | | | | | | | |
| 26–27 | | | | | | | | | | |
| 25–26 | | | | | | | | | | |
| 24–25 | | | | | | | | | | |
| 23–24 | | | | | | | | | | |
| 22–23 | | | | | | | | | | |
| 21–22 | | | | | | | | | | |
| 20–21 | | | | | | | | | | |
| 19–20 | | | | | | | | | | |
| 18–19 | | | | | | | | | | |
| 17–18 | <0.01 | | | | | | | | <0.01 | |
| 16–17 | 0.04 | 0.03 | | | | | | | 0.07 | 0.07 |
| 15–16 | 0.03 | 0.05 | | | | | | | 0.08 | 0.15 |
| 14–15 | 0.13 | 0.09 | | | | 0.02 | | <0.01 | 0.24 | 0.39 |
| 13–14 | 0.06 | 0.23 | 0.02 | | 0.08 | 0.02 | | 0.03 | 0.42 | 0.81 |
| 12–13 | 0.19 | 0.19 | 0.02 | <0.01 | 0.08 | 0.03 | | 0.04 | 0.55 | 1.36 |
| 11–12 | 0.33 | 0.30 | 0.02 | | 0.16 | 0.07 | 0.03 | 0.08 | 0.97 | 2.34 |
| 10–11 | 0.68 | 0.57 | 0.03 | 0.02 | 0.26 | 0.12 | 0.07 | 0.18 | 1.94 | 4.28 |
| 9–10 | 0.93 | 0.69 | 0.05 | 0.02 | 0.43 | 0.23 | 0.09 | 0.38 | 2.81 | 7.08 |
| 8–9 | 1.00 | 0.78 | 0.09 | 0.10 | 0.79 | 0.50 | 0.13 | 0.67 | 4.04 | 11.12 |
| 7–8 | 1.41 | 1.07 | 0.24 | 0.21 | 1.62 | 1.25 | 0.41 | 0.68 | 6.90 | 18.03 |
| 6–7 | 1.88 | 1.46 | 0.44 | 0.42 | 2.38 | 2.45 | 0.56 | 0.87 | 10.46 | 28.48 |
| 5–6 | 1.92 | 1.66 | 1.06 | 1.01 | 3.04 | 2.82 | 0.79 | 1.11 | 13.42 | 41.90 |
| 4–5 | 2.01 | 1.91 | 1.33 | 1.28 | 3.30 | 3.30 | 1.16 | 1.48 | 15.76 | 57.67 |
| 3–4 | 1.90 | 1.93 | 1.71 | 2.36 | 4.13 | 4.07 | 1.92 | 1.72 | 19.73 | 77.40 |
| 2–3 | 1.35 | 1.36 | 1.52 | 2.33 | 3.36 | 3.27 | 1.51 | 1.12 | 15.83 | 93.23 |
| 1–2 | 0.58 | 0.56 | 0.53 | 0.74 | 1.18 | 1.25 | 0.77 | 0.72 | 6.34 | 99.57 |
| 0–1 | 0.08 | 0.04 | 0.05 | 0.03 | 0.06 | 0.07 | 0.05 | 0.06 | 0.43 | |

1hr Wind Direction at 10m (°T From)

Figure 2-17 Percentage Occurrence of Wind Speed and Direction Including Hurricanes – May

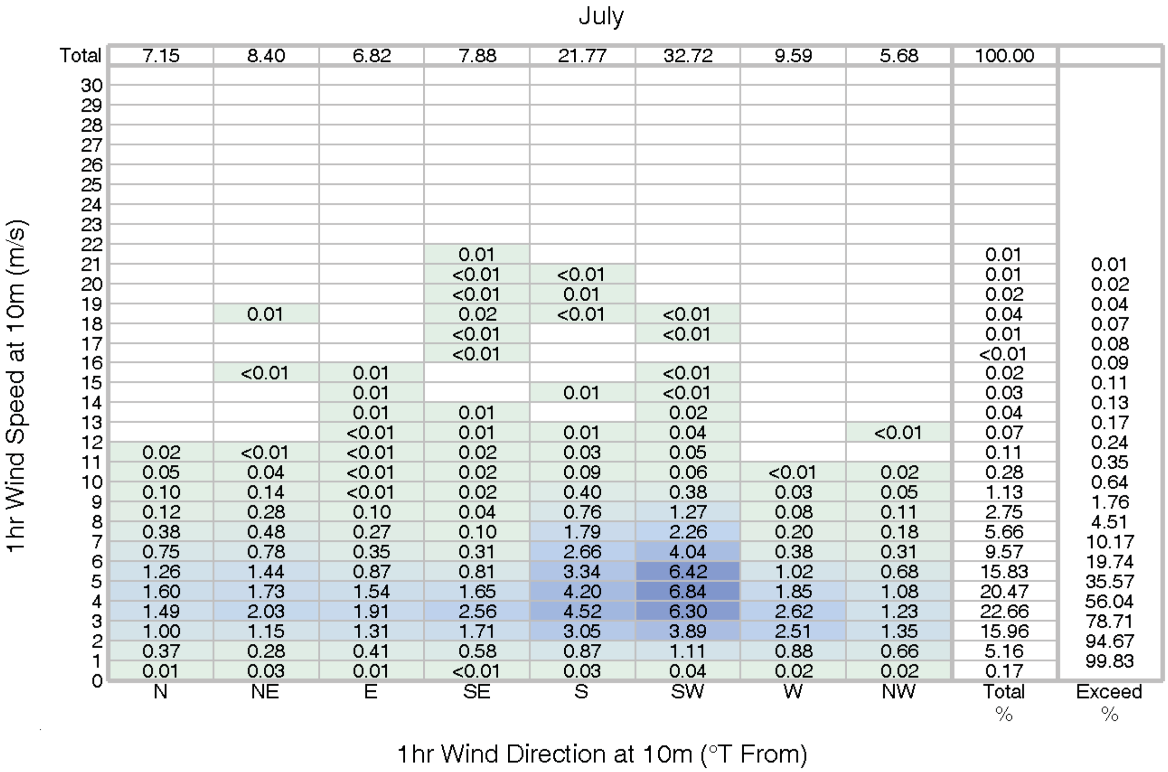


June

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 8.44 | 12.01 | 9.05 | 9.23 | 21.69 | 25.02 | 8.24 | 6.32 | 100.00 | |
| 29–30 | | | | | | | | | | |
| 28–29 | | | | | | | | | | |
| 27–28 | | | | | | | | | | |
| 26–27 | | | | | | | | | | |
| 25–26 | | | | | | | | | | |
| 24–25 | | | | | | | | | | |
| 23–24 | | | | | | | | | | |
| 22–23 | | | | | | | | | | |
| 21–22 | | | | | | | | | | |
| 20–21 | | | | | | | | | | |
| 19–20 | | | | | | | | | | |
| 18–19 | | | | | | | | | | |
| 17–18 | | | | | | | | | | |
| 16–17 | | | | | | | | | | |
| 15–16 | | <0.01 | | | | | | | <0.01 | |
| 14–15 | | <0.01 | | | | | | | <0.01 | 0.01 |
| 13–14 | | 0.01 | | | | | | | 0.01 | 0.02 |
| 12–13 | <0.01 | 0.04 | | | | | | 0.02 | 0.07 | 0.09 |
| 11–12 | 0.07 | 0.07 | 0.01 | | 0.02 | | 0.01 | 0.02 | 0.21 | 0.30 |
| 10–11 | 0.09 | 0.24 | 0.01 | | 0.13 | 0.03 | 0.03 | 0.07 | 0.60 | 0.90 |
| 9–10 | 0.25 | 0.36 | 0.03 | 0.04 | 0.13 | 0.20 | 0.09 | 0.17 | 1.27 | 2.16 |
| 8–9 | 0.53 | 0.56 | 0.07 | 0.11 | 0.39 | 0.71 | 0.12 | 0.15 | 2.64 | 4.81 |
| 7–8 | 0.87 | 0.90 | 0.34 | 0.20 | 1.13 | 2.04 | 0.15 | 0.44 | 6.06 | 10.87 |
| 6–7 | 1.19 | 1.45 | 0.49 | 0.48 | 2.35 | 3.22 | 0.29 | 0.63 | 10.09 | 20.96 |
| 5–6 | 1.10 | 1.98 | 0.85 | 0.88 | 3.50 | 5.19 | 0.83 | 0.91 | 15.23 | 36.19 |
| 4–5 | 1.24 | 2.02 | 1.54 | 1.42 | 4.42 | 4.62 | 1.72 | 0.91 | 17.88 | 54.07 |
| 3–4 | 1.50 | 1.92 | 2.44 | 2.33 | 4.12 | 4.59 | 2.04 | 1.26 | 20.18 | 74.25 |
| 2–3 | 1.17 | 1.71 | 2.11 | 2.63 | 3.78 | 3.10 | 1.97 | 1.19 | 17.65 | 91.91 |
| 1–2 | 0.37 | 0.67 | 1.06 | 1.08 | 1.61 | 1.30 | 0.93 | 0.55 | 7.58 | 99.49 |
| 0–1 | 0.05 | 0.06 | 0.12 | 0.05 | 0.12 | 0.04 | 0.05 | 0.02 | 0.51 | |

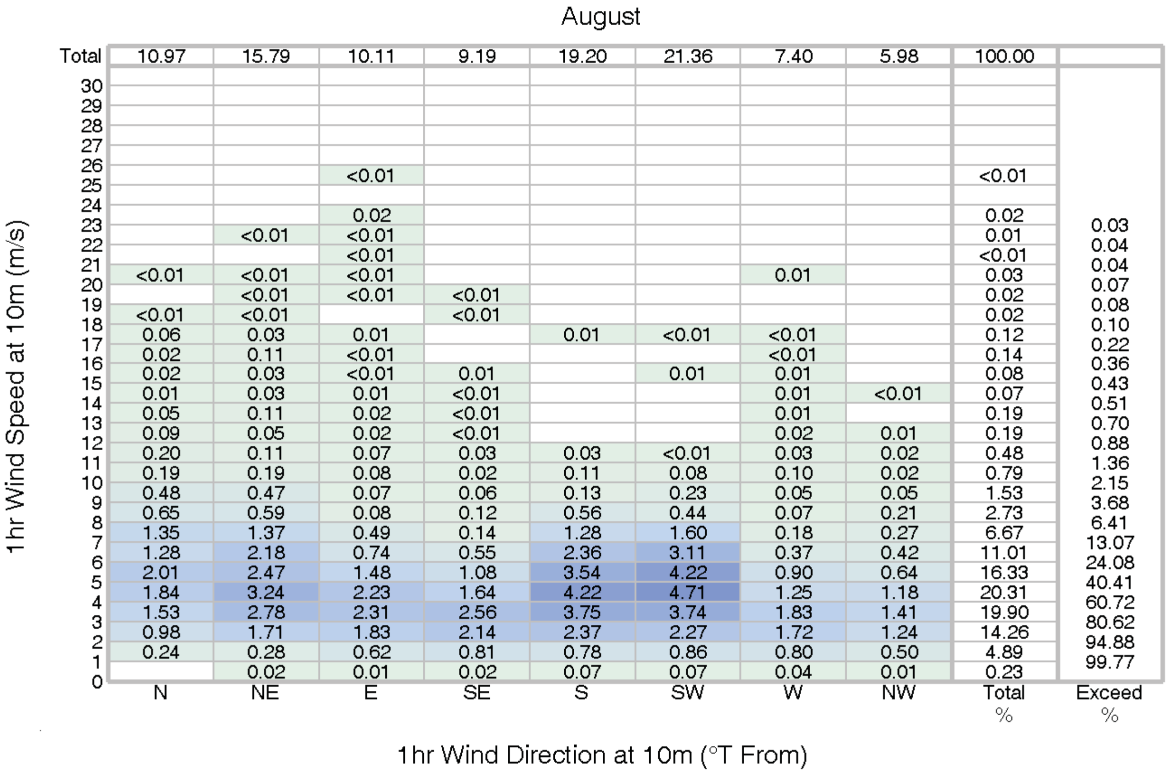
1hr Wind Direction at 10m (°T From)

Figure 2-18 Percentage Occurrence of Wind Speed and Direction Including Hurricanes – June



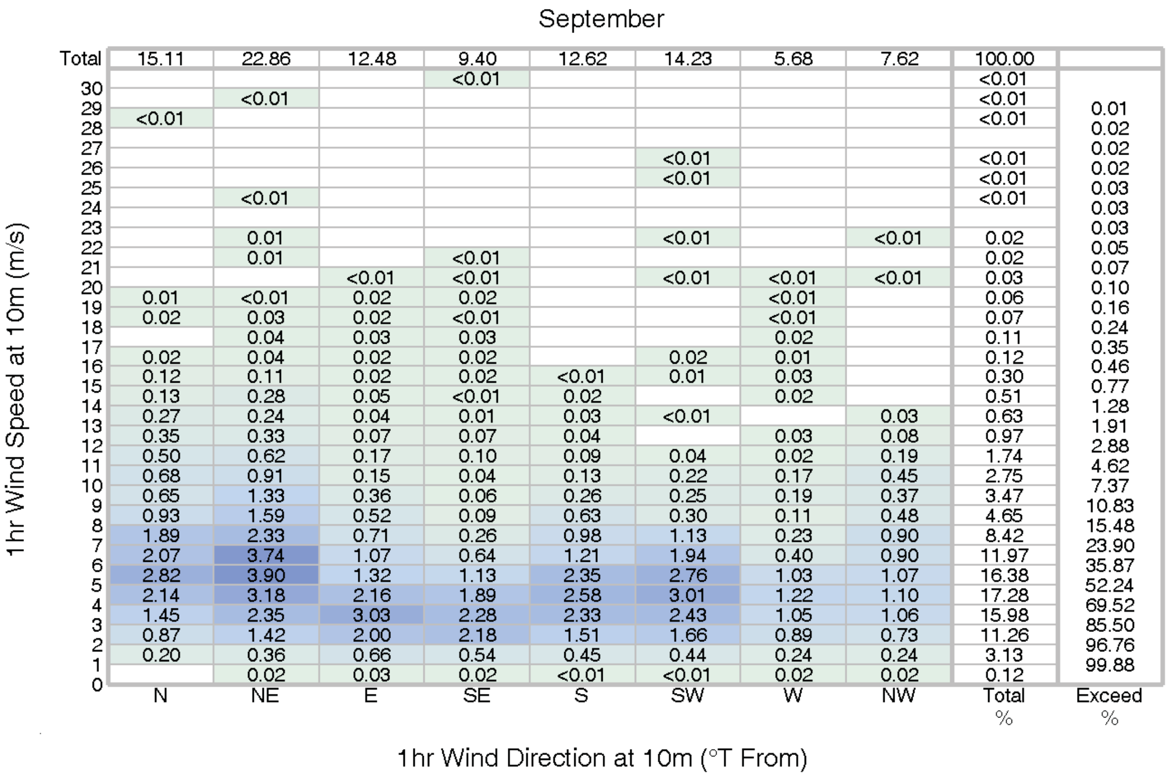
| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 7.15 | 8.40 | 6.82 | 7.88 | 21.77 | 32.72 | 9.59 | 5.68 | 100.00 | |
| 30 | | | | | | | | | | |
| 29 | | | | | | | | | | |
| 28 | | | | | | | | | | |
| 27 | | | | | | | | | | |
| 26 | | | | | | | | | | |
| 25 | | | | | | | | | | |
| 24 | | | | | | | | | | |
| 23 | | | | | | | | | | |
| 22 | | | | | | | | | | |
| 21 | | | | 0.01 | | | | | 0.01 | 0.01 |
| 20 | | | | <0.01 | <0.01 | | | | 0.01 | 0.02 |
| 19 | | | | <0.01 | 0.01 | | | | 0.02 | 0.04 |
| 18 | | 0.01 | | 0.02 | <0.01 | <0.01 | | | 0.04 | 0.07 |
| 17 | | | | <0.01 | | <0.01 | | | 0.01 | 0.08 |
| 16 | | | | <0.01 | | | | | <0.01 | 0.09 |
| 15 | | <0.01 | 0.01 | | | <0.01 | | | 0.02 | 0.11 |
| 14 | | | 0.01 | | 0.01 | <0.01 | | | 0.03 | 0.13 |
| 13 | | | 0.01 | 0.01 | | 0.02 | | | 0.04 | 0.17 |
| 12 | | | <0.01 | 0.01 | 0.01 | 0.04 | | <0.01 | 0.07 | 0.24 |
| 11 | 0.02 | <0.01 | <0.01 | 0.02 | 0.03 | 0.05 | | | 0.11 | 0.35 |
| 10 | 0.05 | 0.04 | <0.01 | 0.02 | 0.09 | 0.06 | <0.01 | 0.02 | 0.28 | 0.64 |
| 9 | 0.10 | 0.14 | <0.01 | 0.02 | 0.40 | 0.38 | 0.03 | 0.05 | 1.13 | 1.76 |
| 8 | 0.12 | 0.28 | 0.10 | 0.04 | 0.76 | 1.27 | 0.08 | 0.11 | 2.75 | 4.51 |
| 7 | 0.38 | 0.48 | 0.27 | 0.10 | 1.79 | 2.26 | 0.20 | 0.18 | 5.66 | 10.17 |
| 6 | 0.75 | 0.78 | 0.35 | 0.31 | 2.66 | 4.04 | 0.38 | 0.31 | 9.57 | 19.74 |
| 5 | 1.26 | 1.44 | 0.87 | 0.81 | 3.34 | 6.42 | 1.02 | 0.68 | 15.83 | 35.57 |
| 4 | 1.60 | 1.73 | 1.54 | 1.65 | 4.20 | 6.84 | 1.85 | 1.08 | 20.47 | 56.04 |
| 3 | 1.49 | 2.03 | 1.91 | 2.56 | 4.52 | 6.30 | 2.62 | 1.23 | 22.66 | 78.71 |
| 2 | 1.00 | 1.15 | 1.31 | 1.71 | 3.05 | 3.89 | 2.51 | 1.35 | 15.96 | 94.67 |
| 1 | 0.37 | 0.28 | 0.41 | 0.58 | 0.87 | 1.11 | 0.88 | 0.66 | 5.16 | 99.83 |
| 0 | 0.01 | 0.03 | 0.01 | <0.01 | 0.03 | 0.04 | 0.02 | 0.02 | 0.17 | |

**Figure 2-19 Percentage Occurrence of Wind Speed and Direction Including Hurricanes – July**



| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 10.97 | 15.79 | 10.11 | 9.19 | 19.20 | 21.36 | 7.40 | 5.98 | 100.00 | |
| 30 | | | | | | | | | | |
| 29 | | | | | | | | | | |
| 28 | | | | | | | | | | |
| 27 | | | | | | | | | | |
| 26 | | | | | | | | | | |
| 25 | | | <0.01 | | | | | | <0.01 | |
| 24 | | | | | | | | | | |
| 23 | | | 0.02 | | | | | | 0.02 | 0.03 |
| 22 | | <0.01 | <0.01 | | | | | | 0.01 | 0.04 |
| 21 | | | <0.01 | | | | | | <0.01 | 0.04 |
| 20 | <0.01 | <0.01 | <0.01 | | | | 0.01 | | 0.03 | 0.07 |
| 19 | | <0.01 | <0.01 | <0.01 | | | | | 0.02 | 0.08 |
| 18 | <0.01 | <0.01 | | <0.01 | | | | | 0.02 | 0.10 |
| 17 | 0.06 | 0.03 | 0.01 | | 0.01 | <0.01 | <0.01 | | 0.12 | 0.22 |
| 16 | 0.02 | 0.11 | <0.01 | | | | <0.01 | | 0.14 | 0.36 |
| 15 | 0.02 | 0.03 | <0.01 | 0.01 | | 0.01 | 0.01 | | 0.08 | 0.43 |
| 14 | 0.01 | 0.03 | 0.01 | <0.01 | | | 0.01 | <0.01 | 0.07 | 0.51 |
| 13 | 0.05 | 0.11 | 0.02 | <0.01 | | | 0.01 | | 0.19 | 0.70 |
| 12 | 0.09 | 0.05 | 0.02 | <0.01 | | | 0.02 | 0.01 | 0.19 | 0.88 |
| 11 | 0.20 | 0.11 | 0.07 | 0.03 | 0.03 | <0.01 | 0.03 | 0.02 | 0.48 | 1.36 |
| 10 | 0.19 | 0.19 | 0.08 | 0.02 | 0.11 | 0.08 | 0.10 | 0.02 | 0.79 | 2.15 |
| 9 | 0.48 | 0.47 | 0.07 | 0.06 | 0.13 | 0.23 | 0.05 | 0.05 | 1.53 | 3.68 |
| 8 | 0.65 | 0.59 | 0.08 | 0.12 | 0.56 | 0.44 | 0.07 | 0.21 | 2.73 | 6.41 |
| 7 | 1.35 | 1.37 | 0.49 | 0.14 | 1.28 | 1.60 | 0.18 | 0.27 | 6.67 | 13.07 |
| 6 | 1.28 | 2.18 | 0.74 | 0.55 | 2.36 | 3.11 | 0.37 | 0.42 | 11.01 | 24.08 |
| 5 | 2.01 | 2.47 | 1.48 | 1.08 | 3.54 | 4.22 | 0.90 | 0.64 | 16.33 | 40.41 |
| 4 | 1.84 | 3.24 | 2.23 | 1.64 | 4.22 | 4.71 | 1.25 | 1.18 | 20.31 | 60.72 |
| 3 | 1.53 | 2.78 | 2.31 | 2.56 | 3.75 | 3.74 | 1.83 | 1.41 | 19.90 | 80.62 |
| 2 | 0.98 | 1.71 | 1.83 | 2.14 | 2.37 | 2.27 | 1.72 | 1.24 | 14.26 | 94.88 |
| 1 | 0.24 | 0.28 | 0.62 | 0.81 | 0.78 | 0.86 | 0.80 | 0.50 | 4.89 | 99.77 |
| 0 | | 0.02 | 0.01 | 0.02 | 0.07 | 0.07 | 0.04 | 0.01 | 0.23 | |

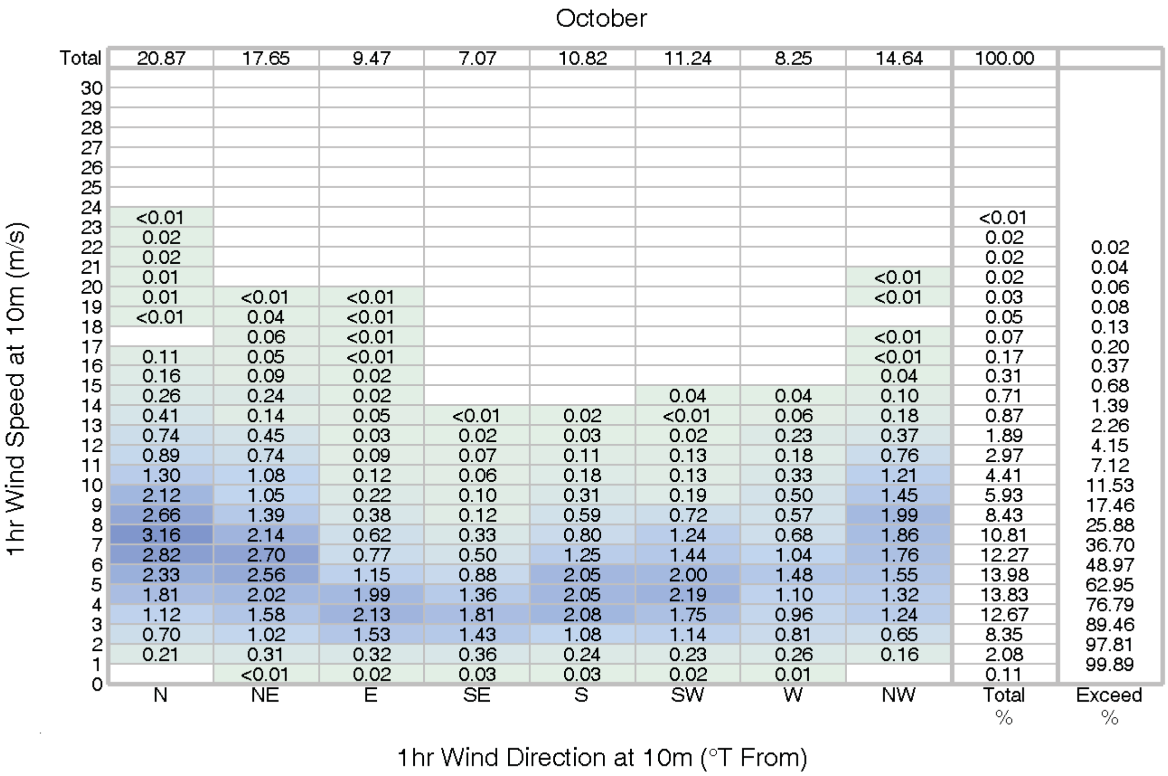
**Figure 2-20 Percentage Occurrence of Wind Speed and Direction Including Hurricanes – August**



September

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 15.11 | 22.86 | 12.48 | 9.40 | 12.62 | 14.23 | 5.68 | 7.62 | 100.00 | |
| 30 | | | | <0.01 | | | | | <0.01 | |
| 29 | | <0.01 | | | | | | | <0.01 | 0.01 |
| 28 | <0.01 | | | | | | | | <0.01 | 0.02 |
| 27 | | | | | | | | | | 0.02 |
| 26 | | | | | | <0.01 | | | <0.01 | 0.02 |
| 25 | | | | | | <0.01 | | | <0.01 | 0.03 |
| 24 | | <0.01 | | | | | | | <0.01 | 0.03 |
| 23 | | | | | | | | | | 0.03 |
| 22 | | 0.01 | | | | <0.01 | | <0.01 | 0.02 | 0.05 |
| 21 | | 0.01 | | <0.01 | | | | | 0.02 | 0.07 |
| 20 | | | <0.01 | <0.01 | | <0.01 | <0.01 | <0.01 | 0.03 | 0.10 |
| 19 | 0.01 | <0.01 | 0.02 | 0.02 | | | <0.01 | | 0.06 | 0.16 |
| 18 | 0.02 | 0.03 | 0.02 | <0.01 | | | <0.01 | | 0.07 | 0.24 |
| 17 | | 0.04 | 0.03 | 0.03 | | | 0.02 | | 0.11 | 0.35 |
| 16 | 0.02 | 0.04 | 0.02 | 0.02 | | 0.02 | 0.01 | | 0.12 | 0.46 |
| 15 | 0.12 | 0.11 | 0.02 | 0.02 | <0.01 | 0.01 | 0.03 | | 0.30 | 0.77 |
| 14 | 0.13 | 0.28 | 0.05 | <0.01 | 0.02 | | 0.02 | | 0.51 | 1.28 |
| 13 | 0.27 | 0.24 | 0.04 | 0.01 | 0.03 | <0.01 | | 0.03 | 0.63 | 1.91 |
| 12 | 0.35 | 0.33 | 0.07 | 0.07 | 0.04 | | 0.03 | 0.08 | 0.97 | 2.88 |
| 11 | 0.50 | 0.62 | 0.17 | 0.10 | 0.09 | 0.04 | 0.02 | 0.19 | 1.74 | 4.62 |
| 10 | 0.68 | 0.91 | 0.15 | 0.04 | 0.13 | 0.22 | 0.17 | 0.45 | 2.75 | 7.37 |
| 9 | 0.65 | 1.33 | 0.36 | 0.06 | 0.26 | 0.25 | 0.19 | 0.37 | 3.47 | 10.83 |
| 8 | 0.93 | 1.59 | 0.52 | 0.09 | 0.63 | 0.30 | 0.11 | 0.48 | 4.65 | 15.48 |
| 7 | 1.89 | 2.33 | 0.71 | 0.26 | 0.98 | 1.13 | 0.23 | 0.90 | 8.42 | 23.90 |
| 6 | 2.07 | 3.74 | 1.07 | 0.64 | 1.21 | 1.94 | 0.40 | 0.90 | 11.97 | 35.87 |
| 5 | 2.82 | 3.90 | 1.32 | 1.13 | 2.35 | 2.76 | 1.03 | 1.07 | 16.38 | 52.24 |
| 4 | 2.14 | 3.18 | 2.16 | 1.89 | 2.58 | 3.01 | 1.22 | 1.10 | 17.28 | 69.52 |
| 3 | 1.45 | 2.35 | 3.03 | 2.28 | 2.33 | 2.43 | 1.05 | 1.06 | 15.98 | 85.50 |
| 2 | 0.87 | 1.42 | 2.00 | 2.18 | 1.51 | 1.66 | 0.89 | 0.73 | 11.26 | 96.76 |
| 1 | 0.20 | 0.36 | 0.66 | 0.54 | 0.45 | 0.44 | 0.24 | 0.24 | 3.13 | 99.88 |
| 0 | | 0.02 | 0.03 | 0.02 | <0.01 | <0.01 | 0.02 | 0.02 | 0.12 | |

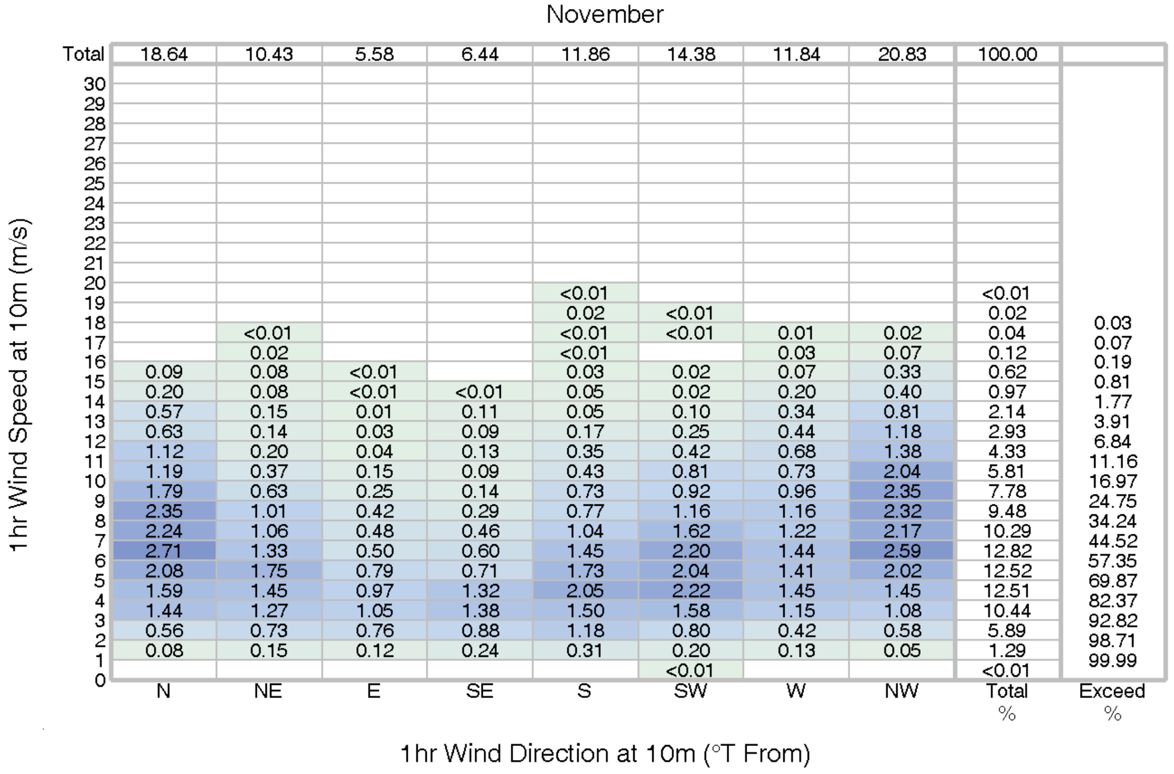
Figure 2-21 Percentage Occurrence of Wind Speed and Direction Including Hurricanes – September



October

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 20.87 | 17.65 | 9.47 | 7.07 | 10.82 | 11.24 | 8.25 | 14.64 | 100.00 | |
| 30 | | | | | | | | | | |
| 29 | | | | | | | | | | |
| 28 | | | | | | | | | | |
| 27 | | | | | | | | | | |
| 26 | | | | | | | | | | |
| 25 | | | | | | | | | | |
| 24 | | | | | | | | | | |
| 23 | <0.01 | | | | | | | | <0.01 | |
| 22 | 0.02 | | | | | | | | 0.02 | 0.02 |
| 21 | 0.02 | | | | | | | | 0.02 | 0.04 |
| 20 | 0.01 | | | | | | | <0.01 | 0.02 | 0.06 |
| 19 | 0.01 | <0.01 | <0.01 | | | | | <0.01 | 0.03 | 0.08 |
| 18 | <0.01 | 0.04 | <0.01 | | | | | | 0.05 | 0.13 |
| 17 | | 0.06 | <0.01 | | | | | <0.01 | 0.07 | 0.20 |
| 16 | 0.11 | 0.05 | <0.01 | | | | | <0.01 | 0.17 | 0.37 |
| 15 | 0.16 | 0.09 | 0.02 | | | | | 0.04 | 0.31 | 0.68 |
| 14 | 0.26 | 0.24 | 0.02 | | | 0.04 | 0.04 | 0.10 | 0.71 | 1.39 |
| 13 | 0.41 | 0.14 | 0.05 | <0.01 | 0.02 | <0.01 | 0.06 | 0.18 | 0.87 | 2.26 |
| 12 | 0.74 | 0.45 | 0.03 | 0.02 | 0.03 | 0.02 | 0.23 | 0.37 | 1.89 | 4.15 |
| 11 | 0.89 | 0.74 | 0.09 | 0.07 | 0.11 | 0.13 | 0.18 | 0.76 | 2.97 | 7.12 |
| 10 | 1.30 | 1.08 | 0.12 | 0.06 | 0.18 | 0.13 | 0.33 | 1.21 | 4.41 | 11.53 |
| 9 | 2.12 | 1.05 | 0.22 | 0.10 | 0.31 | 0.19 | 0.50 | 1.45 | 5.93 | 17.46 |
| 8 | 2.66 | 1.39 | 0.38 | 0.12 | 0.59 | 0.72 | 0.57 | 1.99 | 8.43 | 25.88 |
| 7 | 3.16 | 2.14 | 0.62 | 0.33 | 0.80 | 1.24 | 0.68 | 1.86 | 10.81 | 36.70 |
| 6 | 2.82 | 2.70 | 0.77 | 0.50 | 1.25 | 1.44 | 1.04 | 1.76 | 12.27 | 48.97 |
| 5 | 2.33 | 2.56 | 1.15 | 0.88 | 2.05 | 2.00 | 1.48 | 1.55 | 13.98 | 62.95 |
| 4 | 1.81 | 2.02 | 1.99 | 1.36 | 2.05 | 2.19 | 1.10 | 1.32 | 13.83 | 76.79 |
| 3 | 1.12 | 1.58 | 2.13 | 1.81 | 2.08 | 1.75 | 0.96 | 1.24 | 12.67 | 89.46 |
| 2 | 0.70 | 1.02 | 1.53 | 1.43 | 1.08 | 1.14 | 0.81 | 0.65 | 8.35 | 97.81 |
| 1 | 0.21 | 0.31 | 0.32 | 0.36 | 0.24 | 0.23 | 0.26 | 0.16 | 2.08 | 99.89 |
| 0 | | <0.01 | 0.02 | 0.03 | 0.03 | 0.02 | 0.01 | | 0.11 | |

Figure 2-22 Percentage Occurrence of Wind Speed and Direction Including Hurricanes – October

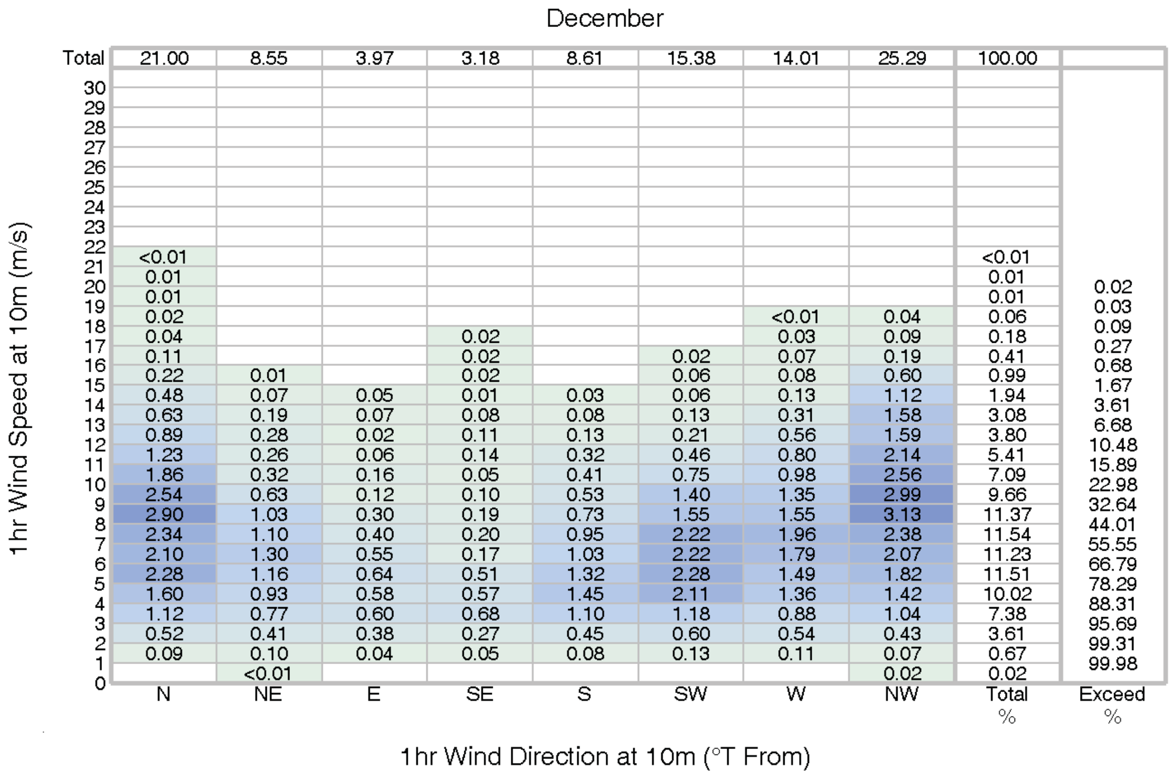


November

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 18.64 | 10.43 | 5.58 | 6.44 | 11.86 | 14.38 | 11.84 | 20.83 | 100.00 | |
| 30 | | | | | | | | | | |
| 29 | | | | | | | | | | |
| 28 | | | | | | | | | | |
| 27 | | | | | | | | | | |
| 26 | | | | | | | | | | |
| 25 | | | | | | | | | | |
| 24 | | | | | | | | | | |
| 23 | | | | | | | | | | |
| 22 | | | | | | | | | | |
| 21 | | | | | | | | | | |
| 20 | | | | | | | | | | |
| 19 | | | | | <0.01 | | | | <0.01 | |
| 18 | | | | | 0.02 | <0.01 | | | 0.02 | 0.03 |
| 17 | | <0.01 | | | <0.01 | <0.01 | 0.01 | 0.02 | 0.04 | 0.07 |
| 16 | | 0.02 | | | <0.01 | | 0.03 | 0.07 | 0.12 | 0.19 |
| 15 | 0.09 | 0.08 | <0.01 | | 0.03 | 0.02 | 0.07 | 0.33 | 0.62 | 0.81 |
| 14 | 0.20 | 0.08 | <0.01 | <0.01 | 0.05 | 0.02 | 0.20 | 0.40 | 0.97 | 1.77 |
| 13 | 0.57 | 0.15 | 0.01 | 0.11 | 0.05 | 0.10 | 0.34 | 0.81 | 2.14 | 3.91 |
| 12 | 0.63 | 0.14 | 0.03 | 0.09 | 0.17 | 0.25 | 0.44 | 1.18 | 2.93 | 6.84 |
| 11 | 1.12 | 0.20 | 0.04 | 0.13 | 0.35 | 0.42 | 0.68 | 1.38 | 4.33 | 11.16 |
| 10 | 1.19 | 0.37 | 0.15 | 0.09 | 0.43 | 0.81 | 0.73 | 2.04 | 5.81 | 16.97 |
| 9 | 1.79 | 0.63 | 0.25 | 0.14 | 0.73 | 0.92 | 0.96 | 2.35 | 7.78 | 24.75 |
| 8 | 2.35 | 1.01 | 0.42 | 0.29 | 0.77 | 1.16 | 1.16 | 2.32 | 9.48 | 34.24 |
| 7 | 2.24 | 1.06 | 0.48 | 0.46 | 1.04 | 1.62 | 1.22 | 2.17 | 10.29 | 44.52 |
| 6 | 2.71 | 1.33 | 0.50 | 0.60 | 1.45 | 2.20 | 1.44 | 2.59 | 12.82 | 57.35 |
| 5 | 2.08 | 1.75 | 0.79 | 0.71 | 1.73 | 2.04 | 1.41 | 2.02 | 12.52 | 69.87 |
| 4 | 1.59 | 1.45 | 0.97 | 1.32 | 2.05 | 2.22 | 1.45 | 1.45 | 12.51 | 82.37 |
| 3 | 1.44 | 1.27 | 1.05 | 1.38 | 1.50 | 1.58 | 1.15 | 1.08 | 10.44 | 92.82 |
| 2 | 0.56 | 0.73 | 0.76 | 0.88 | 1.18 | 0.80 | 0.42 | 0.58 | 5.89 | 98.71 |
| 1 | 0.08 | 0.15 | 0.12 | 0.24 | 0.31 | 0.20 | 0.13 | 0.05 | 1.29 | 99.99 |
| 0 | | | | | | <0.01 | | | <0.01 | |

1hr Wind Direction at 10m (°T From)

Figure 2-23 Percentage Occurrence of Wind Speed and Direction Including Hurricanes – November



December

| 1hr Wind Speed at 10m (m/s) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 21.00 | 8.55 | 3.97 | 3.18 | 8.61 | 15.38 | 14.01 | 25.29 | 100.00 | |
| 30 | | | | | | | | | | |
| 29 | | | | | | | | | | |
| 28 | | | | | | | | | | |
| 27 | | | | | | | | | | |
| 26 | | | | | | | | | | |
| 25 | | | | | | | | | | |
| 24 | | | | | | | | | | |
| 23 | | | | | | | | | | |
| 22 | | | | | | | | | | |
| 21 | <0.01 | | | | | | | | <0.01 | |
| 20 | 0.01 | | | | | | | | 0.01 | 0.02 |
| 19 | 0.01 | | | | | | | | 0.01 | 0.03 |
| 18 | 0.02 | | | | | | <0.01 | 0.04 | 0.06 | 0.09 |
| 17 | 0.04 | | | 0.02 | | | 0.03 | 0.09 | 0.18 | 0.27 |
| 16 | 0.11 | | | 0.02 | | 0.02 | 0.07 | 0.19 | 0.41 | 0.68 |
| 15 | 0.22 | 0.01 | | 0.02 | | 0.06 | 0.08 | 0.60 | 0.99 | 1.67 |
| 14 | 0.48 | 0.07 | 0.05 | 0.01 | 0.03 | 0.06 | 0.13 | 1.12 | 1.94 | 3.61 |
| 13 | 0.63 | 0.19 | 0.07 | 0.08 | 0.08 | 0.13 | 0.31 | 1.58 | 3.08 | 6.68 |
| 12 | 0.89 | 0.28 | 0.02 | 0.11 | 0.13 | 0.21 | 0.56 | 1.59 | 3.80 | 10.48 |
| 11 | 1.23 | 0.26 | 0.06 | 0.14 | 0.32 | 0.46 | 0.80 | 2.14 | 5.41 | 15.89 |
| 10 | 1.86 | 0.32 | 0.16 | 0.05 | 0.41 | 0.75 | 0.98 | 2.56 | 7.09 | 22.98 |
| 9 | 2.54 | 0.63 | 0.12 | 0.10 | 0.53 | 1.40 | 1.35 | 2.99 | 9.66 | 32.64 |
| 8 | 2.90 | 1.03 | 0.30 | 0.19 | 0.73 | 1.55 | 1.55 | 3.13 | 11.37 | 44.01 |
| 7 | 2.34 | 1.10 | 0.40 | 0.20 | 0.95 | 2.22 | 1.96 | 2.38 | 11.54 | 55.55 |
| 6 | 2.10 | 1.30 | 0.55 | 0.17 | 1.03 | 2.22 | 1.79 | 2.07 | 11.23 | 66.79 |
| 5 | 2.28 | 1.16 | 0.64 | 0.51 | 1.32 | 2.28 | 1.49 | 1.82 | 11.51 | 78.29 |
| 4 | 1.60 | 0.93 | 0.58 | 0.57 | 1.45 | 2.11 | 1.36 | 1.42 | 10.02 | 88.31 |
| 3 | 1.12 | 0.77 | 0.60 | 0.68 | 1.10 | 1.18 | 0.88 | 1.04 | 7.38 | 95.69 |
| 2 | 0.52 | 0.41 | 0.38 | 0.27 | 0.45 | 0.60 | 0.54 | 0.43 | 3.61 | 99.31 |
| 1 | 0.09 | 0.10 | 0.04 | 0.05 | 0.08 | 0.13 | 0.11 | 0.07 | 0.67 | 99.98 |
| 0 | | <0.01 | | | | | | 0.02 | 0.02 | |

1hr Wind Direction at 10m (°T From)

Figure 2-24 Percentage Occurrence of Wind Speed and Direction Including Hurricanes – December

### 2.1.18 Wind Speed Distribution at Hub Height Excluding Hurricanes

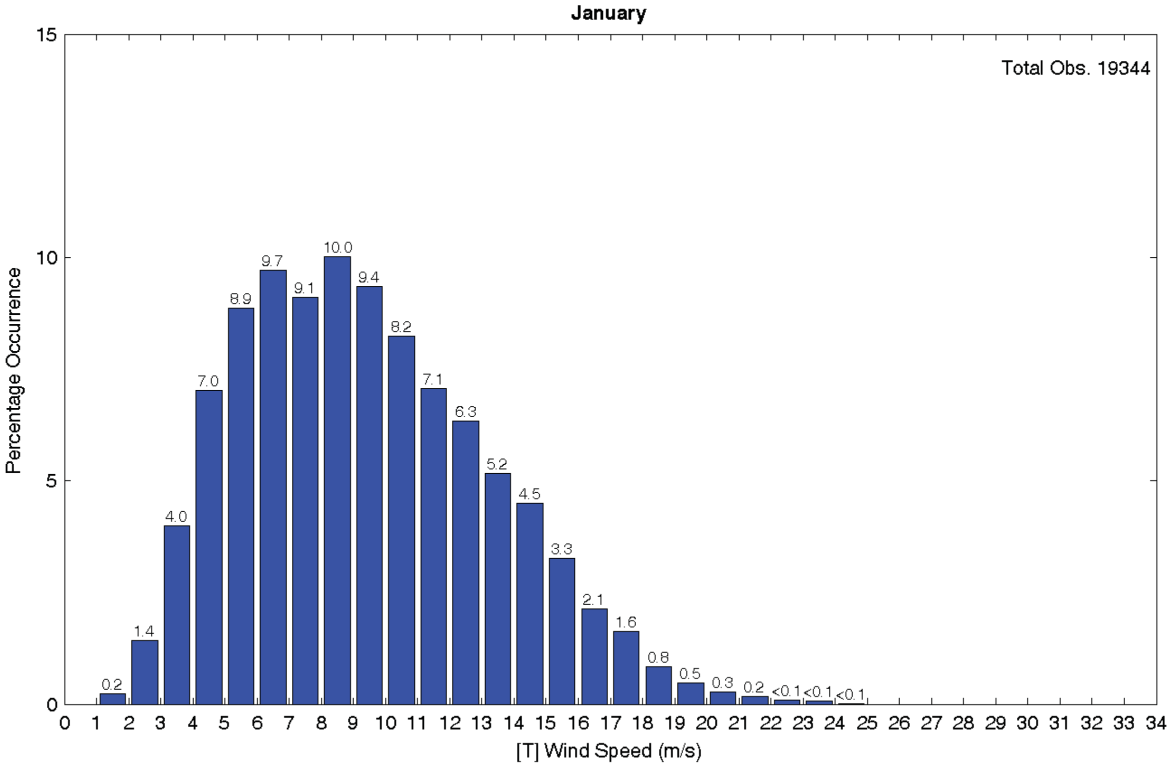


Figure 2-25 Percentage Occurrence of Wind Speed at Hub Height Excluding Hurricanes – January

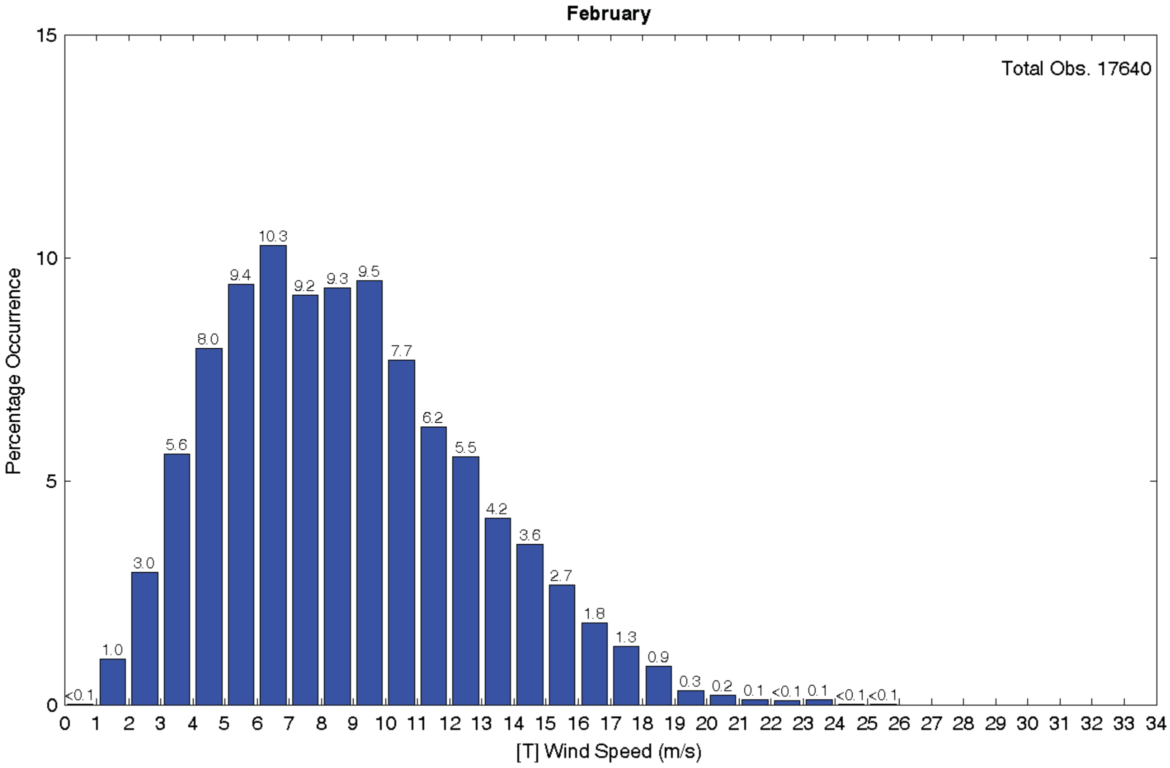


Figure 2-26 Percentage Occurrence of Wind Speed at Hub Height Excluding Hurricanes – February

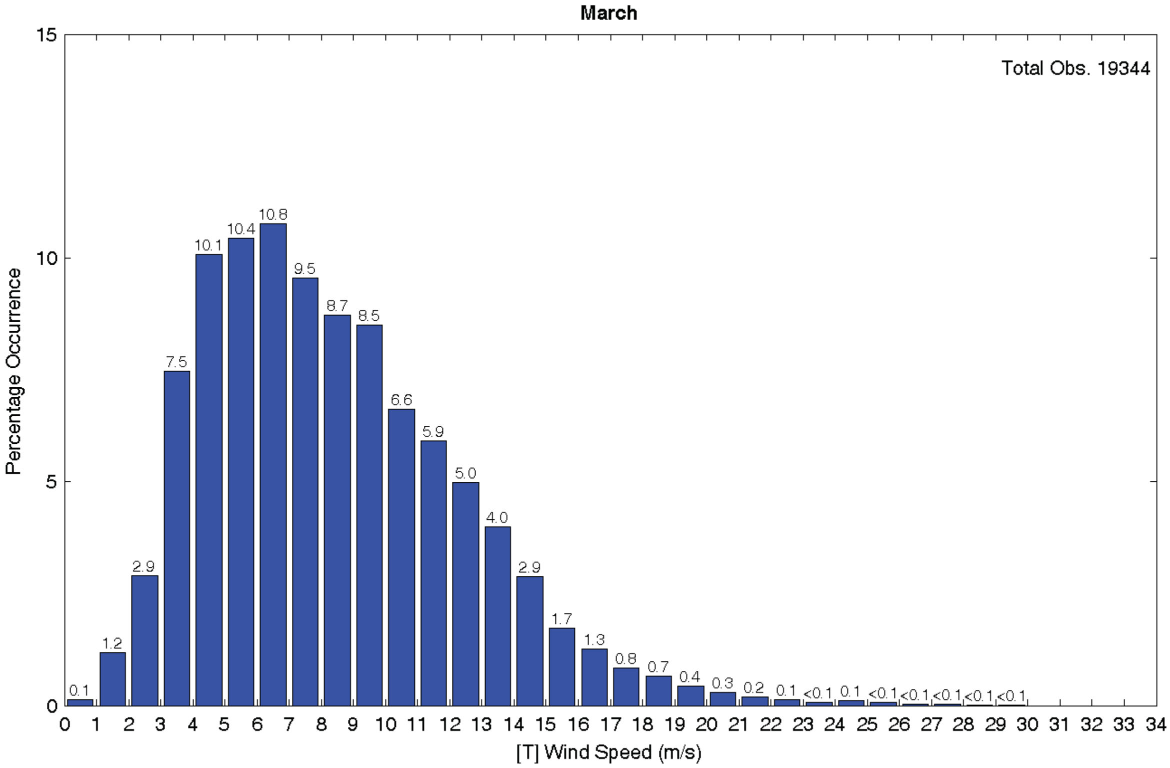


Figure 2-27 Percentage Occurrence of Wind Speed at Hub Height Excluding Hurricanes – March

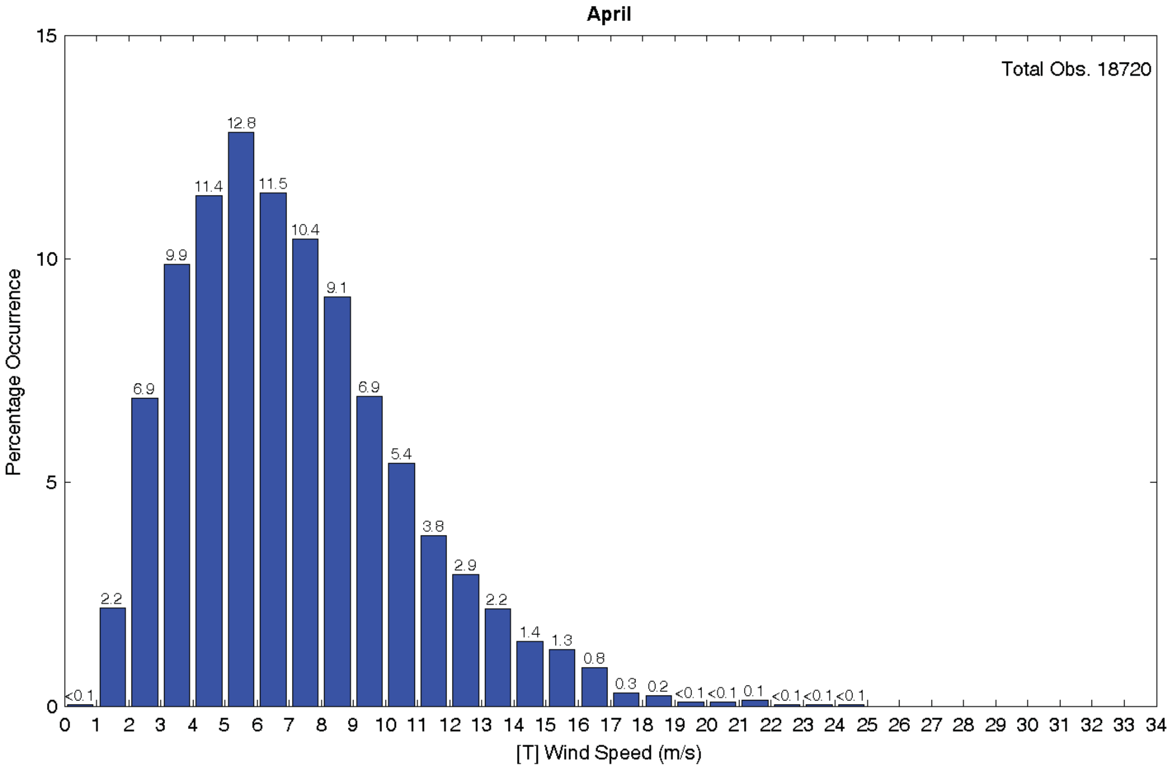


Figure 2-28 Percentage Occurrence of Wind Speed at Hub Height Excluding Hurricanes – April

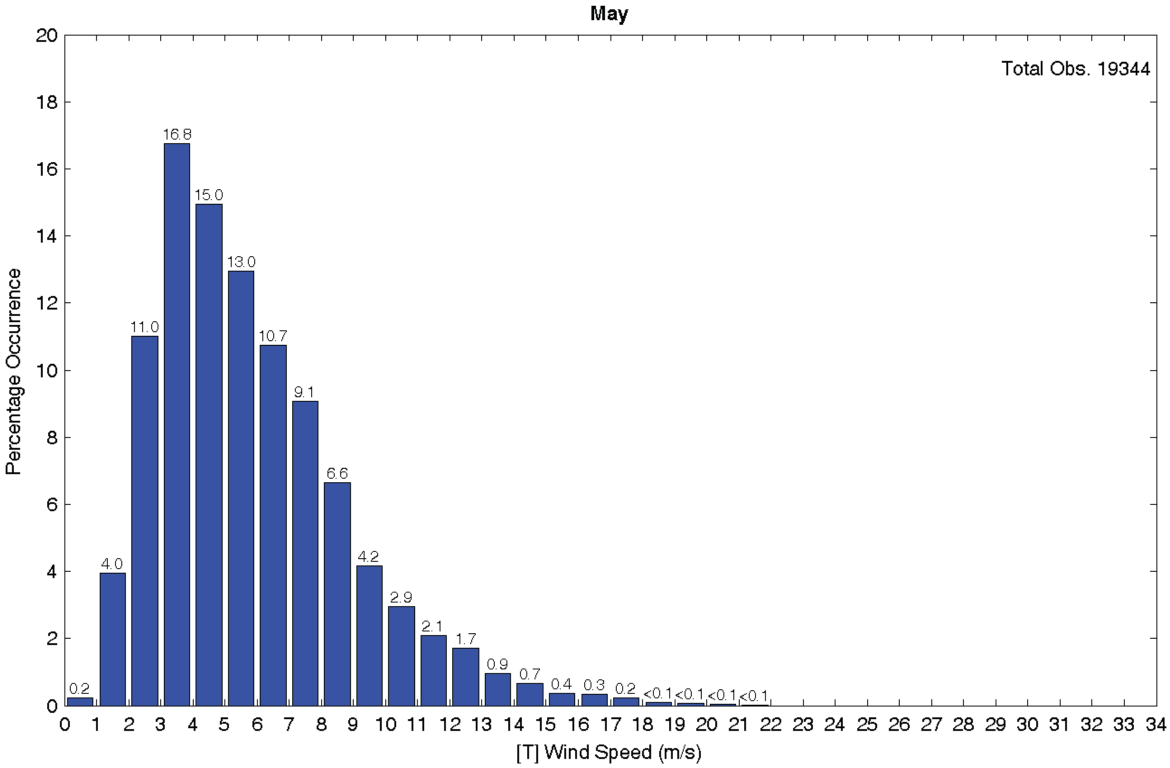


Figure 2-29 Percentage Occurrence of Wind Speed at Hub Height Excluding Hurricanes – May

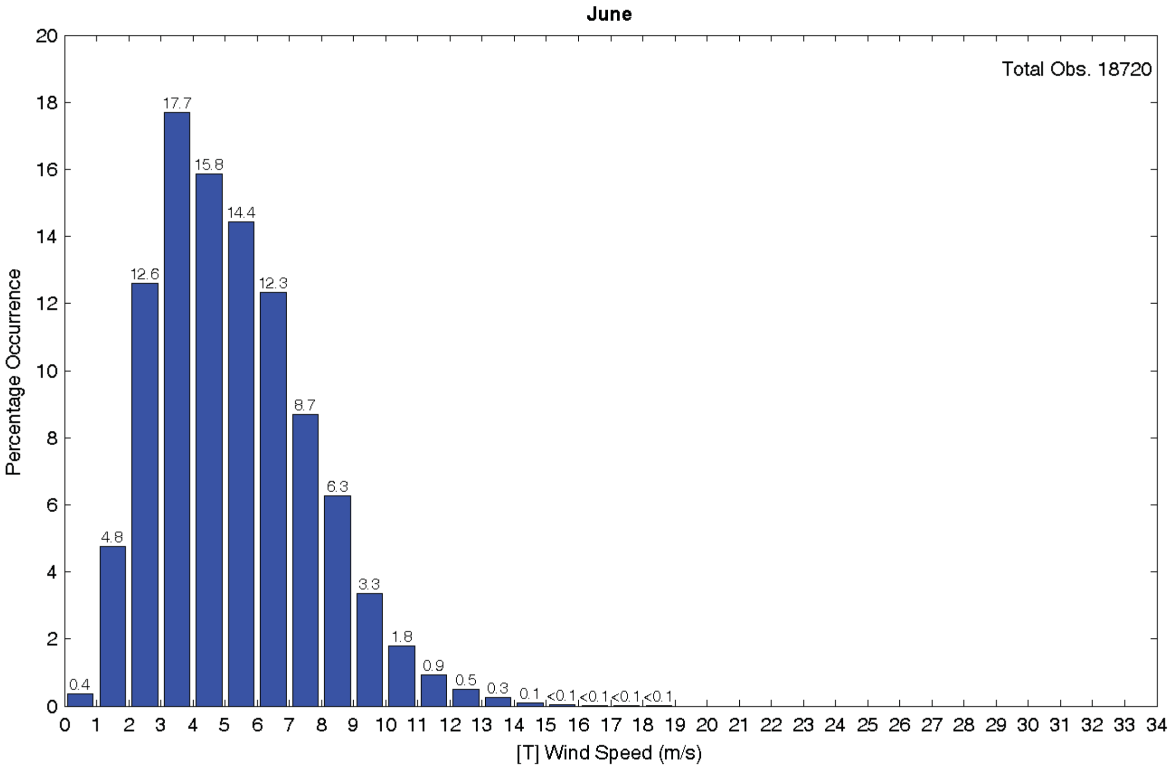


Figure 2-30 Percentage Occurrence of Wind Speed at Hub Height Excluding Hurricanes – June

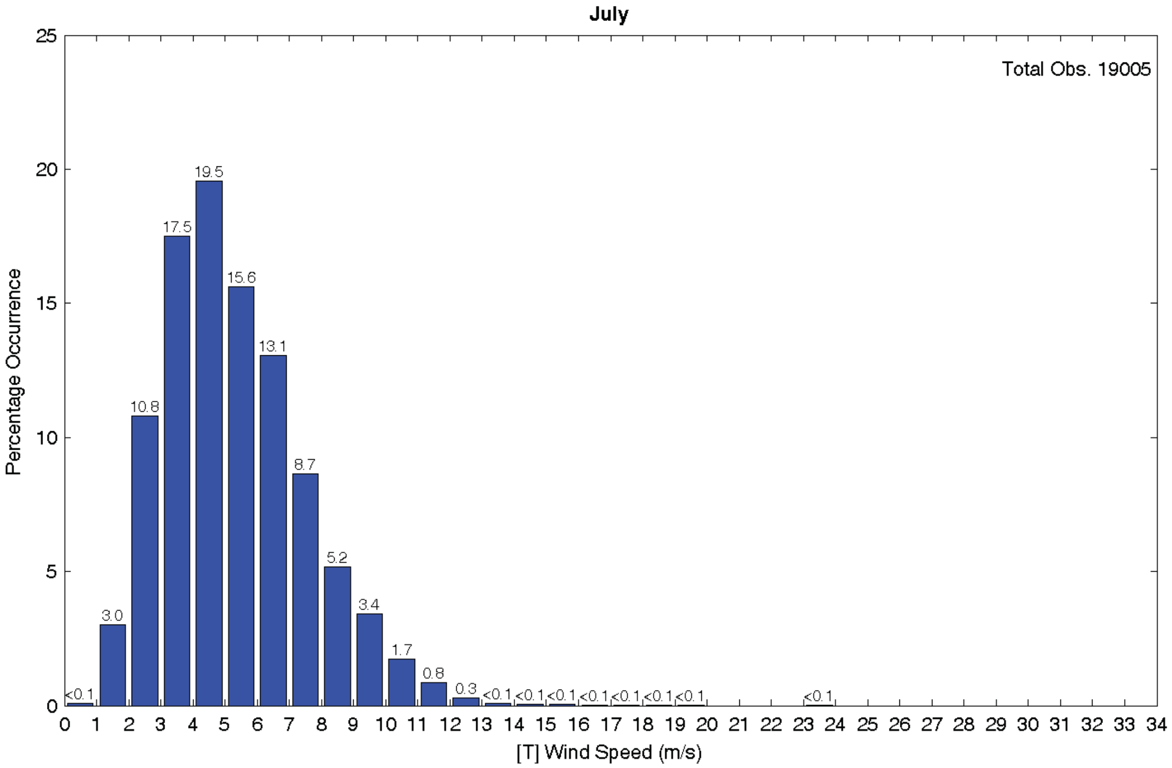


Figure 2-31 Percentage Occurrence of Wind Speed at Hub Height Excluding Hurricanes – July

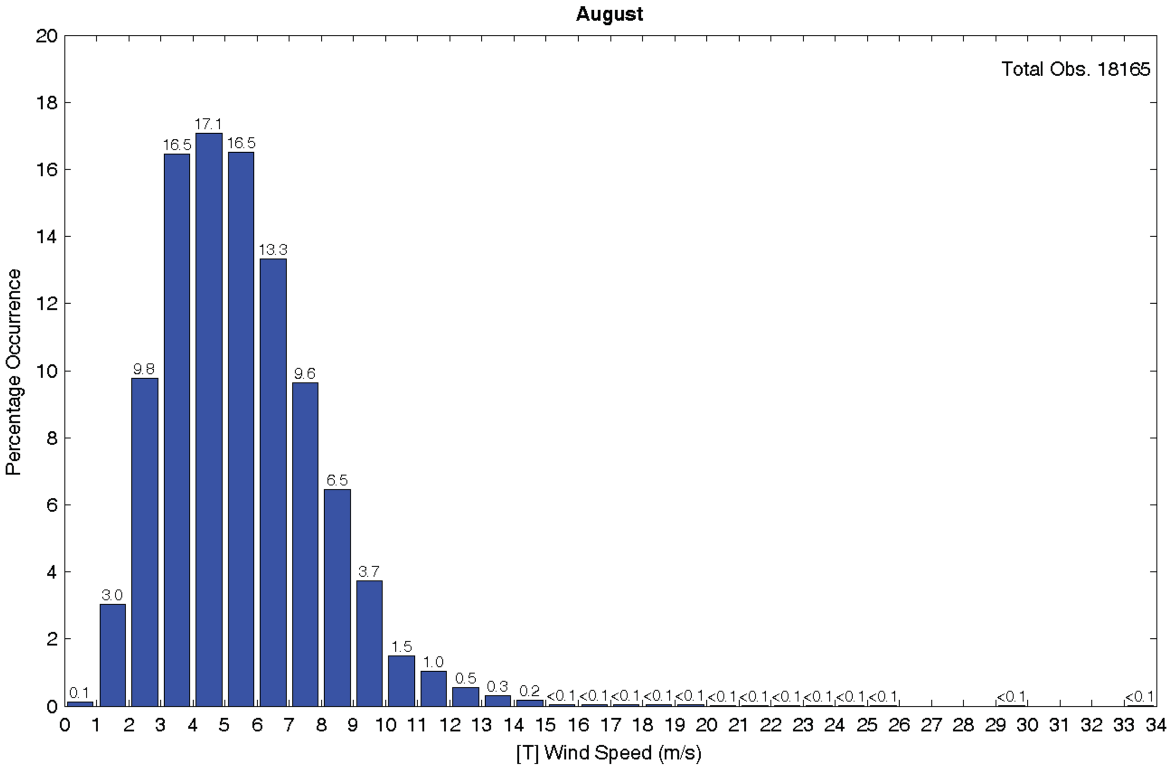


Figure 2-32 Percentage Occurrence of Wind Speed at Hub Height Excluding Hurricanes – August

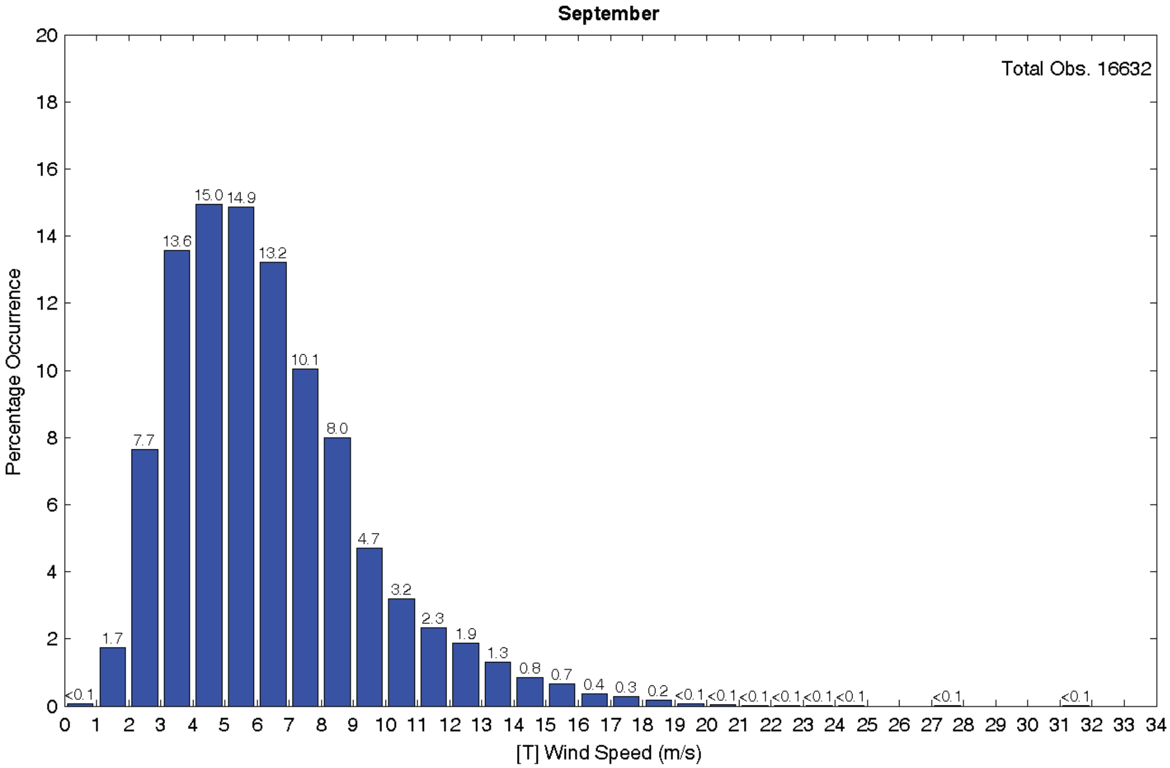


Figure 2-33 Percentage Occurrence of Wind Speed at Hub Height Excluding Hurricanes – September

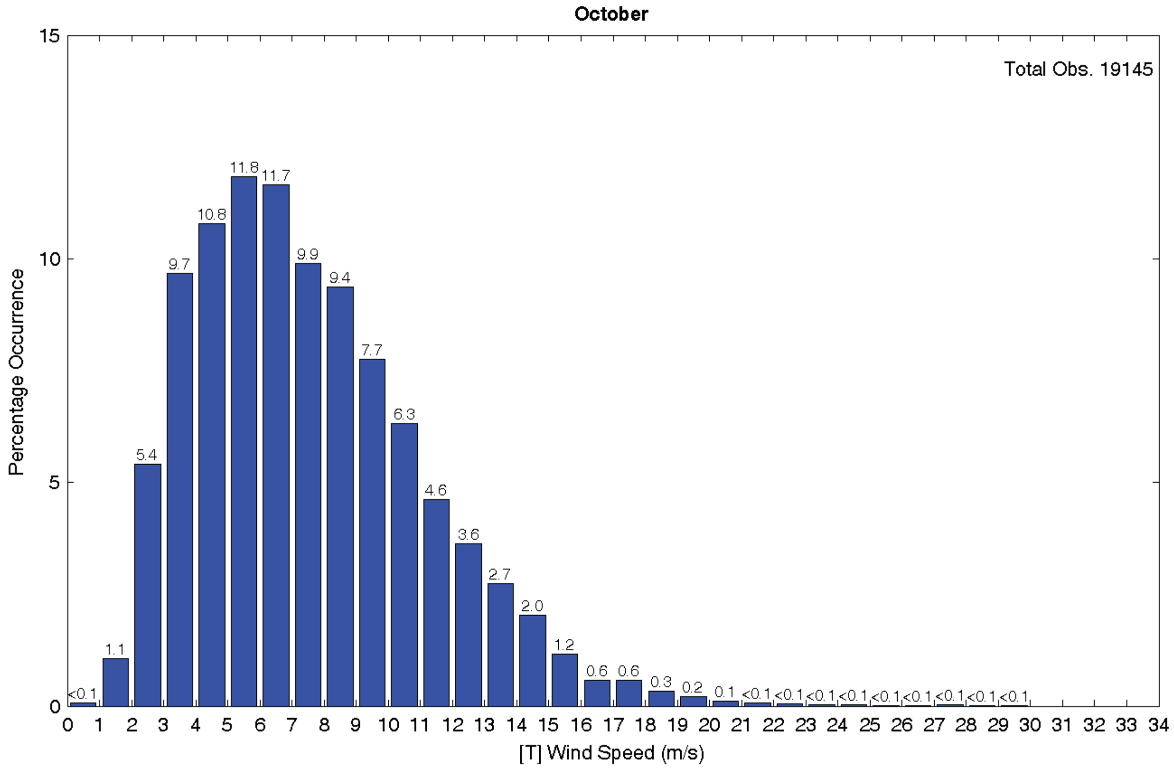


Figure 2-34 Percentage Occurrence of Wind Speed at Hub Height Excluding Hurricanes – October

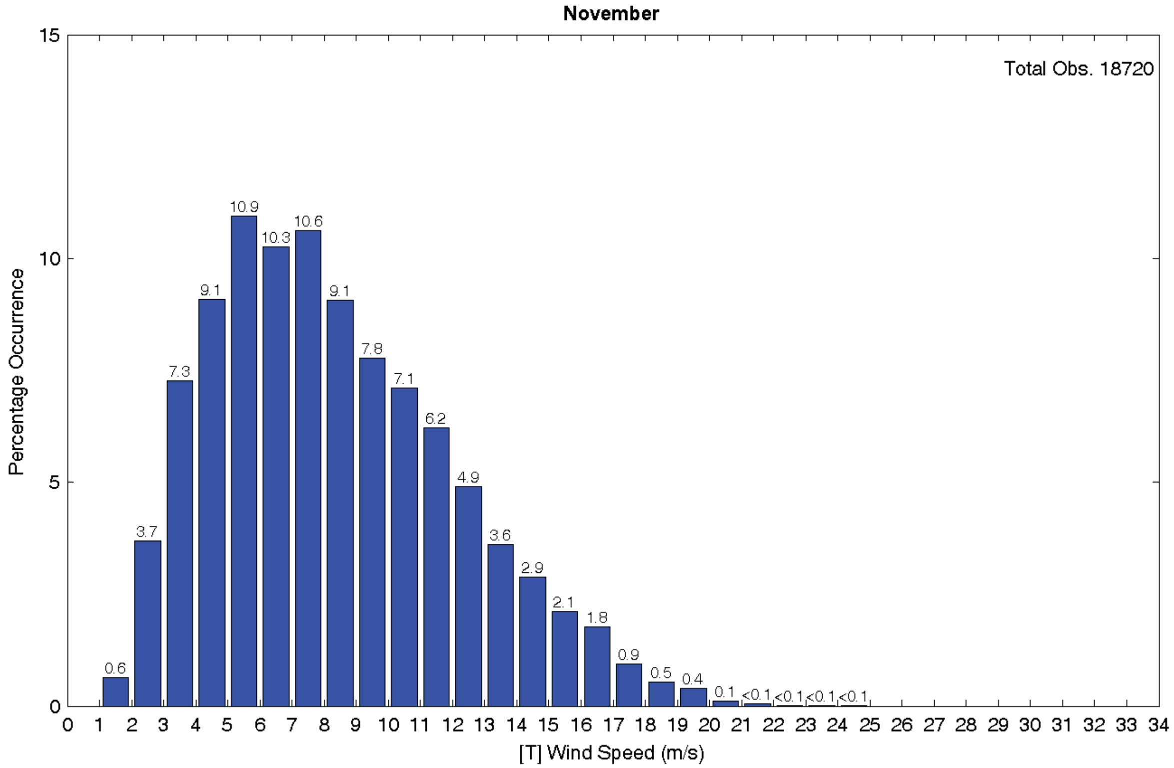


Figure 2-35 Percentage Occurrence of Wind Speed at Hub Height Excluding Hurricanes – November

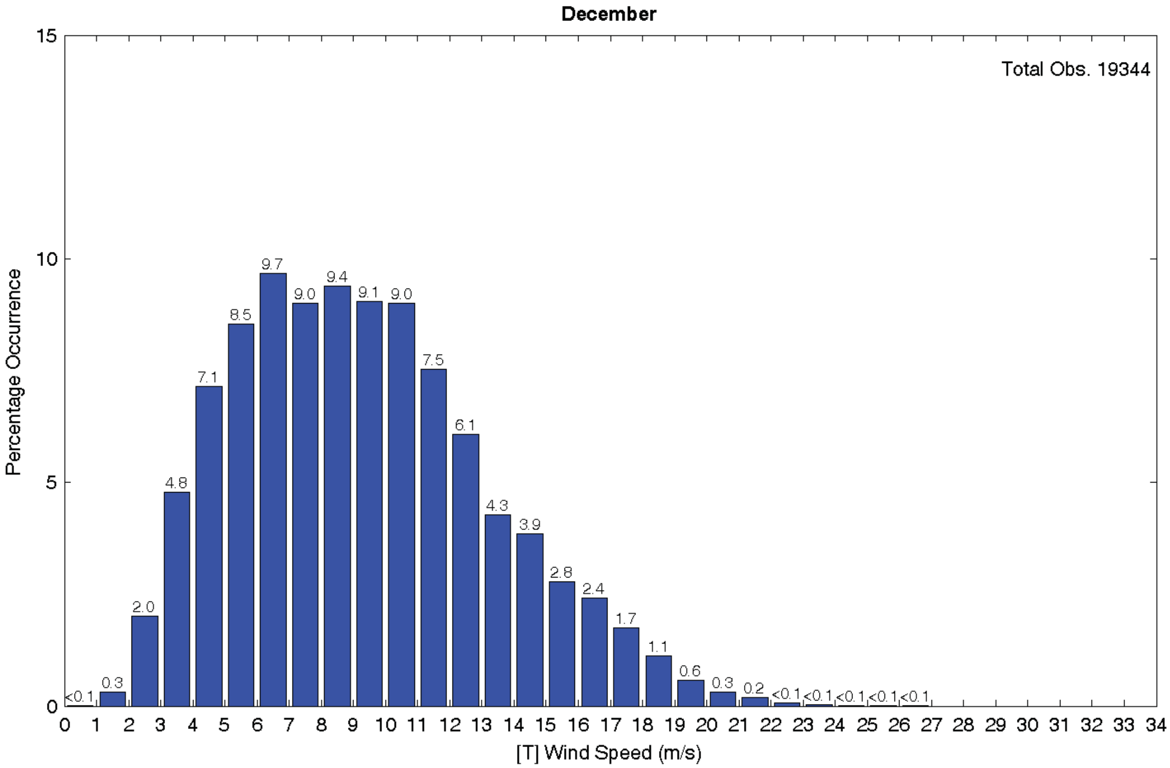


**Figure 2-36 Percentage Occurrence of Wind Speed at Hub Height Excluding Hurricanes – December**

### 2.1.19 Wind Speed Distribution at Hub Height Including Hurricanes

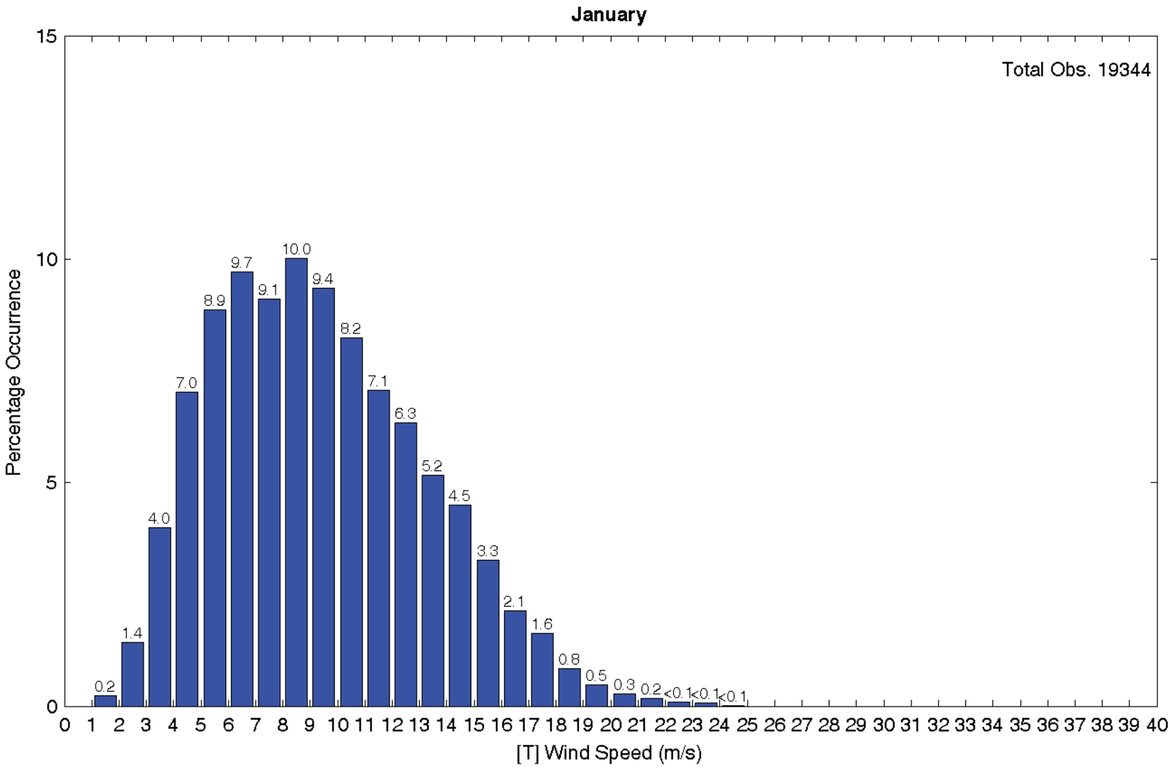


Figure 2-37 Percentage Occurrence of Wind Speed at Hub Height Including Hurricanes – January

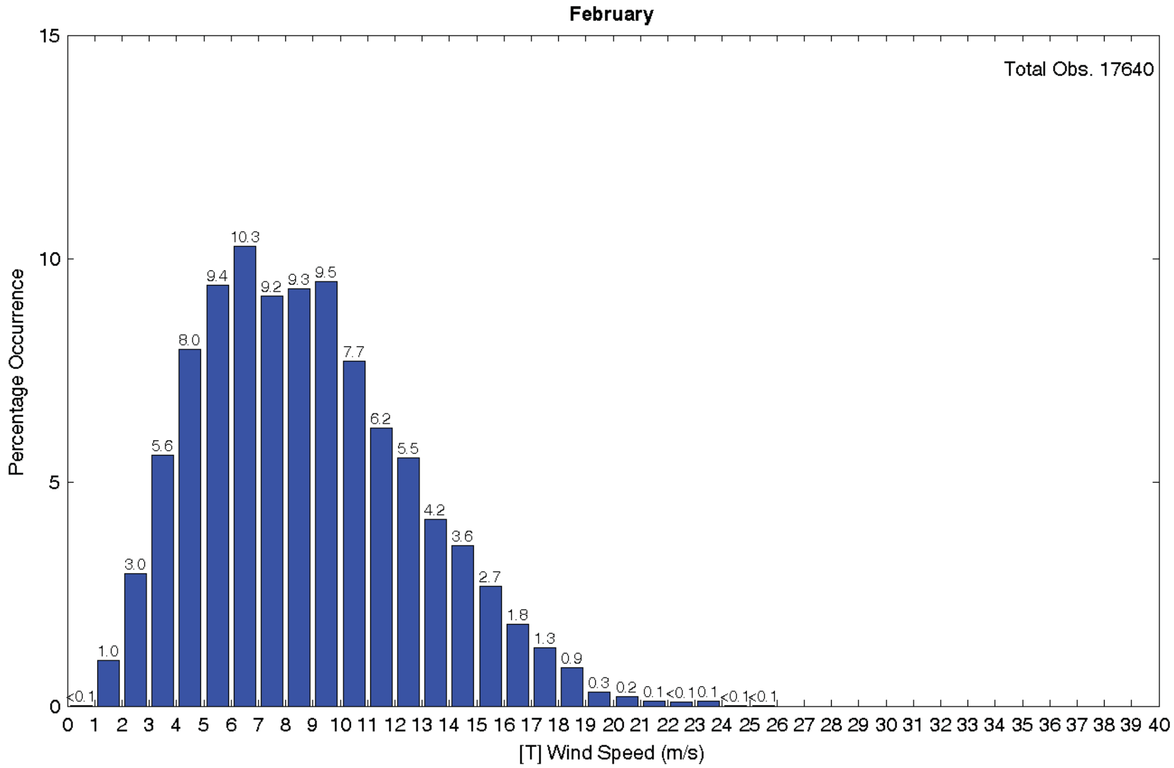


Figure 2-38 Percentage Occurrence of Wind Speed at Hub Height Including Hurricanes – February

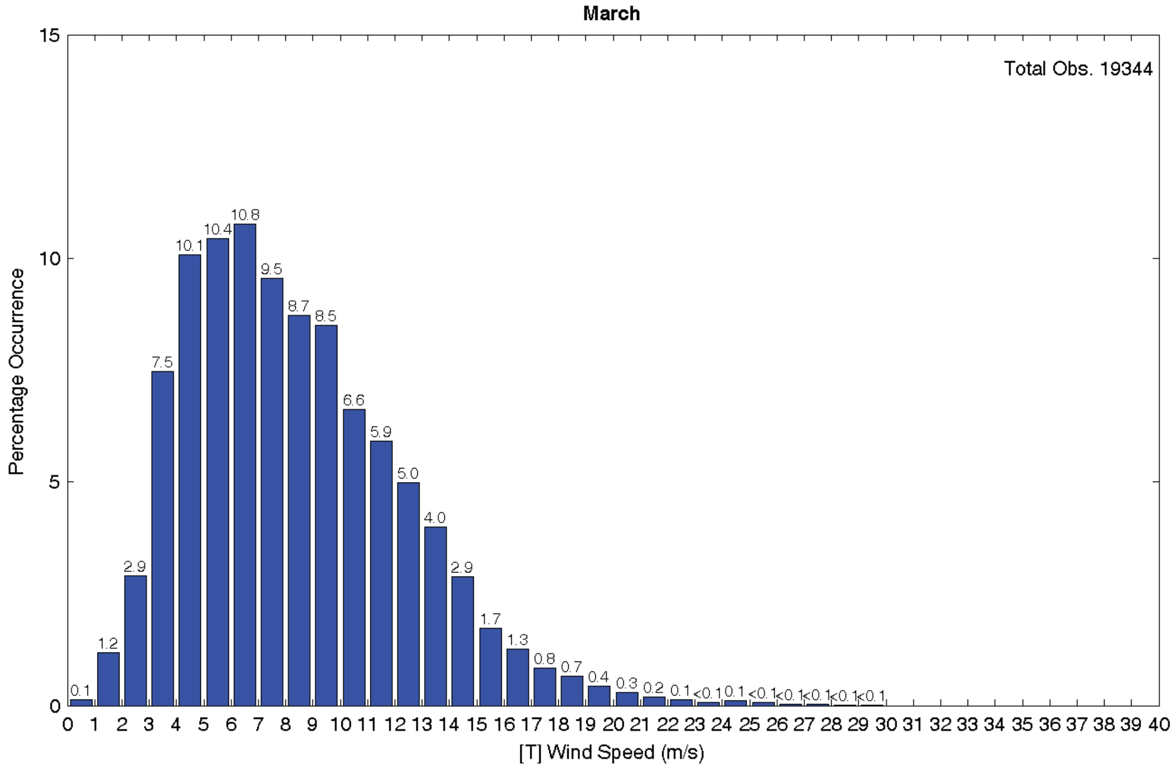


Figure 2-39 Percentage Occurrence of Wind Speed at Hub Height Including Hurricanes – March

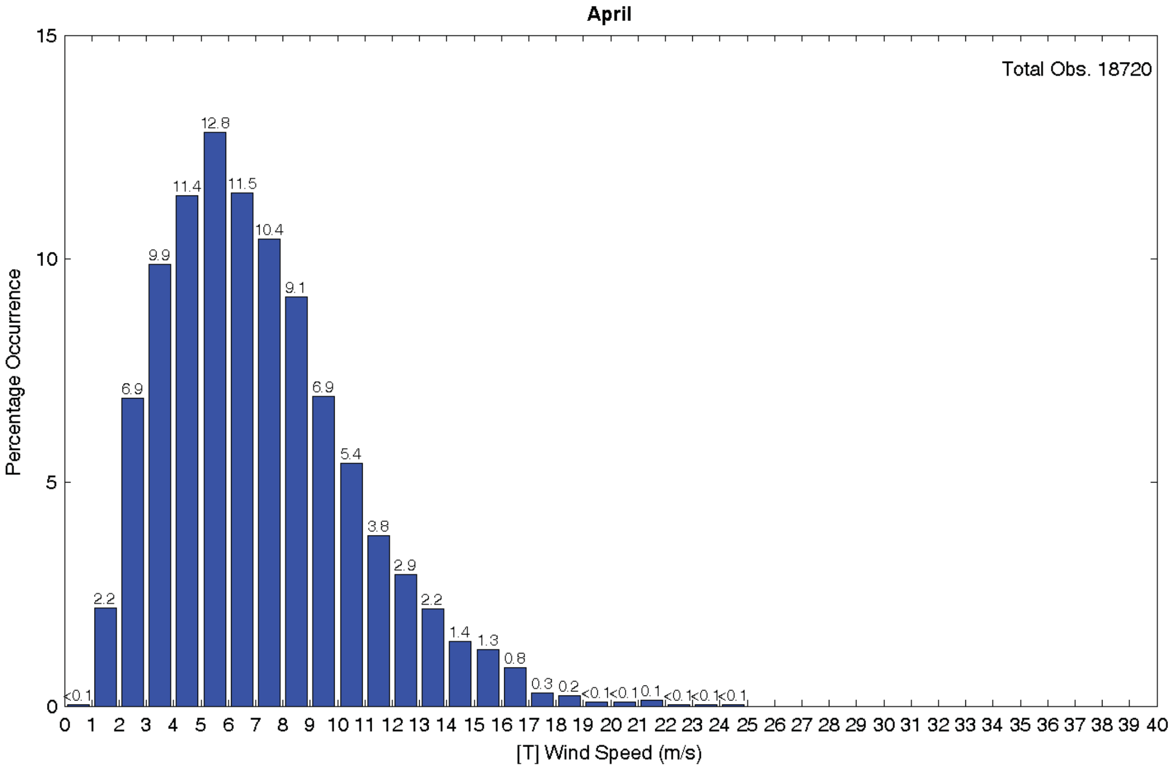


Figure 2-40 Percentage Occurrence of Wind Speed at Hub Height Including Hurricanes – April

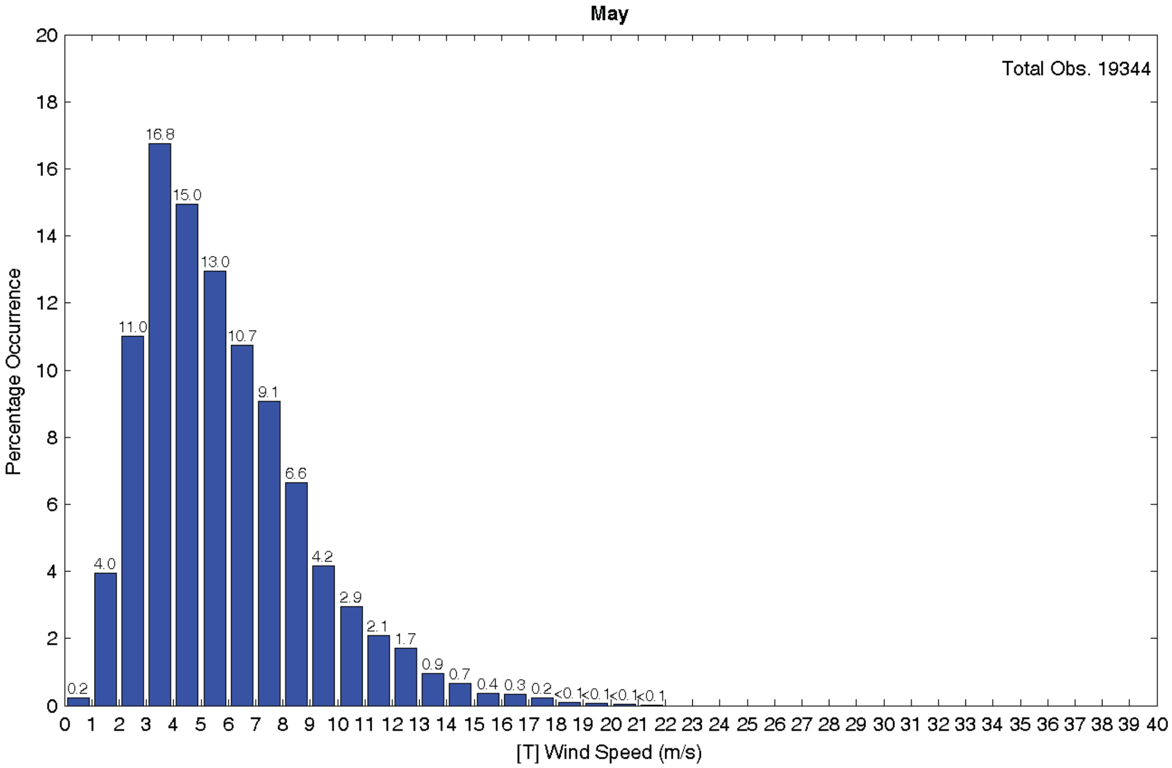


Figure 2-41 Percentage Occurrence of Wind Speed at Hub Height Including Hurricanes – May

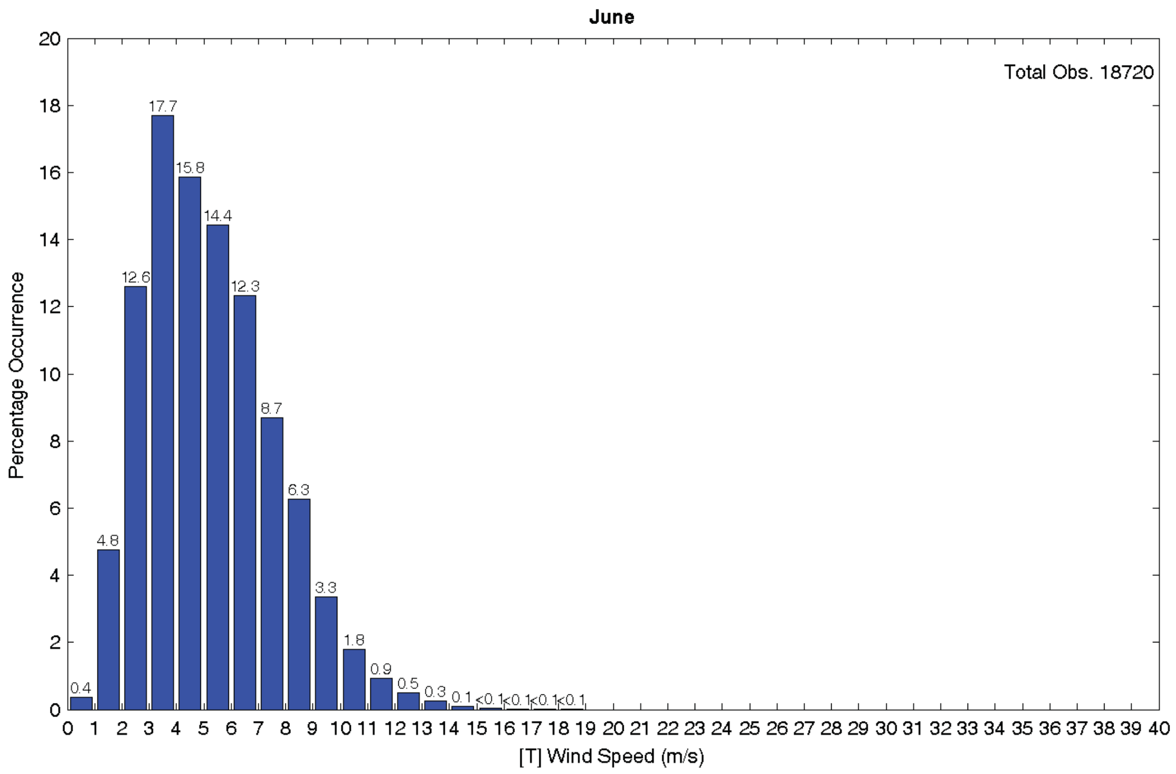


Figure 2-42 Percentage Occurrence of Wind Speed at Hub Height Including Hurricanes – June

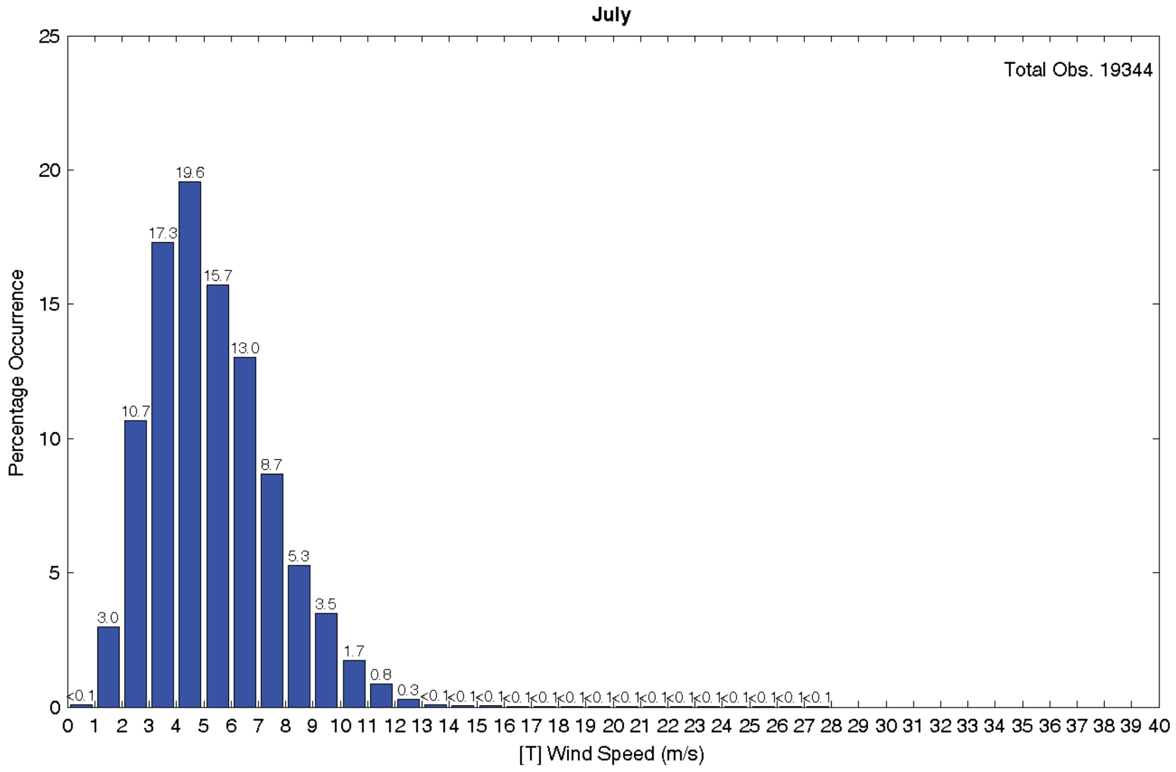


Figure 2-43 Percentage Occurrence of Wind Speed at Hub Height Including Hurricanes – July

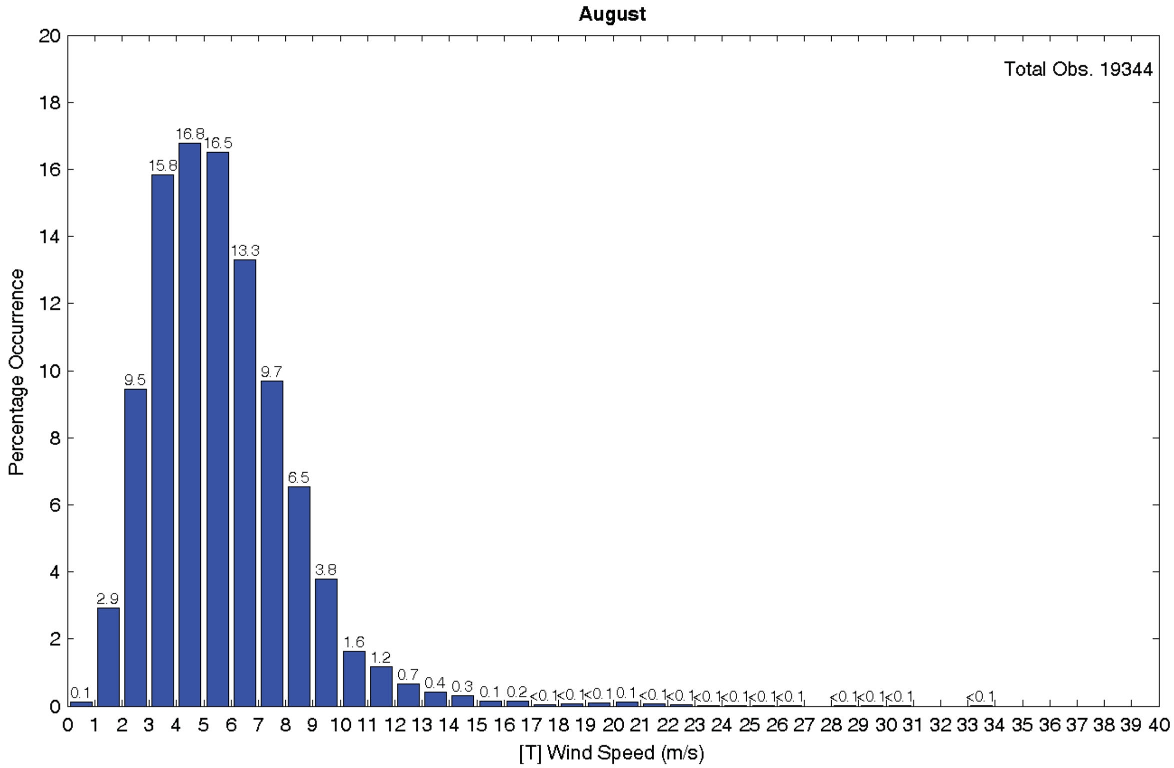


Figure 2-44 Percentage Occurrence of Wind Speed at Hub Height Including Hurricanes – August

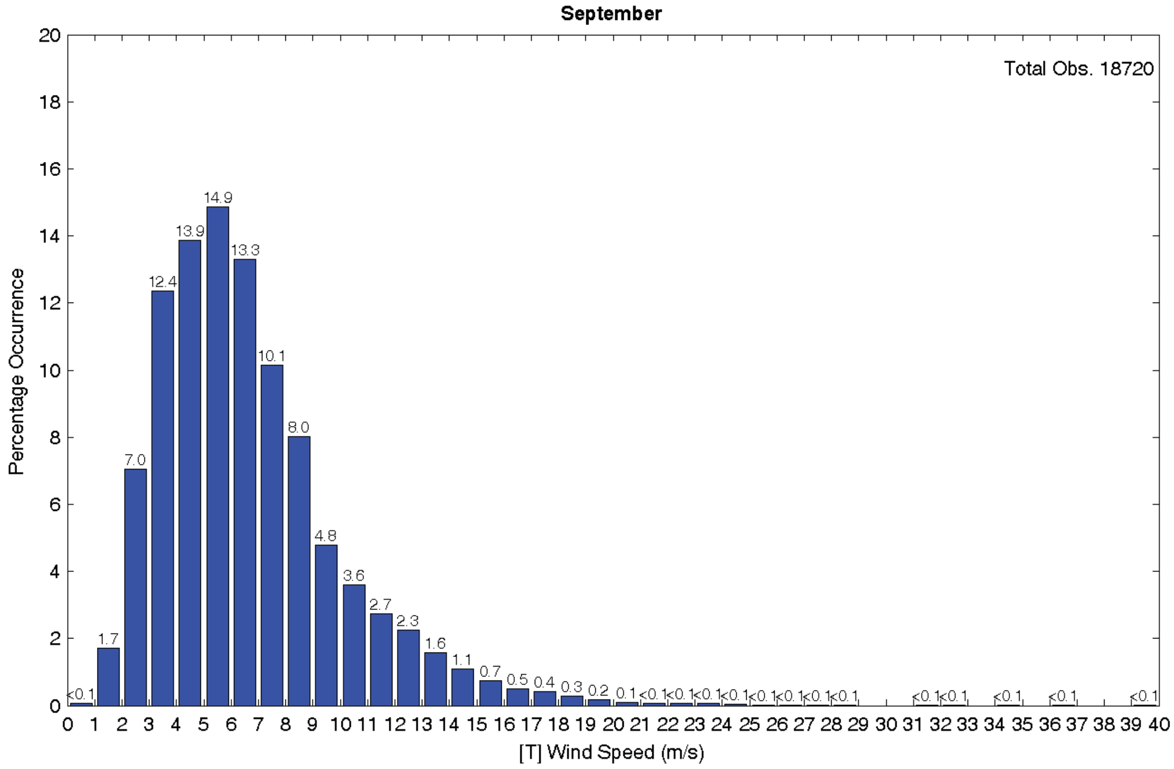


Figure 2-45 Percentage Occurrence of Wind Speed at Hub Height Including Hurricanes – September

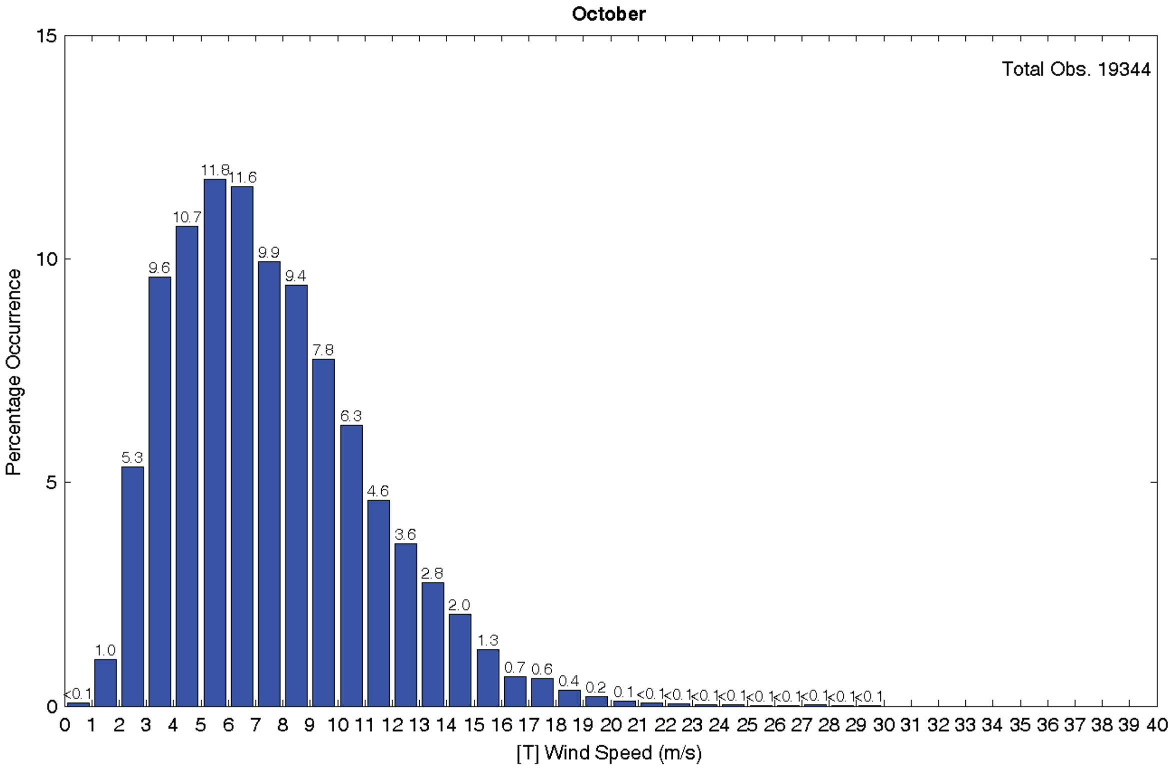


Figure 2-46 Percentage Occurrence of Wind Speed at Hub Height Including Hurricanes – October

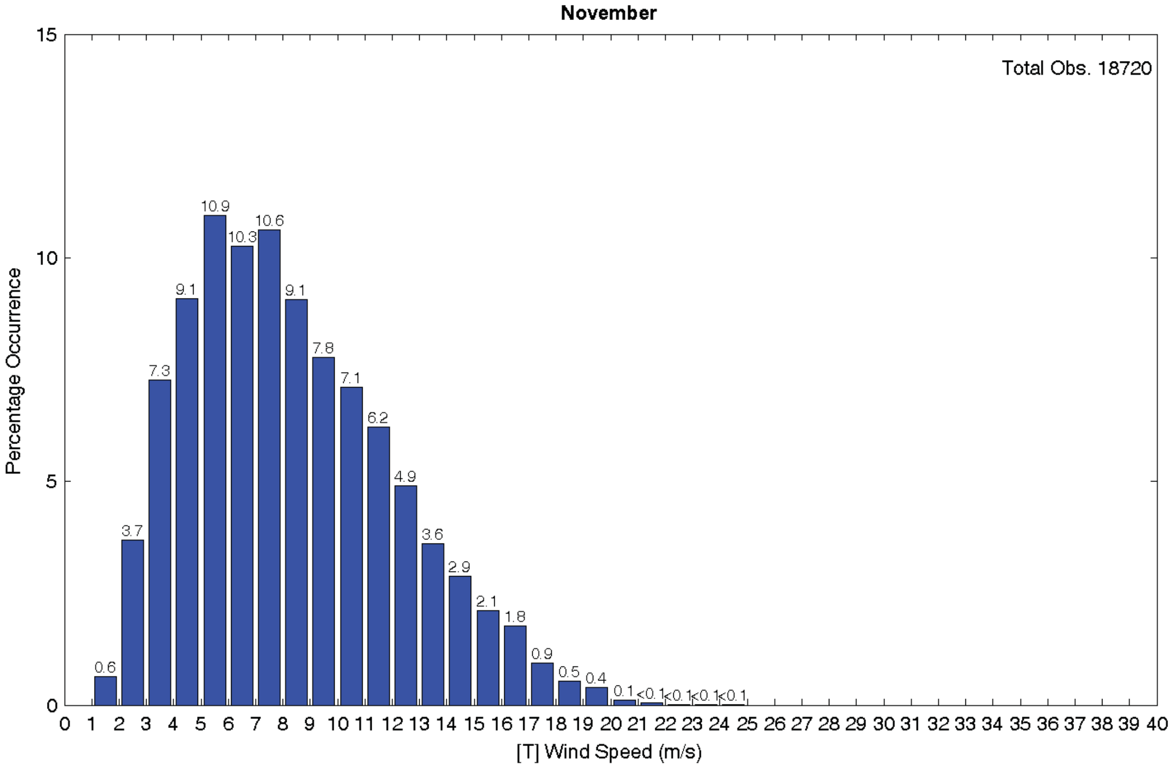


Figure 2-47 Percentage Occurrence of Wind Speed at Hub Height Including Hurricanes – November

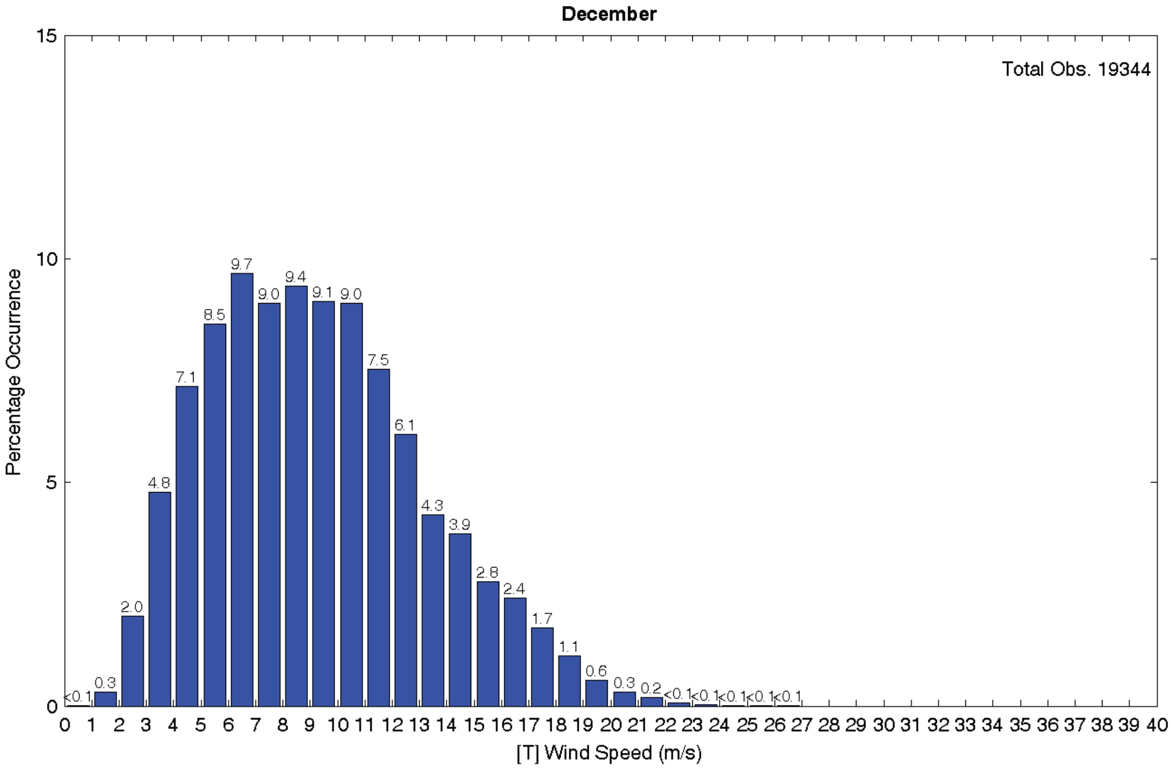


Figure 2-48 Percentage Occurrence of Wind Speed at Hub Height Including Hurricanes – December

### 2.1.20 Wind Speed Turbulence Formula

The equation used for calculating wind speed turbulence, was optained from ISO 19901-1[1]. The equation reads as follows,

$$I_u(z)=(0.06)*[1+0.043*U_{w0}]*(z/z_r)^{-0.22}$$

Where:
Uw0 is the 1hr mean wind speed at 10m above MSL.
$z_r$ - 10m
z - hub height above MSL

### 2.1.21 Wind Speed Formula for Adjusting to Different Elevations

The equation used for adjusting wind speed at different elevations, was optained from ISO 19901-1[1]. The equation reads as follows,

$$U_{w,1hr}\,(z)=U_{w0}[1+C*Ln(z/z_r)]$$
$$C=(0.0573)*(1+0.15*U_{w0})^{1/2}$$

Where $U_{w,1hr}(z)$ is the 1 hour sustained wind speed at a height $z$ above mean sea level. $U_{w0}$ is the 1 hour sustained wind speed at the reference elevation $z_r$ and is the standard reference speed for sustained winds. $z_r$ is the reference elevation above MSL, 10 meters. C is a dimensionally dependent coefficient, the value of which is dependent on the reference elevation and the wind speed. $z$ is the hub height above MSL, 99.587 meters.

Example: $C=0.0981=(0.0573)*(1+0.15*12.87)^{1/2}$, $U_{w,1hr}\,(z)=15.77=12.87[1+0.0981*Ln(99.587/10)]$

### 2.1.22 Wind Speed Shear Model

The wind shear model was optained from IEC 61400-1[2] document. The equation and parameters read as follows,

Transient (positive and negative) vertical shear:

$$V(z,t)=\begin{cases} v_{hub}*(z/z_{hub})^{\alpha}\pm((z-z_{hub})/D)*(2.5*0.2*\beta*\sigma_1*(D/\Lambda_1)^{1/4})*(1-\cos(2*\pi*t/T)) & \text{for} \quad 0\leq t\leq T \\ v_{hub}(z/z_{hub})^{\alpha} & \text{otherwise} \end{cases}$$

Transient horizontal shear:

$$V(y,z,t)=\begin{cases} v_{hub}*(z/z_{hub})^{\alpha}\pm(y/D)*(2.5*0.2*\beta*\sigma_1*(D/\Lambda_1)^{1/4})*(1-\cos(2*\pi*t/T)) & \text{for} \quad 0\leq t\leq T \\ v_{hub}(z/z_{hub})^{\alpha} & \text{otherwise} \end{cases}$$

Where both vertical and horizontal shear:
$\alpha=0.2$; $\beta=6.4$; $T=12$ s;
$\sigma_1=I_{ref}(0.75*v_{hub}+b)$; $b=5.6$ m/s; $I_{ref}$ low = 0.12; $I_{ref}$ medium = 0.14; $I_{ref}$ high = 0.16;
$\Lambda_1=0.7*z$ for $z \leq 60$m; $\Lambda_1=42$ meters for $z \geq 60$m
D is the rotor diameter.

## 2.2 Wave Criteria

### 2.2.1 All Waves for Winter Storms

Extreme value analysis was carried out on a subset of peak wave heights from the Oceanweather hindcast data. The analysis only considered winter storm events from 1957 to 2003. The 1-year criteria are derive from 26-years (1980 to 2005) Oceanweather operational hindcast data. For platform elevation and Hc see section 2.2.24.

### 2.2.2 Omni-Directiona 1 Year Extreme Values

| Return Period | Hs | Tz | Tp | Hc | Hmax | THmax Low | THmax Mid | THmax High | Wave Length |
|---|---|---|---|---|---|---|---|---|---|
| | [m] | [s] | [s] | [m] | [m] | [s] | [s] | [s] | [m] |
| **1-Year** | 5.34 | 6.5 | 9.9 | 6.22 | 10.01 | 8.8 | 10.0 | 10.9 | 128.0 |

**Table 2-16 Omni-Directional 1 Year Extreme Values for All Waves**

### 2.2.3 Directional 1 Year Extreme Values

| Return Period | Hs | Tz | Tp | Hc | Hmax | THmax Low | THmax Mid | THmax High |
|---|---|---|---|---|---|---|---|---|
| **Direction [from]** | **[m]** | **[s]** | **[s]** | **[m]** | **[m]** | **[s]** | **[s]** | **[s]** |
| **1-Year** | **5.34** | **6.5** | **9.9** | **6.22** | **10.01** | **8.8** | **10.0** | **10.9** |
| North | 3.76 | 6.1 | 8.4 | 4.38 | 7.05 | 7.4 | 8.4 | 9.2 |
| North-east | 4.26 | 6.3 | 8.9 | 4.96 | 7.98 | 7.9 | 8.9 | 9.7 |
| East | 5.34 | 6.5 | 9.9 | 6.22 | 10.01 | 8.8 | 10.0 | 10.9 |
| South-east | 5.14 | 6.5 | 9.7 | 5.99 | 9.64 | 8.6 | 9.8 | 10.7 |
| South | 4.35 | 6.3 | 9.0 | 5.07 | 8.16 | 7.9 | 9.0 | 9.8 |
| South-west | 3.88 | 6.2 | 8.5 | 4.52 | 7.27 | 7.5 | 8.5 | 9.3 |
| West | 3.31 | 6.0 | 7.9 | 3.86 | 6.21 | 7.0 | 7.9 | 8.6 |
| North-west | 3.24 | 6.0 | 7.8 | 3.78 | 6.08 | 6.9 | 7.8 | 8.5 |

**Table 2-17 Directional 1 Year Extreme Values for All Waves**

### 2.2.4 1-Year Wave Fitting Parameters

The independent omni-directional wave cases are given in Table 2-16 and detailed descriptions of the calculations are given below. The analysis considered 26-years (1980 to 2005) Oceanweather operational hindcast data.

Cumulative frequency extrapolation involves grouping all the parameter values in the data set using specified class intervals and then forming a cumulative frequency distribution (cfd) by summing the number of observations greater than or equal to the lower bound of the class interval. This method was then employed to derive the 1-year criteria.

The Exponential (EXP), Fisher-Tippett 1 (FT1), Fisher-Tippett 2 (FT2), Fisher-Tippett 3 (FT3), Weibull 2 (W2) and Weibull 3 (W3) distributions were tested for goodness-of-fit to the OceanWeather data using the method of least squares (LS). The best fits for the 1-year wind speed are summarised in Table 2-18.

| | Distribution | Fit | Threshold | # Peaks | Extreme Values |
|---|---|---|---|---|---|
| | | | | | 1-yr |
| Hs (m) | EXP | LS | 90.00 | 116297 | 5.37 |
| | EXP | LS | 10.00 | 22529 | 5.34 |
| | FT1 | LS | 95.00 | 214551 | 5.34 |
| | FT2 | LS | 95.00 | 214551 | 5.34 |
| | FT2 | LS | 10.00 | 22529 | 5.33 |
| | FT3 | LS | 95.00 | 214551 | 5.33 |
| | FT3 | LS | 90.00 | 116297 | 5.33 |
| | FT3 | LS | 50.00 | 52040 | 5.33 |
| | FT3 | LS | 10.00 | 22529 | 5.33 |
| | FT3 | LS | 5.00 | 8776 | 5.34 |
| | AVERAGE | | | | 5.34 |

Table 2-18 Extreme Omni-directional All Wave Fitting Parameters for 1-year Extreme

## 2.2.5 Omni-Directional Winter Storm Extreme Values

| Return Period | Hs | Tz | Tp | Hc | Hmax | THmax Low | THmax Mid | THmax High | Wave Length |
|---|---|---|---|---|---|---|---|---|---|
| | [m] | [s] | [s] | [m] | [m] | [s] | [s] | [s] | [m] |
| **50-years** | 6.25 | 7.3 | 10.6 | 7.35 | 11.69 | 9.4 | 10.6 | 11.6 | 140.62 |
| **100-years** | 6.83 | 7.6 | 11.0 | 8.03 | 12.77 | 9.8 | 11.1 | 12.1 | 149.32 |
| **500-years** | 8.16 | 8.0 | 12.0 | 9.60 | 15.28 | 10.7 | 12.1 | 13.2 | 168.74 |
| **1000-years** | 8.74 | 8.2 | 12.4 | 10.28 | 16.36 | 11.0 | 12.5 | 13.6 | 176.97 |
| **10000-years** | 10.65 | 8.8 | 13.7 | 12.53 | 19.94 | 12.1 | 13.8 | 15.0 | 203.32 |

Table 2-19 Omni-Directional Winter Storm Extreme Values for All Waves

## 2.2.6 Directional Winter Storm Extreme Values

| Return Period | Hs | Tz | Tp | Hc | Hmax | THmax Low | THmax Mid | THmax High |
|---|---|---|---|---|---|---|---|---|
| **Direction [from]** | [m] | [s] | [s] | [m] | [m] | [s] | [s] | [s] |
| **50-Years** | **6.25** | **7.3** | **10.6** | **7.35** | **11.69** | **9.4** | **10.6** | **11.6** |
| North | 4.49 | 6.6 | 9.0 | 5.28 | 8.40 | 8.0 | 9.0 | 9.9 |
| North-east | 6.25 | 7.3 | 10.6 | 7.35 | 11.69 | 9.4 | 10.6 | 11.6 |
| East | 4.88 | 6.7 | 9.4 | 5.74 | 9.13 | 8.3 | 9.4 | 10.3 |
| South-east | 5.98 | 7.2 | 10.3 | 7.03 | 11.19 | 9.2 | 10.4 | 11.3 |
| South | 5.19 | 6.9 | 9.7 | 6.10 | 9.71 | 8.6 | 9.7 | 10.6 |
| South-west | 4.60 | 6.6 | 9.1 | 5.41 | 8.61 | 8.1 | 9.2 | 10.0 |
| West | 3.57 | 6.1 | 8.1 | 4.20 | 6.69 | 7.1 | 8.1 | 8.8 |
| North-west | 3.72 | 6.1 | 8.2 | 4.37 | 6.96 | 7.3 | 8.3 | 9.0 |
| **100-Years** | **6.83** | **7.6** | **11.0** | **8.03** | **12.77** | **9.8** | **11.1** | **12.1** |
| North | 4.90 | 6.8 | 9.4 | 5.77 | 9.17 | 8.3 | 9.4 | 10.3 |
| North-east | 6.83 | 7.6 | 11.0 | 8.03 | 12.77 | 9.8 | 11.1 | 12.1 |
| East | 5.33 | 7.0 | 9.8 | 6.27 | 9.97 | 8.7 | 9.8 | 10.7 |
| South-east | 6.53 | 7.5 | 10.8 | 7.68 | 12.22 | 9.6 | 10.8 | 11.8 |
| South | 5.67 | 7.1 | 10.1 | 6.67 | 10.61 | 8.9 | 10.1 | 11.0 |
| South-west | 5.03 | 6.8 | 9.5 | 5.91 | 9.41 | 8.4 | 9.6 | 10.4 |
| West | 3.90 | 6.3 | 8.4 | 4.59 | 7.31 | 7.5 | 8.5 | 9.2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| North-west | 4.06 | 6.3 | 8.6 | 4.78 | 7.60 | 7.6 | 8.6 | 9.4 |
| **500-Years** | **8.16** | **8.0** | **12.0** | **9.60** | **15.28** | **10.7** | **12.1** | **13.2** |
| North | 5.86 | 7.2 | 10.2 | 6.90 | 10.97 | 9.1 | 10.3 | 11.2 |
| North-east | 8.16 | 8.0 | 12.0 | 9.60 | 15.28 | 10.7 | 12.1 | 13.2 |
| East | 6.37 | 7.4 | 10.7 | 7.50 | 11.93 | 9.5 | 10.7 | 11.7 |
| South-east | 7.81 | 7.9 | 11.8 | 9.19 | 14.62 | 10.4 | 11.8 | 12.9 |
| South | 6.78 | 7.5 | 11.0 | 7.98 | 12.69 | 9.7 | 11.0 | 12.0 |
| South-west | 6.01 | 7.2 | 10.4 | 7.07 | 11.25 | 9.2 | 10.4 | 11.4 |
| West | 4.67 | 6.6 | 9.2 | 5.49 | 8.74 | 8.1 | 9.2 | 10.1 |
| North-west | 4.86 | 6.7 | 9.3 | 5.71 | 9.09 | 8.3 | 9.4 | 10.2 |
| **1000-Years** | **8.74** | **8.2** | **12.4** | **10.28** | **16.36** | **11.0** | **12.5** | **13.6** |
| North | 6.28 | 7.4 | 10.6 | 7.38 | 11.74 | 9.4 | 10.6 | 11.6 |
| North-east | 8.74 | 8.2 | 12.4 | 10.28 | 16.36 | 11.0 | 12.5 | 13.6 |
| East | 6.82 | 7.6 | 11.0 | 8.03 | 12.77 | 9.8 | 11.1 | 12.1 |
| South-east | 8.36 | 8.1 | 12.2 | 9.84 | 15.65 | 10.8 | 12.2 | 13.3 |
| South | 7.26 | 7.7 | 11.4 | 8.54 | 13.58 | 10.1 | 11.4 | 12.5 |
| South-west | 6.44 | 7.4 | 10.7 | 7.57 | 12.05 | 9.5 | 10.8 | 11.7 |
| West | 5.00 | 6.8 | 9.5 | 5.88 | 9.36 | 8.4 | 9.5 | 10.4 |
| North-west | 5.20 | 6.9 | 9.7 | 6.12 | 9.73 | 8.6 | 9.7 | 10.6 |
| **10000-Years** | **10.65** | **8.8** | **13.7** | **12.53** | **19.94** | **12.1** | **13.8** | **15.0** |
| North | 7.65 | 7.9 | 11.7 | 9.00 | 14.32 | 10.3 | 11.7 | 12.8 |
| North-east | 10.65 | 8.8 | 13.7 | 12.53 | 19.94 | 12.1 | 13.8 | 15.0 |
| East | 8.32 | 8.1 | 12.1 | 9.78 | 15.56 | 10.8 | 12.2 | 13.3 |
| South-east | 10.19 | 8.7 | 13.4 | 11.99 | 19.08 | 11.9 | 13.5 | 14.7 |
| South | 8.85 | 8.3 | 12.5 | 10.41 | 16.56 | 11.1 | 12.6 | 13.7 |
| South-west | 7.85 | 7.9 | 11.8 | 9.23 | 14.68 | 10.5 | 11.9 | 12.9 |
| West | 6.09 | 7.3 | 10.4 | 7.17 | 11.40 | 9.2 | 10.5 | 11.4 |
| North-west | 6.34 | 7.4 | 10.6 | 7.46 | 11.86 | 9.4 | 10.7 | 11.7 |

**Table 2-20 Directional Winter Storm Extreme Values for All Waves**

### 2.2.7 All Wave Fitting Parameters for Winter Storm

The independent omni-directional wave cases are given in Table 2-19 and detailed descriptions of the calculations are given below.

Extreme value analysis was carried out on a subset of peak wave heights from the OceanWeather data. The analysis only considered winter storm events from 1957 to 2003.

The Peaks Over Threshold (POT) method consisted of declustering the data by selecting peak events to produce a set of independent and identically distributed observations. This method was then employed to derive the 50-, 100-, 500-, 1000-, and 10000-year criteria. The number of peaks exceeding a given level, divided by the number of years of record, gave the rate of exceedance which could then be used to find the expected number of occurrences in a specified period of time.

The Exponential (EXP), Fisher-Tippett 1 (FT1), Generalised Pareto (GP), Weibull 2 (W2) and Weibull 3 (W3) distributions were tested for goodness-of-fit to the OceanWeather data using the method of least squares (LS), maximum likelihood (MLE), and the method of moments (MoM). The best fits for 50-, 100-, 500-, 1000-, and 10000-year significant wave height are summarised in Table 2-21.

|  | Distribution | Fit | Threshold | # Peaks | Extreme Values |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  | 50-yr | 100-yr | 500-yr | 1000-yr | 10000-yr |
| Hs (m) | EXP | MLE | 2.69 | 50 | 6.54 | 7.21 | 8.75 | 9.42 | 11.63 |
|  | EXP | MoM | 2.69 | 50 | 6.05 | 6.60 | 7.89 | 8.44 | 10.27 |
|  | EXP | MoM | 1.54 | 85 | 6.46 | 7.13 | 8.69 | 9.35 | 11.57 |
|  | FT1 | LS | 2.69 | 50 | 6.07 | 6.56 | 7.69 | 8.18 | 9.79 |
|  | FT1 | LS | 1.54 | 85 | 6.27 | 6.84 | 8.15 | 8.71 | 10.57 |
|  | FT1 | MoM | 0.74 | 99 | 6.33 | 6.93 | 8.32 | 8.91 | 10.90 |
|  | FT1 | MoM | 1.09 | 96 | 6.24 | 6.82 | 8.16 | 8.74 | 10.65 |
|  | FT1 | MoM | 1.54 | 85 | 6.03 | 6.55 | 7.76 | 8.28 | 10.01 |
|  | FT1 | MLE | 1.09 | 96 | 6.48 | 7.10 | 8.53 | 9.15 | 11.19 |
|  | FT1 | MLE | 1.54 | 85 | 6.00 | 6.52 | 7.72 | 8.24 | 9.96 |
|  | AVERAGE |  |  |  | 6.25 | 6.83 | 8.16 | 8.74 | 10.65 |

**Table 2-21 Extreme Omni-directional All Wave Fitting Parameters for Winter Storm**

### 2.2.8 Wave Height and Length for Winter Storms for Site 1 and 2

Wave Length is calculated using the omni-directional winter storm extreme values found in Table 2-16 and Table 2-19 with the associated depths for each site.

| Extreme Wave Criteria at Site 1 |  | Return Period |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
|  |  | 1-year | 50-year | 100-year | 500-year | 1000-year | 10000-year |
| Significant Wave Height (m) |  | 5.34 | 6.25 | 6.83 | 8.16 | 8.74 | 10.65 |
| Peak Period (s) |  | 9.9 | 10.57 | 11.03 | 12.03 | 12.44 | 13.69 |
| Wave Length (m) | Total Water Depth 24.7m | 130.59 | 143.59 | 152.53 | 172.34 | 180.69 | 207.29 |

**Table 2-22 Extreme Wave and Associated Wave Length for Winter Storms at Site 1**

| Extreme Wave Criteria at Site 2 |  | Return Period |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
|  |  | 1-year | 50-year | 100-year | 500-year | 1000-year | 10000-year |
| Significant Wave Height (m) |  | 5.34 | 6.25 | 6.83 | 8.16 | 8.74 | 10.65 |
| Peak Period (s) |  | 9.9 | 10.57 | 11.03 | 12.03 | 12.44 | 13.69 |
| Wave Length (m) | Total Water Depth 25.4m | 131.60 | 144.75 | 153.79 | 173.78 | 182.19 | 208.91 |

**Table 2-23 Extreme Wave and Associated Wave Length for Winter Storms at Site 2**

### 2.2.9 Wave Orbital Velocity at 1m Above Seabed for Winter Storms for Site 1 and 2

Orbital velocity at 1 m above seabed is calculated using the omni-directional winter storm extreme values found in Table 2-16 and Table 2-19 with associated depths at each site. Table 2-25 and Table 2-27 show wave orbital velocity using Hmax and Tp associated with Hmax (THmax high). Unable to compute wave orbital velocity for the 10000 year event because the wave is a breaking wave.

| Extreme Wave Criteria at Site 1 | | Return Period | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1-year | 50-year | 100-year | 500-year | 1000-year | 10000-year |
| Significant Wave Height (m) | | 5.34 | 6.25 | 6.83 | 8.16 | 8.74 | 10.65 |
| Peak Period (s) | | 9.9 | 10.57 | 11.03 | 12.03 | 12.44 | 13.69 |
| Wave Orbital Velocity (m/s) at 1m above seabed | Total Water Depth 24.7m | 1.12 | 1.41 | 1.60 | 2.04 | 2.23 | 2.86 |

Table 2-24 Extreme Wave and Associated Wave Orbital Velocity at 1m Above Seabed for Winter Storms at Site 1

| Extreme Wave Criteria at Site 1 | | Return Period | | | | |
|---|---|---|---|---|---|---|
| | | 1-year | 50-year | 100-year | 500-year | 1000-year |
| Hmax (m) | | 10.01 | 11.69 | 12.77 | 15.28 | 16.36 |
| Peak Period Associated with Hmax (s) | | 10.9 | 11.6 | 12.1 | 13.2 | 13.6 |
| Wave Orbital Velocity (m/s) at 1m above seabed | Total Water Depth 24.7m | 2.26 | 2.75 | 3.04 | 3.61 | 3.73 |

Table 2-25 Extreme Hmax and Associated Wave Orbital Velocity at 1m Above Seabed for Winter Storms at Site 1

| Extreme Wave Criteria at Site 2 | | Return Period | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1-year | 50-year | 100-year | 500-year | 1000-year | 10000-year |
| Significant Wave Height (m) | | 5.34 | 6.25 | 6.83 | 8.16 | 8.74 | 10.65 |
| Peak Period (s) | | 9.9 | 10.57 | 11.03 | 12.03 | 12.44 | 13.69 |
| Wave Orbital Velocity (m/s) at 1m above seabed | Total Water Depth 25.4m | 1.09 | 1.37 | 1.55 | 1.99 | 2.18 | 2.80 |

Table 2-26 Extreme Wave and Associated Wave Orbital Velocity at 1m Above Seabed for Winter Storms at Site 2

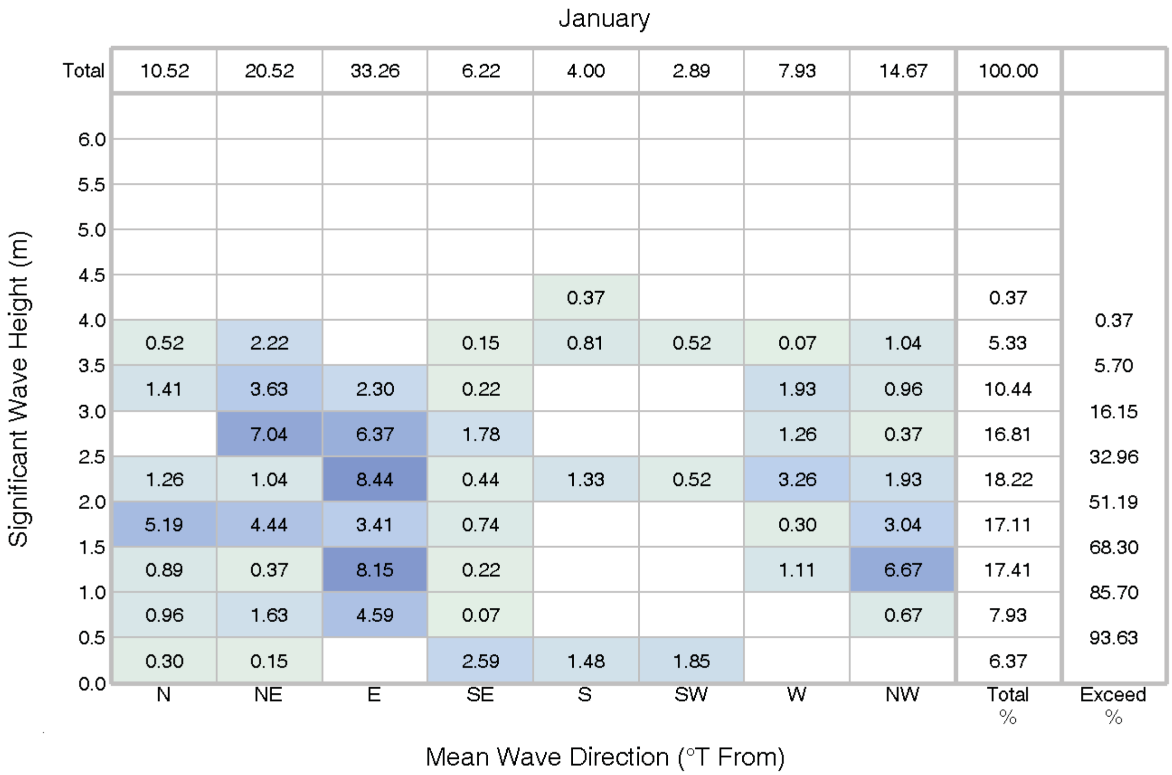
| Extreme Wave Criteria at Site 2 | | Return Period | | | | |
|---|---|---|---|---|---|---|
| | | 1-year | 50-year | 100-year | 500-year | 1000-year |
| Hmax (m) | | 10.01 | 11.69 | 12.77 | 15.28 | 16.36 |
| Peak Period Associated with Hmax (s) | | 10.9 | 11.6 | 12.1 | 13.2 | 13.6 |
| Wave Orbital Velocity (m/s) at 1m above seabed | Total Water Depth 25.4m | 2.22 | 2.69 | 2.99 | 3.58 | 3.74 |

Table 2-27 Extreme Hmax and Associated Wave Orbital Velocity at 1m Above Seabed for Winter Storms at Site 2

### 2.2.10 Fatigue Waves for Winter Storms

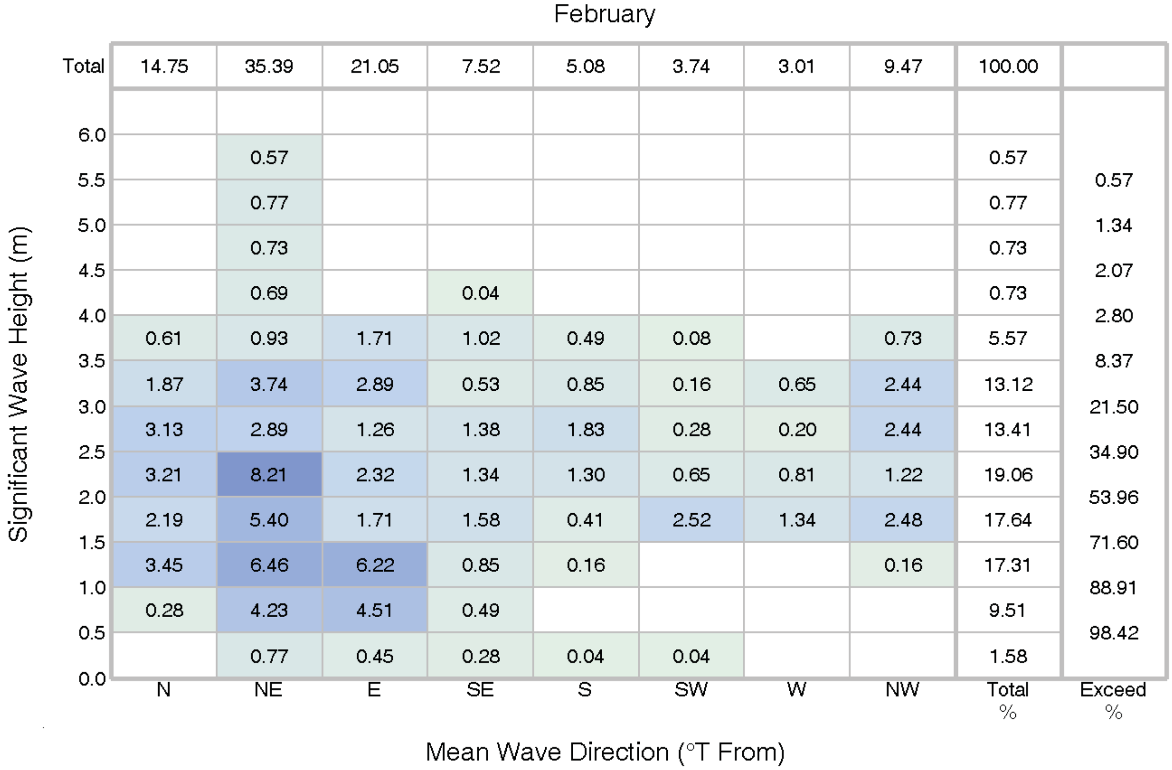
Extreme all-year omni-directonal and directional fatigueindividuale wave heights and periods for winter storms are provided in the attached Excel spreadsheet "Virgina_Extreme_Fatigue_WinterStorm." Directional scatter table of individuale fatigue wave heights and periods scaled to an interval of 20 years at 45 degree intervals for winter storms are provided in the Excel spreadsheets "Virginia_Fatigue_20years_WinterStorm." Directional tables of mid height, median period, and 15 and 85 percentile period limits for fatigue waves at 45 degree intervals for winter storms are provided in the Excel spreadsheets "Virginia_Fatigue_Tables_WinterStorm."

### 2.2.11 Joint Frequency Distribution of Significant Wave Height and Direction for Winter Storms



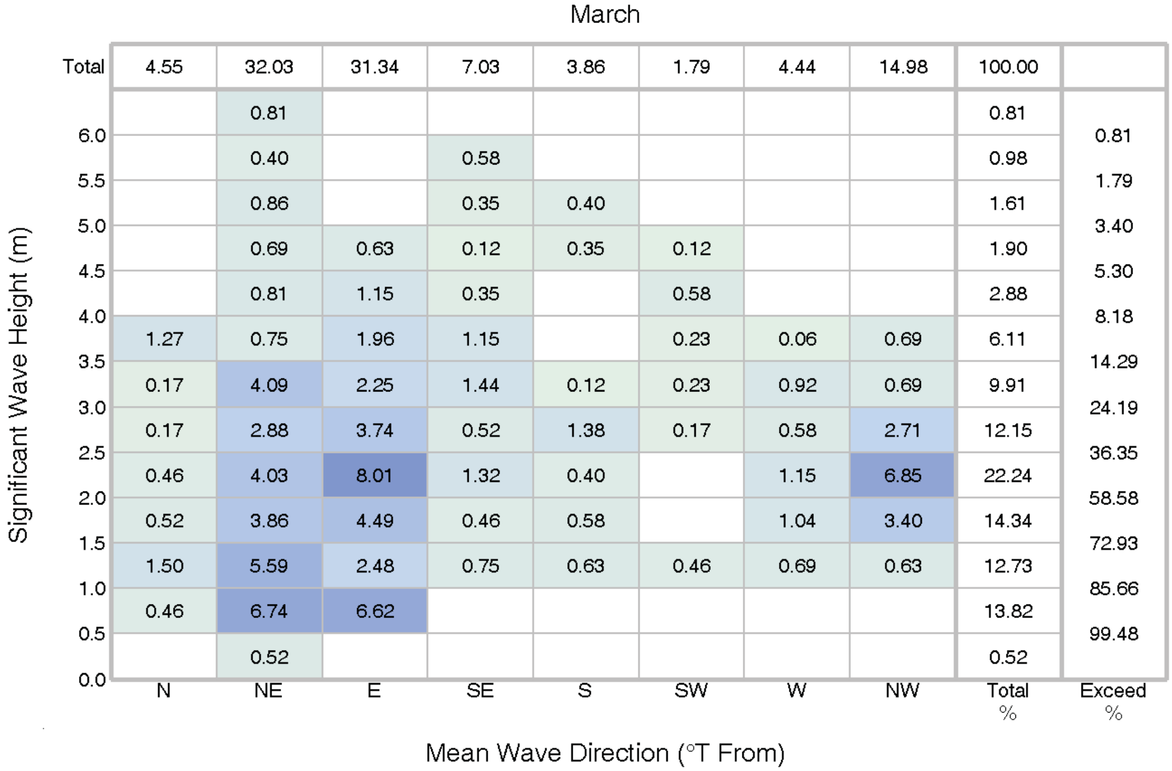
| Significant Wave Height (m) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 10.52 | 20.52 | 33.26 | 6.22 | 4.00 | 2.89 | 7.93 | 14.67 | 100.00 | |
| > 6.0 | | | | | | | | | | |
| 5.5–6.0 | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | |
| 4.0–4.5 | | | | | 0.37 | | | | 0.37 | 0.37 |
| 3.5–4.0 | 0.52 | 2.22 | | 0.15 | 0.81 | 0.52 | 0.07 | 1.04 | 5.33 | 5.70 |
| 3.0–3.5 | 1.41 | 3.63 | 2.30 | 0.22 | | | 1.93 | 0.96 | 10.44 | 16.15 |
| 2.5–3.0 | | 7.04 | 6.37 | 1.78 | | | 1.26 | 0.37 | 16.81 | 32.96 |
| 2.0–2.5 | 1.26 | 1.04 | 8.44 | 0.44 | 1.33 | 0.52 | 3.26 | 1.93 | 18.22 | 51.19 |
| 1.5–2.0 | 5.19 | 4.44 | 3.41 | 0.74 | | | 0.30 | 3.04 | 17.11 | 68.30 |
| 1.0–1.5 | 0.89 | 0.37 | 8.15 | 0.22 | | | 1.11 | 6.67 | 17.41 | 85.70 |
| 0.5–1.0 | 0.96 | 1.63 | 4.59 | 0.07 | | | | 0.67 | 7.93 | 93.63 |
| 0.0–0.5 | 0.30 | 0.15 | | 2.59 | 1.48 | 1.85 | | | 6.37 | |

Figure 2-49 Percentage Occurrence of Significant Wave Height and Direction for Winter Storms – January



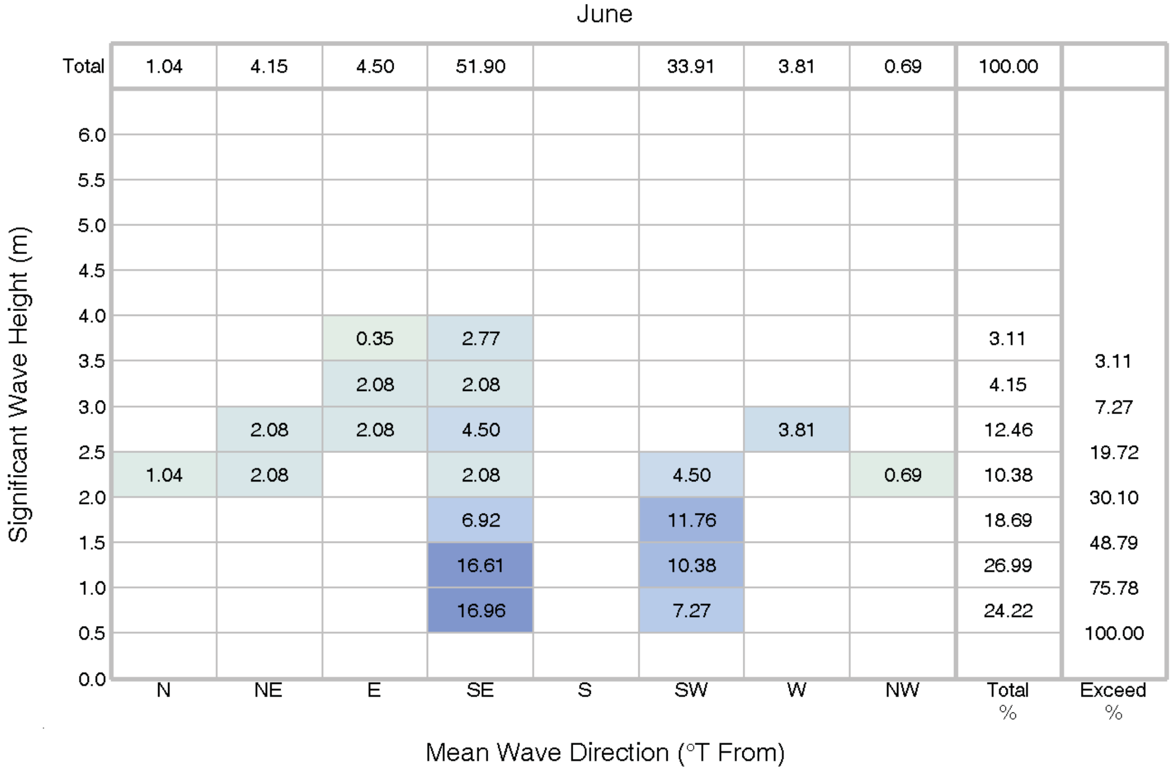
| Significant Wave Height (m) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 14.75 | 35.39 | 21.05 | 7.52 | 5.08 | 3.74 | 3.01 | 9.47 | 100.00 | |
| > 6.0 | | | | | | | | | | |
| 5.5–6.0 | | 0.57 | | | | | | | 0.57 | 0.57 |
| 5.0–5.5 | | 0.77 | | | | | | | 0.77 | 1.34 |
| 4.5–5.0 | | 0.73 | | | | | | | 0.73 | 2.07 |
| 4.0–4.5 | | 0.69 | | 0.04 | | | | | 0.73 | 2.80 |
| 3.5–4.0 | 0.61 | 0.93 | 1.71 | 1.02 | 0.49 | 0.08 | | 0.73 | 5.57 | 8.37 |
| 3.0–3.5 | 1.87 | 3.74 | 2.89 | 0.53 | 0.85 | 0.16 | 0.65 | 2.44 | 13.12 | 21.50 |
| 2.5–3.0 | 3.13 | 2.89 | 1.26 | 1.38 | 1.83 | 0.28 | 0.20 | 2.44 | 13.41 | 34.90 |
| 2.0–2.5 | 3.21 | 8.21 | 2.32 | 1.34 | 1.30 | 0.65 | 0.81 | 1.22 | 19.06 | 53.96 |
| 1.5–2.0 | 2.19 | 5.40 | 1.71 | 1.58 | 0.41 | 2.52 | 1.34 | 2.48 | 17.64 | 71.60 |
| 1.0–1.5 | 3.45 | 6.46 | 6.22 | 0.85 | 0.16 | | | 0.16 | 17.31 | 88.91 |
| 0.5–1.0 | 0.28 | 4.23 | 4.51 | 0.49 | | | | | 9.51 | 98.42 |
| 0.0–0.5 | | 0.77 | 0.45 | 0.28 | 0.04 | 0.04 | | | 1.58 | |

Figure 2-50 Percentage Occurrence of Significant Wave Height and Direction for Winter Storms – February



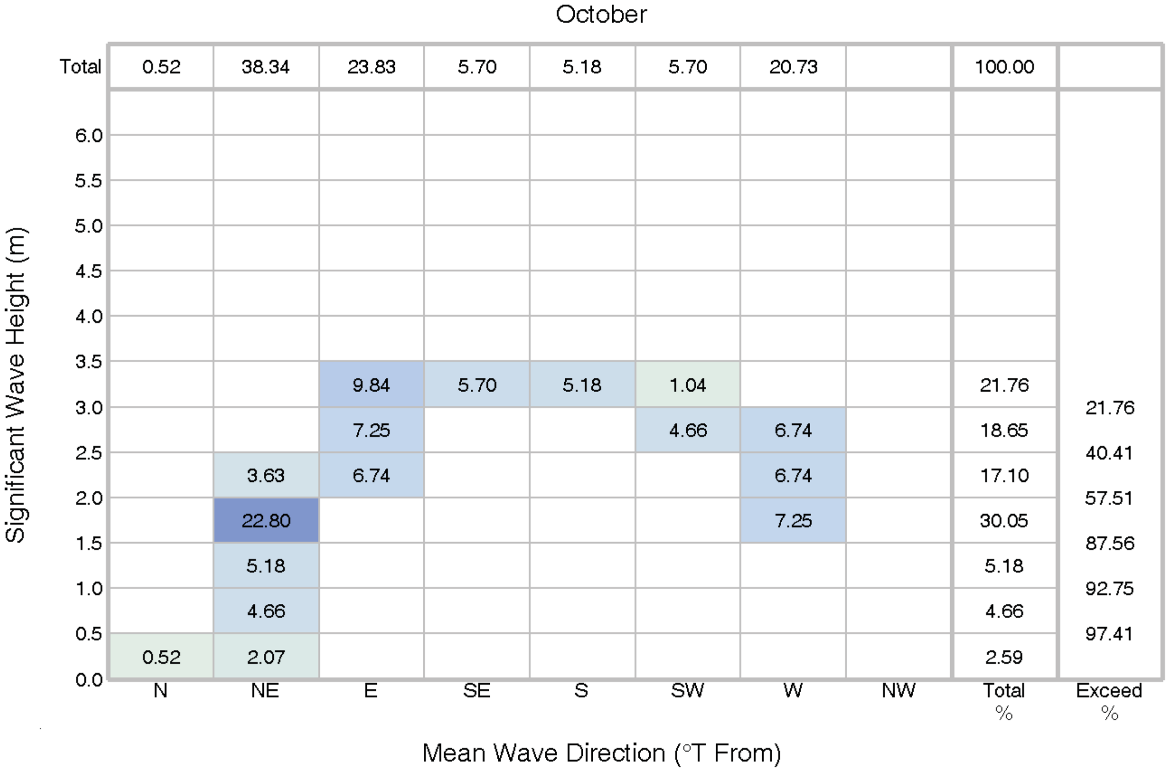
| Significant Wave Height (m) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 4.55 | 32.03 | 31.34 | 7.03 | 3.86 | 1.79 | 4.44 | 14.98 | 100.00 | |
| | | 0.81 | | | | | | | 0.81 | |
| 6.0 | | | | | | | | | | 0.81 |
| | | 0.40 | | 0.58 | | | | | 0.98 | |
| 5.5 | | | | | | | | | | 1.79 |
| | | 0.86 | | 0.35 | 0.40 | | | | 1.61 | |
| 5.0 | | | | | | | | | | 3.40 |
| | | 0.69 | 0.63 | 0.12 | 0.35 | 0.12 | | | 1.90 | |
| 4.5 | | | | | | | | | | 5.30 |
| | | 0.81 | 1.15 | 0.35 | | 0.58 | | | 2.88 | |
| 4.0 | | | | | | | | | | 8.18 |
| | 1.27 | 0.75 | 1.96 | 1.15 | | 0.23 | 0.06 | 0.69 | 6.11 | |
| 3.5 | | | | | | | | | | 14.29 |
| | 0.17 | 4.09 | 2.25 | 1.44 | 0.12 | 0.23 | 0.92 | 0.69 | 9.91 | |
| 3.0 | | | | | | | | | | 24.19 |
| | 0.17 | 2.88 | 3.74 | 0.52 | 1.38 | 0.17 | 0.58 | 2.71 | 12.15 | |
| 2.5 | | | | | | | | | | 36.35 |
| | 0.46 | 4.03 | 8.01 | 1.32 | 0.40 | | 1.15 | 6.85 | 22.24 | |
| 2.0 | | | | | | | | | | 58.58 |
| | 0.52 | 3.86 | 4.49 | 0.46 | 0.58 | | 1.04 | 3.40 | 14.34 | |
| 1.5 | | | | | | | | | | 72.93 |
| | 1.50 | 5.59 | 2.48 | 0.75 | 0.63 | 0.46 | 0.69 | 0.63 | 12.73 | |
| 1.0 | | | | | | | | | | 85.66 |
| | 0.46 | 6.74 | 6.62 | | | | | | 13.82 | |
| 0.5 | | | | | | | | | | 99.48 |
| | | 0.52 | | | | | | | 0.52 | |
| 0.0 | | | | | | | | | | |

**Figure 2-51 Percentage Occurrence of Significant Wave Height and Direction for Winter Storms – March**



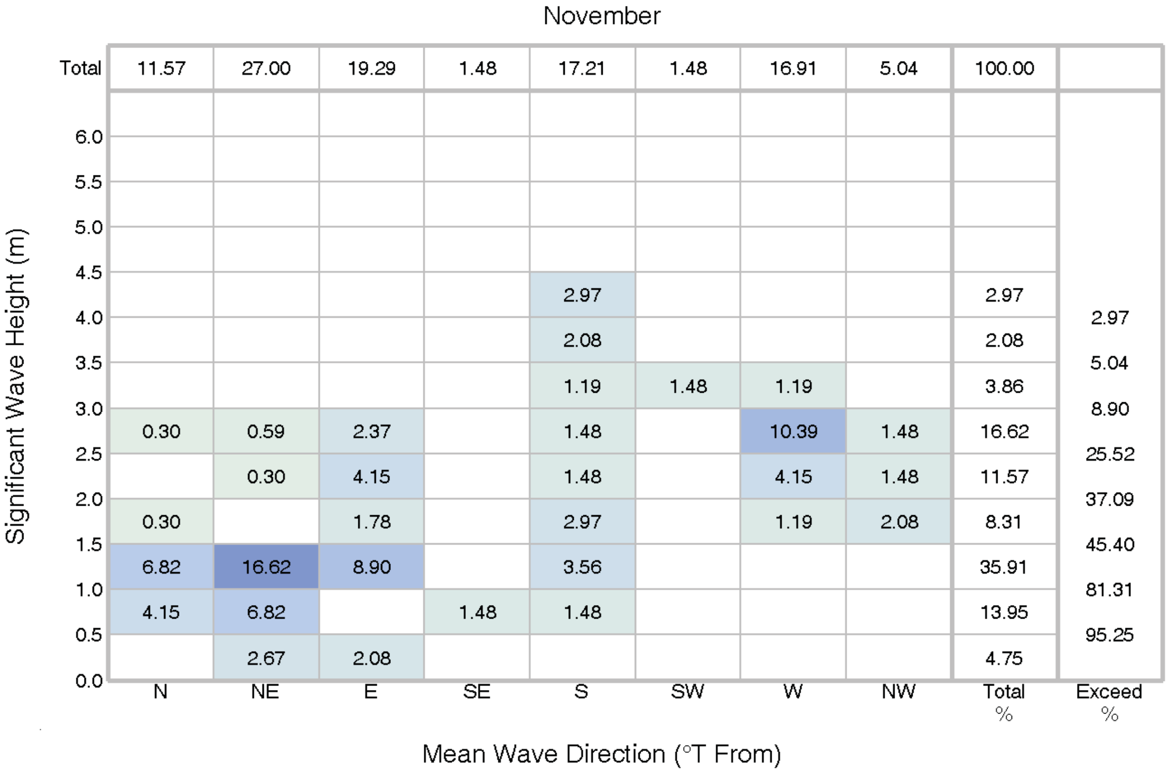
| Significant Wave Height (m) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 1.04 | 4.15 | 4.50 | 51.90 | | 33.91 | 3.81 | 0.69 | 100.00 | |
| | | | | | | | | | | |
| 6.0 | | | | | | | | | | |
| | | | | | | | | | | |
| 5.5 | | | | | | | | | | |
| | | | | | | | | | | |
| 5.0 | | | | | | | | | | |
| | | | | | | | | | | |
| 4.5 | | | | | | | | | | |
| | | | | | | | | | | |
| 4.0 | | | | | | | | | | |
| | | | 0.35 | 2.77 | | | | | 3.11 | |
| 3.5 | | | | | | | | | | 3.11 |
| | | | 2.08 | 2.08 | | | | | 4.15 | |
| 3.0 | | | | | | | | | | 7.27 |
| | | 2.08 | 2.08 | 4.50 | | | 3.81 | | 12.46 | |
| 2.5 | | | | | | | | | | 19.72 |
| | 1.04 | 2.08 | | 2.08 | | 4.50 | | 0.69 | 10.38 | |
| 2.0 | | | | | | | | | | 30.10 |
| | | | | 6.92 | | 11.76 | | | 18.69 | |
| 1.5 | | | | | | | | | | 48.79 |
| | | | | 16.61 | | 10.38 | | | 26.99 | |
| 1.0 | | | | | | | | | | 75.78 |
| | | | | 16.96 | | 7.27 | | | 24.22 | |
| 0.5 | | | | | | | | | | 100.00 |
| | | | | | | | | | | |
| 0.0 | | | | | | | | | | |

**Figure 2-52 Percentage Occurrence of Significant Wave Height and Direction for Winter Storms – June**



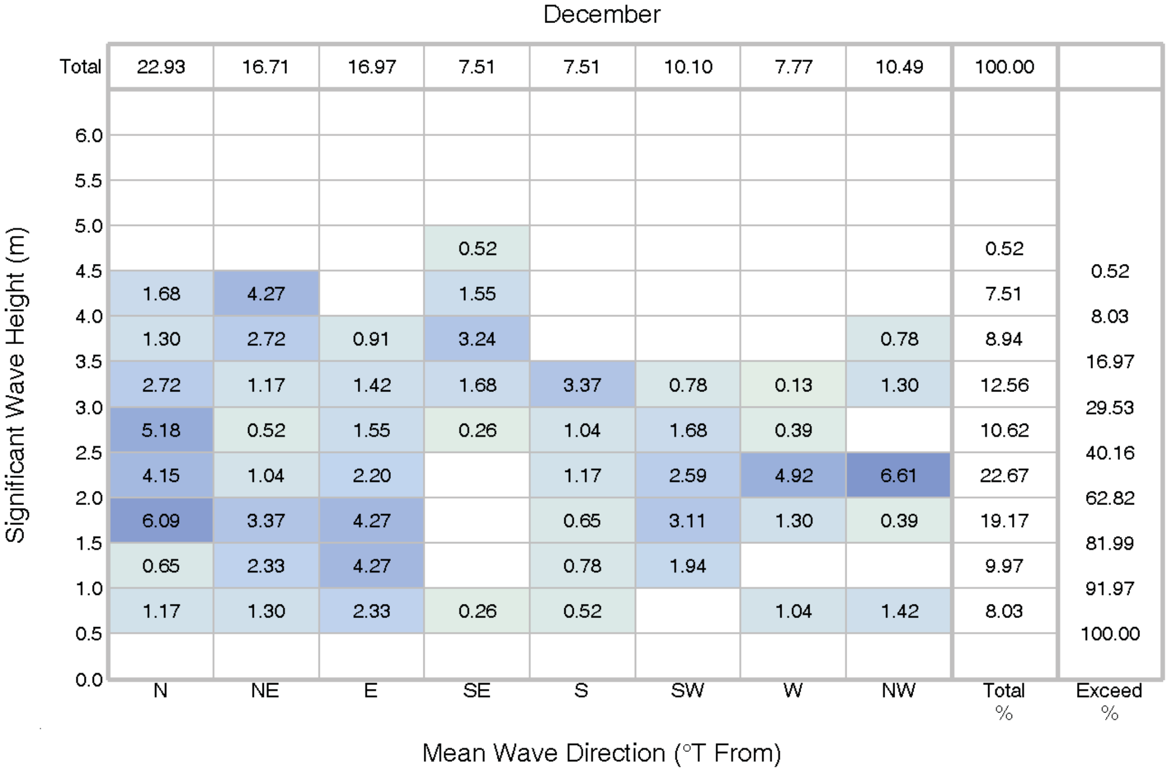
| Significant Wave Height (m) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 0.52 | 38.34 | 23.83 | 5.70 | 5.18 | 5.70 | 20.73 | | 100.00 | |
| 5.5–6.0 | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | |
| 4.0–4.5 | | | | | | | | | | |
| 3.5–4.0 | | | | | | | | | | |
| 3.0–3.5 | | | 9.84 | 5.70 | 5.18 | 1.04 | | | 21.76 | 21.76 |
| 2.5–3.0 | | | 7.25 | | | 4.66 | 6.74 | | 18.65 | 40.41 |
| 2.0–2.5 | | 3.63 | 6.74 | | | | 6.74 | | 17.10 | 57.51 |
| 1.5–2.0 | | 22.80 | | | | | 7.25 | | 30.05 | 87.56 |
| 1.0–1.5 | | 5.18 | | | | | | | 5.18 | 92.75 |
| 0.5–1.0 | | 4.66 | | | | | | | 4.66 | 97.41 |
| 0.0–0.5 | 0.52 | 2.07 | | | | | | | 2.59 | |

Figure 2-53 Percentage Occurrence of Significant Wave Height and Direction for Winter Storms – October



| Significant Wave Height (m) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 11.57 | 27.00 | 19.29 | 1.48 | 17.21 | 1.48 | 16.91 | 5.04 | 100.00 | |
| 5.5–6.0 | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | |
| 4.0–4.5 | | | | | 2.97 | | | | 2.97 | 2.97 |
| 3.5–4.0 | | | | | 2.08 | | | | 2.08 | 5.04 |
| 3.0–3.5 | | | | | 1.19 | 1.48 | 1.19 | | 3.86 | 8.90 |
| 2.5–3.0 | 0.30 | 0.59 | 2.37 | | 1.48 | | 10.39 | 1.48 | 16.62 | 25.52 |
| 2.0–2.5 | | 0.30 | 4.15 | | 1.48 | | 4.15 | 1.48 | 11.57 | 37.09 |
| 1.5–2.0 | 0.30 | | 1.78 | | 2.97 | | 1.19 | 2.08 | 8.31 | 45.40 |
| 1.0–1.5 | 6.82 | 16.62 | 8.90 | | 3.56 | | | | 35.91 | 81.31 |
| 0.5–1.0 | 4.15 | 6.82 | | 1.48 | 1.48 | | | | 13.95 | 95.25 |
| 0.0–0.5 | | 2.67 | 2.08 | | | | | | 4.75 | |

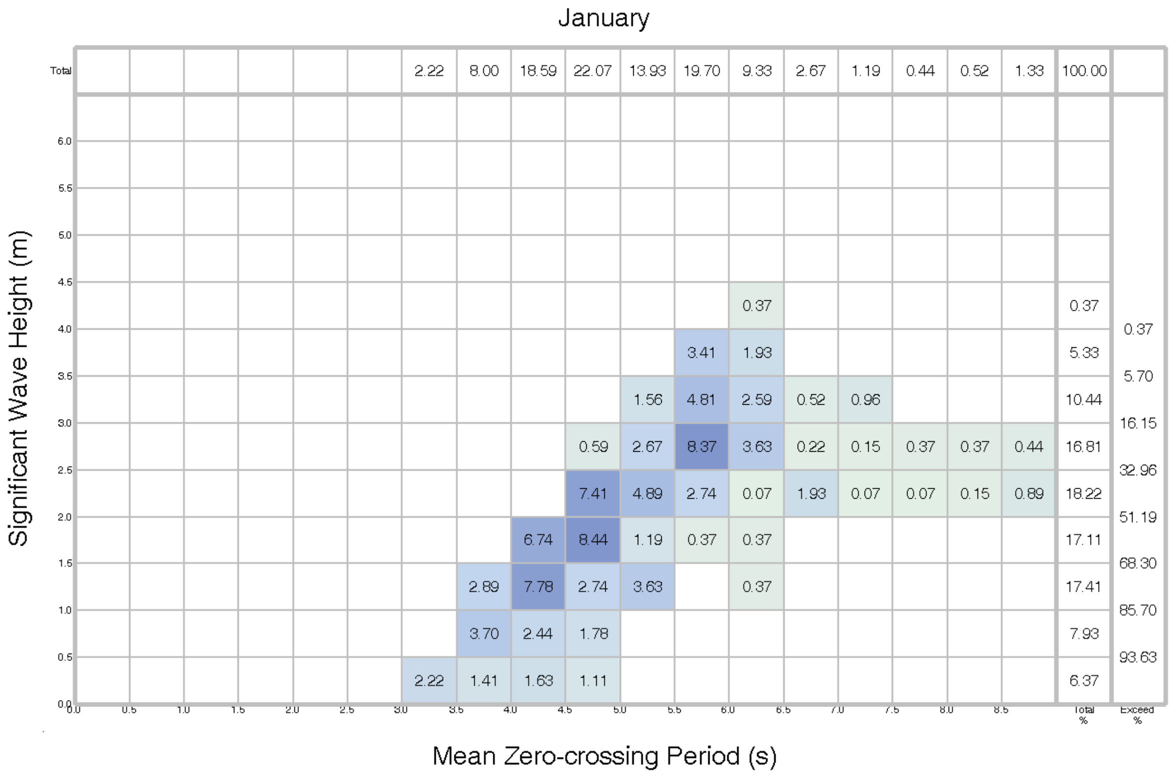
Figure 2-54 Percentage Occurrence of Significant Wave Height and Direction for Winter Storms – November



| Significant Wave Height (m) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 22.93 | 16.71 | 16.97 | 7.51 | 7.51 | 10.10 | 7.77 | 10.49 | 100.00 | |
| 5.5–6.0 | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | |
| 4.5–5.0 | | | | 0.52 | | | | | 0.52 | 0.52 |
| 4.0–4.5 | 1.68 | 4.27 | | 1.55 | | | | | 7.51 | 8.03 |
| 3.5–4.0 | 1.30 | 2.72 | 0.91 | 3.24 | | | | 0.78 | 8.94 | 16.97 |
| 3.0–3.5 | 2.72 | 1.17 | 1.42 | 1.68 | 3.37 | 0.78 | 0.13 | 1.30 | 12.56 | 29.53 |
| 2.5–3.0 | 5.18 | 0.52 | 1.55 | 0.26 | 1.04 | 1.68 | 0.39 | | 10.62 | 40.16 |
| 2.0–2.5 | 4.15 | 1.04 | 2.20 | | 1.17 | 2.59 | 4.92 | 6.61 | 22.67 | 62.82 |
| 1.5–2.0 | 6.09 | 3.37 | 4.27 | | 0.65 | 3.11 | 1.30 | 0.39 | 19.17 | 81.99 |
| 1.0–1.5 | 0.65 | 2.33 | 4.27 | | 0.78 | 1.94 | | | 9.97 | 91.97 |
| 0.5–1.0 | 1.17 | 1.30 | 2.33 | 0.26 | 0.52 | | 1.04 | 1.42 | 8.03 | 100.00 |
| 0.0–0.5 | | | | | | | | | | |

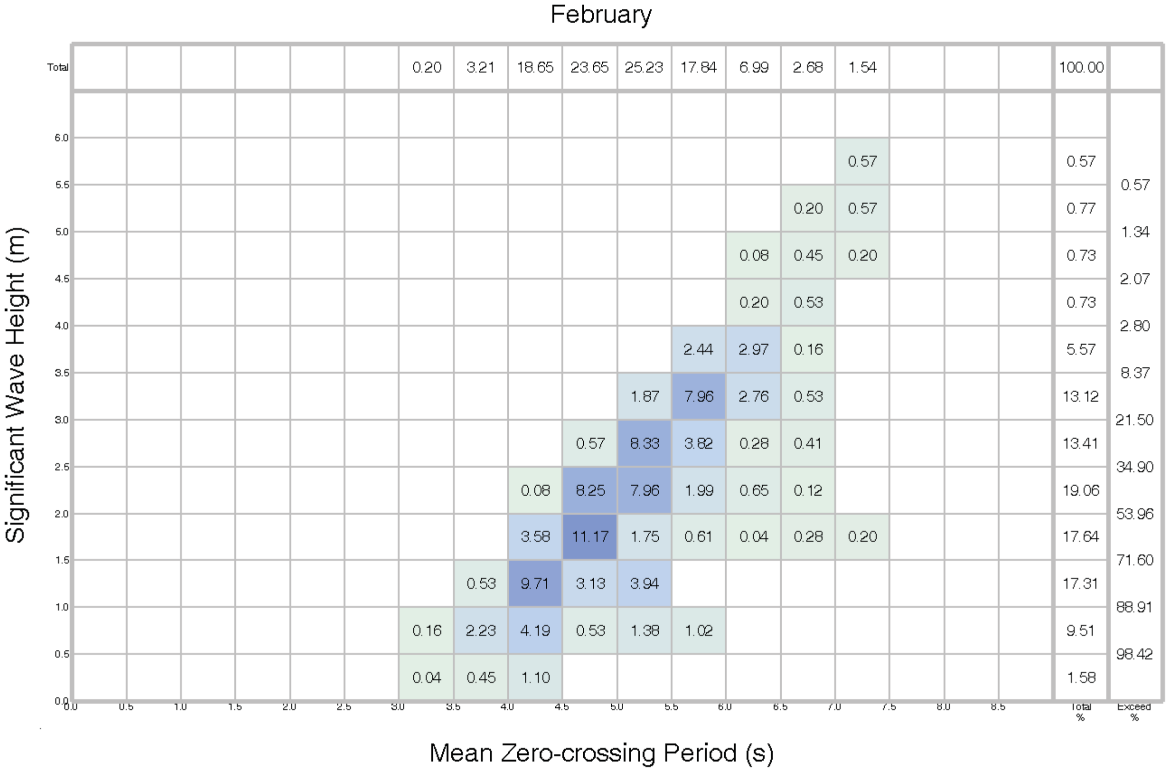
Figure 2-55 Percentage Occurrence of Significant Wave Height and Direction for Winter Storms – December

### 2.2.12 Joint Frequency Distribution of Significant Wave Height and Zero Up-Crossing Period for Winter Storms


January

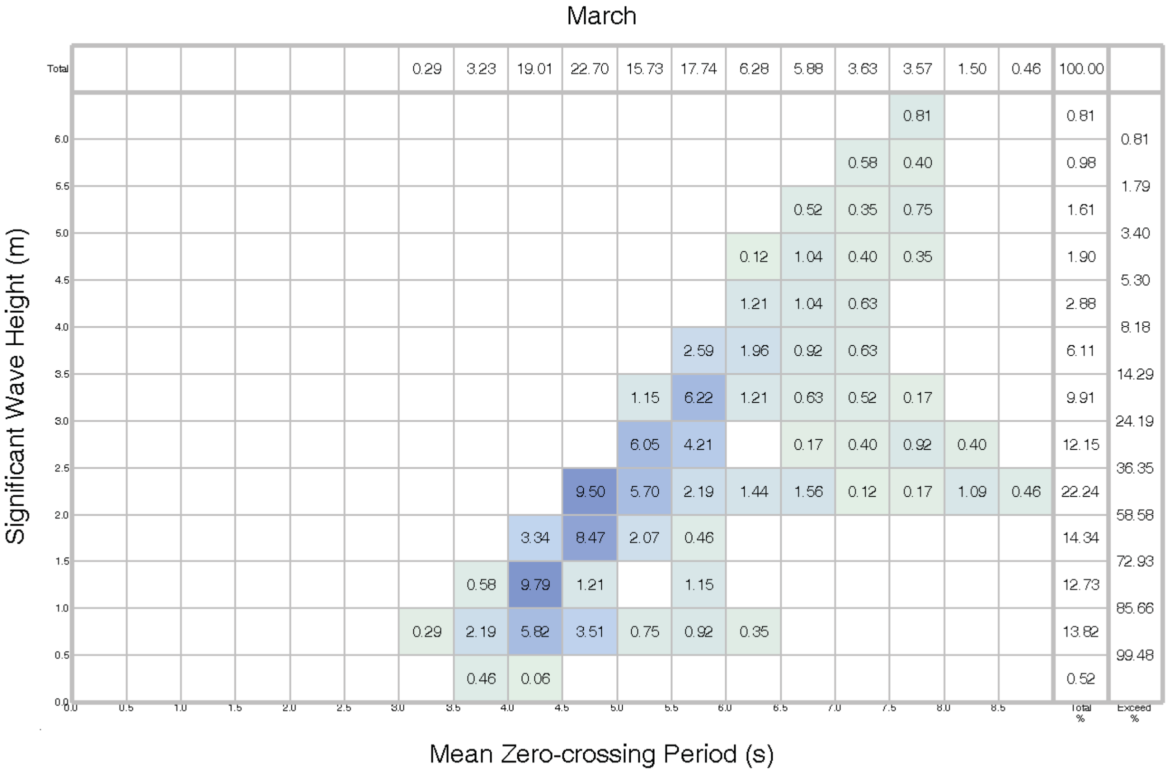
| | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | 2.22 | 8.00 | 18.59 | 22.07 | 13.93 | 19.70 | 9.33 | 2.67 | 1.19 | 0.44 | 0.52 | 1.33 | 100.00 | |
| 6.0 | | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | | | |
| 4.5 | | | | | | | | | | | | | | | | | | | | |
| 4.0 | | | | | | | | | | | | | 0.37 | | | | | | 0.37 | 0.37 |
| 3.5 | | | | | | | | | | | | 3.41 | 1.93 | | | | | | 5.33 | 5.70 |
| 3.0 | | | | | | | | | | | 1.56 | 4.81 | 2.59 | 0.52 | 0.96 | | | | 10.44 | 16.15 |
| 2.5 | | | | | | | | | | 0.59 | 2.67 | 8.37 | 3.63 | 0.22 | 0.15 | 0.37 | 0.37 | 0.44 | 16.81 | 32.96 |
| 2.0 | | | | | | | | | | 7.41 | 4.89 | 2.74 | 0.07 | 1.93 | 0.07 | 0.07 | 0.15 | 0.89 | 18.22 | 51.19 |
| 1.5 | | | | | | | | | 6.74 | 8.44 | 1.19 | 0.37 | 0.37 | | | | | | 17.11 | 68.30 |
| 1.0 | | | | | | | | 2.89 | 7.78 | 2.74 | 3.63 | | 0.37 | | | | | | 17.41 | 85.70 |
| 0.5 | | | | | | | | 3.70 | 2.44 | 1.78 | | | | | | | | | 7.93 | 93.63 |
| 0.0 | | | | | | | 2.22 | 1.41 | 1.63 | 1.11 | | | | | | | | | 6.37 | |

**Figure 2-56 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period for Winter Storms – January**



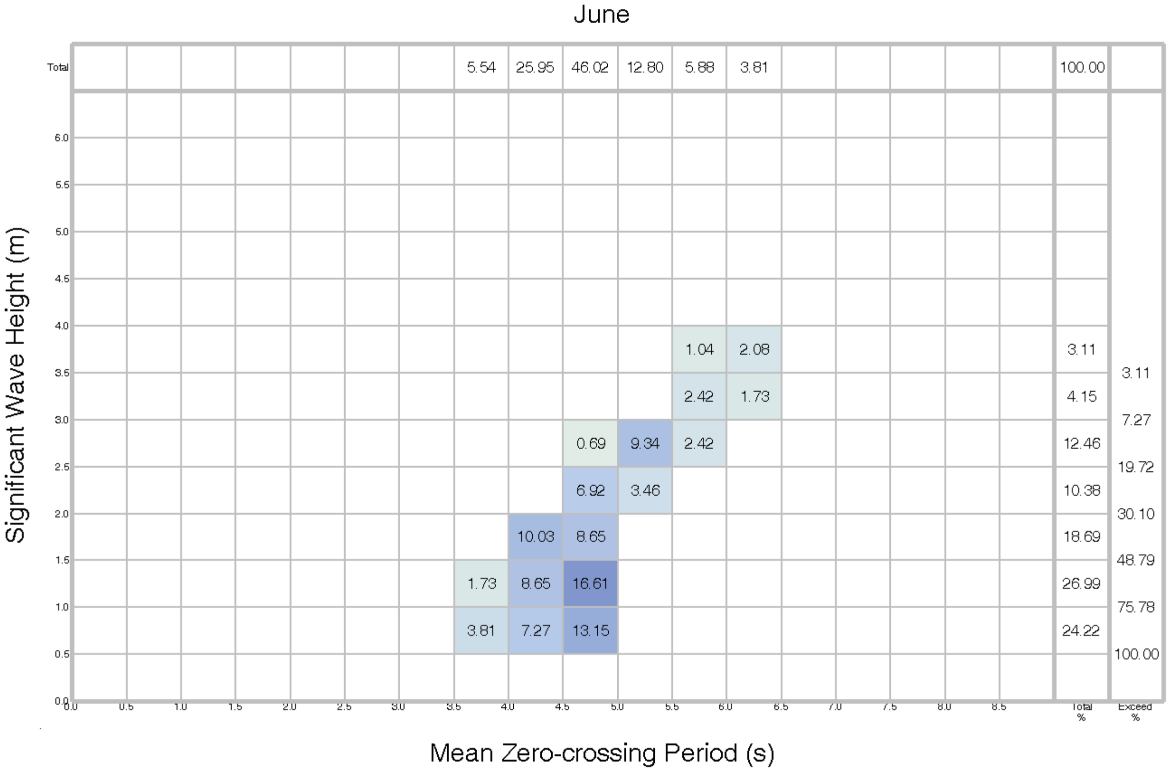
| | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | 0.20 | 3.21 | 18.65 | 23.65 | 25.23 | 17.84 | 6.99 | 2.68 | 1.54 | | | | 100.00 | |
| 6.0 | | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | 0.57 | | | | 0.57 | 0.57 |
| 5.0 | | | | | | | | | | | | | | 0.20 | 0.57 | | | | 0.77 | 1.34 |
| 4.5 | | | | | | | | | | | | | 0.08 | 0.45 | 0.20 | | | | 0.73 | 2.07 |
| 4.0 | | | | | | | | | | | | | 0.20 | 0.53 | | | | | 0.73 | 2.80 |
| 3.5 | | | | | | | | | | | | 2.44 | 2.97 | 0.16 | | | | | 5.57 | 8.37 |
| 3.0 | | | | | | | | | | | 1.87 | 7.96 | 2.76 | 0.53 | | | | | 13.12 | 21.50 |
| 2.5 | | | | | | | | | | 0.57 | 8.33 | 3.82 | 0.28 | 0.41 | | | | | 13.41 | 34.90 |
| 2.0 | | | | | | | | | 0.08 | 8.25 | 7.96 | 1.99 | 0.65 | 0.12 | | | | | 19.06 | 53.96 |
| 1.5 | | | | | | | | | 3.58 | 11.17 | 1.75 | 0.61 | 0.04 | 0.28 | 0.20 | | | | 17.64 | 71.60 |
| 1.0 | | | | | | | | 0.53 | 9.71 | 3.13 | 3.94 | | | | | | | | 17.31 | 88.91 |
| 0.5 | | | | | | | 0.16 | 2.23 | 4.19 | 0.53 | 1.38 | 1.02 | | | | | | | 9.51 | 98.42 |
| 0.0 | | | | | | | 0.04 | 0.45 | 1.10 | | | | | | | | | | 1.58 | |

**Figure 2-57 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period for Winter Storms – February**



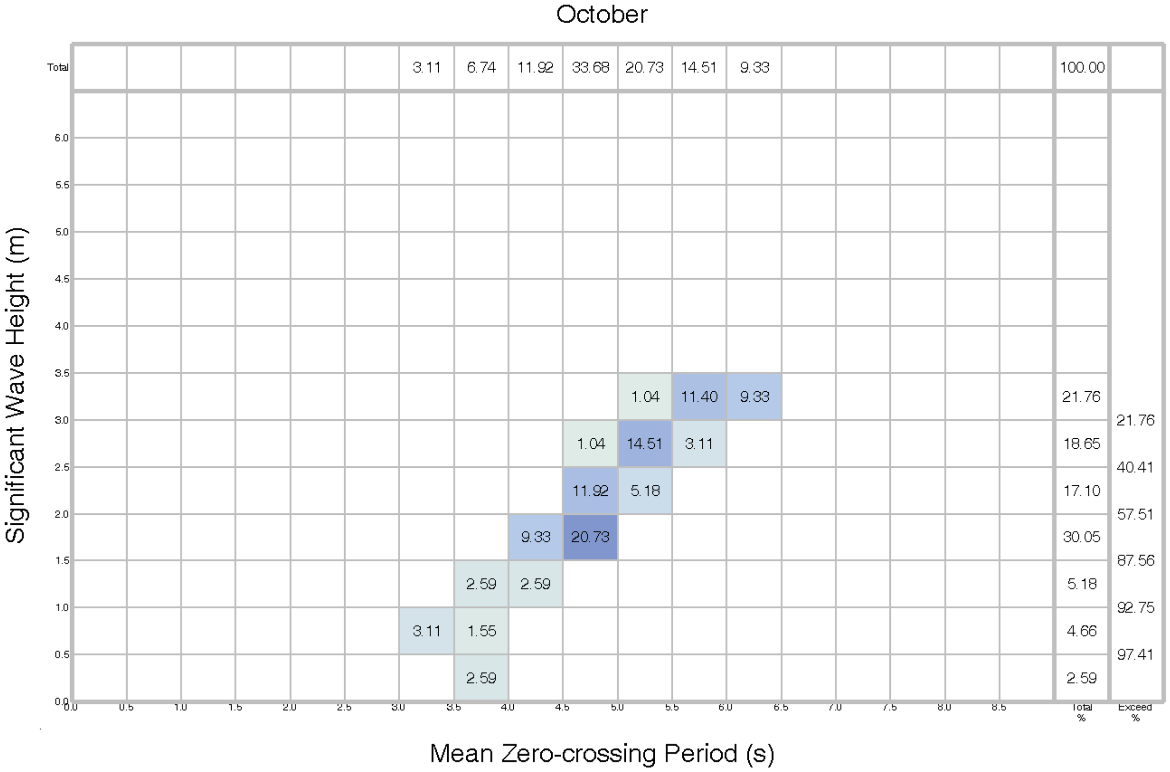
| | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | 0.29 | 3.23 | 19.01 | 22.70 | 15.73 | 17.74 | 6.28 | 5.88 | 3.63 | 3.57 | 1.50 | 0.46 | 100.00 | |
| 6.0 | | | | | | | | | | | | | | | | 0.81 | | | 0.81 | 0.81 |
| 5.5 | | | | | | | | | | | | | | | 0.58 | 0.40 | | | 0.98 | 1.79 |
| 5.0 | | | | | | | | | | | | | | 0.52 | 0.35 | 0.75 | | | 1.61 | 3.40 |
| 4.5 | | | | | | | | | | | | | 0.12 | 1.04 | 0.40 | 0.35 | | | 1.90 | 5.30 |
| 4.0 | | | | | | | | | | | | | 1.21 | 1.04 | 0.63 | | | | 2.88 | 8.18 |
| 3.5 | | | | | | | | | | | | 2.59 | 1.96 | 0.92 | 0.63 | | | | 6.11 | 14.29 |
| 3.0 | | | | | | | | | | | 1.15 | 6.22 | 1.21 | 0.63 | 0.52 | 0.17 | | | 9.91 | 24.19 |
| 2.5 | | | | | | | | | | | 6.05 | 4.21 | | 0.17 | 0.40 | 0.92 | 0.40 | | 12.15 | 36.35 |
| 2.0 | | | | | | | | | | 9.50 | 5.70 | 2.19 | 1.44 | 1.56 | 0.12 | 0.17 | 1.09 | 0.46 | 22.24 | 58.58 |
| 1.5 | | | | | | | | | 3.34 | 8.47 | 2.07 | 0.46 | | | | | | | 14.34 | 72.93 |
| 1.0 | | | | | | | | 0.58 | 9.79 | 1.21 | | 1.15 | | | | | | | 12.73 | 85.66 |
| 0.5 | | | | | | | 0.29 | 2.19 | 5.82 | 3.51 | 0.75 | 0.92 | 0.35 | | | | | | 13.82 | 99.48 |
| 0.0 | | | | | | | | 0.46 | 0.06 | | | | | | | | | | 0.52 | |

**Figure 2-58 Percentage Occurrence of Significant Wave Height and Peak Period Zero Up-Crossing Period for Winter Storms – March**


June

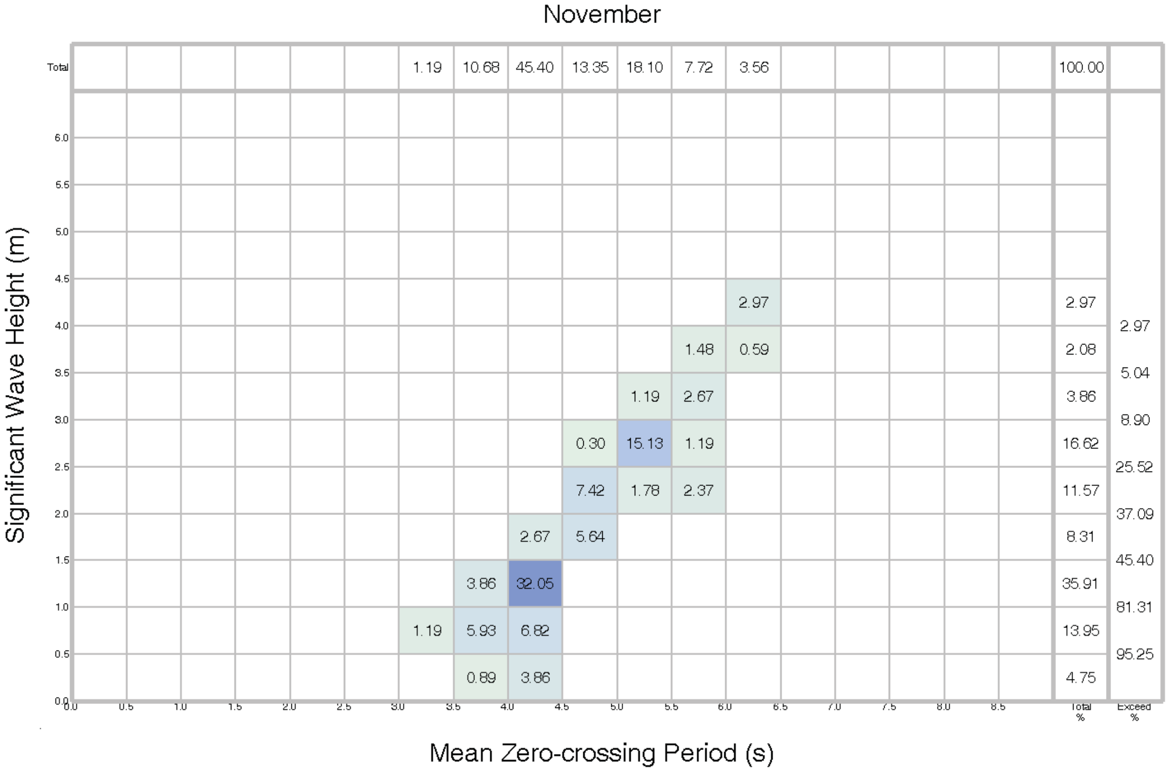
| | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | | 5.54 | 25.95 | 46.02 | 12.80 | 5.88 | 3.81 | | | | | | 100.00 | |
| 6.0 | | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | | | |
| 4.5 | | | | | | | | | | | | | | | | | | | | |
| 4.0 | | | | | | | | | | | | | | | | | | | | |
| 3.5 | | | | | | | | | | | | 1.04 | 2.08 | | | | | | 3.11 | 3.11 |
| 3.0 | | | | | | | | | | | | 2.42 | 1.73 | | | | | | 4.15 | 7.27 |
| 2.5 | | | | | | | | | | 0.69 | 9.34 | 2.42 | | | | | | | 12.46 | 19.72 |
| 2.0 | | | | | | | | | | 6.92 | 3.46 | | | | | | | | 10.38 | 30.10 |
| 1.5 | | | | | | | | | 10.03 | 8.65 | | | | | | | | | 18.69 | 48.79 |
| 1.0 | | | | | | | | 1.73 | 8.65 | 16.61 | | | | | | | | | 26.99 | 75.78 |
| 0.5 | | | | | | | | 3.81 | 7.27 | 13.15 | | | | | | | | | 24.22 | 100.00 |
| 0.0 | | | | | | | | | | | | | | | | | | | | |

**Figure 2-59 Percentage Occurrence of Significant Wave Height and Peak Period Zero Up-Crossing Period for Winter Storms – June**


October

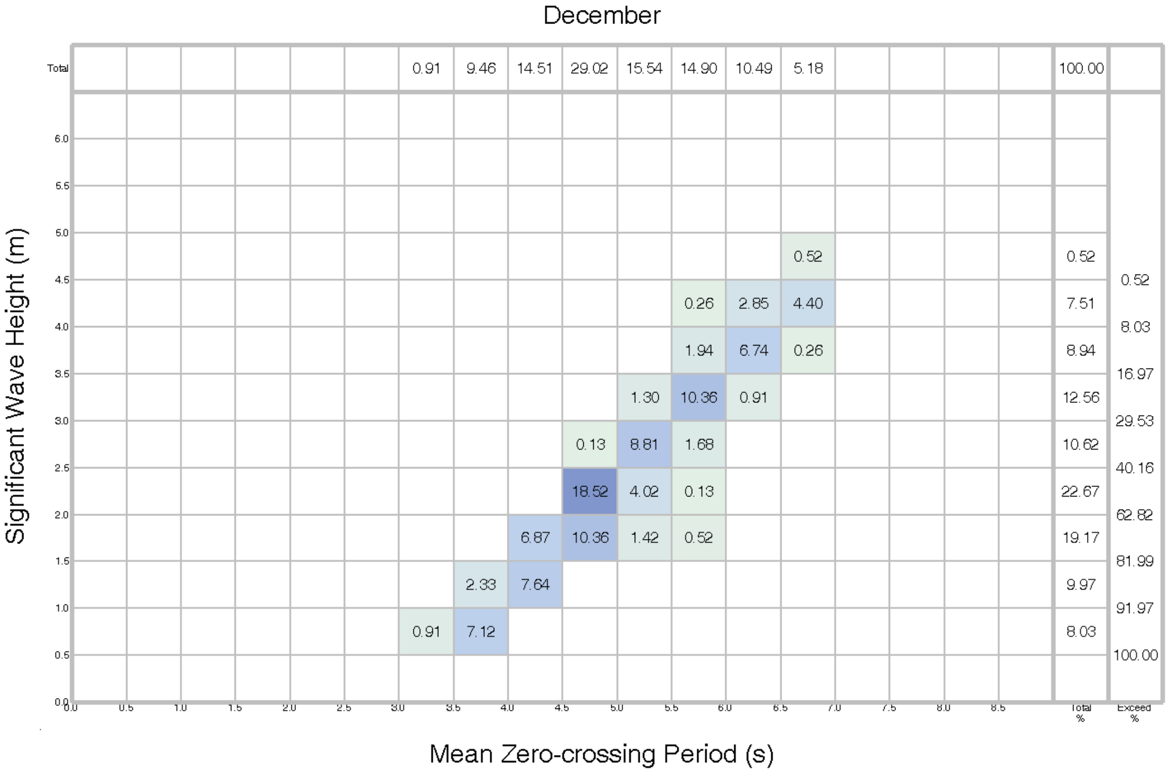
| | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | 3.11 | 6.74 | 11.92 | 33.68 | 20.73 | 14.51 | 9.33 | | | | | | 100.00 | |
| 6.0 | | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | | | |
| 4.5 | | | | | | | | | | | | | | | | | | | | |
| 4.0 | | | | | | | | | | | | | | | | | | | | |
| 3.5 | | | | | | | | | | | | | | | | | | | | |
| 3.0 | | | | | | | | | | | 1.04 | 11.40 | 9.33 | | | | | | 21.76 | 21.76 |
| 2.5 | | | | | | | | | | 1.04 | 14.51 | 3.11 | | | | | | | 18.65 | 40.41 |
| 2.0 | | | | | | | | | | 11.92 | 5.18 | | | | | | | | 17.10 | 57.51 |
| 1.5 | | | | | | | | | 9.33 | 20.73 | | | | | | | | | 30.05 | 87.56 |
| 1.0 | | | | | | | | 2.59 | 2.59 | | | | | | | | | | 5.18 | 92.75 |
| 0.5 | | | | | | | 3.11 | 1.55 | | | | | | | | | | | 4.66 | 97.41 |
| 0.0 | | | | | | | | 2.59 | | | | | | | | | | | 2.59 | |

**Figure 2-60 Percentage Occurrence of Significant Wave Height and Peak Period Zero Up-Crossing Period for Winter Storms – October**



| Hs (m) \ Tz (s) | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|
| Total | 1.19 | 10.68 | 45.40 | 13.35 | 18.10 | 7.72 | 3.56 | 100.00 | |
| 4.0 | | | | | | | 2.97 | 2.97 | 2.97 |
| 3.5 | | | | | | 1.48 | 0.59 | 2.08 | 5.04 |
| 3.0 | | | | | 1.19 | 2.67 | | 3.86 | 8.90 |
| 2.5 | | | | 0.30 | 15.13 | 1.19 | | 16.62 | 25.52 |
| 2.0 | | | | 7.42 | 1.78 | 2.37 | | 11.57 | 37.09 |
| 1.5 | | | 2.67 | 5.64 | | | | 8.31 | 45.40 |
| 1.0 | | 3.86 | 32.05 | | | | | 35.91 | 81.31 |
| 0.5 | 1.19 | 5.93 | 6.82 | | | | | 13.95 | 95.25 |
| 0.0 | | 0.89 | 3.86 | | | | | 4.75 | |

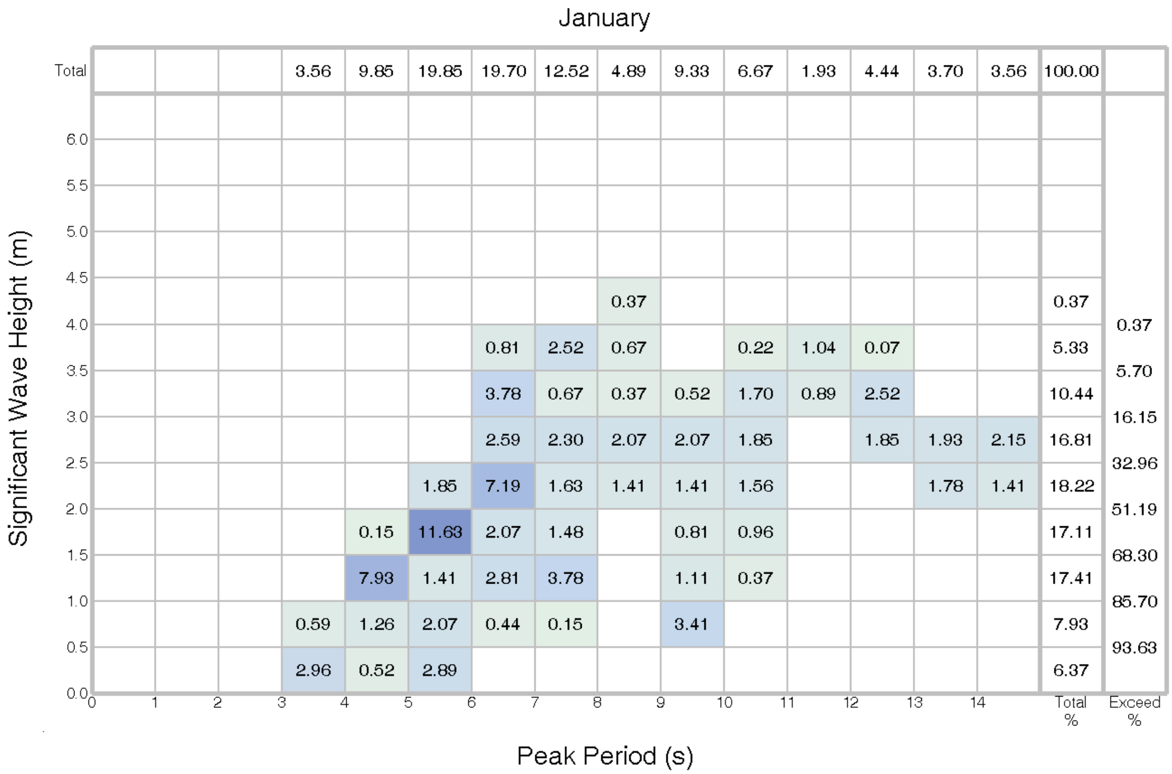
Figure 2-61 Percentage Occurrence of Significant Wave Height and Peak Period Zero Up-Crossing Period for Winter Storms – November



| Hs (m) \ Tz (s) | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 0.91 | 9.46 | 14.51 | 29.02 | 15.54 | 14.90 | 10.49 | 5.18 | 100.00 | |
| 4.5 | | | | | | | | 0.52 | 0.52 | 0.52 |
| 4.0 | | | | | | 0.26 | 2.85 | 4.40 | 7.51 | 8.03 |
| 3.5 | | | | | | 1.94 | 6.74 | 0.26 | 8.94 | 16.97 |
| 3.0 | | | | | 1.30 | 10.36 | 0.91 | | 12.56 | 29.53 |
| 2.5 | | | | 0.13 | 8.81 | 1.68 | | | 10.62 | 40.16 |
| 2.0 | | | | 18.52 | 4.02 | 0.13 | | | 22.67 | 62.82 |
| 1.5 | | | 6.87 | 10.36 | 1.42 | 0.52 | | | 19.17 | 81.99 |
| 1.0 | | 2.33 | 7.64 | | | | | | 9.97 | 91.97 |
| 0.5 | 0.91 | 7.12 | | | | | | | 8.03 | 100.00 |

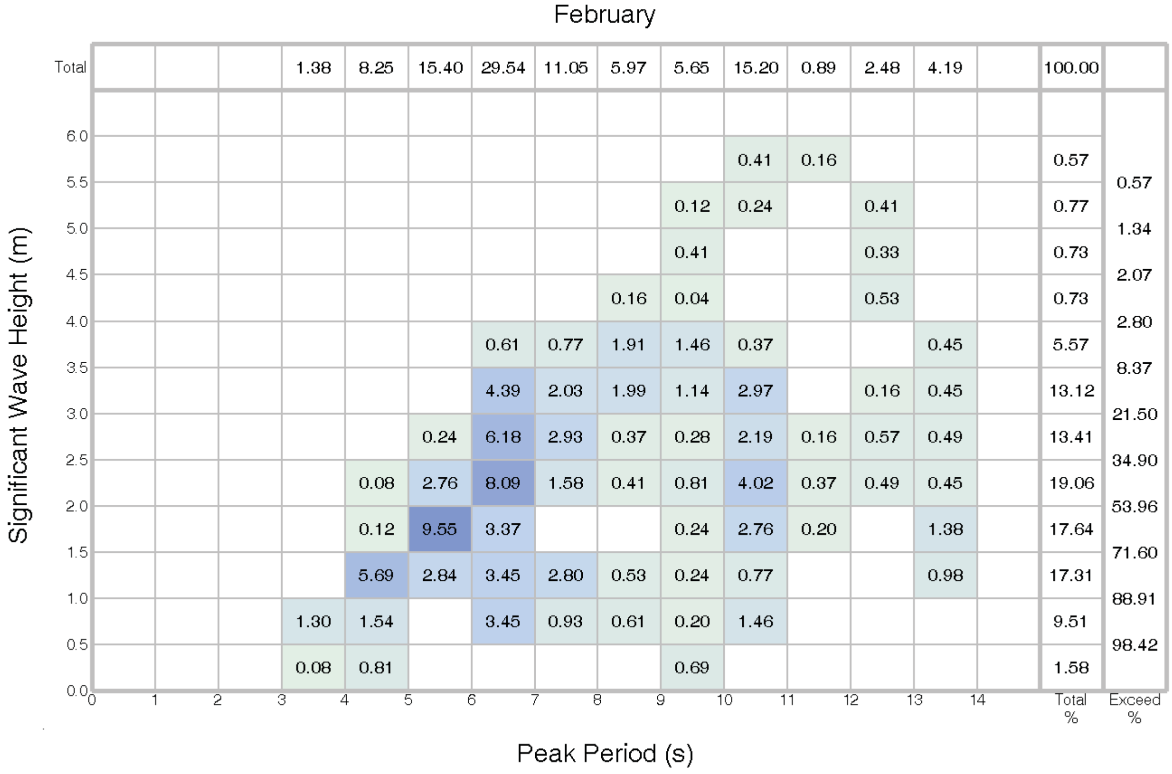
Figure 2-62 Percentage Occurrence of Significant Wave Height and Peak Period Zero Up-Crossing Period for Winter Storms – December

### 2.2.13 Joint Frequency Distribution of Significant Wave Height and Peak Period for Winter Storms



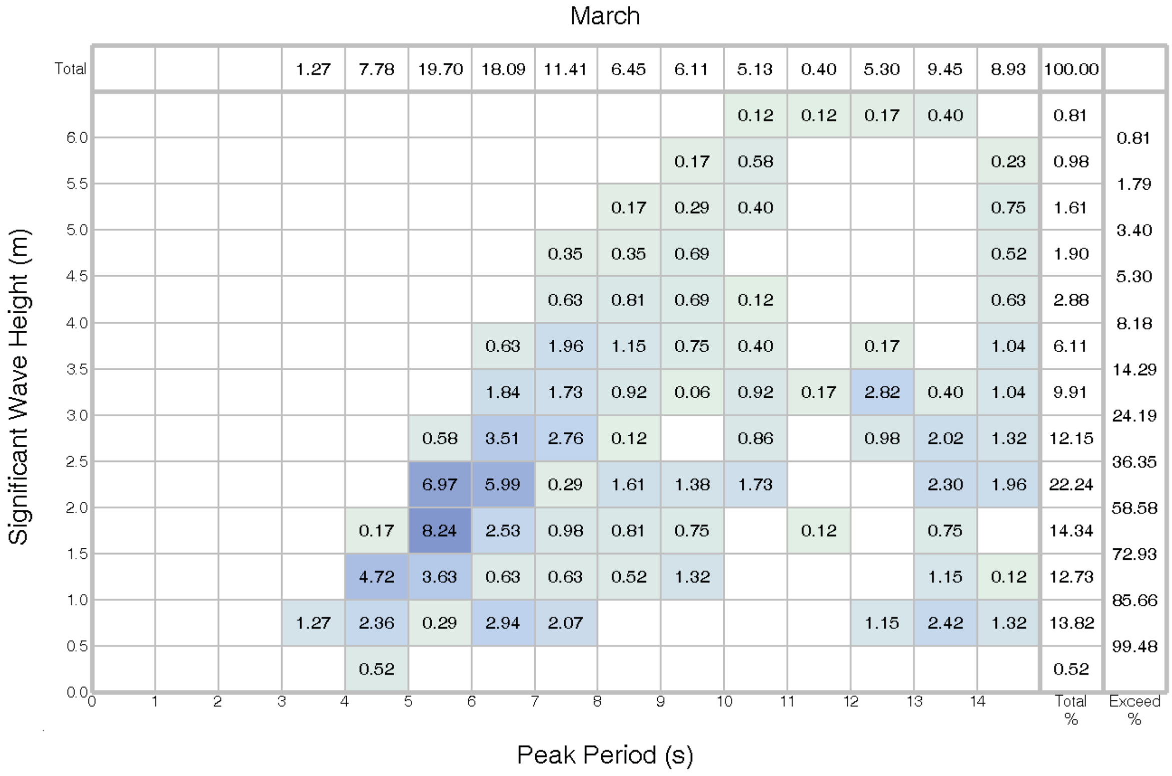
| Significant Wave Height (m) \ Peak Period (s) | 0–1 | 1–2 | 2–3 | 3–4 | 4–5 | 5–6 | 6–7 | 7–8 | 8–9 | 9–10 | 10–11 | 11–12 | 12–13 | 13–14 | 14– | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | 3.56 | 9.85 | 19.85 | 19.70 | 12.52 | 4.89 | 9.33 | 6.67 | 1.93 | 4.44 | 3.70 | 3.56 | 100.00 | |
| 6.0– | | | | | | | | | | | | | | | | | |
| 5.5–6.0 | | | | | | | | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | | | | | | | | |
| 4.0–4.5 | | | | | | | | | 0.37 | | | | | | | 0.37 | 0.37 |
| 3.5–4.0 | | | | | | | 0.81 | 2.52 | 0.67 | | 0.22 | 1.04 | 0.07 | | | 5.33 | 5.70 |
| 3.0–3.5 | | | | | | | 3.78 | 0.67 | 0.37 | 0.52 | 1.70 | 0.89 | 2.52 | | | 10.44 | 16.15 |
| 2.5–3.0 | | | | | | | 2.59 | 2.30 | 2.07 | 2.07 | 1.85 | | 1.85 | 1.93 | 2.15 | 16.81 | 32.96 |
| 2.0–2.5 | | | | | | 1.85 | 7.19 | 1.63 | 1.41 | 1.41 | 1.56 | | | 1.78 | 1.41 | 18.22 | 51.19 |
| 1.5–2.0 | | | | | 0.15 | 11.63 | 2.07 | 1.48 | | 0.81 | 0.96 | | | | | 17.11 | 68.30 |
| 1.0–1.5 | | | | | 7.93 | 1.41 | 2.81 | 3.78 | | 1.11 | 0.37 | | | | | 17.41 | 85.70 |
| 0.5–1.0 | | | | 0.59 | 1.26 | 2.07 | 0.44 | 0.15 | | 3.41 | | | | | | 7.93 | 93.63 |
| 0.0–0.5 | | | | 2.96 | 0.52 | 2.89 | | | | | | | | | | 6.37 | |

Figure 2-63 Percentage Occurrence of Significant Wave Height and Peak Period for Winter Storms – January



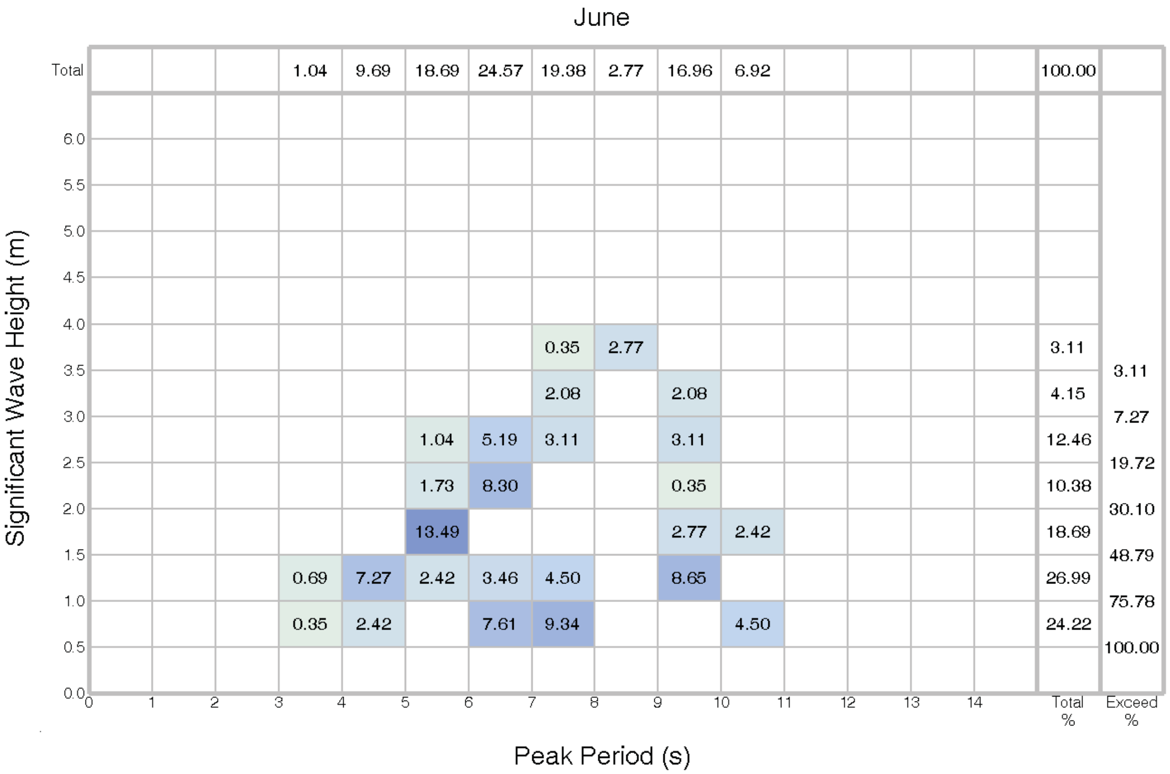
| Significant Wave Height (m) | 0–1 | 1–2 | 2–3 | 3–4 | 4–5 | 5–6 | 6–7 | 7–8 | 8–9 | 9–10 | 10–11 | 11–12 | 12–13 | 13–14 | 14– | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | 1.38 | 8.25 | 15.40 | 29.54 | 11.05 | 5.97 | 5.65 | 15.20 | 0.89 | 2.48 | 4.19 | | 100.00 | |
| 6.0– | | | | | | | | | | | | | | | | | |
| 5.5–6.0 | | | | | | | | | | | 0.41 | 0.16 | | | | 0.57 | 0.57 |
| 5.0–5.5 | | | | | | | | | | 0.12 | 0.24 | | 0.41 | | | 0.77 | 1.34 |
| 4.5–5.0 | | | | | | | | | | 0.41 | | | 0.33 | | | 0.73 | 2.07 |
| 4.0–4.5 | | | | | | | | | 0.16 | 0.04 | | | 0.53 | | | 0.73 | 2.80 |
| 3.5–4.0 | | | | | | | 0.61 | 0.77 | 1.91 | 1.46 | 0.37 | | | 0.45 | | 5.57 | 8.37 |
| 3.0–3.5 | | | | | | | 4.39 | 2.03 | 1.99 | 1.14 | 2.97 | | 0.16 | 0.45 | | 13.12 | 21.50 |
| 2.5–3.0 | | | | | | 0.24 | 6.18 | 2.93 | 0.37 | 0.28 | 2.19 | 0.16 | 0.57 | 0.49 | | 13.41 | 34.90 |
| 2.0–2.5 | | | | | 0.08 | 2.76 | 8.09 | 1.58 | 0.41 | 0.81 | 4.02 | 0.37 | 0.49 | 0.45 | | 19.06 | 53.96 |
| 1.5–2.0 | | | | | 0.12 | 9.55 | 3.37 | | | 0.24 | 2.76 | 0.20 | | 1.38 | | 17.64 | 71.60 |
| 1.0–1.5 | | | | | 5.69 | 2.84 | 3.45 | 2.80 | 0.53 | 0.24 | 0.77 | | | 0.98 | | 17.31 | 88.91 |
| 0.5–1.0 | | | | 1.30 | 1.54 | | 3.45 | 0.93 | 0.61 | 0.20 | 1.46 | | | | | 9.51 | 98.42 |
| 0.0–0.5 | | | | 0.08 | 0.81 | | | | | 0.69 | | | | | | 1.58 | |

Figure 2-64 Percentage Occurrence of Significant Wave Height and Peak Period for Winter Storms – February



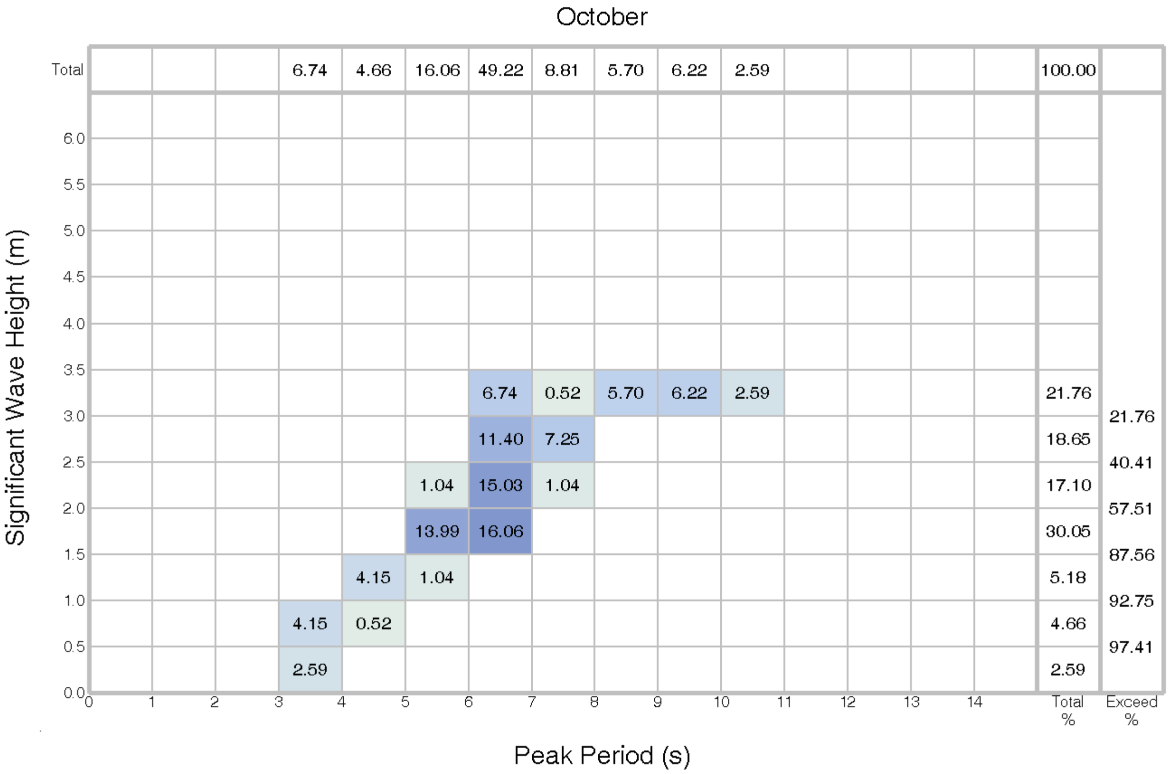
| Significant Wave Height (m) | 0–1 | 1–2 | 2–3 | 3–4 | 4–5 | 5–6 | 6–7 | 7–8 | 8–9 | 9–10 | 10–11 | 11–12 | 12–13 | 13–14 | 14– | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | 1.27 | 7.78 | 19.70 | 18.09 | 11.41 | 6.45 | 6.11 | 5.13 | 0.40 | 5.30 | 9.45 | 8.93 | 100.00 | |
| 6.0– | | | | | | | | | | | 0.12 | 0.12 | 0.17 | 0.40 | | 0.81 | 0.81 |
| 5.5–6.0 | | | | | | | | | | 0.17 | 0.58 | | | | 0.23 | 0.98 | 1.79 |
| 5.0–5.5 | | | | | | | | | 0.17 | 0.29 | 0.40 | | | | 0.75 | 1.61 | 3.40 |
| 4.5–5.0 | | | | | | | | 0.35 | 0.35 | 0.69 | | | | | 0.52 | 1.90 | 5.30 |
| 4.0–4.5 | | | | | | | | 0.63 | 0.81 | 0.69 | 0.12 | | | | 0.63 | 2.88 | 8.18 |
| 3.5–4.0 | | | | | | | 0.63 | 1.96 | 1.15 | 0.75 | 0.40 | | 0.17 | | 1.04 | 6.11 | 14.29 |
| 3.0–3.5 | | | | | | | 1.84 | 1.73 | 0.92 | 0.06 | 0.92 | 0.17 | 2.82 | 0.40 | 1.04 | 9.91 | 24.19 |
| 2.5–3.0 | | | | | | 0.58 | 3.51 | 2.76 | 0.12 | | 0.86 | | 0.98 | 2.02 | 1.32 | 12.15 | 36.35 |
| 2.0–2.5 | | | | | | 6.97 | 5.99 | 0.29 | 1.61 | 1.38 | 1.73 | | | 2.30 | 1.96 | 22.24 | 58.58 |
| 1.5–2.0 | | | | | 0.17 | 8.24 | 2.53 | 0.98 | 0.81 | 0.75 | | 0.12 | | 0.75 | | 14.34 | 72.93 |
| 1.0–1.5 | | | | | 4.72 | 3.63 | 0.63 | 0.63 | 0.52 | 1.32 | | | | 1.15 | 0.12 | 12.73 | 85.66 |
| 0.5–1.0 | | | | 1.27 | 2.36 | 0.29 | 2.94 | 2.07 | | | | | 1.15 | 2.42 | 1.32 | 13.82 | 99.48 |
| 0.0–0.5 | | | | | 0.52 | | | | | | | | | | | 0.52 | |

Figure 2-65 Percentage Occurrence of Significant Wave Height and Peak Period for Winter Storms – March


June

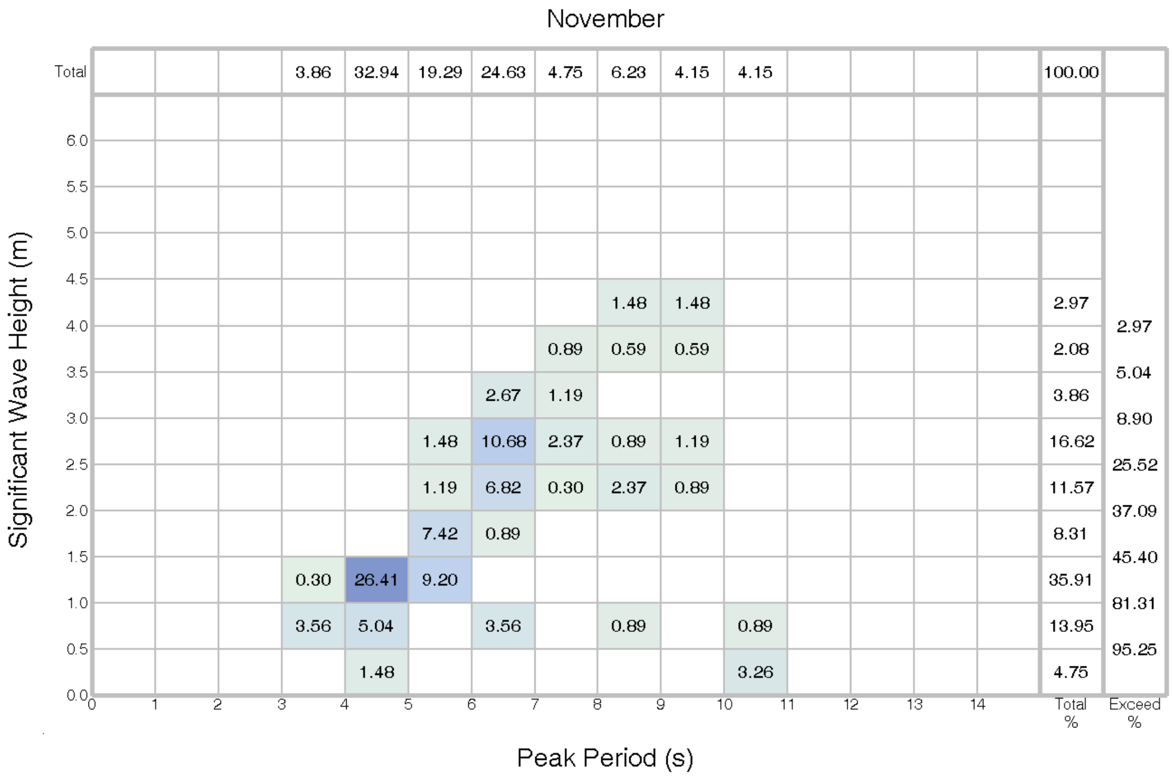
| Significant Wave Height (m) \ Peak Period (s) | 0–1 | 1–2 | 2–3 | 3–4 | 4–5 | 5–6 | 6–7 | 7–8 | 8–9 | 9–10 | 10–11 | 11–12 | 12–13 | 13–14 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | 1.04 | 9.69 | 18.69 | 24.57 | 19.38 | 2.77 | 16.96 | 6.92 | | | | 100.00 | |
| 6.0– | | | | | | | | | | | | | | | | |
| 5.5–6.0 | | | | | | | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | | | | | | | |
| 4.0–4.5 | | | | | | | | | | | | | | | | |
| 3.5–4.0 | | | | | | | | 0.35 | 2.77 | | | | | | 3.11 | 3.11 |
| 3.0–3.5 | | | | | | | | 2.08 | | 2.08 | | | | | 4.15 | 7.27 |
| 2.5–3.0 | | | | | | 1.04 | 5.19 | 3.11 | | 3.11 | | | | | 12.46 | 19.72 |
| 2.0–2.5 | | | | | | 1.73 | 8.30 | | | 0.35 | | | | | 10.38 | 30.10 |
| 1.5–2.0 | | | | | | 13.49 | | | | 2.77 | 2.42 | | | | 18.69 | 48.79 |
| 1.0–1.5 | | | | 0.69 | 7.27 | 2.42 | 3.46 | 4.50 | | 8.65 | | | | | 26.99 | 75.78 |
| 0.5–1.0 | | | | 0.35 | 2.42 | | 7.61 | 9.34 | | | 4.50 | | | | 24.22 | 100.00 |
| 0.0–0.5 | | | | | | | | | | | | | | | | |

Figure 2-66 Percentage Occurrence of Significant Wave Height and Peak Period for Winter Storms – June


October

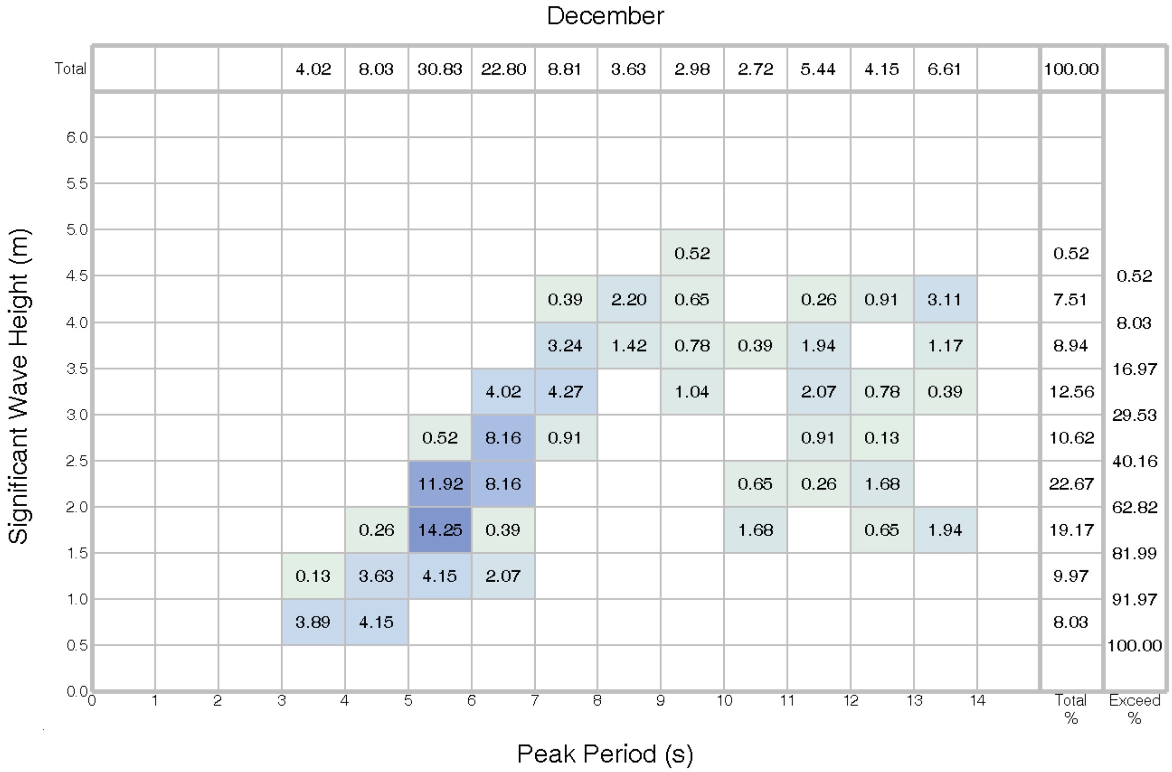
| Significant Wave Height (m) \ Peak Period (s) | 0–1 | 1–2 | 2–3 | 3–4 | 4–5 | 5–6 | 6–7 | 7–8 | 8–9 | 9–10 | 10–11 | 11–12 | 12–13 | 13–14 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | 6.74 | 4.66 | 16.06 | 49.22 | 8.81 | 5.70 | 6.22 | 2.59 | | | | 100.00 | |
| 6.0– | | | | | | | | | | | | | | | | |
| 5.5–6.0 | | | | | | | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | | | | | | | |
| 4.0–4.5 | | | | | | | | | | | | | | | | |
| 3.5–4.0 | | | | | | | | | | | | | | | | |
| 3.0–3.5 | | | | | | | 6.74 | 0.52 | 5.70 | 6.22 | 2.59 | | | | 21.76 | 21.76 |
| 2.5–3.0 | | | | | | | 11.40 | 7.25 | | | | | | | 18.65 | 40.41 |
| 2.0–2.5 | | | | | | 1.04 | 15.03 | 1.04 | | | | | | | 17.10 | 57.51 |
| 1.5–2.0 | | | | | | 13.99 | 16.06 | | | | | | | | 30.05 | 87.56 |
| 1.0–1.5 | | | | | 4.15 | 1.04 | | | | | | | | | 5.18 | 92.75 |
| 0.5–1.0 | | | | 4.15 | 0.52 | | | | | | | | | | 4.66 | 97.41 |
| 0.0–0.5 | | | | 2.59 | | | | | | | | | | | 2.59 | |

Figure 2-67 Percentage Occurrence of Significant Wave Height and Peak Period for Winter Storms – October



| Significant Wave Height (m) | 0–1 | 1–2 | 2–3 | 3–4 | 4–5 | 5–6 | 6–7 | 7–8 | 8–9 | 9–10 | 10–11 | 11–12 | 12–13 | 13–14 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | 3.86 | 32.94 | 19.29 | 24.63 | 4.75 | 6.23 | 4.15 | 4.15 | | | | 100.00 | |
| 6.0+ | | | | | | | | | | | | | | | | |
| 5.5–6.0 | | | | | | | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | | | | | | | |
| 4.0–4.5 | | | | | | | | | 1.48 | 1.48 | | | | | 2.97 | 2.97 |
| 3.5–4.0 | | | | | | | | 0.89 | 0.59 | 0.59 | | | | | 2.08 | 5.04 |
| 3.0–3.5 | | | | | | | 2.67 | 1.19 | | | | | | | 3.86 | 8.90 |
| 2.5–3.0 | | | | | | 1.48 | 10.68 | 2.37 | 0.89 | 1.19 | | | | | 16.62 | 25.52 |
| 2.0–2.5 | | | | | | 1.19 | 6.82 | 0.30 | 2.37 | 0.89 | | | | | 11.57 | 37.09 |
| 1.5–2.0 | | | | | | 7.42 | 0.89 | | | | | | | | 8.31 | 45.40 |
| 1.0–1.5 | | | | 0.30 | 26.41 | 9.20 | | | | | | | | | 35.91 | 81.31 |
| 0.5–1.0 | | | | 3.56 | 5.04 | | 3.56 | | 0.89 | | 0.89 | | | | 13.95 | 95.25 |
| 0.0–0.5 | | | | | 1.48 | | | | | | 3.26 | | | | 4.75 | |

**Figure 2-68 Percentage Occurrence of Significant Wave Height and Peak Period for Winter Storms – November**



| Significant Wave Height (m) | 0–1 | 1–2 | 2–3 | 3–4 | 4–5 | 5–6 | 6–7 | 7–8 | 8–9 | 9–10 | 10–11 | 11–12 | 12–13 | 13–14 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | 4.02 | 8.03 | 30.83 | 22.80 | 8.81 | 3.63 | 2.98 | 2.72 | 5.44 | 4.15 | 6.61 | 100.00 | |
| 6.0+ | | | | | | | | | | | | | | | | |
| 5.5–6.0 | | | | | | | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | 0.52 | | | | | 0.52 | 0.52 |
| 4.0–4.5 | | | | | | | | 0.39 | 2.20 | 0.65 | | 0.26 | 0.91 | 3.11 | 7.51 | 8.03 |
| 3.5–4.0 | | | | | | | | 3.24 | 1.42 | 0.78 | 0.39 | 1.94 | | 1.17 | 8.94 | 16.97 |
| 3.0–3.5 | | | | | | | 4.02 | 4.27 | | 1.04 | | 2.07 | 0.78 | 0.39 | 12.56 | 29.53 |
| 2.5–3.0 | | | | | | 0.52 | 8.16 | 0.91 | | | | 0.91 | 0.13 | | 10.62 | 40.16 |
| 2.0–2.5 | | | | | | 11.92 | 8.16 | | | | 0.65 | 0.26 | 1.68 | | 22.67 | 62.82 |
| 1.5–2.0 | | | | | 0.26 | 14.25 | 0.39 | | | | 1.68 | | 0.65 | 1.94 | 19.17 | 81.99 |
| 1.0–1.5 | | | | 0.13 | 3.63 | 4.15 | 2.07 | | | | | | | | 9.97 | 91.97 |
| 0.5–1.0 | | | | 3.89 | 4.15 | | | | | | | | | | 8.03 | 100.00 |
| 0.0–0.5 | | | | | | | | | | | | | | | | |

**Figure 2-69 Percentage Occurrence of Significant Wave Height and Peak Period for Winter Storms – December**

### 2.2.14 All Waves for Hurricanes

Extreme value analysis was carried out on a subset of peak wave heights from the Oceanweather hindcast data. The analysis only considered hurricane storm events from 1924 to 2005.

### 2.2.15 Omni-Directional Hurricane Extreme Values

| Return Period | Hs | Tz | Tp | Hc | Hmax | THmax Low | THmax Mid | THmax High | Wave Length |
|---|---|---|---|---|---|---|---|---|---|
| | [m] | [s] | [s] | [m] | [m] | [s] | [s] | [s] | [m] |
| **50-years** | 8.16 | 8.0 | 12.0 | 9.49 | 14.72 | 10.6 | 12.0 | 13.1 | 167.52 |
| **100-years** | 9.13 | 8.3 | 12.6 | 10.61 | 16.46 | 11.2 | 12.7 | 13.8 | 180.72 |
| **500-years** | 11.38 | 8.9 | 14.0 | 13.23 | 20.52 | 12.4 | 14.1 | 15.3 | 210.58 |
| **1000-years** | 12.35 | 9.1 | 14.5 | 14.35 | 22.26 | 12.9 | 14.6 | 15.9 | 223.23 |
| **10000-years** | 15.57 | 9.8 | 16.2 | 18.09 | 28.06 | 14.4 | 16.3 | 17.8 | 263.17 |

**Table 2-28 Omni-Directional Hurricane Extreme Values for All Waves**

### 2.2.16 Directional Hurricane Extreme Values

| Return Period | Hs | Tz | Tp | Hc | Hmax | THmax Low | THmax Mid | THmax High |
|---|---|---|---|---|---|---|---|---|
| **Direction [from]** | [m] | [s] | [s] | [m] | [m] | [s] | [s] | [s] |
| **50-Years** | **8.16** | **8.0** | **12.0** | **9.49** | **14.72** | **10.6** | **12.0** | **13.1** |
| North | 4.77 | 6.8 | 9.3 | 5.54 | 8.59 | 8.2 | 9.3 | 10.2 |
| North-east | 6.45 | 7.4 | 10.7 | 7.50 | 11.63 | 9.5 | 10.8 | 11.7 |
| East | 8.16 | 8.0 | 12.0 | 9.49 | 14.72 | 10.6 | 12.0 | 13.1 |
| South-east | 8.13 | 8.0 | 11.9 | 9.45 | 14.65 | 10.6 | 12.0 | 13.1 |
| South | 5.36 | 7.0 | 9.8 | 6.23 | 9.66 | 8.7 | 9.9 | 10.8 |
| South-west | 3.94 | 6.4 | 8.5 | 4.58 | 7.11 | 7.5 | 8.5 | 9.3 |
| West | 3.74 | 6.3 | 8.3 | 4.35 | 6.75 | 7.3 | 8.3 | 9.1 |
| North-west | 3.70 | 6.3 | 8.2 | 4.30 | 6.67 | 7.3 | 8.3 | 9.0 |
| **100-Years** | **9.13** | **8.3** | **12.6** | **10.61** | **16.46** | **11.2** | **12.7** | **13.8** |
| North | 5.33 | 7.0 | 9.8 | 6.20 | 9.61 | 8.7 | 9.8 | 10.7 |
| North-east | 7.21 | 7.7 | 11.3 | 8.38 | 13.01 | 10.0 | 11.3 | 12.4 |
| East | 9.13 | 8.3 | 12.6 | 10.61 | 16.46 | 11.2 | 12.7 | 13.8 |
| South-east | 9.09 | 8.3 | 12.6 | 10.57 | 16.39 | 11.2 | 12.6 | 13.8 |
| South | 5.99 | 7.3 | 10.3 | 6.97 | 10.81 | 9.2 | 10.4 | 11.3 |
| South-west | 4.41 | 6.6 | 9.0 | 5.12 | 7.95 | 7.9 | 9.0 | 9.8 |
| West | 4.19 | 6.5 | 8.7 | 4.87 | 7.55 | 7.7 | 8.8 | 9.6 |
| North-west | 4.14 | 6.5 | 8.7 | 4.81 | 7.46 | 7.7 | 8.7 | 9.5 |
| **500-Years** | **11.38** | **8.9** | **14.0** | **13.23** | **20.52** | **12.4** | **14.1** | **15.3** |
| North | 6.64 | 7.5 | 10.9 | 7.72 | 11.98 | 9.6 | 10.9 | 11.9 |
| North-east | 8.99 | 8.2 | 12.5 | 10.45 | 16.21 | 11.1 | 12.6 | 13.7 |
| East | 11.38 | 8.9 | 14.0 | 13.23 | 20.52 | 12.4 | 14.1 | 15.3 |
| South-east | 11.33 | 8.8 | 14.0 | 13.17 | 20.42 | 12.4 | 14.0 | 15.3 |
| South | 7.47 | 7.8 | 11.5 | 8.68 | 13.47 | 10.2 | 11.5 | 12.6 |
| South-west | 5.50 | 7.1 | 9.9 | 6.39 | 9.91 | 8.8 | 10.0 | 10.9 |
| West | 5.22 | 7.0 | 9.7 | 6.06 | 9.41 | 8.6 | 9.7 | 10.6 |
| North-west | 5.16 | 6.9 | 9.6 | 5.99 | 9.30 | 8.5 | 9.7 | 10.6 |
| **1000-Years** | **12.35** | **9.1** | **14.5** | **14.35** | **22.26** | **12.9** | **14.6** | **15.9** |
| North | 7.21 | 7.7 | 11.3 | 8.38 | 13.00 | 10.0 | 11.3 | 12.4 |
| North-east | 9.76 | 8.4 | 13.0 | 11.34 | 17.59 | 11.5 | 13.1 | 14.3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| East | 12.35 | 9.1 | 14.5 | 14.35 | 22.26 | 12.9 | 14.6 | 15.9 |
| South-east | 12.29 | 9.1 | 14.5 | 14.29 | 22.16 | 12.9 | 14.6 | 15.9 |
| South | 8.11 | 8.0 | 11.9 | 9.42 | 14.61 | 10.6 | 12.0 | 13.1 |
| South-west | 5.96 | 7.2 | 10.3 | 6.93 | 10.75 | 9.1 | 10.4 | 11.3 |
| West | 5.66 | 7.1 | 10.1 | 6.58 | 10.21 | 8.9 | 10.1 | 11.0 |
| North-west | 5.60 | 7.1 | 10.0 | 6.50 | 10.09 | 8.9 | 10.1 | 11.0 |
| **10000-Years** | **15.57** | **9.8** | **16.2** | **18.09** | **28.06** | **14.4** | **16.3** | **17.8** |
| North | 9.09 | 8.3 | 12.6 | 10.56 | 16.38 | 11.1 | 12.6 | 13.8 |
| North-east | 12.30 | 9.1 | 14.5 | 14.29 | 22.16 | 12.9 | 14.6 | 15.9 |
| East | 15.57 | 9.8 | 16.2 | 18.09 | 28.06 | 14.4 | 16.3 | 17.8 |
| South-east | 15.50 | 9.7 | 16.2 | 18.01 | 27.93 | 14.3 | 16.3 | 17.7 |
| South | 10.22 | 8.6 | 13.3 | 11.87 | 18.42 | 11.8 | 13.4 | 14.6 |
| South-west | 7.52 | 7.8 | 11.5 | 8.73 | 13.55 | 10.2 | 11.6 | 12.6 |
| West | 7.14 | 7.7 | 11.2 | 8.29 | 12.86 | 9.9 | 11.3 | 12.3 |
| North-west | 7.05 | 7.6 | 11.2 | 8.20 | 12.72 | 9.9 | 11.2 | 12.2 |

**Table 2-29 Directional Hurricane Extreme Values for All Waves**

### 2.2.17 All Wave Fitting Parameters for Hurricanes

The independent omni-directional wave cases are given in Table 2-28 and detailed descriptions of the calculations are given below.

Extreme value analysis was carried out on a subset of peak wave heights from the OceanWeather data. The analysis only considered hurricane storm events from 1924 to 2005.

The Peaks Over Threshold (POT) method consisted of declustering the data by selecting peak events to produce a set of independent and identically distributed observations. This method was then employed to derive the 50-, 100-, 500-, 1000-, and 10000-year criteria. The number of peaks exceeding a given level, divided by the number of years of record, gave the rate of exceedance which could then be used to find the expected number of occurrences in a specified period of time.

The Exponential (EXP), Fisher-Tippett 1 (FT1), Generalised Pareto (GP), Weibull 2 (W2) and Weibull 3 (W3) distributions were tested for goodness-of-fit to the OceanWeather data using the method of least squares (LS), maximum likelihood (MLE), and the method of moments (MoM). The best fits for 50-, 100-, 500-, 1000-, and 10000-year significant wave height are summarised in Table 2-30.

| | **Distribution** | **Fit** | **Threshold** | **# Peaks** | **Extreme Values** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **50-yr** | **100-yr** | **500-yr** | **1000-yr** | **10000-yr** |
| **Hs (m)** | EXP | LS | 1.00 | 367 | 7.98 | 8.91 | 11.06 | 11.99 | 15.07 |
| | EXP | LS | 1.50 | 201 | 8.39 | 9.41 | 11.79 | 12.81 | 16.20 |
| | EXP | MoM | 1.50 | 201 | 8.07 | 9.03 | 11.28 | 12.25 | 15.46 |
| | EXP | MoM | 2.20 | 101 | 8.25 | 9.27 | 11.63 | 12.65 | 16.03 |
| | EXP | MLE | 2.20 | 101 | 8.20 | 9.20 | 11.54 | 12.55 | 15.89 |
| | FT1 | LS | 2.20 | 101 | 8.11 | 8.98 | 10.99 | 11.86 | 14.74 |
| | **AVERAGE** | | | | 8.16 | 9.13 | 11.38 | 12.35 | 15.57 |

**Table 2-30 Extreme Omni-directional All Wave Fitting Parameters for Hurricanes**

### 2.2.18 Wave Height and Length for Hurricanes for Site 1 and 2

Wave Length is calculated using the omni-directional hurricane extreme values found in Table 2-16 and Table 2-28 with the associated depths for each site.

| Extreme Wave Criteria at Site 1 | | Return Period | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1-year | 50-year | 100-year | 500-year | 1000-year | 10000-year |
| Significant Wave Height (m) | | 5.34 | 8.16 | 9.13 | 11.38 | 12.35 | 15.57 |
| Peak Period (s) | | 9.9 | 11.96 | 12.61 | 13.99 | 14.54 | 16.21 |
| Wave Length (m) | Total Water Depth 24.7m | 130.59 | 171.08 | 184.46 | 214.56 | 227.28 | 268.26 |

Table 2-31 Extreme Wave and Associated Wave Length for Hurricanes at Site 1

| Extreme Wave Criteria at Site 2 | | Return Period | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1-year | 50-year | 100-year | 500-year | 1000-year | 10000-year |
| Significant Wave Height (m) | | 5.34 | 8.16 | 9.13 | 11.38 | 12.35 | 15.57 |
| Peak Period (s) | | 9.9 | 11.96 | 12.61 | 13.99 | 14.54 | 16.21 |
| Wave Length (m) | Total Water Depth 25.4m | 131.60 | 172.51 | 185.97 | 216.17 | 228.92 | 270.14 |

Table 2-32 Extreme Wave and Associated Wave Length for Hurricanes at Site 2

### 2.2.19 Wave Orbital Velocity at 1m Above Seabed for Hurricanes for Site 1 and 2

Wave orbital velocity at 1 m above seabed is calculated using the omni-directional hurricane extreme values found in Table 2-16 and Table 2-28 with the associated depths for each site. Table 2-34 and Table 2-36 show wave orbital velocity using Hmax and Tp associated with Hmax (THmax high). Unable to compute wave orbital velocity for the 500-, 1000,- and 10000 year event because the wave is a breaking wave.

| Extreme Wave Criteria at Site 1 | | Return Period | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1-year | 50-year | 100-year | 500-year | 1000-year | 10000-year |
| Significant Wave Height (m) | | 5.34 | 8.16 | 9.13 | 11.38 | 12.35 | 15.57 |
| Peak Period (s) | | 9.9 | 11.96 | 12.61 | 13.99 | 14.54 | 16.21 |
| Wave Orbital Velocity (m/s) at 1m above seabed | Total Water Depth 24.7m | 1.12 | 2.02 | 2.35 | 3.07 | 3.36 | 4.12 |

Table 2-33 Extreme Wave and Associated Wave Orbital Velocity at 1m Above Seabed for Hurricanes at Site 1

| Extreme Wave Criteria at Site 1 | | Return Period | | |
|---|---|---|---|---|
| | | 1-year | 50-year | 100-year |
| Hmax (m) | | 10.01 | 14.71 | 16.46 |
| Peak Period Associated with Hmax (s) | | 10.9 | 13.1 | 13.8 |
| Wave Orbital Velocity (m/s) at 1m above seabed | Total Water Depth 24.7m | 2.26 | 3.53 | 3.76 |

Table 2-34 Extreme Hmax and Associated Wave Orbital Velocity at 1m Above Seabed for Hurricanes at Site 1

| Extreme Wave Criteria at Site 2 | | Return Period | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1-year | 50-year | 100-year | 500-year | 1000-year | 10000-year |
| Significant Wave Height (m) | | 5.34 | 8.16 | 9.13 | 11.38 | 12.35 | 15.57 |
| Peak Period (s) | | 9.9 | 11.96 | 12.61 | 13.99 | 14.54 | 16.21 |
| Wave Orbital Velocity (m/s) at 1m above seabed | Total Water Depth 25.4m | 1.09 | 1.98 | 2.30 | 3.01 | 3.30 | 4.10 |

Table 2-35 Extreme Wave and Associated Wave Orbital Velocity at 1m Above Seabed for Hurricanes at Site 2

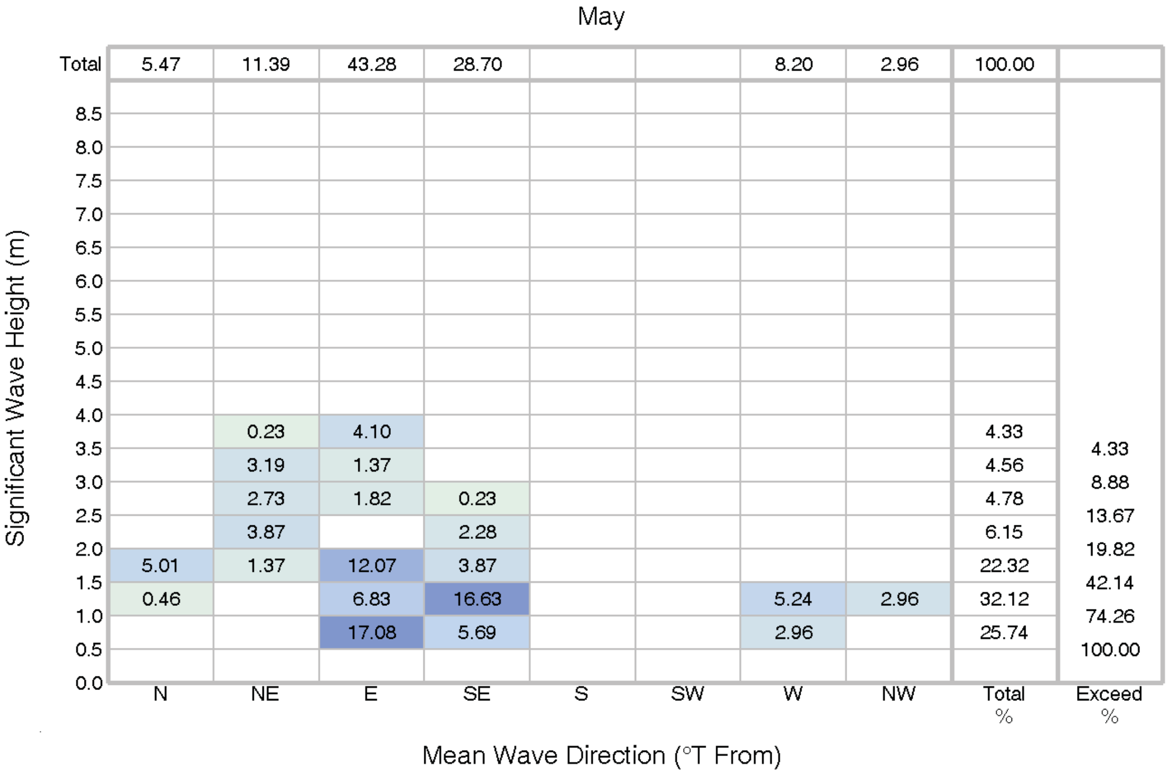
| Extreme Wave Criteria at Site 2 | | Return Period | | |
|---|---|---|---|---|
| | | 1-year | 50-year | 100-year |
| Hmax (m) | | 10.01 | 14.71 | 16.46 |
| Peak Period Associated with Hmax (s) | | 10.9 | 13.1 | 13.8 |
| Wave Orbital Velocity (m/s) at 1m above seabed | Total Water Depth 25.4m | 2.22 | 3.49 | 3.78 |

Table 2-36 Extreme Hmax and Associated Wave Orbital Velocity at 1m Above Seabed for Hurricanes at Site 2

### 2.2.20 Fatigue Waves for Hurricanes

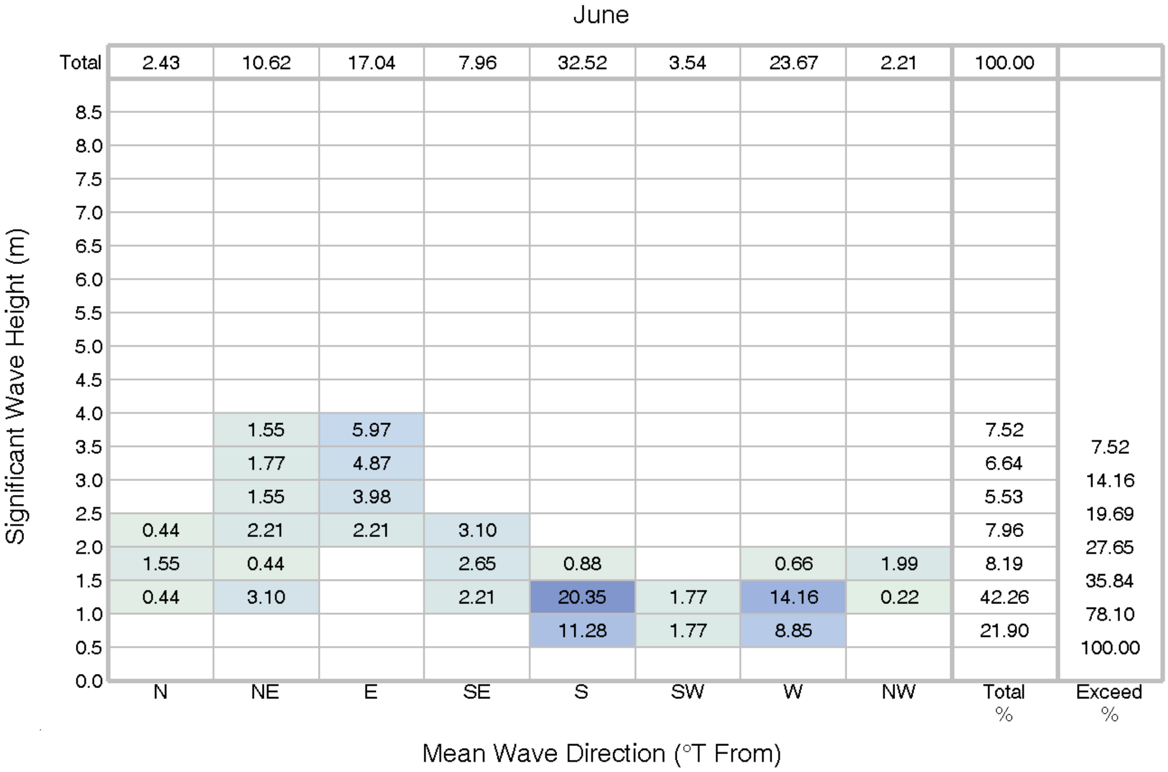
Extreme all-year omni-directonal and directional fatigue individuale wave heights and periods for hurricanes are provided in the attached Excel spreadsheet “Virgina_Extreme_Fatigue_Hurricane.” Directional scatter table of individuale fatigue wave heights and periods scaled to an interval of 20 years at 45 degree intervals for hurricanes are provided in the Excel spreadsheets “Virginia_Fatigue_20years_Hurricane.” Directional tables of mid height, median period, and 15 and 85 percentile period limits for fatigue waves at 45 degree intervals for hurricanes are provided in the Excel spreadsheets “Virginia_Fatigue_Tables_Hurricane.”

### 2.2.21 Joint Frequency Distribution of Significant Wave Height and Direction for Hurricanes



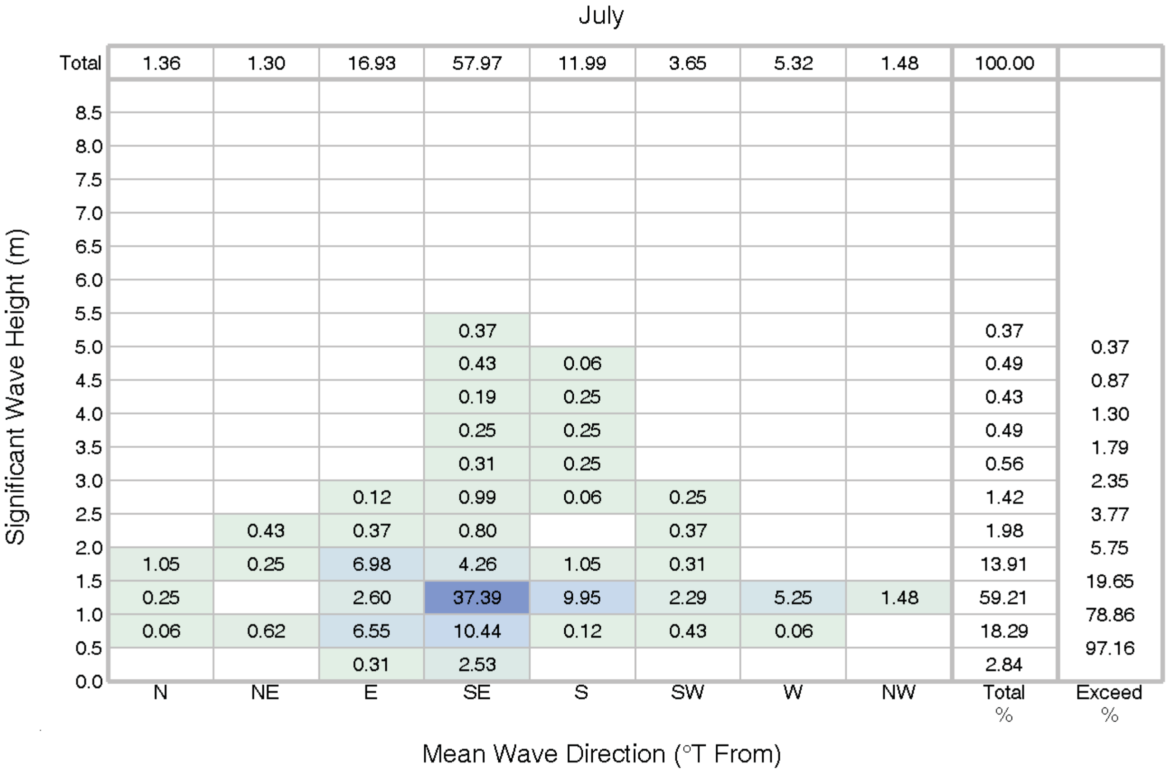
| Significant Wave Height (m) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 5.47 | 11.39 | 43.28 | 28.70 | | | 8.20 | 2.96 | 100.00 | |
| 8.0–8.5 | | | | | | | | | | |
| 7.5–8.0 | | | | | | | | | | |
| 7.0–7.5 | | | | | | | | | | |
| 6.5–7.0 | | | | | | | | | | |
| 6.0–6.5 | | | | | | | | | | |
| 5.5–6.0 | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | |
| 4.0–4.5 | | | | | | | | | | |
| 3.5–4.0 | | 0.23 | 4.10 | | | | | | 4.33 | 4.33 |
| 3.0–3.5 | | 3.19 | 1.37 | | | | | | 4.56 | 8.88 |
| 2.5–3.0 | | 2.73 | 1.82 | 0.23 | | | | | 4.78 | 13.67 |
| 2.0–2.5 | | 3.87 | | 2.28 | | | | | 6.15 | 19.82 |
| 1.5–2.0 | 5.01 | 1.37 | 12.07 | 3.87 | | | | | 22.32 | 42.14 |
| 1.0–1.5 | 0.46 | | 6.83 | 16.63 | | | 5.24 | 2.96 | 32.12 | 74.26 |
| 0.5–1.0 | | | 17.08 | 5.69 | | | 2.96 | | 25.74 | 100.00 |
| 0.0–0.5 | | | | | | | | | | |

Figure 2-70 Percentage Occurrence of Significant Wave Height and Direction for Hurricanes – May



| Significant Wave Height (m) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 2.43 | 10.62 | 17.04 | 7.96 | 32.52 | 3.54 | 23.67 | 2.21 | 100.00 | |
| 8.0–8.5 | | | | | | | | | | |
| 7.5–8.0 | | | | | | | | | | |
| 7.0–7.5 | | | | | | | | | | |
| 6.5–7.0 | | | | | | | | | | |
| 6.0–6.5 | | | | | | | | | | |
| 5.5–6.0 | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | |
| 4.0–4.5 | | | | | | | | | | |
| 3.5–4.0 | | 1.55 | 5.97 | | | | | | 7.52 | 7.52 |
| 3.0–3.5 | | 1.77 | 4.87 | | | | | | 6.64 | 14.16 |
| 2.5–3.0 | | 1.55 | 3.98 | | | | | | 5.53 | 19.69 |
| 2.0–2.5 | 0.44 | 2.21 | 2.21 | 3.10 | | | | | 7.96 | 27.65 |
| 1.5–2.0 | 1.55 | 0.44 | | 2.65 | 0.88 | | 0.66 | 1.99 | 8.19 | 35.84 |
| 1.0–1.5 | 0.44 | 3.10 | | 2.21 | 20.35 | 1.77 | 14.16 | 0.22 | 42.26 | 78.10 |
| 0.5–1.0 | | | | | 11.28 | 1.77 | 8.85 | | 21.90 | 100.00 |
| 0.0–0.5 | | | | | | | | | | |

Figure 2-71 Percentage Occurrence of Significant Wave Height and Direction for Hurricanes – June

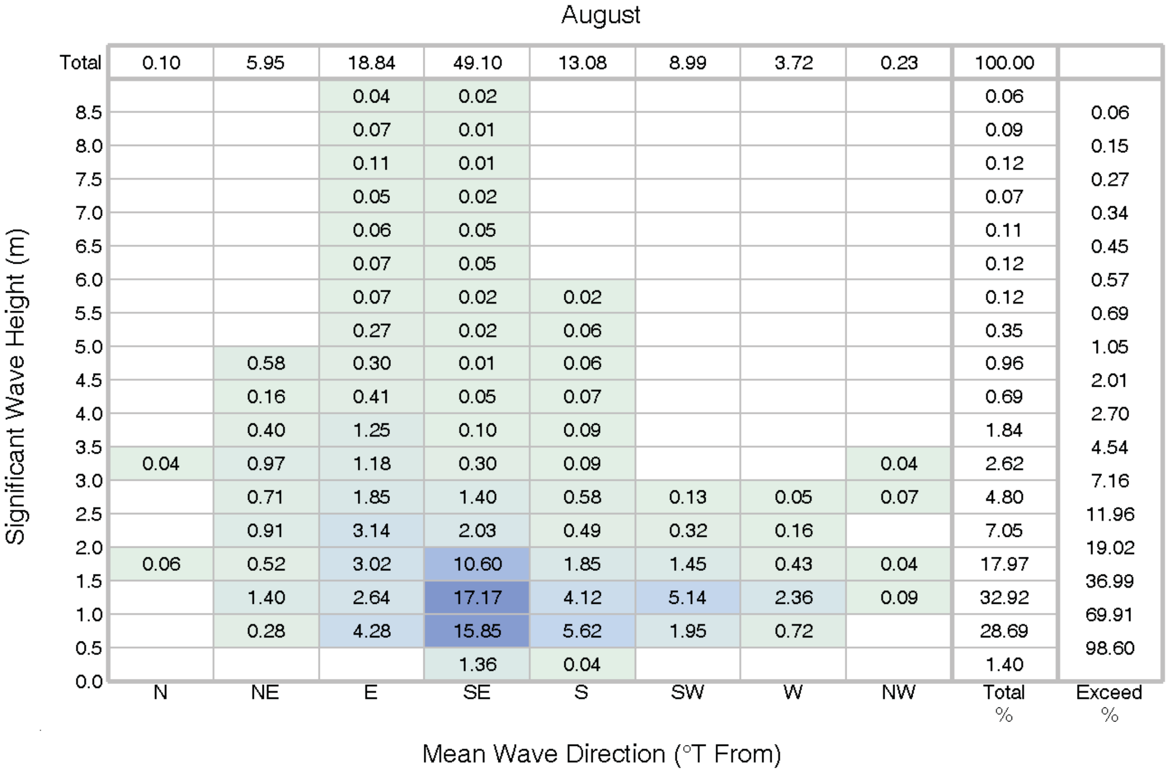


July

| Significant Wave Height (m) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 1.36 | 1.30 | 16.93 | 57.97 | 11.99 | 3.65 | 5.32 | 1.48 | 100.00 | |
| 8.5 | | | | | | | | | | |
| 8.0 | | | | | | | | | | |
| 7.5 | | | | | | | | | | |
| 7.0 | | | | | | | | | | |
| 6.5 | | | | | | | | | | |
| 6.0 | | | | | | | | | | |
| 5.5 | | | | | | | | | | |
| 5.0 | | | | 0.37 | | | | | 0.37 | 0.37 |
| 4.5 | | | | 0.43 | 0.06 | | | | 0.49 | 0.87 |
| 4.0 | | | | 0.19 | 0.25 | | | | 0.43 | 1.30 |
| 3.5 | | | | 0.25 | 0.25 | | | | 0.49 | 1.79 |
| 3.0 | | | | 0.31 | 0.25 | | | | 0.56 | 2.35 |
| 2.5 | | | 0.12 | 0.99 | 0.06 | 0.25 | | | 1.42 | 3.77 |
| 2.0 | | 0.43 | 0.37 | 0.80 | | 0.37 | | | 1.98 | 5.75 |
| 1.5 | 1.05 | 0.25 | 6.98 | 4.26 | 1.05 | 0.31 | | | 13.91 | 19.65 |
| 1.0 | 0.25 | | 2.60 | 37.39 | 9.95 | 2.29 | 5.25 | 1.48 | 59.21 | 78.86 |
| 0.5 | 0.06 | 0.62 | 6.55 | 10.44 | 0.12 | 0.43 | 0.06 | | 18.29 | 97.16 |
| 0.0 | | | 0.31 | 2.53 | | | | | 2.84 | |

Mean Wave Direction (°T From)

Figure 2-72 Percentage Occurrence of Significant Wave Height and Direction for Hurricanes – July

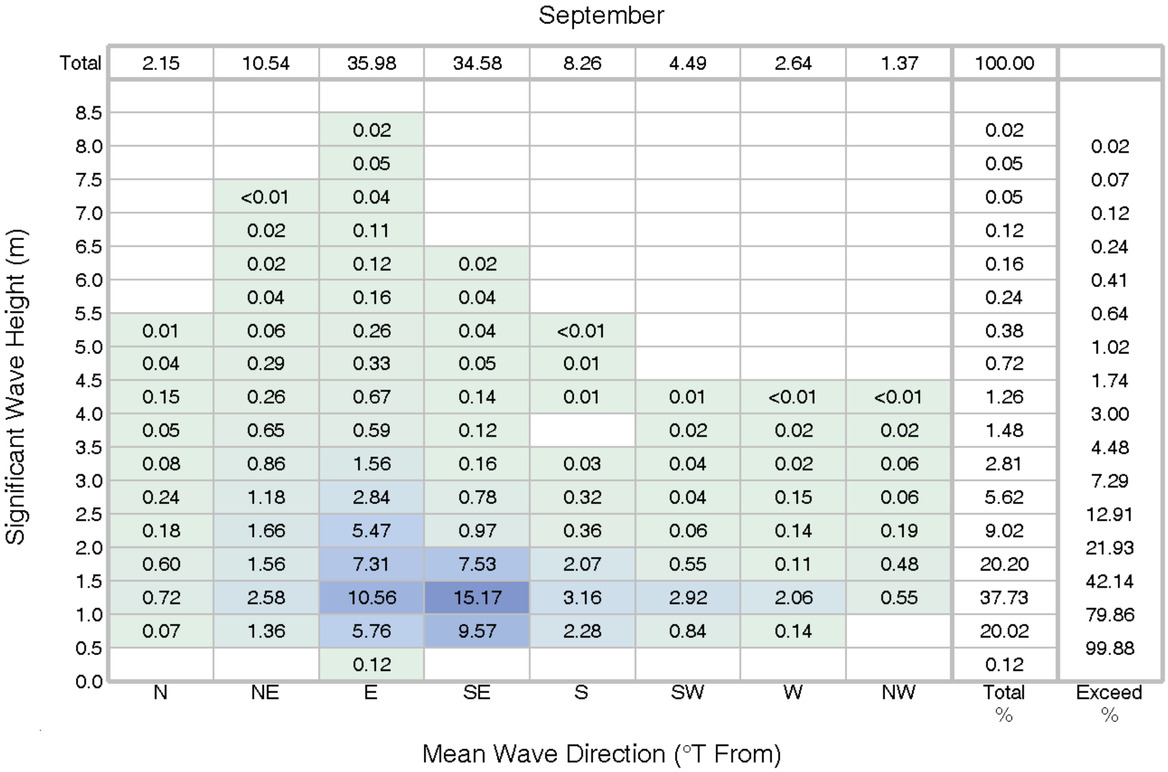


August

| Significant Wave Height (m) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 0.10 | 5.95 | 18.84 | 49.10 | 13.08 | 8.99 | 3.72 | 0.23 | 100.00 | |
| 8.5 | | | 0.04 | 0.02 | | | | | 0.06 | 0.06 |
| 8.0 | | | 0.07 | 0.01 | | | | | 0.09 | 0.15 |
| 7.5 | | | 0.11 | 0.01 | | | | | 0.12 | 0.27 |
| 7.0 | | | 0.05 | 0.02 | | | | | 0.07 | 0.34 |
| 6.5 | | | 0.06 | 0.05 | | | | | 0.11 | 0.45 |
| 6.0 | | | 0.07 | 0.05 | | | | | 0.12 | 0.57 |
| 5.5 | | | 0.07 | 0.02 | 0.02 | | | | 0.12 | 0.69 |
| 5.0 | | | 0.27 | 0.02 | 0.06 | | | | 0.35 | 1.05 |
| 4.5 | | 0.58 | 0.30 | 0.01 | 0.06 | | | | 0.96 | 2.01 |
| 4.0 | | 0.16 | 0.41 | 0.05 | 0.07 | | | | 0.69 | 2.70 |
| 3.5 | | 0.40 | 1.25 | 0.10 | 0.09 | | | | 1.84 | 4.54 |
| 3.0 | 0.04 | 0.97 | 1.18 | 0.30 | 0.09 | | | 0.04 | 2.62 | 7.16 |
| 2.5 | | 0.71 | 1.85 | 1.40 | 0.58 | 0.13 | 0.05 | 0.07 | 4.80 | 11.96 |
| 2.0 | | 0.91 | 3.14 | 2.03 | 0.49 | 0.32 | 0.16 | | 7.05 | 19.02 |
| 1.5 | 0.06 | 0.52 | 3.02 | 10.60 | 1.85 | 1.45 | 0.43 | 0.04 | 17.97 | 36.99 |
| 1.0 | | 1.40 | 2.64 | 17.17 | 4.12 | 5.14 | 2.36 | 0.09 | 32.92 | 69.91 |
| 0.5 | | 0.28 | 4.28 | 15.85 | 5.62 | 1.95 | 0.72 | | 28.69 | 98.60 |
| 0.0 | | | | 1.36 | 0.04 | | | | 1.40 | |

Mean Wave Direction (°T From)

Figure 2-73 Percentage Occurrence of Significant Wave Height and Direction for Hurricanes – August

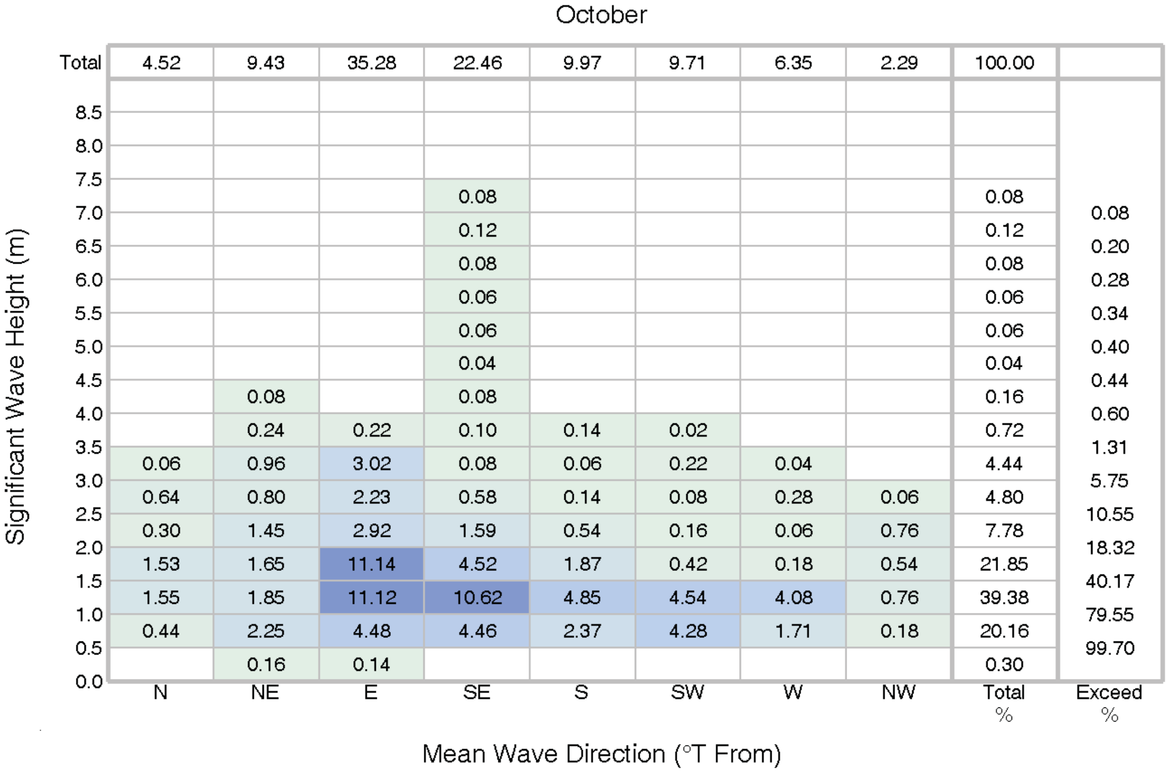


September

| Significant Wave Height (m) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 2.15 | 10.54 | 35.98 | 34.58 | 8.26 | 4.49 | 2.64 | 1.37 | 100.00 | |
| 8.0–8.5 | | | 0.02 | | | | | | 0.02 | 0.02 |
| 7.5–8.0 | | | 0.05 | | | | | | 0.05 | 0.07 |
| 7.0–7.5 | | <0.01 | 0.04 | | | | | | 0.05 | 0.12 |
| 6.5–7.0 | | 0.02 | 0.11 | | | | | | 0.12 | 0.24 |
| 6.0–6.5 | | 0.02 | 0.12 | 0.02 | | | | | 0.16 | 0.41 |
| 5.5–6.0 | | 0.04 | 0.16 | 0.04 | | | | | 0.24 | 0.64 |
| 5.0–5.5 | 0.01 | 0.06 | 0.26 | 0.04 | <0.01 | | | | 0.38 | 1.02 |
| 4.5–5.0 | 0.04 | 0.29 | 0.33 | 0.05 | 0.01 | | | | 0.72 | 1.74 |
| 4.0–4.5 | 0.15 | 0.26 | 0.67 | 0.14 | 0.01 | 0.01 | <0.01 | <0.01 | 1.26 | 3.00 |
| 3.5–4.0 | 0.05 | 0.65 | 0.59 | 0.12 | | 0.02 | 0.02 | 0.02 | 1.48 | 4.48 |
| 3.0–3.5 | 0.08 | 0.86 | 1.56 | 0.16 | 0.03 | 0.04 | 0.02 | 0.06 | 2.81 | 7.29 |
| 2.5–3.0 | 0.24 | 1.18 | 2.84 | 0.78 | 0.32 | 0.04 | 0.15 | 0.06 | 5.62 | 12.91 |
| 2.0–2.5 | 0.18 | 1.66 | 5.47 | 0.97 | 0.36 | 0.06 | 0.14 | 0.19 | 9.02 | 21.93 |
| 1.5–2.0 | 0.60 | 1.56 | 7.31 | 7.53 | 2.07 | 0.55 | 0.11 | 0.48 | 20.20 | 42.14 |
| 1.0–1.5 | 0.72 | 2.58 | 10.56 | 15.17 | 3.16 | 2.92 | 2.06 | 0.55 | 37.73 | 79.86 |
| 0.5–1.0 | 0.07 | 1.36 | 5.76 | 9.57 | 2.28 | 0.84 | 0.14 | | 20.02 | 99.88 |
| 0.0–0.5 | | | 0.12 | | | | | | 0.12 | |

Mean Wave Direction (°T From)

Figure 2-74 Percentage Occurrence of Significant Wave Height and Direction for Hurricanes – September

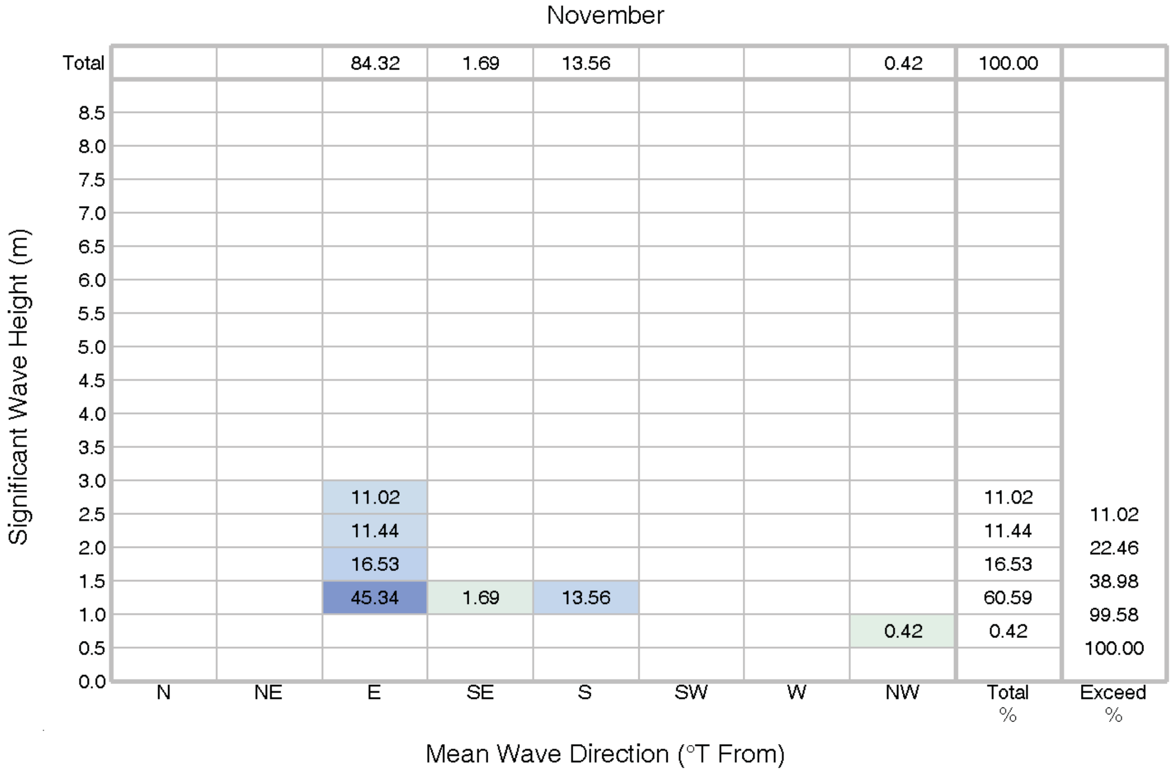


October

| Significant Wave Height (m) | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 4.52 | 9.43 | 35.28 | 22.46 | 9.97 | 9.71 | 6.35 | 2.29 | 100.00 | |
| 8.0–8.5 | | | | | | | | | | |
| 7.5–8.0 | | | | | | | | | | |
| 7.0–7.5 | | | | 0.08 | | | | | 0.08 | 0.08 |
| 6.5–7.0 | | | | 0.12 | | | | | 0.12 | 0.20 |
| 6.0–6.5 | | | | 0.08 | | | | | 0.08 | 0.28 |
| 5.5–6.0 | | | | 0.06 | | | | | 0.06 | 0.34 |
| 5.0–5.5 | | | | 0.06 | | | | | 0.06 | 0.40 |
| 4.5–5.0 | | | | 0.04 | | | | | 0.04 | 0.44 |
| 4.0–4.5 | | 0.08 | | 0.08 | | | | | 0.16 | 0.60 |
| 3.5–4.0 | | 0.24 | 0.22 | 0.10 | 0.14 | 0.02 | | | 0.72 | 1.31 |
| 3.0–3.5 | 0.06 | 0.96 | 3.02 | 0.08 | 0.06 | 0.22 | 0.04 | | 4.44 | 5.75 |
| 2.5–3.0 | 0.64 | 0.80 | 2.23 | 0.58 | 0.14 | 0.08 | 0.28 | 0.06 | 4.80 | 10.55 |
| 2.0–2.5 | 0.30 | 1.45 | 2.92 | 1.59 | 0.54 | 0.16 | 0.06 | 0.76 | 7.78 | 18.32 |
| 1.5–2.0 | 1.53 | 1.65 | 11.14 | 4.52 | 1.87 | 0.42 | 0.18 | 0.54 | 21.85 | 40.17 |
| 1.0–1.5 | 1.55 | 1.85 | 11.12 | 10.62 | 4.85 | 4.54 | 4.08 | 0.76 | 39.38 | 79.55 |
| 0.5–1.0 | 0.44 | 2.25 | 4.48 | 4.46 | 2.37 | 4.28 | 1.71 | 0.18 | 20.16 | 99.70 |
| 0.0–0.5 | | 0.16 | 0.14 | | | | | | 0.30 | |

Mean Wave Direction (°T From)

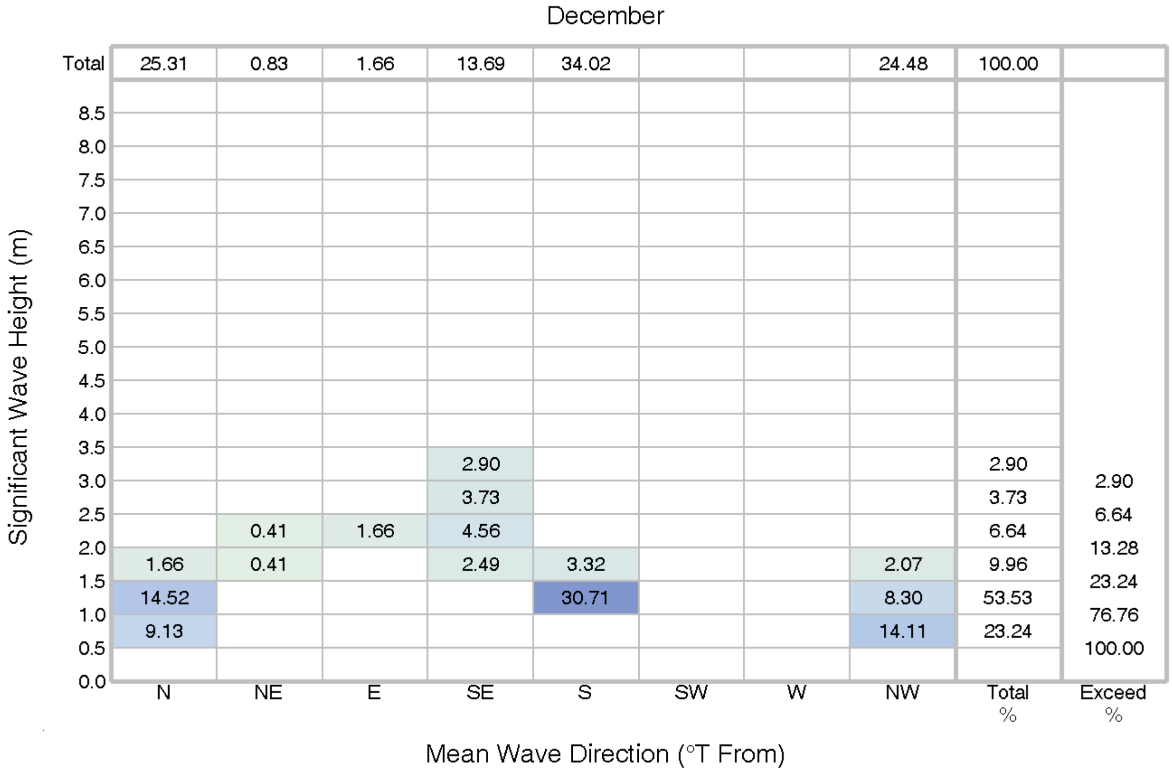
Figure 2-75 Percentage Occurrence of Significant Wave Height and Direction for Hurricanes – October



November

| | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | 84.32 | 1.69 | 13.56 | | | 0.42 | 100.00 | |
| 8.5 | | | | | | | | | | |
| 8.0 | | | | | | | | | | |
| 7.5 | | | | | | | | | | |
| 7.0 | | | | | | | | | | |
| 6.5 | | | | | | | | | | |
| 6.0 | | | | | | | | | | |
| 5.5 | | | | | | | | | | |
| 5.0 | | | | | | | | | | |
| 4.5 | | | | | | | | | | |
| 4.0 | | | | | | | | | | |
| 3.5 | | | | | | | | | | |
| 3.0 | | | | | | | | | | |
| 2.5 | | | 11.02 | | | | | | 11.02 | 11.02 |
| 2.0 | | | 11.44 | | | | | | 11.44 | 22.46 |
| 1.5 | | | 16.53 | | | | | | 16.53 | 38.98 |
| 1.0 | | | 45.34 | 1.69 | 13.56 | | | | 60.59 | 99.58 |
| 0.5 | | | | | | | | 0.42 | 0.42 | 100.00 |
| 0.0 | | | | | | | | | | |

Figure 2-76 Percentage Occurrence of Significant Wave Height and Direction for Hurricanes – November

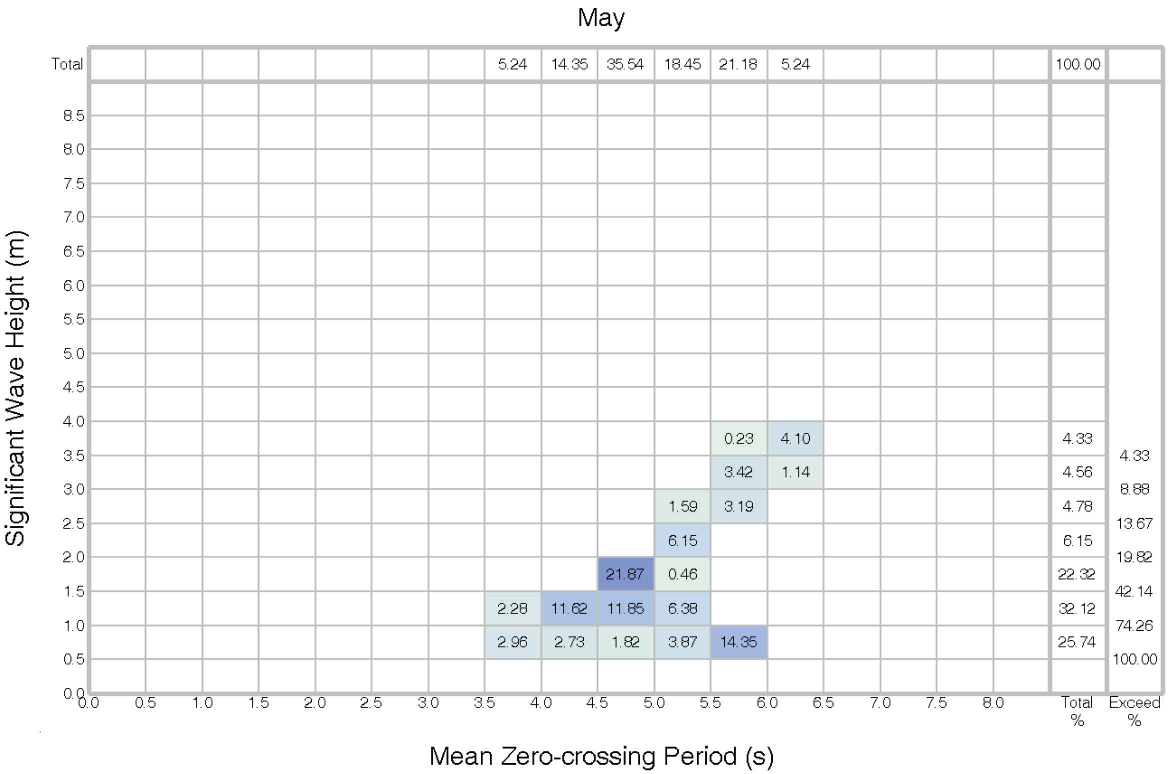


December

| | N | NE | E | SE | S | SW | W | NW | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 25.31 | 0.83 | 1.66 | 13.69 | 34.02 | | | 24.48 | 100.00 | |
| 8.5 | | | | | | | | | | |
| 8.0 | | | | | | | | | | |
| 7.5 | | | | | | | | | | |
| 7.0 | | | | | | | | | | |
| 6.5 | | | | | | | | | | |
| 6.0 | | | | | | | | | | |
| 5.5 | | | | | | | | | | |
| 5.0 | | | | | | | | | | |
| 4.5 | | | | | | | | | | |
| 4.0 | | | | | | | | | | |
| 3.5 | | | | | | | | | | |
| 3.0 | | | | 2.90 | | | | | 2.90 | 2.90 |
| 2.5 | | | | 3.73 | | | | | 3.73 | 6.64 |
| 2.0 | | 0.41 | 1.66 | 4.56 | | | | | 6.64 | 13.28 |
| 1.5 | 1.66 | 0.41 | | 2.49 | 3.32 | | | 2.07 | 9.96 | 23.24 |
| 1.0 | 14.52 | | | | 30.71 | | | 8.30 | 53.53 | 76.76 |
| 0.5 | 9.13 | | | | | | | 14.11 | 23.24 | 100.00 |
| 0.0 | | | | | | | | | | |

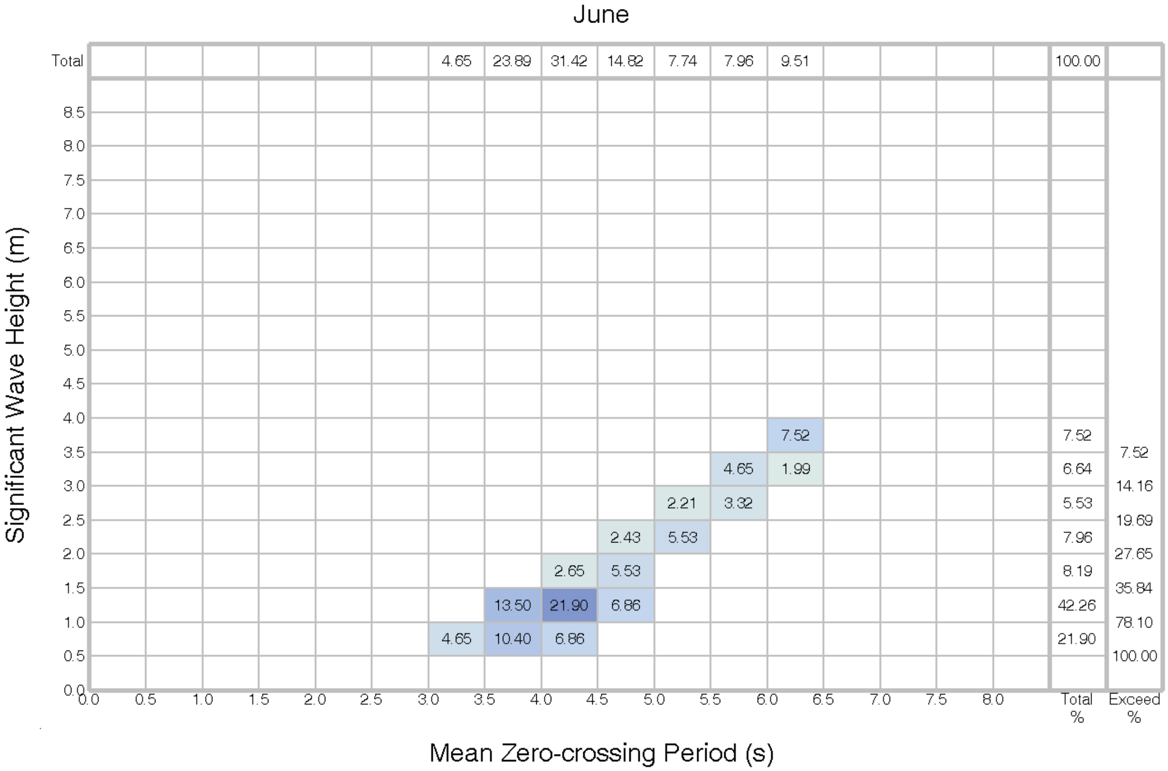
Figure 2-77 Percentage Occurrence of Significant Wave Height and Direction for Hurricanes – December

### 2.2.22 Joint Frequency Distribution of Significant Wave Height and Zero Up-Crossing Period for Hurricanes



| Significant Wave Height (m) | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | | 5.24 | 14.35 | 35.54 | 18.45 | 21.18 | 5.24 | | | | | 100.00 | |
| 8.5 | | | | | | | | | | | | | | | | | | | |
| 8.0 | | | | | | | | | | | | | | | | | | | |
| 7.5 | | | | | | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | | |
| 6.5 | | | | | | | | | | | | | | | | | | | |
| 6.0 | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | | |
| 4.5 | | | | | | | | | | | | | | | | | | | |
| 4.0 | | | | | | | | | | | | | | | | | | | |
| 3.5 | | | | | | | | | | | | 0.23 | 4.10 | | | | | 4.33 | 4.33 |
| 3.0 | | | | | | | | | | | | 3.42 | 1.14 | | | | | 4.56 | 8.88 |
| 2.5 | | | | | | | | | | | 1.59 | 3.19 | | | | | | 4.78 | 13.67 |
| 2.0 | | | | | | | | | | | 6.15 | | | | | | | 6.15 | 19.82 |
| 1.5 | | | | | | | | | | 21.87 | 0.46 | | | | | | | 22.32 | 42.14 |
| 1.0 | | | | | | | | 2.28 | 11.62 | 11.85 | 6.38 | | | | | | | 32.12 | 74.26 |
| 0.5 | | | | | | | | 2.96 | 2.73 | 1.82 | 3.87 | 14.35 | | | | | | 25.74 | 100.00 |
| 0.0 | | | | | | | | | | | | | | | | | | | |

**Figure 2-78 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period for Hurricanes – May**



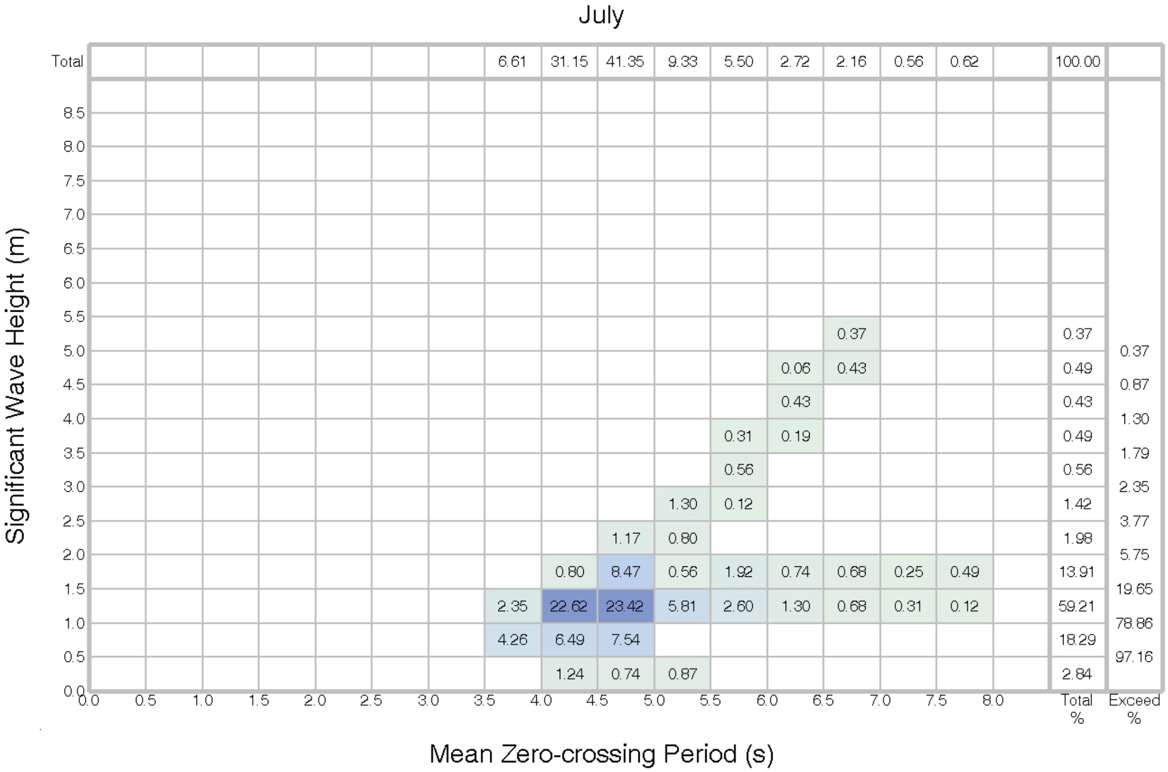
June

| | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | 4.65 | 23.89 | 31.42 | 14.82 | 7.74 | 7.96 | 9.51 | | | | | 100.00 | |
| 8.5 | | | | | | | | | | | | | | | | | | | |
| 8.0 | | | | | | | | | | | | | | | | | | | |
| 7.5 | | | | | | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | | |
| 6.5 | | | | | | | | | | | | | | | | | | | |
| 6.0 | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | | |
| 4.5 | | | | | | | | | | | | | | | | | | | |
| 4.0 | | | | | | | | | | | | | | | | | | | |
| 3.5 | | | | | | | | | | | | | 7.52 | | | | | 7.52 | 7.52 |
| 3.0 | | | | | | | | | | | | 4.65 | 1.99 | | | | | 6.64 | 14.16 |
| 2.5 | | | | | | | | | | | 2.21 | 3.32 | | | | | | 5.53 | 19.69 |
| 2.0 | | | | | | | | | | 2.43 | 5.53 | | | | | | | 7.96 | 27.65 |
| 1.5 | | | | | | | | | 2.65 | 5.53 | | | | | | | | 8.19 | 35.84 |
| 1.0 | | | | | | | | 13.50 | 21.90 | 6.86 | | | | | | | | 42.26 | 78.10 |
| 0.5 | | | | | | | 4.65 | 10.40 | 6.86 | | | | | | | | | 21.90 | 100.00 |
| 0.0 | | | | | | | | | | | | | | | | | | | |

Significant Wave Height (m)

Mean Zero-crossing Period (s)

Figure 2-79 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period for Hurricanes – June



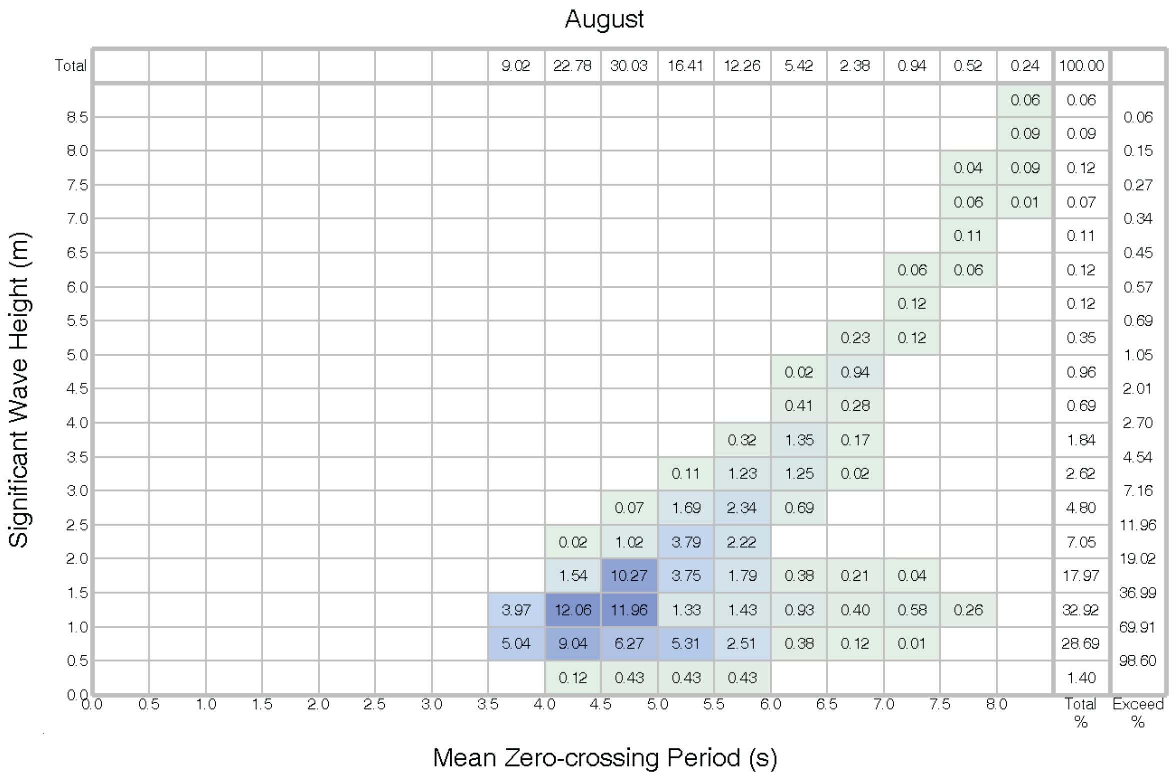
July

| | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | | 6.61 | 31.15 | 41.35 | 9.33 | 5.50 | 2.72 | 2.16 | 0.56 | 0.62 | | 100.00 | |
| 8.5 | | | | | | | | | | | | | | | | | | | |
| 8.0 | | | | | | | | | | | | | | | | | | | |
| 7.5 | | | | | | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | | |
| 6.5 | | | | | | | | | | | | | | | | | | | |
| 6.0 | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | 0.37 | | | | 0.37 | 0.37 |
| 4.5 | | | | | | | | | | | | | 0.06 | 0.43 | | | | 0.49 | 0.87 |
| 4.0 | | | | | | | | | | | | | 0.43 | | | | | 0.43 | 1.30 |
| 3.5 | | | | | | | | | | | | 0.31 | 0.19 | | | | | 0.49 | 1.79 |
| 3.0 | | | | | | | | | | | | 0.56 | | | | | | 0.56 | 2.35 |
| 2.5 | | | | | | | | | | | 1.30 | 0.12 | | | | | | 1.42 | 3.77 |
| 2.0 | | | | | | | | | | 1.17 | 0.80 | | | | | | | 1.98 | 5.75 |
| 1.5 | | | | | | | | | 0.80 | 8.47 | 0.56 | 1.92 | 0.74 | 0.68 | 0.25 | 0.49 | | 13.91 | 19.65 |
| 1.0 | | | | | | | | 2.35 | 22.62 | 23.42 | 5.81 | 2.60 | 1.30 | 0.68 | 0.31 | 0.12 | | 59.21 | 78.86 |
| 0.5 | | | | | | | | 4.26 | 6.49 | 7.54 | | | | | | | | 18.29 | 97.16 |
| 0.0 | | | | | | | | | 1.24 | 0.74 | 0.87 | | | | | | | 2.84 | |

Significant Wave Height (m)

Mean Zero-crossing Period (s)

Figure 2-80 Percentage Occurrence of Significant Wave Height and Peak Period Zero Up-Crossing Period for Hurricanes – July

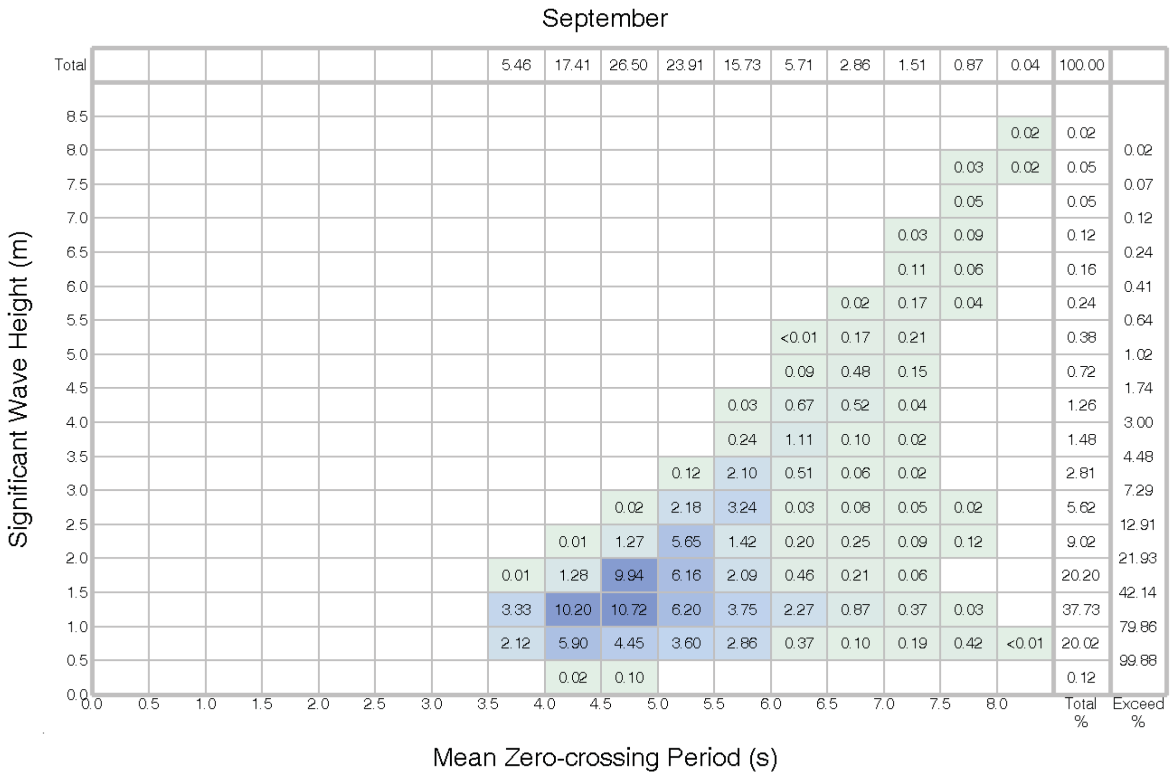


August

| Significant Wave Height (m) | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | | 9.02 | 22.78 | 30.03 | 16.41 | 12.26 | 5.42 | 2.38 | 0.94 | 0.52 | 0.24 | 100.00 | |
| 8.5 | | | | | | | | | | | | | | | | | 0.06 | 0.06 | 0.06 |
| 8.0 | | | | | | | | | | | | | | | | | 0.09 | 0.09 | 0.15 |
| 7.5 | | | | | | | | | | | | | | | | 0.04 | 0.09 | 0.12 | 0.27 |
| 7.0 | | | | | | | | | | | | | | | | 0.06 | 0.01 | 0.07 | 0.34 |
| 6.5 | | | | | | | | | | | | | | | | 0.11 | | 0.11 | 0.45 |
| 6.0 | | | | | | | | | | | | | | | 0.06 | 0.06 | | 0.12 | 0.57 |
| 5.5 | | | | | | | | | | | | | | | 0.12 | | | 0.12 | 0.69 |
| 5.0 | | | | | | | | | | | | | | 0.23 | 0.12 | | | 0.35 | 1.05 |
| 4.5 | | | | | | | | | | | | | 0.02 | 0.94 | | | | 0.96 | 2.01 |
| 4.0 | | | | | | | | | | | | | 0.41 | 0.28 | | | | 0.69 | 2.70 |
| 3.5 | | | | | | | | | | | | 0.32 | 1.35 | 0.17 | | | | 1.84 | 4.54 |
| 3.0 | | | | | | | | | | | 0.11 | 1.23 | 1.25 | 0.02 | | | | 2.62 | 7.16 |
| 2.5 | | | | | | | | | | 0.07 | 1.69 | 2.34 | 0.69 | | | | | 4.80 | 11.96 |
| 2.0 | | | | | | | | | 0.02 | 1.02 | 3.79 | 2.22 | | | | | | 7.05 | 19.02 |
| 1.5 | | | | | | | | | 1.54 | 10.27 | 3.75 | 1.79 | 0.38 | 0.21 | 0.04 | | | 17.97 | 36.99 |
| 1.0 | | | | | | | | 3.97 | 12.06 | 11.96 | 1.33 | 1.43 | 0.93 | 0.40 | 0.58 | 0.26 | | 32.92 | 69.91 |
| 0.5 | | | | | | | | 5.04 | 9.04 | 6.27 | 5.31 | 2.51 | 0.38 | 0.12 | 0.01 | | | 28.69 | 98.60 |
| 0.0 | | | | | | | | | 0.12 | 0.43 | 0.43 | 0.43 | | | | | | 1.40 | |

Mean Zero-crossing Period (s)

**Figure 2-81 Percentage Occurrence of Significant Wave Height and Peak Period Zero Up-Crossing Period for Hurricanes – August**

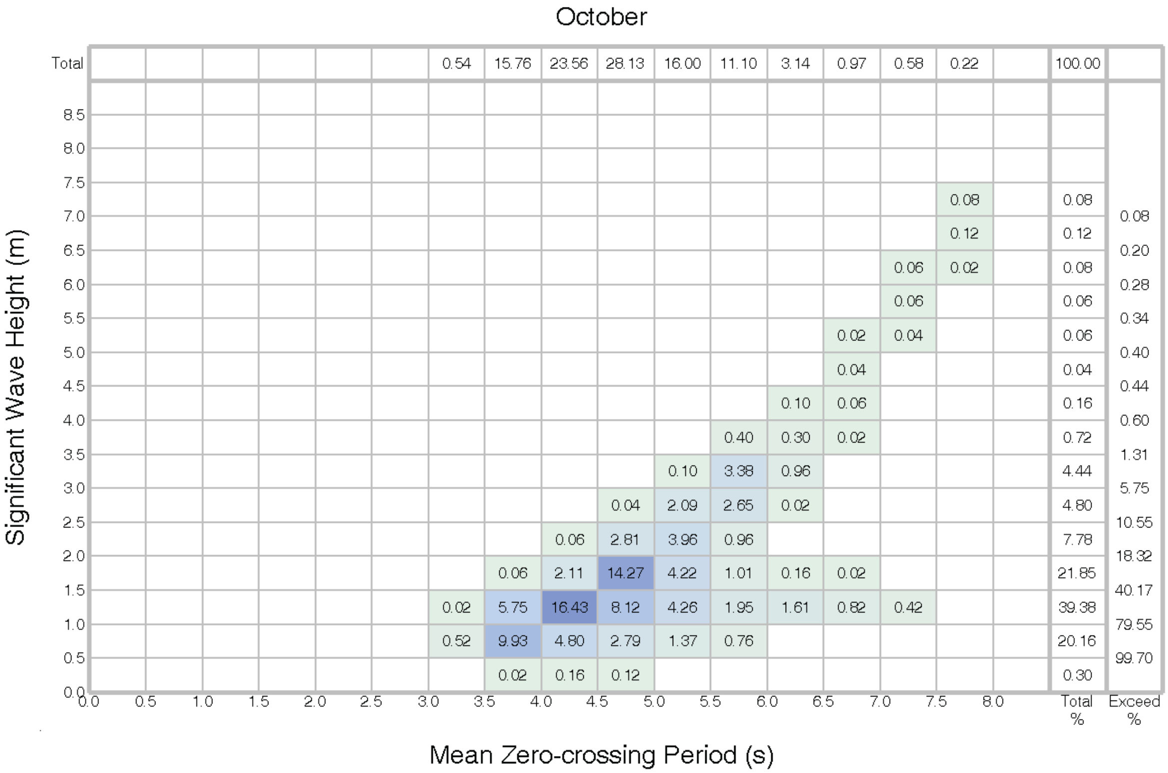


September

| Significant Wave Height (m) | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | | 5.46 | 17.41 | 26.50 | 23.91 | 15.73 | 5.71 | 2.86 | 1.51 | 0.87 | 0.04 | 100.00 | |
| 8.5 | | | | | | | | | | | | | | | | | | | |
| 8.0 | | | | | | | | | | | | | | | | | 0.02 | 0.02 | 0.02 |
| 7.5 | | | | | | | | | | | | | | | | 0.03 | 0.02 | 0.05 | 0.07 |
| 7.0 | | | | | | | | | | | | | | | | 0.05 | | 0.05 | 0.12 |
| 6.5 | | | | | | | | | | | | | | | 0.03 | 0.09 | | 0.12 | 0.24 |
| 6.0 | | | | | | | | | | | | | | | 0.11 | 0.06 | | 0.16 | 0.41 |
| 5.5 | | | | | | | | | | | | | | 0.02 | 0.17 | 0.04 | | 0.24 | 0.64 |
| 5.0 | | | | | | | | | | | | | <0.01 | 0.17 | 0.21 | | | 0.38 | 1.02 |
| 4.5 | | | | | | | | | | | | | 0.09 | 0.48 | 0.15 | | | 0.72 | 1.74 |
| 4.0 | | | | | | | | | | | | 0.03 | 0.67 | 0.52 | 0.04 | | | 1.26 | 3.00 |
| 3.5 | | | | | | | | | | | | 0.24 | 1.11 | 0.10 | 0.02 | | | 1.48 | 4.48 |
| 3.0 | | | | | | | | | | | 0.12 | 2.10 | 0.51 | 0.06 | 0.02 | | | 2.81 | 7.29 |
| 2.5 | | | | | | | | | | 0.02 | 2.18 | 3.24 | 0.03 | 0.08 | 0.05 | 0.02 | | 5.62 | 12.91 |
| 2.0 | | | | | | | | | 0.01 | 1.27 | 5.65 | 1.42 | 0.20 | 0.25 | 0.09 | 0.12 | | 9.02 | 21.93 |
| 1.5 | | | | | | | | 0.01 | 1.28 | 9.94 | 6.16 | 2.09 | 0.46 | 0.21 | 0.06 | | | 20.20 | 42.14 |
| 1.0 | | | | | | | | 3.33 | 10.20 | 10.72 | 6.20 | 3.75 | 2.27 | 0.87 | 0.37 | 0.03 | | 37.73 | 79.86 |
| 0.5 | | | | | | | | 2.12 | 5.90 | 4.45 | 3.60 | 2.86 | 0.37 | 0.10 | 0.19 | 0.42 | <0.01 | 20.02 | 99.88 |
| 0.0 | | | | | | | | | 0.02 | 0.10 | | | | | | | | 0.12 | |

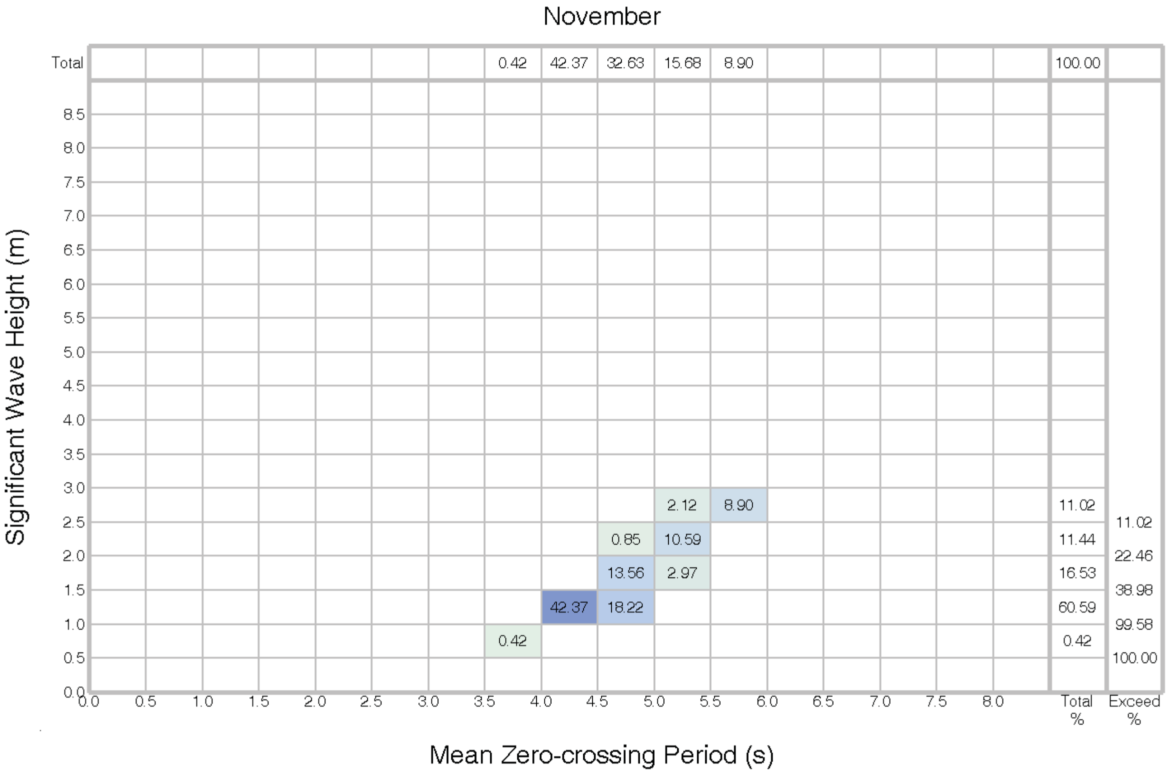
Mean Zero-crossing Period (s)

**Figure 2-82 Percentage Occurrence of Significant Wave Height and Peak Period Zero Up-Crossing Period for Hurricanes – September**



|  | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total |  |  |  |  |  |  | 0.54 | 15.76 | 23.56 | 28.13 | 16.00 | 11.10 | 3.14 | 0.97 | 0.58 | 0.22 |  | 100.00 |  |
| 8.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 8.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.08 |  | 0.08 | 0.08 |
| 6.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.12 |  | 0.12 | 0.20 |
| 6.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.06 | 0.02 |  | 0.08 | 0.28 |
| 5.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.06 |  |  | 0.06 | 0.34 |
| 5.0 |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.02 | 0.04 |  |  | 0.06 | 0.40 |
| 4.5 |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.04 |  |  |  | 0.04 | 0.44 |
| 4.0 |  |  |  |  |  |  |  |  |  |  |  |  | 0.10 | 0.06 |  |  |  | 0.16 | 0.60 |
| 3.5 |  |  |  |  |  |  |  |  |  |  |  | 0.40 | 0.30 | 0.02 |  |  |  | 0.72 | 1.31 |
| 3.0 |  |  |  |  |  |  |  |  |  |  | 0.10 | 3.38 | 0.96 |  |  |  |  | 4.44 | 5.75 |
| 2.5 |  |  |  |  |  |  |  |  |  | 0.04 | 2.09 | 2.65 | 0.02 |  |  |  |  | 4.80 | 10.55 |
| 2.0 |  |  |  |  |  |  |  |  | 0.06 | 2.81 | 3.96 | 0.96 |  |  |  |  |  | 7.78 | 18.32 |
| 1.5 |  |  |  |  |  |  |  | 0.06 | 2.11 | 14.27 | 4.22 | 1.01 | 0.16 | 0.02 |  |  |  | 21.85 | 40.17 |
| 1.0 |  |  |  |  |  |  | 0.02 | 5.75 | 16.43 | 8.12 | 4.26 | 1.95 | 1.61 | 0.82 | 0.42 |  |  | 39.38 | 79.55 |
| 0.5 |  |  |  |  |  |  | 0.52 | 9.93 | 4.80 | 2.79 | 1.37 | 0.76 |  |  |  |  |  | 20.16 | 99.70 |
| 0.0 |  |  |  |  |  |  |  | 0.02 | 0.16 | 0.12 |  |  |  |  |  |  |  | 0.30 |  |

**Figure 2-83 Percentage Occurrence of Significant Wave Height and Peak Period Zero Up-Crossing Period for Hurricanes – October**



|  | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total |  |  |  |  |  |  |  | 0.42 | 42.37 | 32.63 | 15.68 | 8.90 |  |  |  |  |  | 100.00 |  |
| 8.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 8.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2.5 |  |  |  |  |  |  |  |  |  |  | 2.12 | 8.90 |  |  |  |  |  | 11.02 | 11.02 |
| 2.0 |  |  |  |  |  |  |  |  |  | 0.85 | 10.59 |  |  |  |  |  |  | 11.44 | 22.46 |
| 1.5 |  |  |  |  |  |  |  |  |  | 13.56 | 2.97 |  |  |  |  |  |  | 16.53 | 38.98 |
| 1.0 |  |  |  |  |  |  |  |  | 42.37 | 18.22 |  |  |  |  |  |  |  | 60.59 | 99.58 |
| 0.5 |  |  |  |  |  |  |  | 0.42 |  |  |  |  |  |  |  |  |  | 0.42 | 100.00 |
| 0.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**Figure 2-84 Percentage Occurrence of Significant Wave Height and Peak Period Zero Up-Crossing Period for Hurricanes – November**

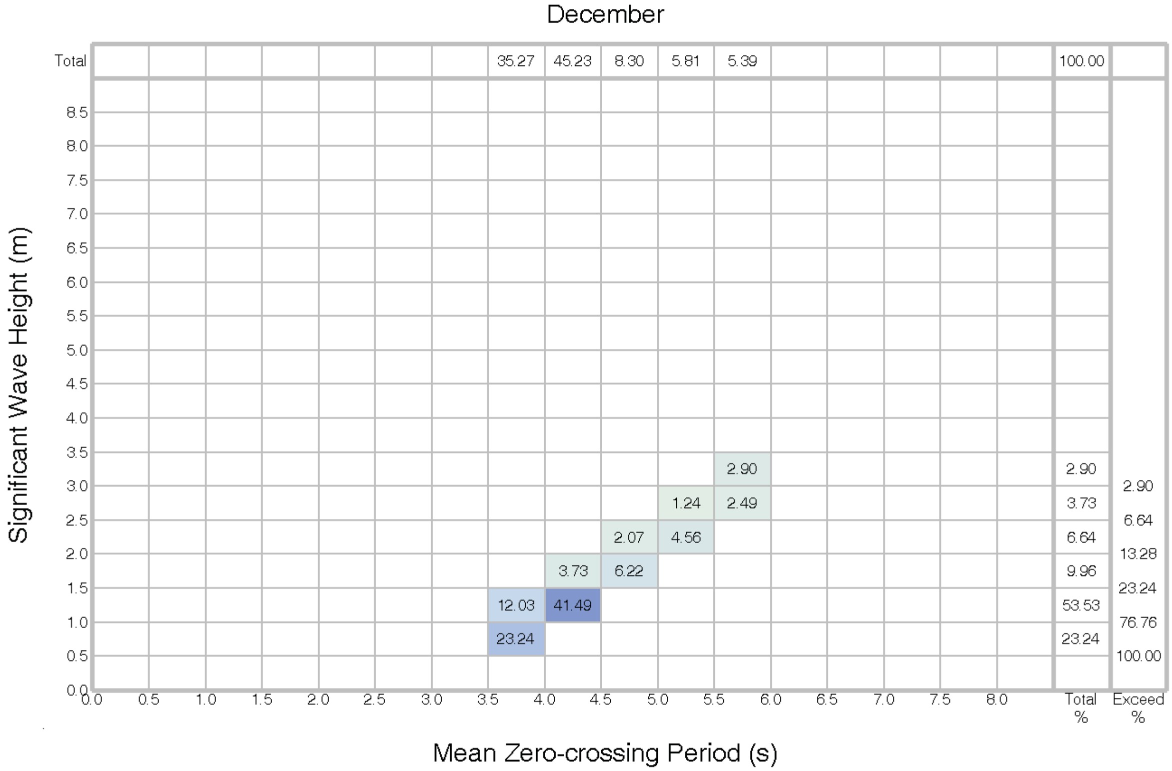
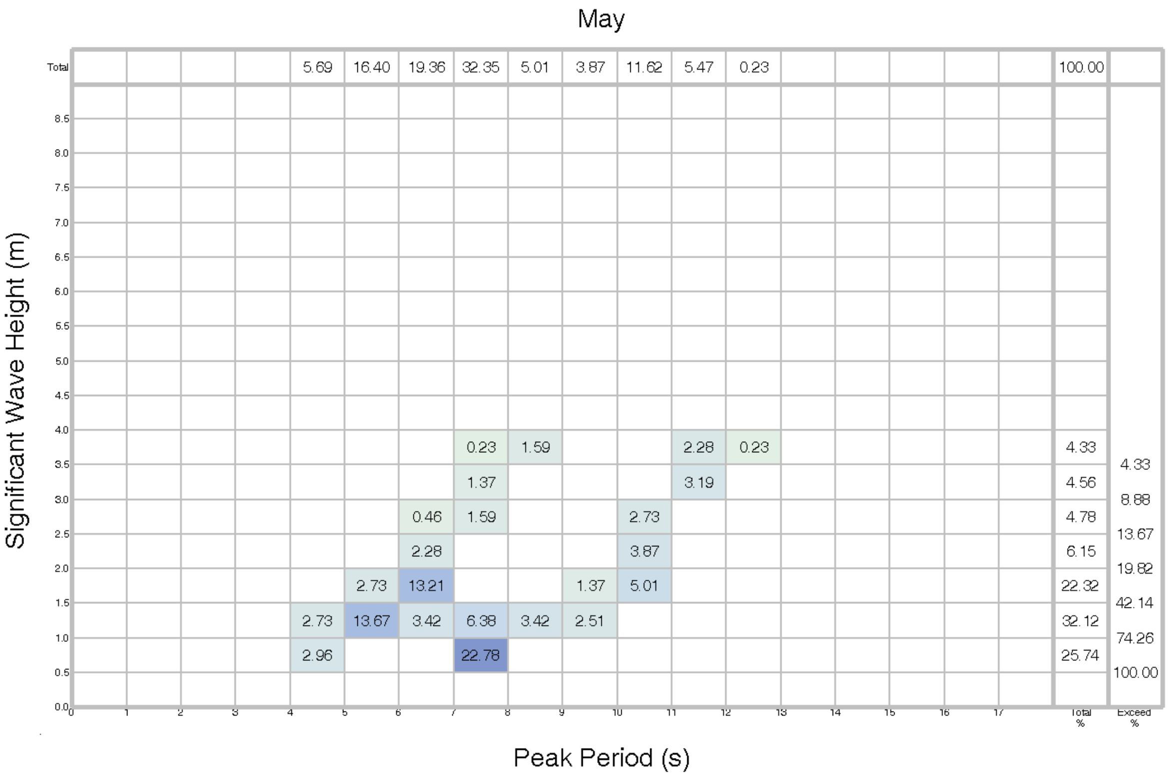


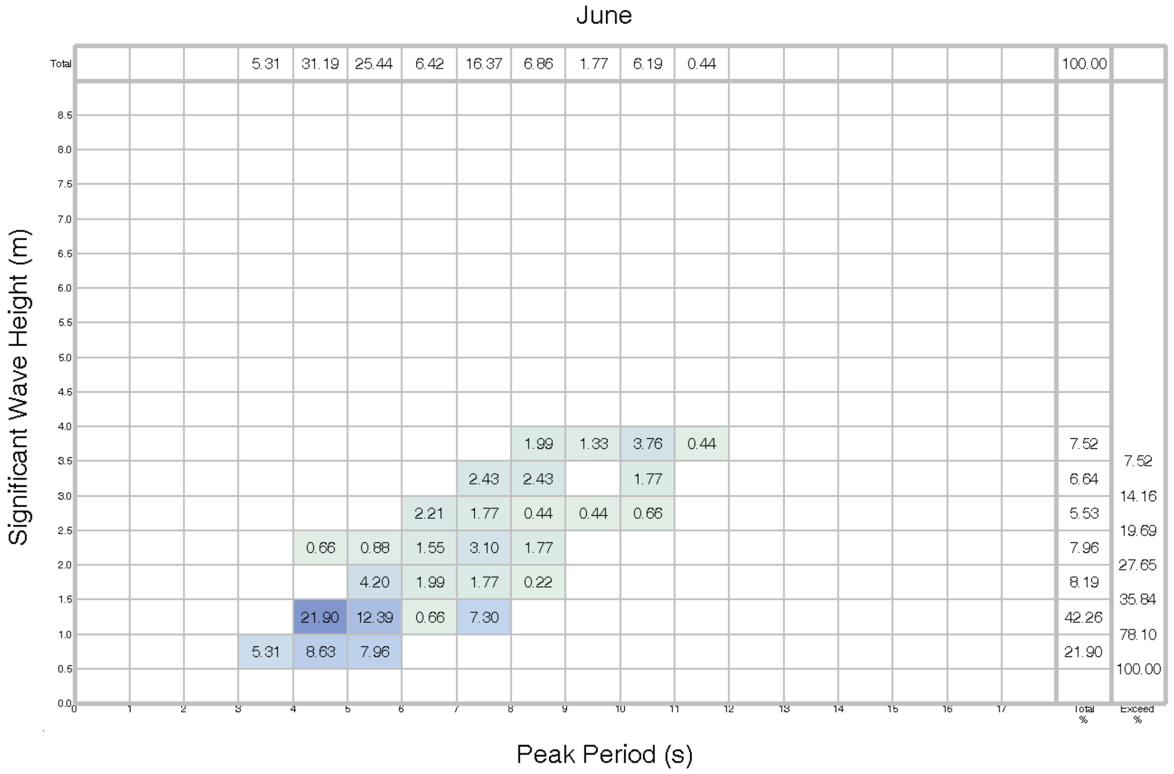
**Figure 2-85 Percentage Occurrence of Significant Wave Height and Peak Period Zero Up-Crossing Period for Hurricanes – December**

### 2.2.23 Joint Frequency Distribution of Significant Wave Height and Peak Period for Hurricanes



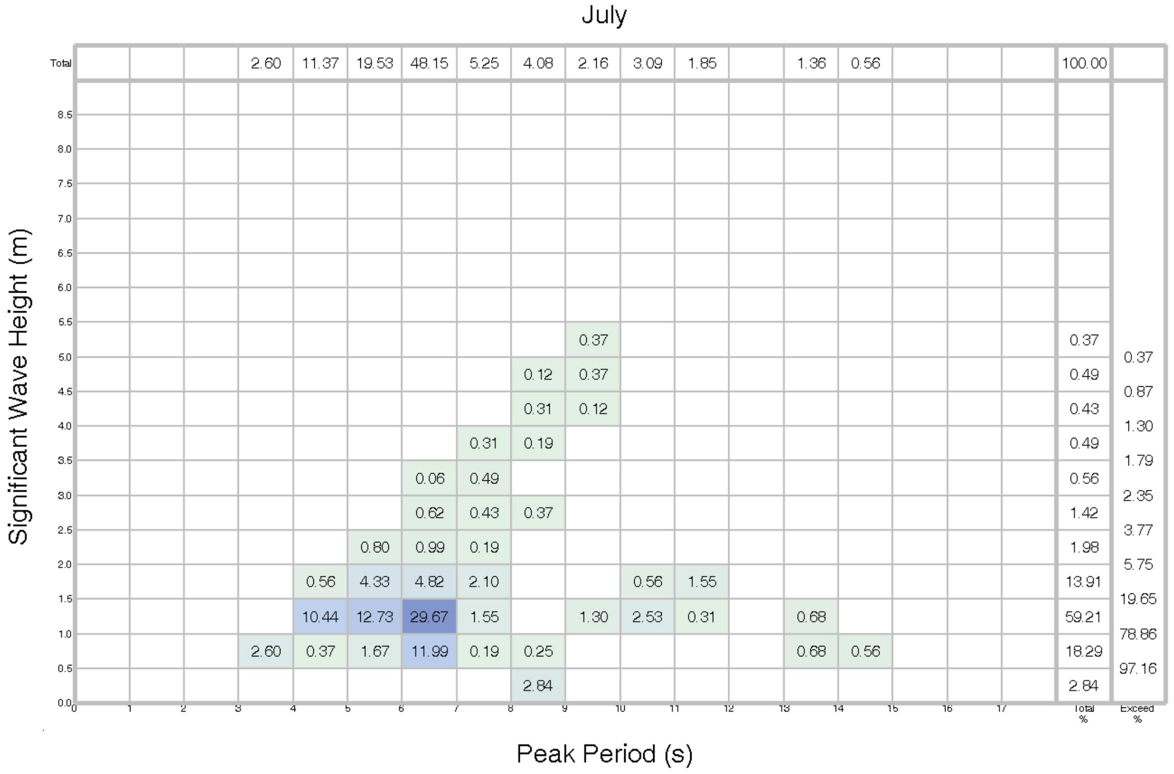
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | 5.69 | 16.40 | 19.36 | 32.35 | 5.01 | 3.87 | 11.62 | 5.47 | 0.23 | | | | | | 100.00 | |
| 8.0 | | | | | | | | | | | | | | | | | | | | |
| 7.5 | | | | | | | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | | | |
| 6.5 | | | | | | | | | | | | | | | | | | | | |
| 6.0 | | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | | | |
| 4.5 | | | | | | | | | | | | | | | | | | | | |
| 4.0 | | | | | | | | | | | | | | | | | | | | |
| 3.5 | | | | | | | | 0.23 | 1.59 | | | 2.28 | 0.23 | | | | | | 4.33 | 4.33 |
| 3.0 | | | | | | | | 1.37 | | | | 3.19 | | | | | | | 4.56 | 8.88 |
| 2.5 | | | | | | | 0.46 | 1.59 | | | 2.73 | | | | | | | | 4.78 | 13.67 |
| 2.0 | | | | | | | 2.28 | | | | 3.87 | | | | | | | | 6.15 | 19.82 |
| 1.5 | | | | | | 2.73 | 13.21 | | | 1.37 | 5.01 | | | | | | | | 22.32 | 42.14 |
| 1.0 | | | | | 2.73 | 13.67 | 3.42 | 6.38 | 3.42 | 2.51 | | | | | | | | | 32.12 | 74.26 |
| 0.5 | | | | | 2.96 | | | 22.78 | | | | | | | | | | | 25.74 | 100.00 |
| 0.0 | | | | | | | | | | | | | | | | | | | | |

Figure 2-86 Percentage Occurrence of Significant Wave Height and Peak Period for Hurricanes – May



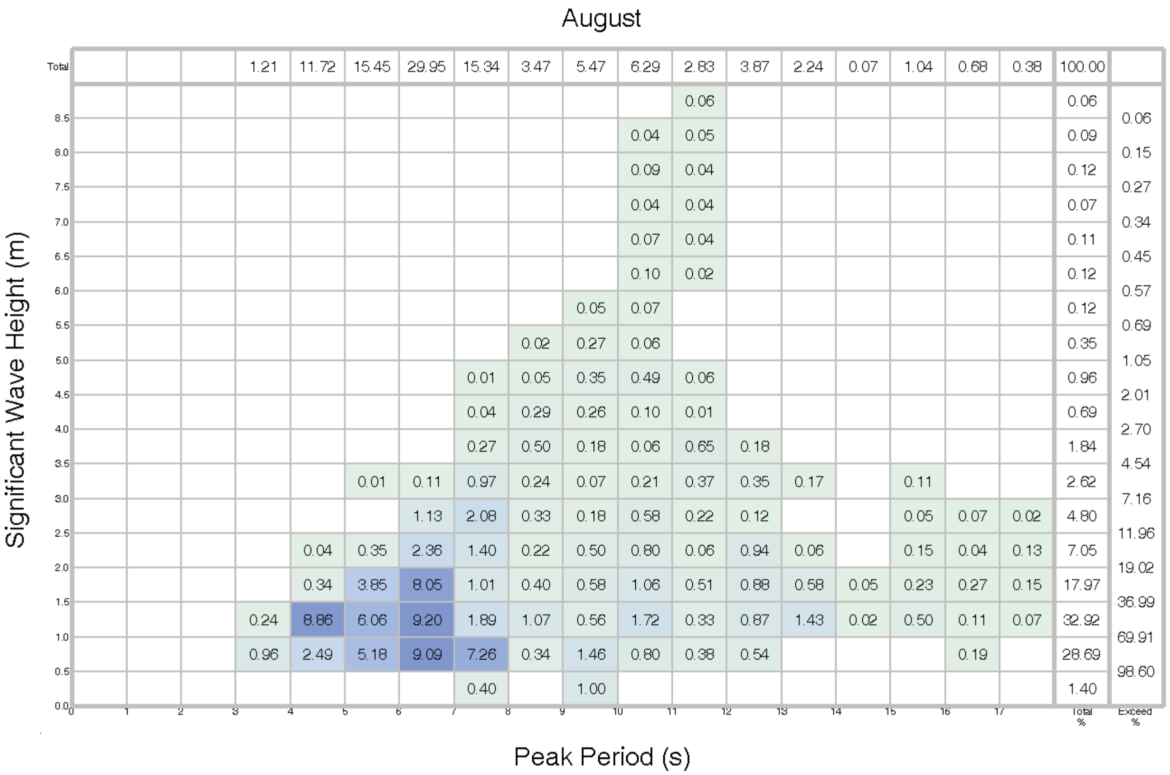
|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total |  |  |  | 5.31 | 31.19 | 25.44 | 6.42 | 16.37 | 6.86 | 1.77 | 6.19 | 0.44 |  |  |  |  |  | 100.00 |  |
| 8.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 8.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3.5 |  |  |  |  |  |  |  |  | 1.99 | 1.33 | 3.76 | 0.44 |  |  |  |  |  | 7.52 | 7.52 |
| 3.0 |  |  |  |  |  |  |  | 2.43 | 2.43 |  | 1.77 |  |  |  |  |  |  | 6.64 | 14.16 |
| 2.5 |  |  |  |  |  |  | 2.21 | 1.77 | 0.44 | 0.44 | 0.66 |  |  |  |  |  |  | 5.53 | 19.69 |
| 2.0 |  |  |  |  | 0.66 | 0.88 | 1.55 | 3.10 | 1.77 |  |  |  |  |  |  |  |  | 7.96 | 27.65 |
| 1.5 |  |  |  |  |  | 4.20 | 1.99 | 1.77 | 0.22 |  |  |  |  |  |  |  |  | 8.19 | 35.84 |
| 1.0 |  |  |  |  | 21.90 | 12.39 | 0.66 | 7.30 |  |  |  |  |  |  |  |  |  | 42.26 | 78.10 |
| 0.5 |  |  |  | 5.31 | 8.63 | 7.96 |  |  |  |  |  |  |  |  |  |  |  | 21.90 | 100.00 |
| 0.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Figure 2-87 Percentage Occurrence of Significant Wave Height and Peak Period for Hurricanes – June



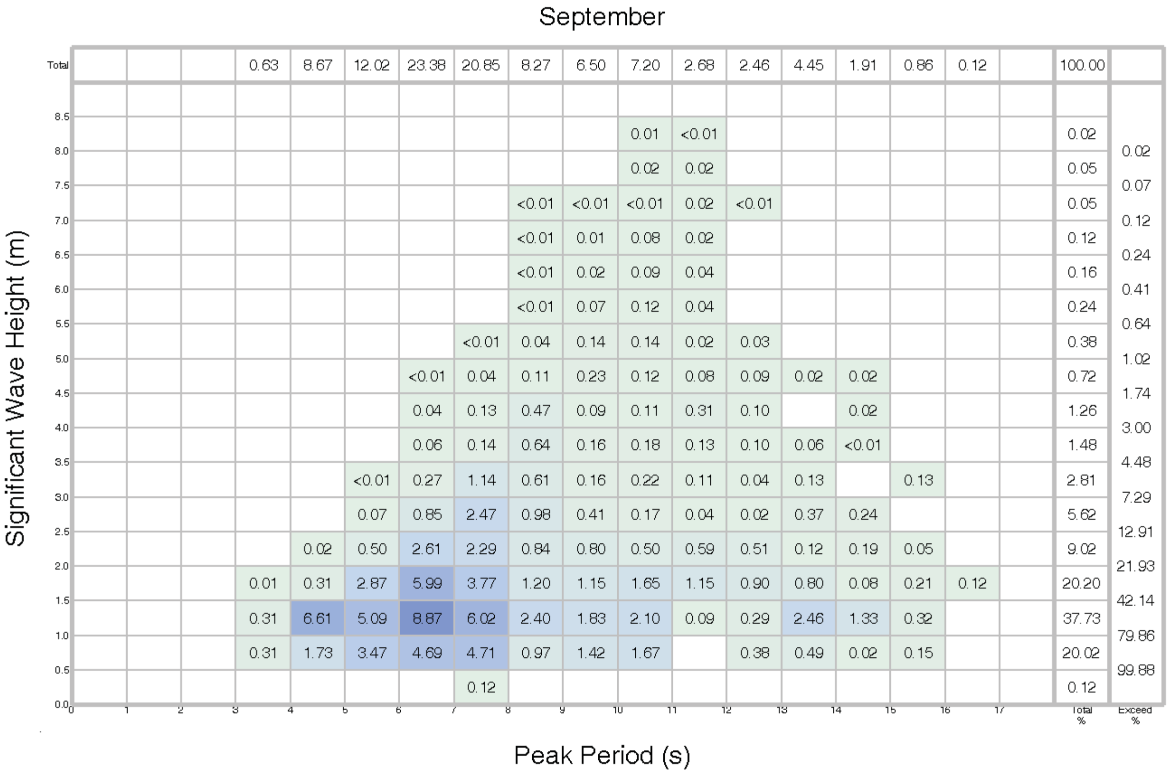
|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total |  |  |  | 2.60 | 11.37 | 19.53 | 48.15 | 5.25 | 4.08 | 2.16 | 3.09 | 1.85 |  | 1.36 | 0.56 |  |  | 100.00 |  |
| 8.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 8.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.0 |  |  |  |  |  |  |  |  |  | 0.37 |  |  |  |  |  |  |  | 0.37 | 0.37 |
| 4.5 |  |  |  |  |  |  |  |  | 0.12 | 0.37 |  |  |  |  |  |  |  | 0.49 | 0.87 |
| 4.0 |  |  |  |  |  |  |  |  | 0.31 | 0.12 |  |  |  |  |  |  |  | 0.43 | 1.30 |
| 3.5 |  |  |  |  |  |  |  | 0.31 | 0.19 |  |  |  |  |  |  |  |  | 0.49 | 1.79 |
| 3.0 |  |  |  |  |  |  | 0.06 | 0.49 |  |  |  |  |  |  |  |  |  | 0.56 | 2.35 |
| 2.5 |  |  |  |  |  |  | 0.62 | 0.43 | 0.37 |  |  |  |  |  |  |  |  | 1.42 | 3.77 |
| 2.0 |  |  |  |  |  | 0.80 | 0.99 | 0.19 |  |  |  |  |  |  |  |  |  | 1.98 | 5.75 |
| 1.5 |  |  |  |  | 0.56 | 4.33 | 4.82 | 2.10 |  |  | 0.56 | 1.55 |  |  |  |  |  | 13.91 | 19.65 |
| 1.0 |  |  |  |  | 10.44 | 12.73 | 29.67 | 1.55 |  | 1.30 | 2.53 | 0.31 |  | 0.68 |  |  |  | 59.21 | 78.86 |
| 0.5 |  |  |  | 2.60 | 0.37 | 1.67 | 11.99 | 0.19 | 0.25 |  |  |  |  | 0.68 | 0.56 |  |  | 18.29 | 97.16 |
| 0.0 |  |  |  |  |  |  |  |  | 2.84 |  |  |  |  |  |  |  |  | 2.84 |  |

Figure 2-88 Percentage Occurrence of Significant Wave Height and Peak Period for Hurricanes – July



| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | 1.21 | 11.72 | 15.45 | 29.95 | 15.34 | 3.47 | 5.47 | 6.29 | 2.83 | 3.87 | 2.24 | 0.07 | 1.04 | 0.68 | 0.38 | 100.00 | |
| 8.5 | | | | | | | | | | | | 0.06 | | | | | | | 0.06 | 0.06 |
| 8.0 | | | | | | | | | | | 0.04 | 0.05 | | | | | | | 0.09 | 0.15 |
| 7.5 | | | | | | | | | | | 0.09 | 0.04 | | | | | | | 0.12 | 0.27 |
| 7.0 | | | | | | | | | | | 0.04 | 0.04 | | | | | | | 0.07 | 0.34 |
| 6.5 | | | | | | | | | | | 0.07 | 0.04 | | | | | | | 0.11 | 0.45 |
| 6.0 | | | | | | | | | | | 0.10 | 0.02 | | | | | | | 0.12 | 0.57 |
| 5.5 | | | | | | | | | | 0.05 | 0.07 | | | | | | | | 0.12 | 0.69 |
| 5.0 | | | | | | | | | 0.02 | 0.27 | 0.06 | | | | | | | | 0.35 | 1.05 |
| 4.5 | | | | | | | | 0.01 | 0.05 | 0.35 | 0.49 | 0.06 | | | | | | | 0.96 | 2.01 |
| 4.0 | | | | | | | | 0.04 | 0.29 | 0.26 | 0.10 | 0.01 | | | | | | | 0.69 | 2.70 |
| 3.5 | | | | | | | | 0.27 | 0.50 | 0.18 | 0.06 | 0.65 | 0.18 | | | | | | 1.84 | 4.54 |
| 3.0 | | | | | | 0.01 | 0.11 | 0.97 | 0.24 | 0.07 | 0.21 | 0.37 | 0.35 | 0.17 | | 0.11 | | | 2.62 | 7.16 |
| 2.5 | | | | | | | 1.13 | 2.08 | 0.33 | 0.18 | 0.58 | 0.22 | 0.12 | | | 0.05 | 0.07 | 0.02 | 4.80 | 11.96 |
| 2.0 | | | | | 0.04 | 0.35 | 2.36 | 1.40 | 0.22 | 0.50 | 0.80 | 0.06 | 0.94 | 0.06 | | 0.15 | 0.04 | 0.13 | 7.05 | 19.02 |
| 1.5 | | | | | 0.34 | 3.85 | 8.05 | 1.01 | 0.40 | 0.58 | 1.06 | 0.51 | 0.88 | 0.58 | 0.05 | 0.23 | 0.27 | 0.15 | 17.97 | 36.99 |
| 1.0 | | | | 0.24 | 8.86 | 6.06 | 9.20 | 1.89 | 1.07 | 0.56 | 1.72 | 0.33 | 0.87 | 1.43 | 0.02 | 0.50 | 0.11 | 0.07 | 32.92 | 69.91 |
| 0.5 | | | | 0.96 | 2.49 | 5.18 | 9.09 | 7.26 | 0.34 | 1.46 | 0.80 | 0.38 | 0.54 | | | | 0.19 | | 28.69 | 98.60 |
| 0.0 | | | | | | | | 0.40 | | 1.00 | | | | | | | | | 1.40 | |

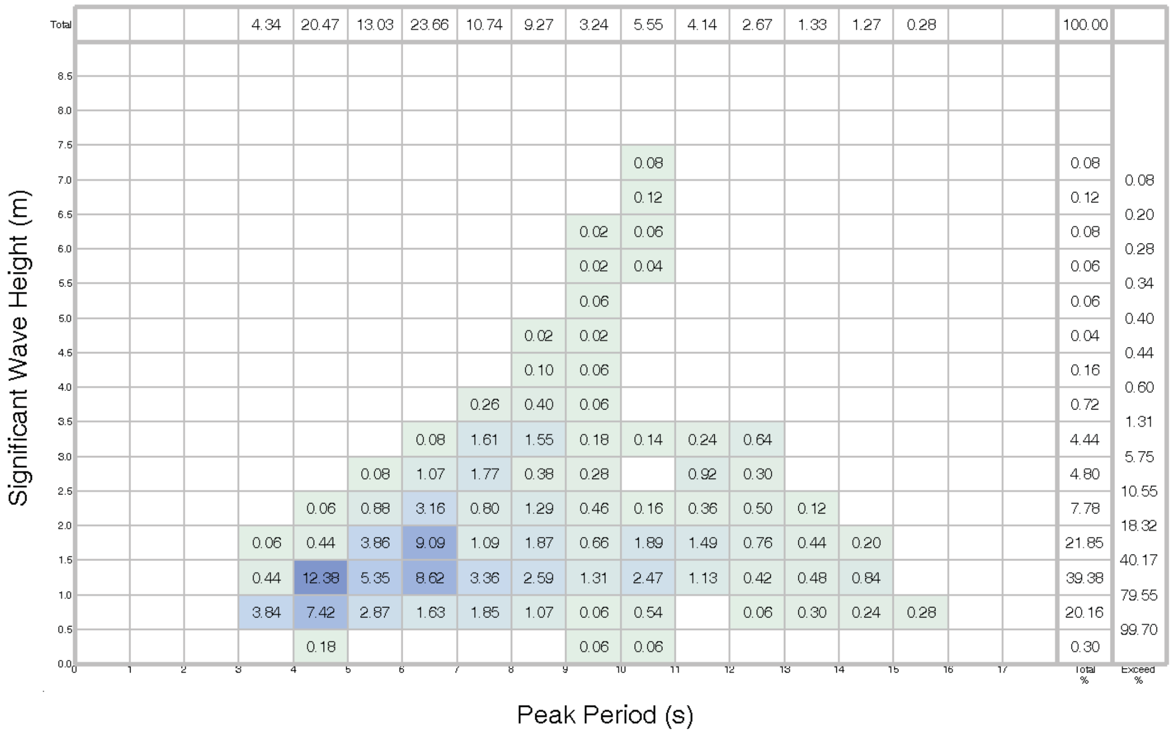
Figure 2-89 Percentage Occurrence of Significant Wave Height and Peak Period for Hurricanes – August



| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | 0.63 | 8.67 | 12.02 | 23.38 | 20.85 | 8.27 | 6.50 | 7.20 | 2.68 | 2.46 | 4.45 | 1.91 | 0.86 | 0.12 | | 100.00 | |
| 8.5 | | | | | | | | | | | | | | | | | | | | |
| 8.0 | | | | | | | | | | | 0.01 | <0.01 | | | | | | | 0.02 | 0.02 |
| 7.5 | | | | | | | | | | | 0.02 | 0.02 | | | | | | | 0.05 | 0.07 |
| 7.0 | | | | | | | | | <0.01 | <0.01 | <0.01 | 0.02 | <0.01 | | | | | | 0.05 | 0.12 |
| 6.5 | | | | | | | | | <0.01 | 0.01 | 0.08 | 0.02 | | | | | | | 0.12 | 0.24 |
| 6.0 | | | | | | | | | <0.01 | 0.02 | 0.09 | 0.04 | | | | | | | 0.16 | 0.41 |
| 5.5 | | | | | | | | | <0.01 | 0.07 | 0.12 | 0.04 | | | | | | | 0.24 | 0.64 |
| 5.0 | | | | | | | | <0.01 | 0.04 | 0.14 | 0.14 | 0.02 | 0.03 | | | | | | 0.38 | 1.02 |
| 4.5 | | | | | | | <0.01 | 0.04 | 0.11 | 0.23 | 0.12 | 0.08 | 0.09 | 0.02 | 0.02 | | | | 0.72 | 1.74 |
| 4.0 | | | | | | | 0.04 | 0.13 | 0.47 | 0.09 | 0.11 | 0.31 | 0.10 | | 0.02 | | | | 1.26 | 3.00 |
| 3.5 | | | | | | | 0.06 | 0.14 | 0.64 | 0.16 | 0.18 | 0.13 | 0.10 | 0.06 | <0.01 | | | | 1.48 | 4.48 |
| 3.0 | | | | | | <0.01 | 0.27 | 1.14 | 0.61 | 0.16 | 0.22 | 0.11 | 0.04 | 0.13 | | 0.13 | | | 2.81 | 7.29 |
| 2.5 | | | | | | 0.07 | 0.85 | 2.47 | 0.98 | 0.41 | 0.17 | 0.04 | 0.02 | 0.37 | 0.24 | | | | 5.62 | 12.91 |
| 2.0 | | | | | 0.02 | 0.50 | 2.61 | 2.29 | 0.84 | 0.80 | 0.50 | 0.59 | 0.51 | 0.12 | 0.19 | 0.05 | | | 9.02 | 21.93 |
| 1.5 | | | | 0.01 | 0.31 | 2.87 | 5.99 | 3.77 | 1.20 | 1.15 | 1.65 | 1.15 | 0.90 | 0.80 | 0.08 | 0.21 | 0.12 | | 20.20 | 42.14 |
| 1.0 | | | | 0.31 | 6.61 | 5.09 | 8.87 | 6.02 | 2.40 | 1.83 | 2.10 | 0.09 | 0.29 | 2.46 | 1.33 | 0.32 | | | 37.73 | 79.86 |
| 0.5 | | | | 0.31 | 1.73 | 3.47 | 4.69 | 4.71 | 0.97 | 1.42 | 1.67 | | 0.38 | 0.49 | 0.02 | 0.15 | | | 20.02 | 99.88 |
| 0.0 | | | | | | | | 0.12 | | | | | | | | | | | 0.12 | |

Figure 2-90 Percentage Occurrence of Significant Wave Height and Peak Period for Hurricanes – September

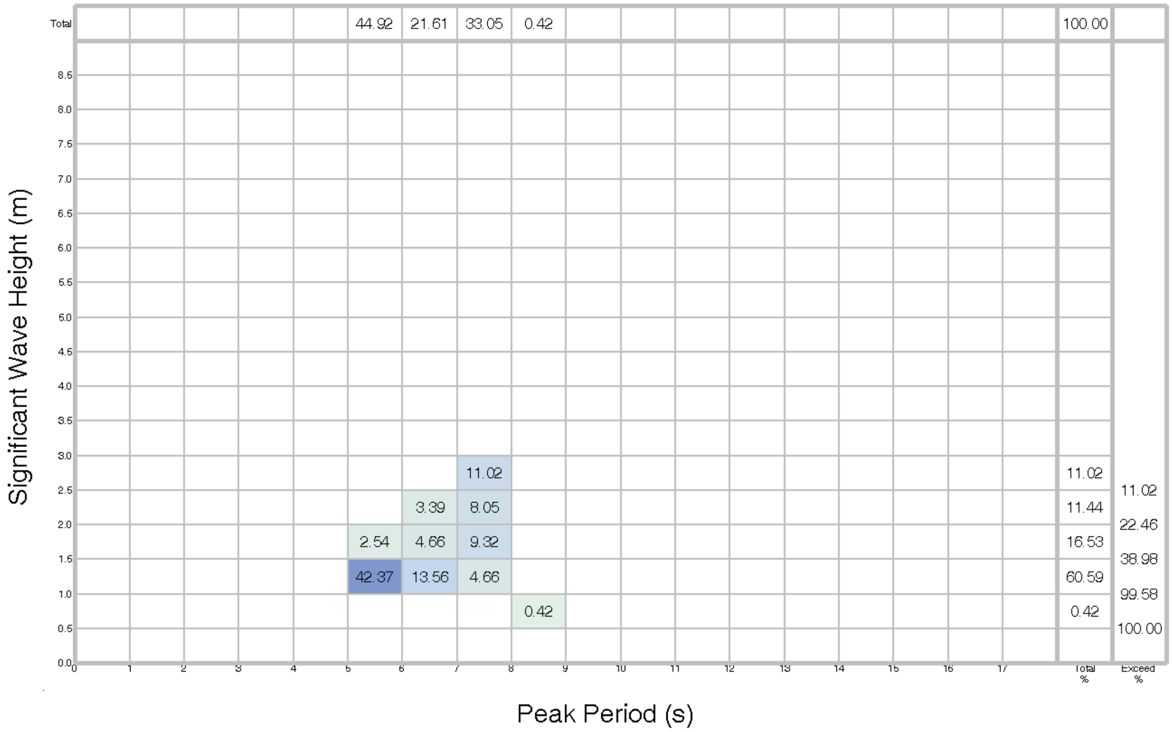
October



|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total |  |  |  | 4.34 | 20.47 | 13.03 | 23.66 | 10.74 | 9.27 | 3.24 | 5.55 | 4.14 | 2.67 | 1.33 | 1.27 | 0.28 |  |  | 100.00 |  |
| 8.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 8.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.0 |  |  |  |  |  |  |  |  |  |  | 0.08 |  |  |  |  |  |  |  | 0.08 | 0.08 |
| 6.5 |  |  |  |  |  |  |  |  |  |  | 0.12 |  |  |  |  |  |  |  | 0.12 | 0.20 |
| 6.0 |  |  |  |  |  |  |  |  |  | 0.02 | 0.06 |  |  |  |  |  |  |  | 0.08 | 0.28 |
| 5.5 |  |  |  |  |  |  |  |  |  | 0.02 | 0.04 |  |  |  |  |  |  |  | 0.06 | 0.34 |
| 5.0 |  |  |  |  |  |  |  |  |  | 0.06 |  |  |  |  |  |  |  |  | 0.06 | 0.40 |
| 4.5 |  |  |  |  |  |  |  |  | 0.02 | 0.02 |  |  |  |  |  |  |  |  | 0.04 | 0.44 |
| 4.0 |  |  |  |  |  |  |  |  | 0.10 | 0.06 |  |  |  |  |  |  |  |  | 0.16 | 0.60 |
| 3.5 |  |  |  |  |  |  |  | 0.26 | 0.40 | 0.06 |  |  |  |  |  |  |  |  | 0.72 | 1.31 |
| 3.0 |  |  |  |  |  |  | 0.08 | 1.61 | 1.55 | 0.18 | 0.14 | 0.24 | 0.64 |  |  |  |  |  | 4.44 | 5.75 |
| 2.5 |  |  |  |  |  | 0.08 | 1.07 | 1.77 | 0.38 | 0.28 |  | 0.92 | 0.30 |  |  |  |  |  | 4.80 | 10.55 |
| 2.0 |  |  |  |  | 0.06 | 0.88 | 3.16 | 0.80 | 1.29 | 0.46 | 0.16 | 0.36 | 0.50 | 0.12 |  |  |  |  | 7.78 | 18.32 |
| 1.5 |  |  |  | 0.06 | 0.44 | 3.86 | 9.09 | 1.09 | 1.87 | 0.66 | 1.89 | 1.49 | 0.76 | 0.44 | 0.20 |  |  |  | 21.85 | 40.17 |
| 1.0 |  |  |  | 0.44 | 12.38 | 5.35 | 8.62 | 3.36 | 2.59 | 1.31 | 2.47 | 1.13 | 0.42 | 0.48 | 0.84 |  |  |  | 39.38 | 79.55 |
| 0.5 |  |  |  | 3.84 | 7.42 | 2.87 | 1.63 | 1.85 | 1.07 | 0.06 | 0.54 |  | 0.06 | 0.30 | 0.24 | 0.28 |  |  | 20.16 | 99.70 |
| 0.0 |  |  |  |  | 0.18 |  |  |  |  | 0.06 | 0.06 |  |  |  |  |  |  |  | 0.30 |  |

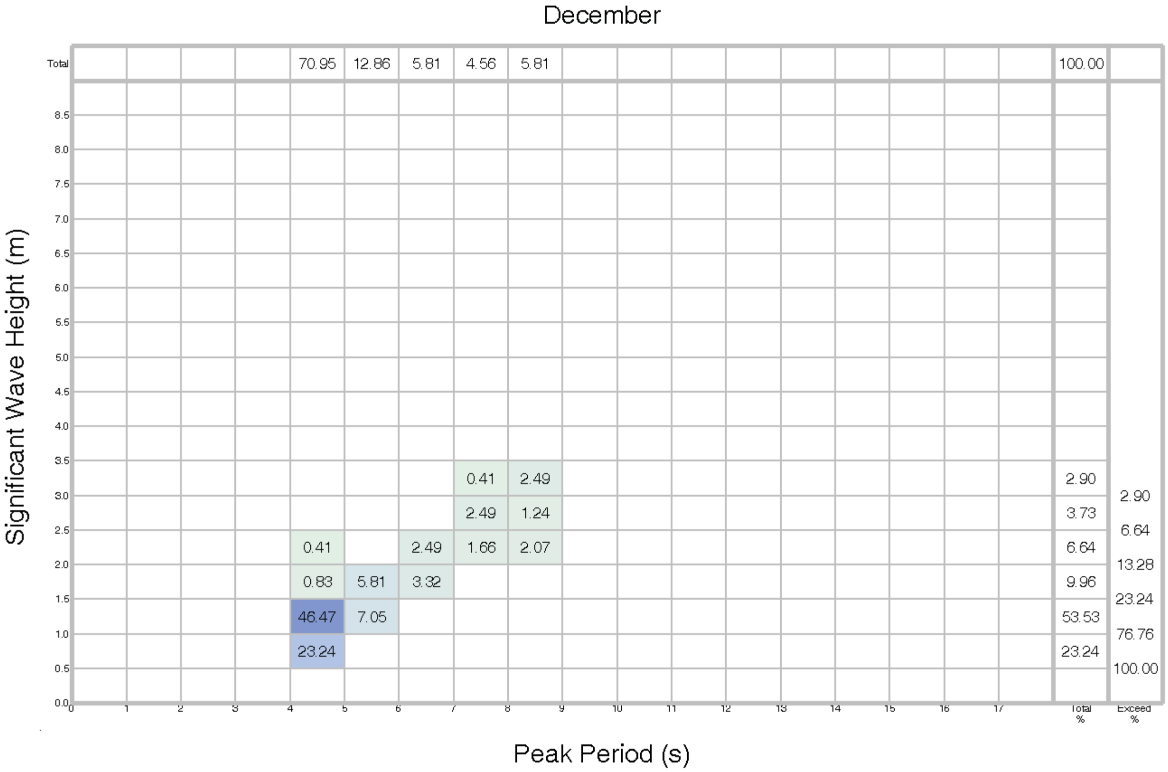
Figure 2-91 Percentage Occurrence of Significant Wave Height and Peak Period for Hurricanes – October

November



|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total |  |  |  |  |  | 44.92 | 21.61 | 33.05 | 0.42 |  |  |  |  |  |  |  |  |  | 100.00 |  |
| 8.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 8.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2.5 |  |  |  |  |  |  |  | 11.02 |  |  |  |  |  |  |  |  |  |  | 11.02 | 11.02 |
| 2.0 |  |  |  |  |  |  | 3.39 | 8.05 |  |  |  |  |  |  |  |  |  |  | 11.44 | 22.46 |
| 1.5 |  |  |  |  |  | 2.54 | 4.66 | 9.32 |  |  |  |  |  |  |  |  |  |  | 16.53 | 38.98 |
| 1.0 |  |  |  |  |  | 42.37 | 13.56 | 4.66 |  |  |  |  |  |  |  |  |  |  | 60.59 | 99.58 |
| 0.5 |  |  |  |  |  |  |  |  | 0.42 |  |  |  |  |  |  |  |  |  | 0.42 | 100.00 |
| 0.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Figure 2-92 Percentage Occurrence of Significant Wave Height and Peak Period for Hurricanes – November



| Significant Wave Height (m) / Peak Period (s) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | 70.95 | 12.86 | 5.81 | 4.56 | 5.81 | | | | | | | | | 100.00 | |
| 8.5 | | | | | | | | | | | | | | | | | | | |
| 8.0 | | | | | | | | | | | | | | | | | | | |
| 7.5 | | | | | | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | | |
| 6.5 | | | | | | | | | | | | | | | | | | | |
| 6.0 | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | | |
| 4.5 | | | | | | | | | | | | | | | | | | | |
| 4.0 | | | | | | | | | | | | | | | | | | | |
| 3.5 | | | | | | | | | | | | | | | | | | | |
| 3.0 | | | | | | | | 0.41 | 2.49 | | | | | | | | | 2.90 | 2.90 |
| 2.5 | | | | | | | | 2.49 | 1.24 | | | | | | | | | 3.73 | 6.64 |
| 2.0 | | | | | 0.41 | | 2.49 | 1.66 | 2.07 | | | | | | | | | 6.64 | 13.28 |
| 1.5 | | | | | 0.83 | 5.81 | 3.32 | | | | | | | | | | | 9.96 | 23.24 |
| 1.0 | | | | | 46.47 | 7.05 | | | | | | | | | | | | 53.53 | 76.76 |
| 0.5 | | | | | 23.24 | | | | | | | | | | | | | 23.24 | 100.00 |
| 0.0 | | | | | | | | | | | | | | | | | | | |

Figure 2-93 Percentage Occurrence of Significant Wave Height and Peak Period for Hurricanes – December

### 2.2.24 Air Gap

Wave forces are the principal environmental force acting on offshore structure. As such they are designed so that the main facilities will not be impacted by wave loading, with the cellar deck generally being the lowest point considered in the air gap calculation. The maximum extreme water level comprises the following elements, which are illustrated in Figure 2-94.

- Tidal height
- Surge height (storm, seasonal)
- Crest height

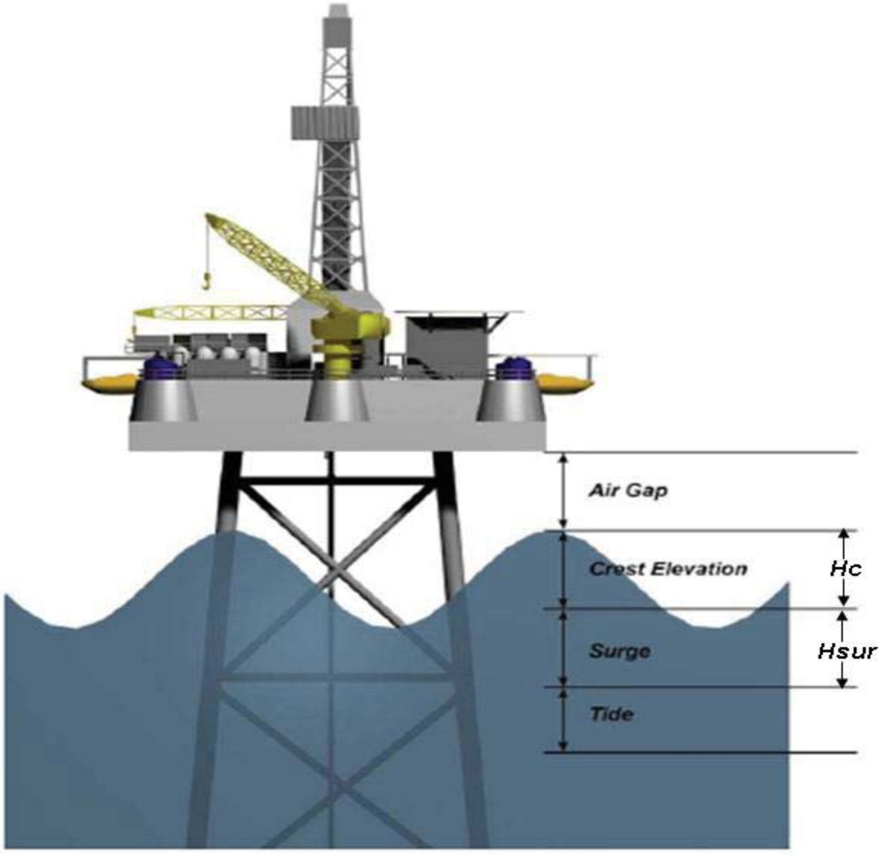


**Figure 2-94 Air Gap Diagram**

Platform elevation is defined as wave crest + 5 ft air gap + 15% of crest height for hurricane conditions.

#### 2.2.24.1 Surge (Hsur)

Storm surge values based on section 2.5.1.

#### 2.2.24.2 Hmax and Hc

Maximum and crest wave height values were derived using in-house software (EXWAN – EXtreme Wave ANalysis).

The probability distributions of maximum wave or crest height for a storm are given by:

$$P(H_{max} < h) = exp\left\{\int_0^T log\{F_{Hs(t)}(h)\}dt / T_{m02}(t)\right\}$$

where:

$P(H_{max} < h)$ is the non-exceedance probability of the maximum wave or crest height in a storm;
$F_{Hs(t)}(h)$ is the short-term non-exceedance probability of wave or crest height, $h$, for a significant wave height, $Hs$, at time, $t$;
$T_{m02}(t)$ is the spectral estimate of the mean zero up-crossing wave period at time, $t$;
$T$ is the duration of the storm.

This approach was developed by Borgman (1973)[1] and has been adopted by the EXWAN software as a means of determining the maximum wave and crest height from each storm. The Oceanweather hindcast data contained an estimate of *Tp* and this parameter is used to derive $T_{m02}$ by multiplying by 0.74.

In order to calculate $F_{Hs(t)}(h)$ for each time step within each storm the Forristall 3-D approach was used for crest height. This formulation is based on the 2-parameter Weibull distribution:

$$F_{Hs}(h) = 1 - exp\left\{-\frac{(4\,h/Hs)^A}{B}\right\}$$

where, $A$ and $B$ are parameters that were empirically fitted.

Forristall (2000)[2] derived estimates of extreme crest heights for given sea states in given water depths by using simulations of JONSWAP spectra and empirically fitted the following for *A* and *B*:

$$A = 2 - 1.7912S - 0.5302U_r + 0.2824U_r^2$$
$$B = \{4(0.3536 + 0.2568S + 0.0800U_r)\}^A$$

where:

$U_r = \frac{Hs}{k_1^2 d^3}$; is the Ursell number, and

$S = \frac{2\pi H_s}{gT_{m01}^2}$; is the wave steepness,

$T_{m01} = m_0/m_1$, the ratio of the zeroth to the first moments of the wave spectrum;
$k_1$ is the deep water wave number corresponding to $T_{m01}$;
$d$ is the water depth.

Time series data from Oceanweather was processed using the EXWAN program to produce a representative crest height for each individual storm. The ratio of crest heights to the highest Hs recorded in each storm was then calculated. The regression equation Hc = 1.1763*Hs was then developed and used to derive the respective crest heights for winter storms and equation Hc = 1.1622*Hs was then developed and used to derive the respective crest heights for hurricanes.

---

[1] Borgman, L., 1973. *Probabilities for highest wave in hurricane*. J. Waterways, Harbors, and Coastal Eng, Div. ASCE **99**, 185-207.

[2] Forristall, G.Z. (2000). *Wave crest distributions: observations and second order theory*. J. Phys. Ocean, **30**, 1931-1943.

The maximum wave height was calculated using EXWAN and the 2-parameter Weibull distribution proposed by Forristall. The values used for A and B are 2.13 and 8.42, respectively. As with the crest heights, the ratio of maximum heights to the highest Hs recorded in each storm was then calculated. The regression equation Hmax = 1.8711*Hs for winter storms and Hmax = 1.8027*Hs for hurricanes, was then developed and used to derive the respective maximum wave heights in the Criteria Reference.

### 2.2.25 Wave Persistence

Total wave persistence values for Virginia are provided in the attached Excel spreadsheet "Virginia_wave_persistence." Persistence statistics are expressed as the percentage of hours in a month that windows of duration 6, 12, 18, 24, 36, 48, and 72 hours occur.

### 2.2.26 Wavelength Equation

Stream function wave theory was developed by Dean (1965)[3] to examine fully nonlinear water waves numerically. The method involves computing a series solution to the fully nonlinear water wave problem, involving the Laplace equation with two nonlinear free surface boundary conditions (constant pressure, and a wave height constraint (Dalrymple, 1974)[4]. Chaplin (1980)[5] reformulated the method to be able to predict correctly the behaviour of steep and near-breaking waves. The Stream Function Matlab package presented here is to calculate wave kinematics for non-linear regular waves on a uniform current with water depth d, wave height H and wave period T are known.

The StreamFunction Matlab package was converted to Matlab from FORTRAN code CW263.FOR. The original FORTRAN code by Dr. John Chaplin of Southampton University was downloaded from:
http://www.civil.soton.ac.uk/hydraulics/download/downloadtable.htm

This wave Streamfunction package has the following features:

- Automatic selection of the order of the stream function. The order of the Stream function wave is a measure of how nonlinear the wave is. In deep water, the order can be low, 3 to 5 say, while, in very shallow water, the order can be as great as 30. A measure of which order to use is to choose an order and then increase it by one and obtain another solution. If the results do not change significantly, then you have the right order.
- Uniform background current
- For steep waves the solution advances in steps, in which the order and the wave height are progressively increased.

### 2.2.27 Wave Spectra and Parameters

The JONSWAP (Joint North Sea Wave Project) wave frequency spectrum is an extention of the Pierson-Moskowitz (PM) spectrum to include fetch limited situation. The PM spectrum was originally propose for a fully-developed sea.

$$S_{JS}(\omega)=F_n*S_{PM}(\omega)*(\gamma\text{^}\exp(-(1/2)*[(\omega-\omega_m)/(\sigma*\omega_m)]^2))$$

Where
$S_{PM}(\omega)$ is the Pierson-Moskowitz spectrum:
$S_{PM}(\omega)=((\alpha*g^2)/\omega^5)*\exp(-1.25*(\omega_m/\omega)^4)$

---

[3] Dean, R.G, 1965, Stream Function Representation of Nonlinear Ocean Waves, JGR, 70(18):4561-4572

[4] Dalrymple, R.A., 1974, A Finite Amplitude Wave on a Linear Shear Current, JGR, 79(30):4498-4504

[5] Chaplin, J.R., 1980, Developments of Stream-Function Wave Theory. Coastal Engineering, 3:179-205

$g$ is the acceleration due to gravity
$\omega$ is the wave frequency in radians per second (rad/s)
$\omega_m$ is the peak frequency
$\alpha$ is 0.0081
$\gamma$ is a non-dimensional peak shape parameter
$\sigma$ is a numerical parameter
$\sigma=\sigma_a$ for $\omega \le \omega_m$
$\sigma=\sigma_b$ for $\omega > \omega_m$
$F_n$ is a normalizing or scaling factor used to ensure that $S_{JS}$ and $S_{PM}$ have the same $H_s$. For $\sigma_a$=0.07 and $\sigma_b$=0.09 $F_n$ becomes:

$F_n(1)=(0.78+0.22\gamma)^{-1}$ for $1\le \gamma \le 6$
$F_n(2)=[5*(0.065\gamma^{0.803}+0.135)]^{-1}$ for $1\le \gamma \le 10$

$F_n(1)$ was obtained by Ewing[4] and $F_n(2)$ by Yamaguchi[5]

In Xwaves, the default option in the spectrum fitting was used. According to the manual, default option uses a modified form of the JONSWAP that is based on significant wave height ($H_s$). peak period ($T_p$), and peak enhancement factor $\gamma$. $\sigma_a$ and $\sigma_b$ are held constant at 0.07 and 0.09, respectively. $\alpha$ is then computed independently based on $H_s$, $T_p$, and $\gamma$.

Example: For $\gamma$ = 1, 2, and 3, $\sigma_a$ = 0.07, $\sigma_b$ = 0.09, $\omega_m$ = 0.5:

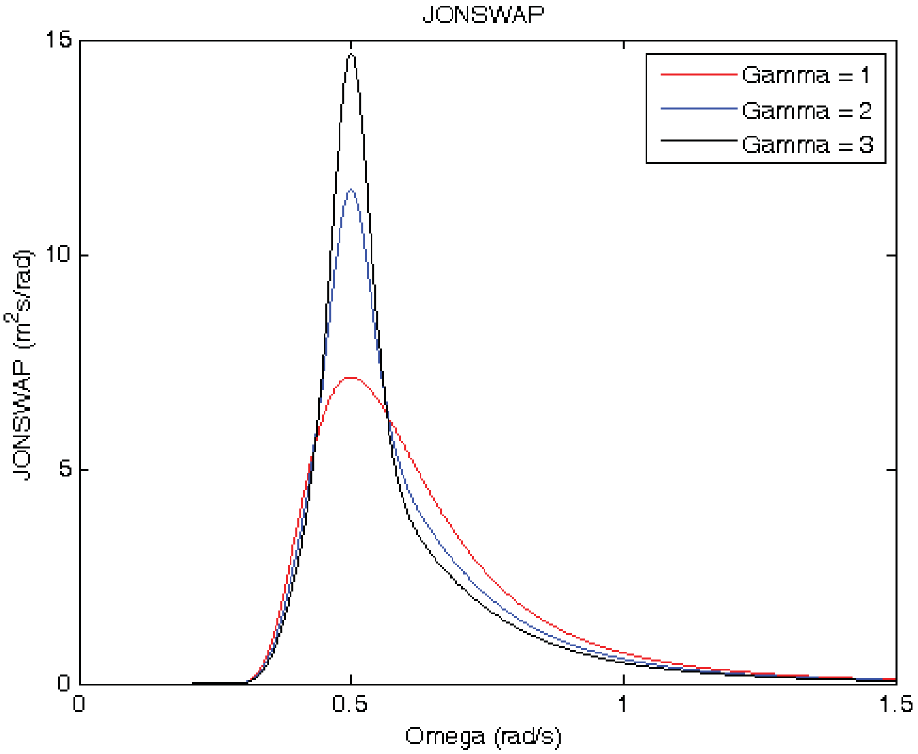


Figure 2-95 JONSWAP Example

### 2.2.28 Breaking Waves

To determine if a wave is a breaking wave, the relationship below was used obtained from ISO 19901-1[1]:

$H_s/H_d \geq 0.78$

Where $H_s$ is Hmax and $H_d$ is the water depth in meters.

Tables below show the $H_s/H_d$ for both sites for winter stomrs and hurricanes. There are breaking waves in the area for return periods of 500- and 1000 years for hurricanes at both sites. The maximum sustainable wave heigh for site 1 is 19.27 m and 19.81 m for site 2.

Breaking waves are classified as spilling, plunging or surging. The first two types, spilling and plunging, are relevant for offshore wind turbines. The water depth, sea floor slope and wave period determine whether the breaking wave is spilling or plunging. Annex C in IEC 61400-3[3] provides guidance relating to shallow water hydrodynamics and the influence of site characteristics on the nature and dimensions of breaking waves. Annex D relates to the calculation of hydrodynamic loads for breaking waves.

| **Extreme Wave Criteria at Site 1** | | **Return Period for Winter Storms** | | | **Return Periods for Hurricanes** | | |
|---|---|---|---|---|---|---|---|
| | | **100-year** | **500-year** | **1000-year** | **100-year** | **500-year** | **1000-year** |
| **Hmax (m)** | | 12.77 | 15.28 | 16.36 | 16.46 | 20.52 | 22.26 |
| **$H_s/H_d$** | **Total Water Depth 24.7m** | 0.51 | 0.62 | 0.66 | 0.67 | 0.83 | 0.90 |

**Table 2-37 $H_s/H_d$ Values for Site 1 for Winter Storms and Hurricanes**

| **Extreme Wave Criteria at Site 2** | | **Return Period for Winter Storms** | | | **Return Periods for Hurricanes** | | |
|---|---|---|---|---|---|---|---|
| | | **100-year** | **500-year** | **1000-year** | **100-year** | **500-year** | **1000-year** |
| **Hmax (m)** | | 12.77 | 15.28 | 16.36 | 16.46 | 20.52 | 22.26 |
| **$H_s/H_d$** | **Total Water Depth 25.4m** | 0.50 | 0.60 | 0.64 | 0.65 | 0.81 | 0.88 |

**Table 2-38 $H_s/H_d$ Values for Site 2 for Winter Storms and Hurricanes**

Breaking waves was also determined by using equation 2-58 in the Shore Protection Manual.

$$\left(\frac{H}{L}\right)_{Max} = 0.142 * \tanh\left(\frac{2 * \pi * d}{L}\right)$$

$$L = \frac{g * T^2}{2 * \pi} \sqrt{\tanh\left(\frac{4 * \pi^2 * d}{T^2 * g}\right)}$$

Where:
T= THmax (s), d= depth (m), H= Hmax (m)

Table 2-39 and Table 2-40 illustrate the maximum wave steepness and the wave steepness for return periods 100-, 500-, and 1000-years. Once the maximum wave steepness is exceded the wave becomes unstable and breaks. There are breaking waves in the area for return periods of 500- and 1000 years for hurricanes at both sites.

| Extreme Wave Criteria at Site 1 | | Return Period for Winter Storms | | | Return Periods for Hurricanes | | |
|---|---|---|---|---|---|---|---|
| | | 100-year | 500-year | 1000-year | 100-year | 500-year | 1000-year |
| (H/L)max (m) | | 0.10 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 |
| Hmax/L | Total Water Depth 24.7m | 0.07 | 0.08 | 0.08 | 0.08 | 0.09 | 0.09 |

Table 2-39 Maximum Wave Steepness for Site 1 for Winter Storms and Hurricanes

| Extreme Wave Criteria at Site 2 | | Return Period for Winter Storms | | | Return Periods for Hurricanes | | |
|---|---|---|---|---|---|---|---|
| | | 100-year | 500-year | 1000-year | 100-year | 500-year | 1000-year |
| (H/L)max (m) | | 0.10 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 |
| Hmax/L | Total Water Depth 25.4m | 0.07 | 0.08 | 0.08 | 0.08 | 0.09 | 0.09 |

Table 2-40 Maximum Wave Steepness for Site 2 for Winter Storms and Hurricanes

### 2.2.29 Advice on Values for Normal, Sever, Extreme and Reduce Wave Data

As described in IEC 61400-3[3], the normal condictions are the directional scatter tables of individuale fatigue wave heights and periods provided in the attached Excel spreadsheet, “Virginia_Fatigue_20Years_WinterStorm” and “Virginia_Fatigue_20years_Hurricane.” The severe conditions are the extreme significant wave heights and peak period as described in Table 2-16 for 1 year extreme, Table 2-19 for winter storms and Table 2-28 for hurricane. The extreme condition are the 1 year and 50 year recurrence Hmax values as described in Table 2-16 for 1 year extreme, Table 2-19 for winter storms and Table 2-28 for hurricane. The reduced conditions, presented in Table 2-41, consist of the extreme 3-sec wind speed with associated Hs and extreme Hs with associated 3-sec wind speed. Reduced values are calculated by dividing by 1.3 as specified in IEC 61400-3[3].

| Reduce Conditions | | 1-year | 50-years | 100-years | 500-years | 1000-years | 10000-years |
|---|---|---|---|---|---|---|---|
| Winter Storm | 3-sec Wind Speed (m/s) | 16.36 | 33.35 | 36.32 | 43.41 | 46.56 | 57.38 |
| | Reduced Hs (m) | 4.11 | 4.81 | 5.25 | 6.28 | 6.72 | 8.19 |
| | Hs (m) | 5.34 | 6.25 | 6.83 | 8.16 | 8.74 | 10.65 |
| | Reduced 3-sec Wind Speed (m/s) | 12.58 | 25.65 | 27.94 | 33.39 | 35.82 | 44.14 |
| Hurricane | 3-sec Wind Speed (m/s) | 14.16 | 46.95 | 52.81 | 67.06 | 73.49 | 96.11 |
| | Reduced Hs (m) | 4.11 | 6.28 | 7.02 | 8.75 | 9.50 | 11.98 |
| | Hs (m) | 5.34 | 8.16 | 9.13 | 11.38 | 12.35 | 15.57 |
| | Reduced 3-sec Wind Speed (m/s) | 10.89 | 36.12 | 40.62 | 51.58 | 56.53 | 73.93 |

Table 2-41 Reduced Values for Wind Speed and Significant Wave Height for Winter Storms and Hurricanes

## 2.3 Currents Criteria

Current criteria are derived from 7-years (2006 to 2012) Rutgers University's ESPreSSO (Experimental System for Predicting Shelf and Slope Optics) hindcast from gridpoint 36.8587°N, 75.5139°W.

### 2.3.1 Omni-Directional Extreme Near Surface Currents

| Return Period | Current Speed (m/s) |
|---|---|
| **1-year** | 1.08 |
| **50-years** | 1.46 |
| **100-years** | 1.53 |
| **500-years** | 1.69 |
| **1000-years** | 1.76 |
| **10000-years** | 1.99 |

**Table 2-42 Omni-Directional Extreme Near Surface Current Speed**

### 2.3.2 Directional Extreme Near Surface Currents

| Return Period | Direction [towards] | Current Speed (m/s) |
|---|---|---|
| **1-year** | **Omni-directional** | 1.08 |
| | North | 0.84 |
| | North-east | 0.90 |
| | East | 0.83 |
| | South-east | 1.07 |
| | South | 1.08 |
| | South-west | 0.90 |
| | West | 0.80 |
| | North-west | 0.67 |
| **50-years** | **Omni-directional** | 1.46 |
| | North | 1.14 |
| | North-east | 1.22 |
| | East | 1.12 |
| | South-east | 1.45 |
| | South | 1.46 |
| | South-west | 1.22 |
| | West | 1.09 |
| | North-west | 0.92 |
| **100-years** | **Omni-directional** | 1.53 |
| | North | 1.19 |
| | North-east | 1.28 |
| | East | 1.17 |
| | South-east | 1.52 |
| | South | 1.53 |
| | South-west | 1.28 |
| | West | 1.14 |
| | North-west | 0.96 |
| **500-years** | **Omni-directional** | 1.69 |
| | North | 1.31 |

| | | |
|---|---|---|
| | North-east | 1.41 |
| | East | 1.29 |
| | South-east | 1.67 |
| | South | 1.69 |
| | South-west | 1.41 |
| | West | 1.26 |
| | North-west | 1.06 |
| **1000-years** | **Omni-directional** | 1.76 |
| | North | 1.37 |
| | North-east | 1.47 |
| | East | 1.35 |
| | South-east | 1.74 |
| | South | 1.76 |
| | South-west | 1.47 |
| | West | 1.31 |
| | North-west | 1.10 |
| **10000-years** | **Omni-directional** | 1.99 |
| | North | 1.55 |
| | North-east | 1.66 |
| | East | 1.52 |
| | South-east | 1.97 |
| | South | 1.99 |
| | South-west | 1.66 |
| | West | 1.48 |
| | North-west | 1.24 |

**Table 2-43 Directional Extreme Near Surface Current Speed**

### 2.3.3 Current Fitting Parameters

The independent omni-directional current cases are given in Table 2-42 and detailed descriptions of the calculations are given below.

Extreme value analysis was carried out on a subset of peak current speeds from the EXPreSSO data. The analysis consist from 2006 to 2012.

The Peaks Over Threshold (POT) method consisted of declustering the data by selecting peak events to produce a set of independent and identically distributed observations. This method was then employed to derive the 1-, 50-, 100-, 500-, 1000-, and 10000-year criteria. The number of peaks exceeding a given level, divided by the number of years of record, gave the rate of exceedance which could then be used to find the expected number of occurrences in a specified period of time.

The Exponential (EXP), Fisher-Tippett 1 (FT1), Fisher-Tippett 2 (FT2), Fisher-Tippett 3 (FT3), Generalised Pareto (GP), Weibull 2 (W2) and Weibull 3 (W3) distributions were tested for goodness-of-fit to the ESPreSSO data using the method of least squares (LS), maximum likelihood (MLE), and the method of moments (MoM). The best fits for 1-, 50-, 100-, 500-, 1000-, and 10000-year current speed are summarised in Table 2-44.

| | Distribution | Fit | Threshold | # Peaks | Extreme Values | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-yr | 50-yr | 100-yr | 500-yr | 1000-yr | 10000-yr |
| Cs (m/s) | EXP | LS | 50.00 | 13283 | 1.08 | 1.46 | 1.53 | 1.69 | 1.76 | 1.98 |
| | FT1 | LS | 95.00 | 41268 | 1.08 | 1.47 | 1.54 | 1.70 | 1.77 | 2.00 |
| | FT1 | LS | 95.00 | 41268 | 1.08 | 1.47 | 1.54 | 1.69 | 1.76 | 1.99 |
| | FT1 | LS | 50.00 | 22672 | 1.07 | 1.45 | 1.51 | 1.67 | 1.73 | 1.95 |
| | FT2 | LS | 95.00 | 41268 | 1.08 | 1.47 | 1.54 | 1.70 | 1.76 | 1.99 |
| | FT2 | LS | 10.00 | 3555 | 1.08 | 1.50 | 1.58 | 1.76 | 1.85 | 2.13 |
| | FT2 | LS | 90.00 | 41268 | 1.07 | 1.46 | 1.52 | 1.68 | 1.75 | 1.97 |
| | FT3 | LS | 50.00 | 13283 | 1.08 | 1.46 | 1.52 | 1.68 | 1.75 | 1.97 |
| | FT3 | LS | 95.00 | 41268 | 1.08 | 1.44 | 1.50 | 1.64 | 1.70 | 1.90 |
| | AVERAGE | | | | 1.08 | 1.46 | 1.53 | 1.69 | 1.76 | 1.99 |

**Table 2-44 Extreme Omni-directional Near Surface Current Speed Fitting Parameters**

## 2.4 Wind-Wave-Current Joint Probability

The joint probability criteria are derive from 26-years (1980 to 2005) Oceanweather operational hindcast data. The GROWFINE Eastcoast data from Oceanweather only have continuous wind and wave data from 1/1/1980 to 12/31/2005, while the current data from Rutgers university are from 2006 to 2012, there is no overlapping period for the three parameters to derive the joint probability.

To derive the joint probability between wind, wave, and current by using the following approach. Obtained NCEP WaveWatch III wind and wave data from 2000 to 2012 at a gridpoint (37N 75.5W) closes to the sites. Compared NCEP WaveWatch III wind and wave data against Oceanweather wind and wave data from 2000 to 2005 and found wind and wave relationship between the two. Figure 2-95 illustrates the wind speed relationship between WaveWatch III and Oceanweather and Figure 2-96 illustrates the significant wave height relationship between WaveWatch III and Oceanweather. The formula y=1*x-0.14, was used to calibrate the wind speed from WaveWatch III to Oceanweather, and formula y=1.1*x+0.086, was used to calibrate the significant wave height from WaveWatch III to Oceanweather. Over all a 7-year (2006-2012) wind, wave, and current data set was used to derive the joint probability between wind, wave, and current. The wind, wave, and current joint probability are provided in the attached Excel spreadsheet "Wind_Wave_Current_Joint_Probability."

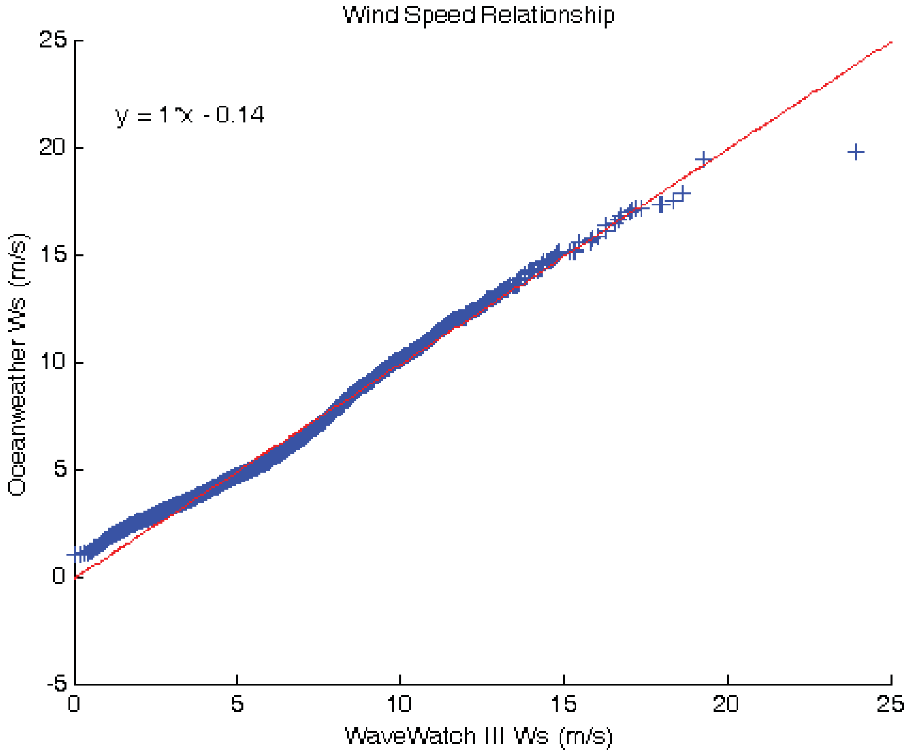


Figure 2-96 Relationship Between WaveWatch III Wind Speed with Oceanweather Wind Speed

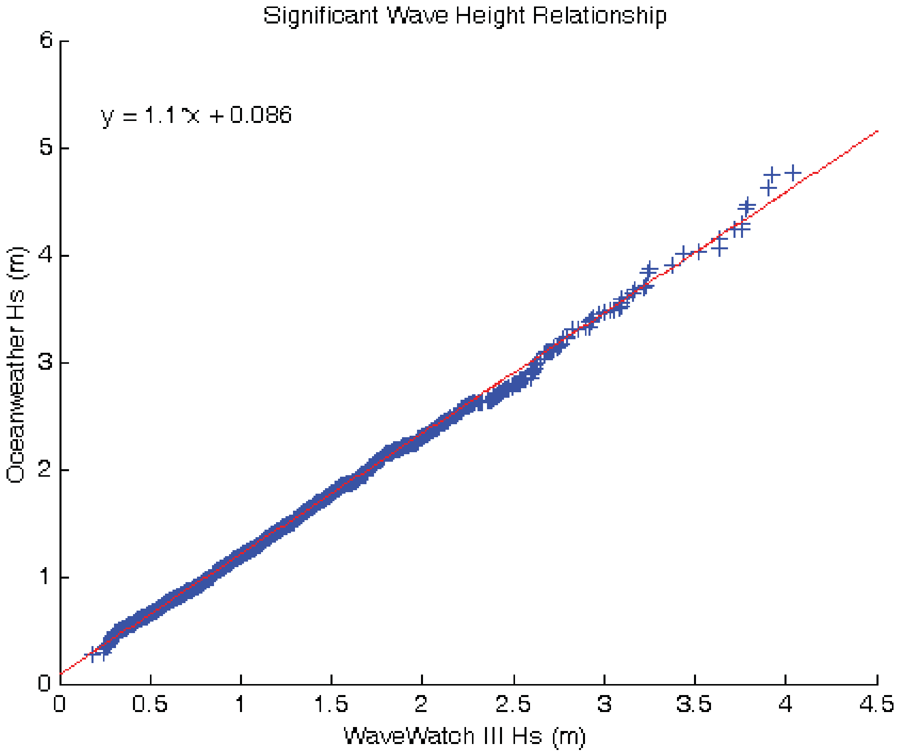
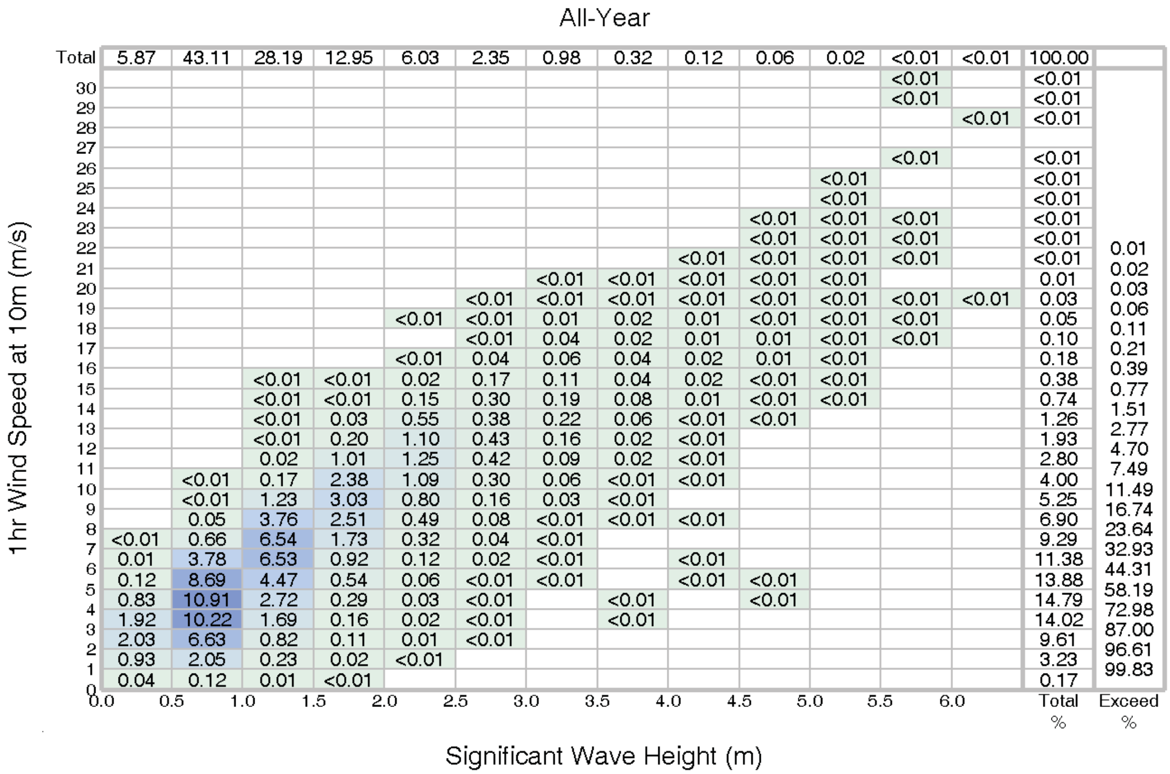


Figure 2-97 Relationship Between WaveWatch III Significant Wave Height with Oceanweather Significant Wave Height

### 2.4.1 Wind-Wave Joint Probability



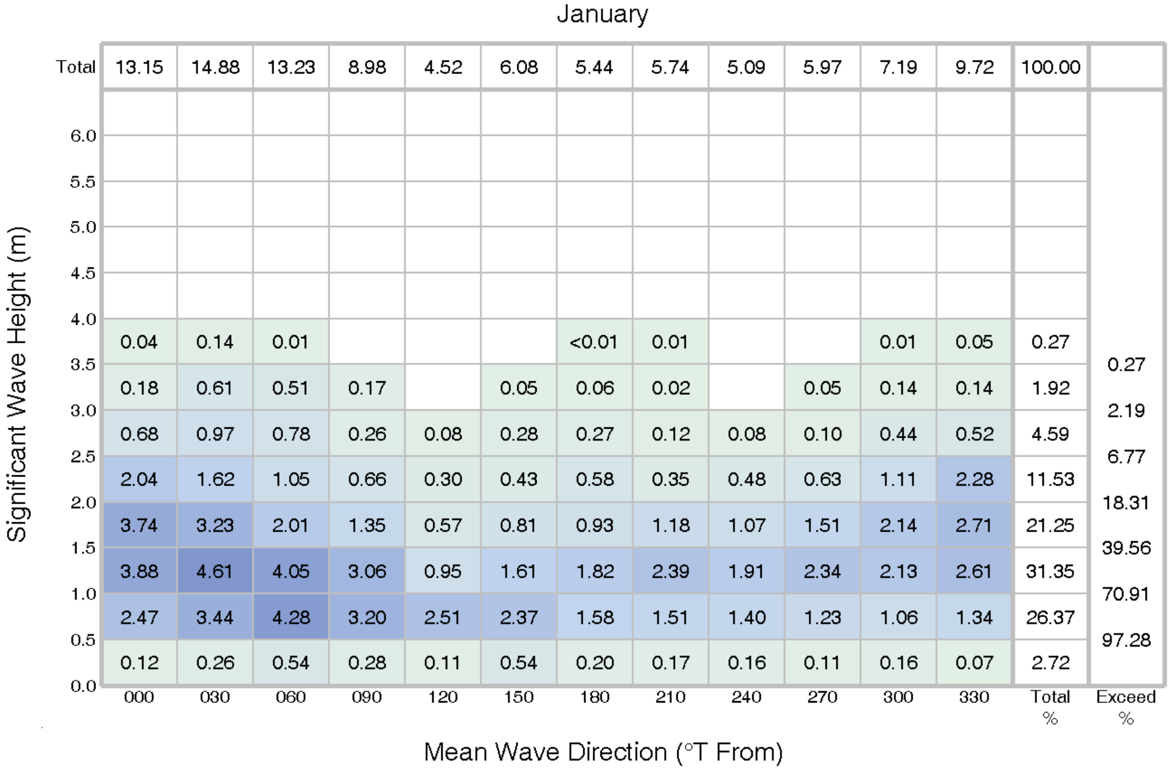
All-Year

| 1hr Wind Speed at 10m (m/s) | 0.0–0.5 | 0.5–1.0 | 1.0–1.5 | 1.5–2.0 | 2.0–2.5 | 2.5–3.0 | 3.0–3.5 | 3.5–4.0 | 4.0–4.5 | 4.5–5.0 | 5.0–5.5 | 5.5–6.0 | 6.0– | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 5.87 | 43.11 | 28.19 | 12.95 | 6.03 | 2.35 | 0.98 | 0.32 | 0.12 | 0.06 | 0.02 | <0.01 | <0.01 | 100.00 | |
| 30–31 | | | | | | | | | | | | <0.01 | | <0.01 | |
| 29–30 | | | | | | | | | | | | <0.01 | | <0.01 | |
| 28–29 | | | | | | | | | | | | | <0.01 | <0.01 | |
| 27–28 | | | | | | | | | | | | | | | |
| 26–27 | | | | | | | | | | | | <0.01 | | <0.01 | |
| 25–26 | | | | | | | | | | | <0.01 | | | <0.01 | |
| 24–25 | | | | | | | | | | | <0.01 | | | <0.01 | |
| 23–24 | | | | | | | | | | <0.01 | <0.01 | <0.01 | | <0.01 | |
| 22–23 | | | | | | | | | | <0.01 | <0.01 | <0.01 | | <0.01 | 0.01 |
| 21–22 | | | | | | | | | <0.01 | <0.01 | <0.01 | <0.01 | | <0.01 | 0.02 |
| 20–21 | | | | | | | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | | | 0.01 | 0.03 |
| 19–20 | | | | | | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.03 | 0.06 |
| 18–19 | | | | | <0.01 | <0.01 | 0.01 | 0.02 | 0.01 | <0.01 | <0.01 | <0.01 | | 0.05 | 0.11 |
| 17–18 | | | | | | <0.01 | 0.04 | 0.02 | 0.01 | 0.01 | <0.01 | <0.01 | | 0.10 | 0.21 |
| 16–17 | | | | | <0.01 | 0.04 | 0.06 | 0.04 | 0.02 | 0.01 | <0.01 | | | 0.18 | 0.39 |
| 15–16 | | | <0.01 | <0.01 | 0.02 | 0.17 | 0.11 | 0.04 | 0.02 | <0.01 | <0.01 | | | 0.38 | 0.77 |
| 14–15 | | | <0.01 | <0.01 | 0.15 | 0.30 | 0.19 | 0.08 | 0.01 | <0.01 | <0.01 | | | 0.74 | 1.51 |
| 13–14 | | | <0.01 | 0.03 | 0.55 | 0.38 | 0.22 | 0.06 | <0.01 | <0.01 | | | | 1.26 | 2.77 |
| 12–13 | | | <0.01 | 0.20 | 1.10 | 0.43 | 0.16 | 0.02 | <0.01 | | | | | 1.93 | 4.70 |
| 11–12 | | | 0.02 | 1.01 | 1.25 | 0.42 | 0.09 | 0.02 | <0.01 | | | | | 2.80 | 7.49 |
| 10–11 | | <0.01 | 0.17 | 2.38 | 1.09 | 0.30 | 0.06 | <0.01 | <0.01 | | | | | 4.00 | 11.49 |
| 9–10 | | <0.01 | 1.23 | 3.03 | 0.80 | 0.16 | 0.03 | <0.01 | | | | | | 5.25 | 16.74 |
| 8–9 | | 0.05 | 3.76 | 2.51 | 0.49 | 0.08 | <0.01 | <0.01 | <0.01 | | | | | 6.90 | 23.64 |
| 7–8 | <0.01 | 0.66 | 6.54 | 1.73 | 0.32 | 0.04 | <0.01 | | | | | | | 9.29 | 32.93 |
| 6–7 | 0.01 | 3.78 | 6.53 | 0.92 | 0.12 | 0.02 | <0.01 | | <0.01 | | | | | 11.38 | 44.31 |
| 5–6 | 0.12 | 8.69 | 4.47 | 0.54 | 0.06 | <0.01 | <0.01 | | <0.01 | <0.01 | | | | 13.88 | 58.19 |
| 4–5 | 0.83 | 10.91 | 2.72 | 0.29 | 0.03 | <0.01 | | <0.01 | | <0.01 | | | | 14.79 | 72.98 |
| 3–4 | 1.92 | 10.22 | 1.69 | 0.16 | 0.02 | <0.01 | | <0.01 | | | | | | 14.02 | 87.00 |
| 2–3 | 2.03 | 6.63 | 0.82 | 0.11 | 0.01 | <0.01 | | | | | | | | 9.61 | 96.61 |
| 1–2 | 0.93 | 2.05 | 0.23 | 0.02 | <0.01 | | | | | | | | | 3.23 | 99.83 |
| 0–1 | 0.04 | 0.12 | 0.01 | <0.01 | | | | | | | | | | 0.17 | |

Significant Wave Height (m)

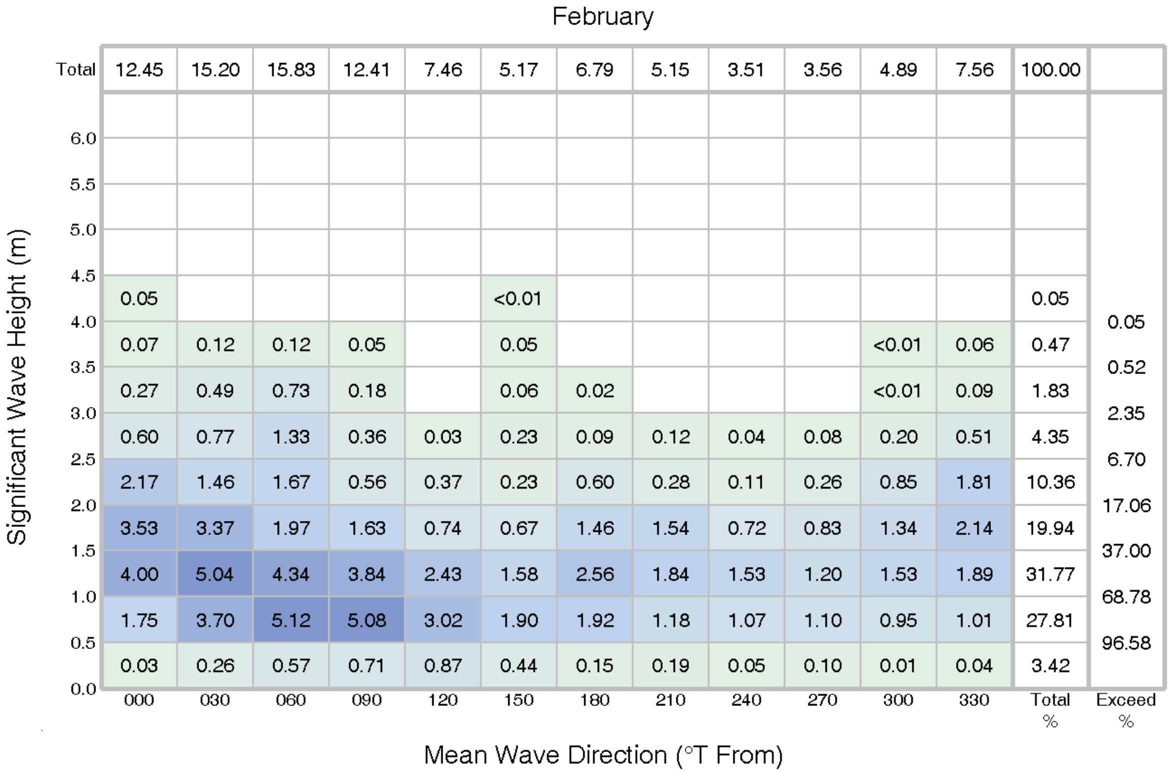
Figure 2-98 All Year Percentage Occurrence of Total Significant Wave Height and Wind Speed

### 2.4.2 Joint Frequency Distribution of Significant Wave Height and 30° Direction Bin



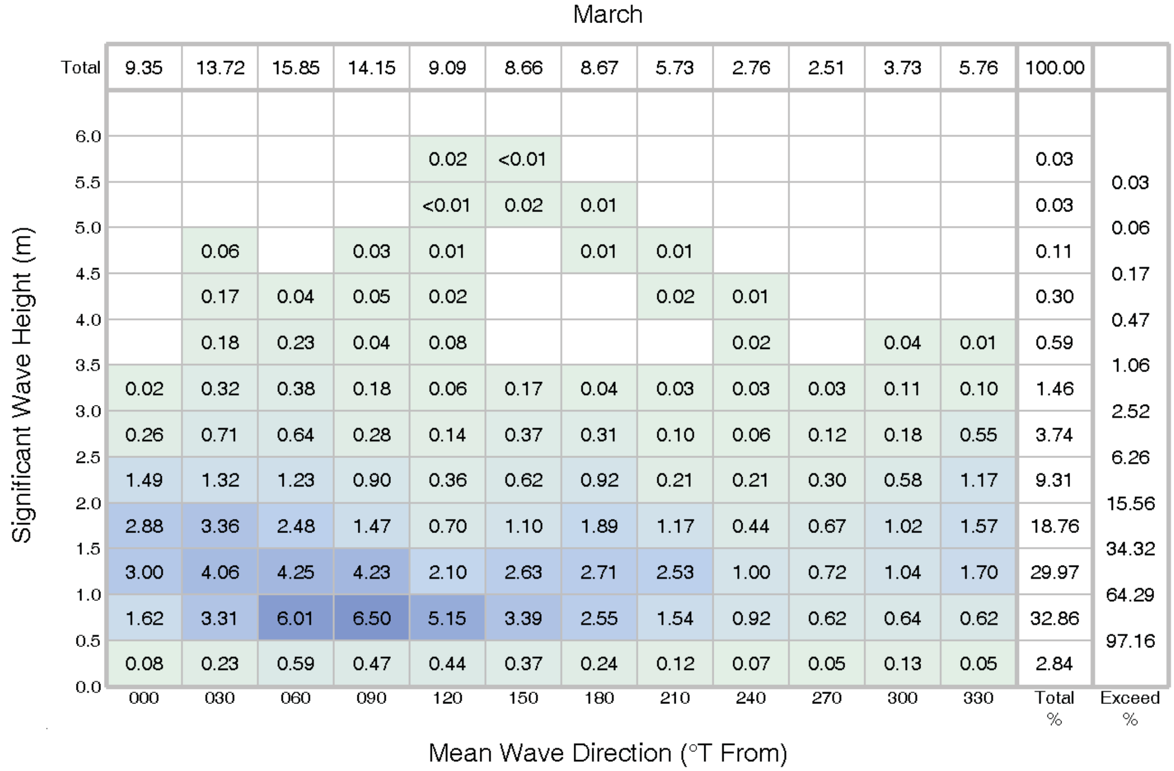
| | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 13.15 | 14.88 | 13.23 | 8.98 | 4.52 | 6.08 | 5.44 | 5.74 | 5.09 | 5.97 | 7.19 | 9.72 | 100.00 | |
| 6.0 | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | |
| 4.5 | | | | | | | | | | | | | | |
| 4.0 | | | | | | | | | | | | | | |
| | 0.04 | 0.14 | 0.01 | | | | <0.01 | 0.01 | | | 0.01 | 0.05 | 0.27 | |
| 3.5 | | | | | | | | | | | | | | 0.27 |
| | 0.18 | 0.61 | 0.51 | 0.17 | | 0.05 | 0.06 | 0.02 | | 0.05 | 0.14 | 0.14 | 1.92 | |
| 3.0 | | | | | | | | | | | | | | 2.19 |
| | 0.68 | 0.97 | 0.78 | 0.26 | 0.08 | 0.28 | 0.27 | 0.12 | 0.08 | 0.10 | 0.44 | 0.52 | 4.59 | |
| 2.5 | | | | | | | | | | | | | | 6.77 |
| | 2.04 | 1.62 | 1.05 | 0.66 | 0.30 | 0.43 | 0.58 | 0.35 | 0.48 | 0.63 | 1.11 | 2.28 | 11.53 | |
| 2.0 | | | | | | | | | | | | | | 18.31 |
| | 3.74 | 3.23 | 2.01 | 1.35 | 0.57 | 0.81 | 0.93 | 1.18 | 1.07 | 1.51 | 2.14 | 2.71 | 21.25 | |
| 1.5 | | | | | | | | | | | | | | 39.56 |
| | 3.88 | 4.61 | 4.05 | 3.06 | 0.95 | 1.61 | 1.82 | 2.39 | 1.91 | 2.34 | 2.13 | 2.61 | 31.35 | |
| 1.0 | | | | | | | | | | | | | | 70.91 |
| | 2.47 | 3.44 | 4.28 | 3.20 | 2.51 | 2.37 | 1.58 | 1.51 | 1.40 | 1.23 | 1.06 | 1.34 | 26.37 | |
| 0.5 | | | | | | | | | | | | | | 97.28 |
| | 0.12 | 0.26 | 0.54 | 0.28 | 0.11 | 0.54 | 0.20 | 0.17 | 0.16 | 0.11 | 0.16 | 0.07 | 2.72 | |
| 0.0 | | | | | | | | | | | | | | |

**Figure 2-99 Percentage Occurrence of Significant Wave Height and 30° Direction Bin - January**



| | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 12.45 | 15.20 | 15.83 | 12.41 | 7.46 | 5.17 | 6.79 | 5.15 | 3.51 | 3.56 | 4.89 | 7.56 | 100.00 | |
| 6.0 | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | |
| 4.5 | | | | | | | | | | | | | | |
| | 0.05 | | | | | <0.01 | | | | | | | 0.05 | |
| 4.0 | | | | | | | | | | | | | | 0.05 |
| | 0.07 | 0.12 | 0.12 | 0.05 | | 0.05 | | | | | <0.01 | 0.06 | 0.47 | |
| 3.5 | | | | | | | | | | | | | | 0.52 |
| | 0.27 | 0.49 | 0.73 | 0.18 | | 0.06 | 0.02 | | | | <0.01 | 0.09 | 1.83 | |
| 3.0 | | | | | | | | | | | | | | 2.35 |
| | 0.60 | 0.77 | 1.33 | 0.36 | 0.03 | 0.23 | 0.09 | 0.12 | 0.04 | 0.08 | 0.20 | 0.51 | 4.35 | |
| 2.5 | | | | | | | | | | | | | | 6.70 |
| | 2.17 | 1.46 | 1.67 | 0.56 | 0.37 | 0.23 | 0.60 | 0.28 | 0.11 | 0.26 | 0.85 | 1.81 | 10.36 | |
| 2.0 | | | | | | | | | | | | | | 17.06 |
| | 3.53 | 3.37 | 1.97 | 1.63 | 0.74 | 0.67 | 1.46 | 1.54 | 0.72 | 0.83 | 1.34 | 2.14 | 19.94 | |
| 1.5 | | | | | | | | | | | | | | 37.00 |
| | 4.00 | 5.04 | 4.34 | 3.84 | 2.43 | 1.58 | 2.56 | 1.84 | 1.53 | 1.20 | 1.53 | 1.89 | 31.77 | |
| 1.0 | | | | | | | | | | | | | | 68.78 |
| | 1.75 | 3.70 | 5.12 | 5.08 | 3.02 | 1.90 | 1.92 | 1.18 | 1.07 | 1.10 | 0.95 | 1.01 | 27.81 | |
| 0.5 | | | | | | | | | | | | | | 96.58 |
| | 0.03 | 0.26 | 0.57 | 0.71 | 0.87 | 0.44 | 0.15 | 0.19 | 0.05 | 0.10 | 0.01 | 0.04 | 3.42 | |
| 0.0 | | | | | | | | | | | | | | |

**Figure 2-100 Percentage Occurrence of Significant Wave Height and 30° Direction Bin - February**

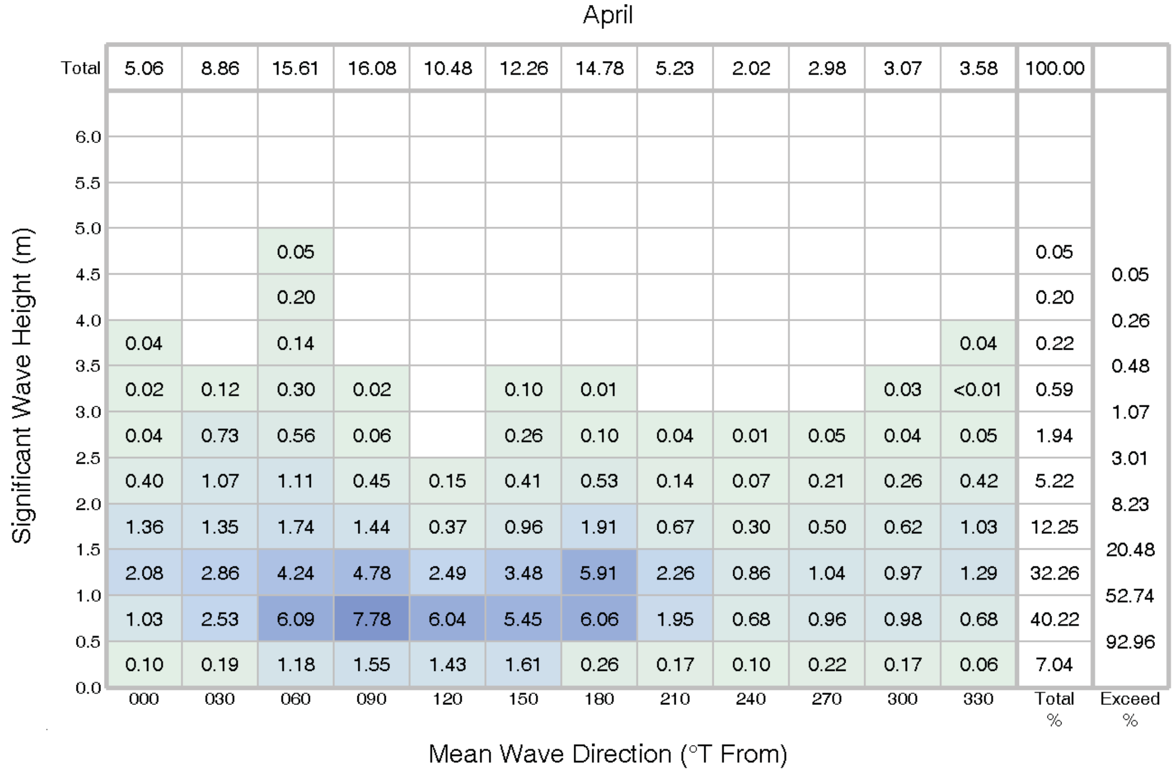


March

| Significant Wave Height (m) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 9.35 | 13.72 | 15.85 | 14.15 | 9.09 | 8.66 | 8.67 | 5.73 | 2.76 | 2.51 | 3.73 | 5.76 | 100.00 | |
| > 6.0 | | | | | | | | | | | | | | |
| 5.5 – 6.0 | | | | | 0.02 | <0.01 | | | | | | | 0.03 | 0.03 |
| 5.0 – 5.5 | | | | | <0.01 | 0.02 | 0.01 | | | | | | 0.03 | 0.06 |
| 4.5 – 5.0 | | 0.06 | | 0.03 | 0.01 | | 0.01 | 0.01 | | | | | 0.11 | 0.17 |
| 4.0 – 4.5 | | 0.17 | 0.04 | 0.05 | 0.02 | | | 0.02 | 0.01 | | | | 0.30 | 0.47 |
| 3.5 – 4.0 | | 0.18 | 0.23 | 0.04 | 0.08 | | | | 0.02 | | 0.04 | 0.01 | 0.59 | 1.06 |
| 3.0 – 3.5 | 0.02 | 0.32 | 0.38 | 0.18 | 0.06 | 0.17 | 0.04 | 0.03 | 0.03 | 0.03 | 0.11 | 0.10 | 1.46 | 2.52 |
| 2.5 – 3.0 | 0.26 | 0.71 | 0.64 | 0.28 | 0.14 | 0.37 | 0.31 | 0.10 | 0.06 | 0.12 | 0.18 | 0.55 | 3.74 | 6.26 |
| 2.0 – 2.5 | 1.49 | 1.32 | 1.23 | 0.90 | 0.36 | 0.62 | 0.92 | 0.21 | 0.21 | 0.30 | 0.58 | 1.17 | 9.31 | 15.56 |
| 1.5 – 2.0 | 2.88 | 3.36 | 2.48 | 1.47 | 0.70 | 1.10 | 1.89 | 1.17 | 0.44 | 0.67 | 1.02 | 1.57 | 18.76 | 34.32 |
| 1.0 – 1.5 | 3.00 | 4.06 | 4.25 | 4.23 | 2.10 | 2.63 | 2.71 | 2.53 | 1.00 | 0.72 | 1.04 | 1.70 | 29.97 | 64.29 |
| 0.5 – 1.0 | 1.62 | 3.31 | 6.01 | 6.50 | 5.15 | 3.39 | 2.55 | 1.54 | 0.92 | 0.62 | 0.64 | 0.62 | 32.86 | 97.16 |
| 0.0 – 0.5 | 0.08 | 0.23 | 0.59 | 0.47 | 0.44 | 0.37 | 0.24 | 0.12 | 0.07 | 0.05 | 0.13 | 0.05 | 2.84 | |

Mean Wave Direction (°T From)

Figure 2-101 Percentage Occurrence of Significant Wave Height and 30° Direction Bin - March

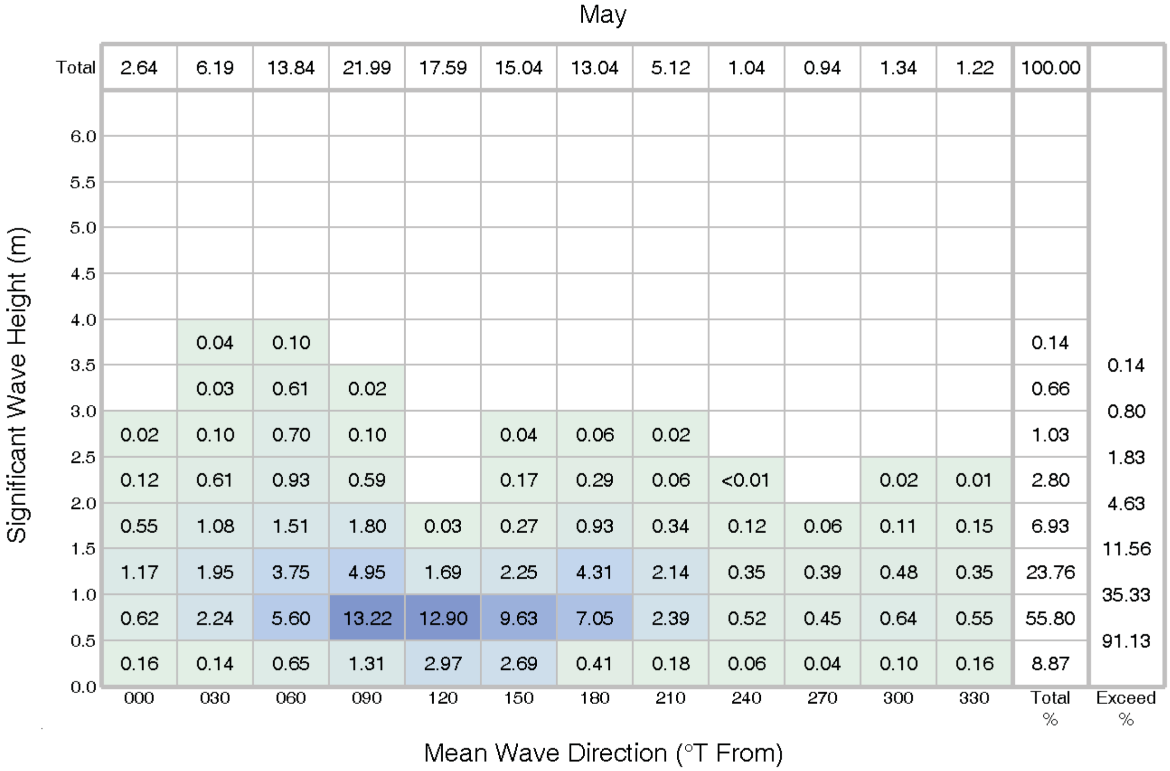


April

| Significant Wave Height (m) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 5.06 | 8.86 | 15.61 | 16.08 | 10.48 | 12.26 | 14.78 | 5.23 | 2.02 | 2.98 | 3.07 | 3.58 | 100.00 | |
| > 6.0 | | | | | | | | | | | | | | |
| 5.5 – 6.0 | | | | | | | | | | | | | | |
| 5.0 – 5.5 | | | | | | | | | | | | | | |
| 4.5 – 5.0 | | | 0.05 | | | | | | | | | | 0.05 | 0.05 |
| 4.0 – 4.5 | | | 0.20 | | | | | | | | | | 0.20 | 0.26 |
| 3.5 – 4.0 | 0.04 | | 0.14 | | | | | | | | | 0.04 | 0.22 | 0.48 |
| 3.0 – 3.5 | 0.02 | 0.12 | 0.30 | 0.02 | | 0.10 | 0.01 | | | | 0.03 | <0.01 | 0.59 | 1.07 |
| 2.5 – 3.0 | 0.04 | 0.73 | 0.56 | 0.06 | | 0.26 | 0.10 | 0.04 | 0.01 | 0.05 | 0.04 | 0.05 | 1.94 | 3.01 |
| 2.0 – 2.5 | 0.40 | 1.07 | 1.11 | 0.45 | 0.15 | 0.41 | 0.53 | 0.14 | 0.07 | 0.21 | 0.26 | 0.42 | 5.22 | 8.23 |
| 1.5 – 2.0 | 1.36 | 1.35 | 1.74 | 1.44 | 0.37 | 0.96 | 1.91 | 0.67 | 0.30 | 0.50 | 0.62 | 1.03 | 12.25 | 20.48 |
| 1.0 – 1.5 | 2.08 | 2.86 | 4.24 | 4.78 | 2.49 | 3.48 | 5.91 | 2.26 | 0.86 | 1.04 | 0.97 | 1.29 | 32.26 | 52.74 |
| 0.5 – 1.0 | 1.03 | 2.53 | 6.09 | 7.78 | 6.04 | 5.45 | 6.06 | 1.95 | 0.68 | 0.96 | 0.98 | 0.68 | 40.22 | 92.96 |
| 0.0 – 0.5 | 0.10 | 0.19 | 1.18 | 1.55 | 1.43 | 1.61 | 0.26 | 0.17 | 0.10 | 0.22 | 0.17 | 0.06 | 7.04 | |

Mean Wave Direction (°T From)

Figure 2-102 Percentage Occurrence of Significant Wave Height and 30° Direction Bin - April

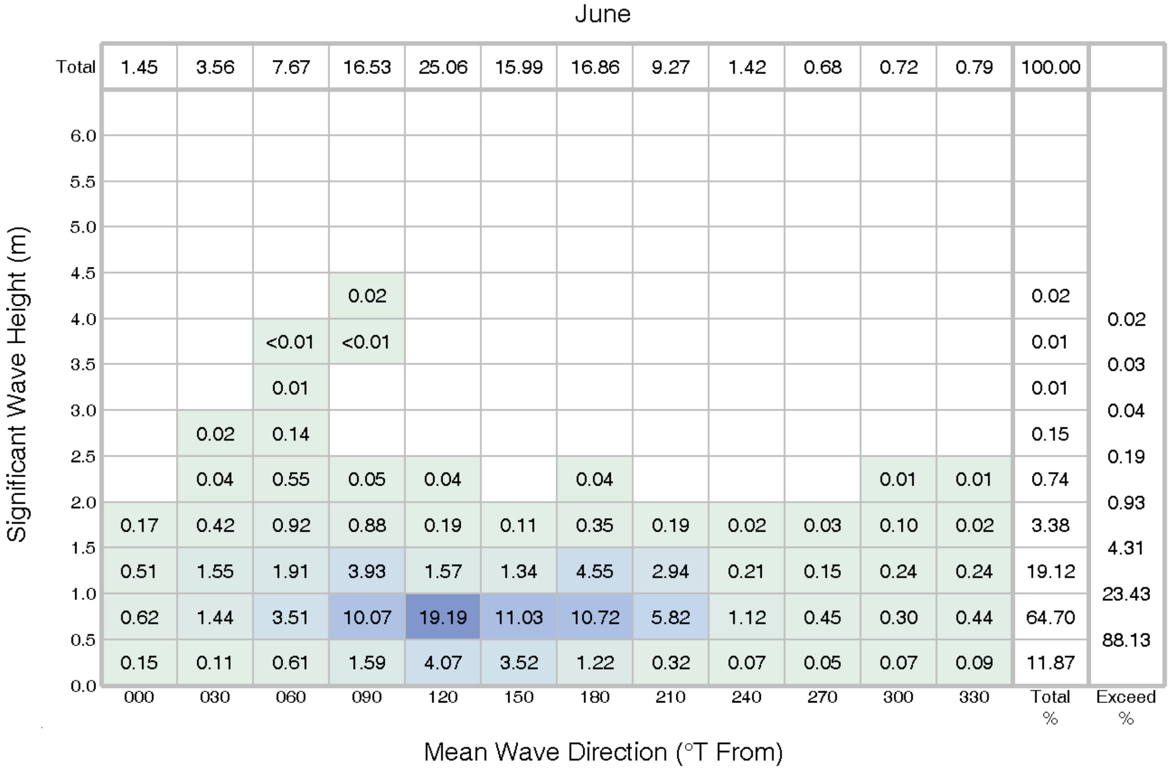


May

| Significant Wave Height (m) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 2.64 | 6.19 | 13.84 | 21.99 | 17.59 | 15.04 | 13.04 | 5.12 | 1.04 | 0.94 | 1.34 | 1.22 | 100.00 | |
| 5.5–6.0 | | | | | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | | | | | |
| 4.0–4.5 | | | | | | | | | | | | | | |
| 3.5–4.0 | | 0.04 | 0.10 | | | | | | | | | | 0.14 | 0.14 |
| 3.0–3.5 | | 0.03 | 0.61 | 0.02 | | | | | | | | | 0.66 | 0.80 |
| 2.5–3.0 | 0.02 | 0.10 | 0.70 | 0.10 | | 0.04 | 0.06 | 0.02 | | | | | 1.03 | 1.83 |
| 2.0–2.5 | 0.12 | 0.61 | 0.93 | 0.59 | | 0.17 | 0.29 | 0.06 | <0.01 | | 0.02 | 0.01 | 2.80 | 4.63 |
| 1.5–2.0 | 0.55 | 1.08 | 1.51 | 1.80 | 0.03 | 0.27 | 0.93 | 0.34 | 0.12 | 0.06 | 0.11 | 0.15 | 6.93 | 11.56 |
| 1.0–1.5 | 1.17 | 1.95 | 3.75 | 4.95 | 1.69 | 2.25 | 4.31 | 2.14 | 0.35 | 0.39 | 0.48 | 0.35 | 23.76 | 35.33 |
| 0.5–1.0 | 0.62 | 2.24 | 5.60 | 13.22 | 12.90 | 9.63 | 7.05 | 2.39 | 0.52 | 0.45 | 0.64 | 0.55 | 55.80 | 91.13 |
| 0.0–0.5 | 0.16 | 0.14 | 0.65 | 1.31 | 2.97 | 2.69 | 0.41 | 0.18 | 0.06 | 0.04 | 0.10 | 0.16 | 8.87 | |

Mean Wave Direction (°T From)

**Figure 2-103 Percentage Occurrence of Significant Wave Height and 30° Direction Bin - May**

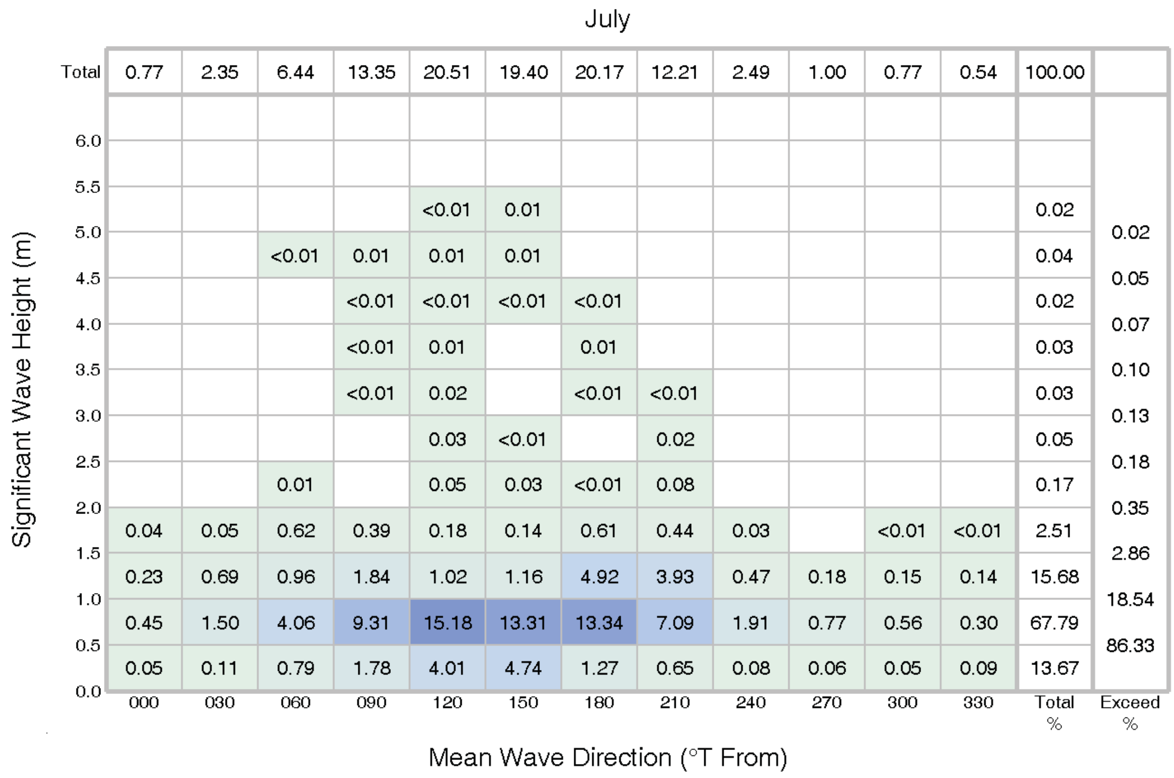


June

| Significant Wave Height (m) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 1.45 | 3.56 | 7.67 | 16.53 | 25.06 | 15.99 | 16.86 | 9.27 | 1.42 | 0.68 | 0.72 | 0.79 | 100.00 | |
| 5.5–6.0 | | | | | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | | | | | |
| 4.0–4.5 | | | | 0.02 | | | | | | | | | 0.02 | 0.02 |
| 3.5–4.0 | | | <0.01 | <0.01 | | | | | | | | | 0.01 | 0.03 |
| 3.0–3.5 | | | 0.01 | | | | | | | | | | 0.01 | 0.04 |
| 2.5–3.0 | | 0.02 | 0.14 | | | | | | | | | | 0.15 | 0.19 |
| 2.0–2.5 | | 0.04 | 0.55 | 0.05 | 0.04 | | 0.04 | | | | 0.01 | 0.01 | 0.74 | 0.93 |
| 1.5–2.0 | 0.17 | 0.42 | 0.92 | 0.88 | 0.19 | 0.11 | 0.35 | 0.19 | 0.02 | 0.03 | 0.10 | 0.02 | 3.38 | 4.31 |
| 1.0–1.5 | 0.51 | 1.55 | 1.91 | 3.93 | 1.57 | 1.34 | 4.55 | 2.94 | 0.21 | 0.15 | 0.24 | 0.24 | 19.12 | 23.43 |
| 0.5–1.0 | 0.62 | 1.44 | 3.51 | 10.07 | 19.19 | 11.03 | 10.72 | 5.82 | 1.12 | 0.45 | 0.30 | 0.44 | 64.70 | 88.13 |
| 0.0–0.5 | 0.15 | 0.11 | 0.61 | 1.59 | 4.07 | 3.52 | 1.22 | 0.32 | 0.07 | 0.05 | 0.07 | 0.09 | 11.87 | |

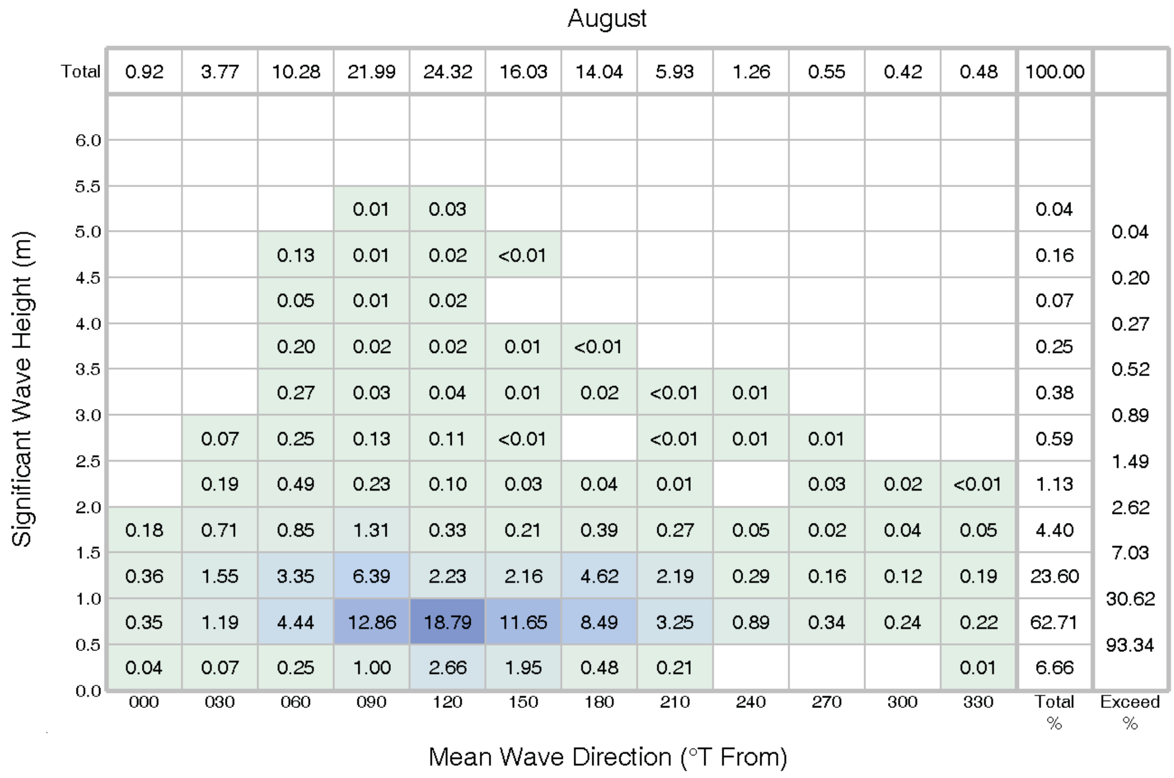
Mean Wave Direction (°T From)

**Figure 2-104 Percentage Occurrence of Significant Wave Height and 30° Direction Bin - June**



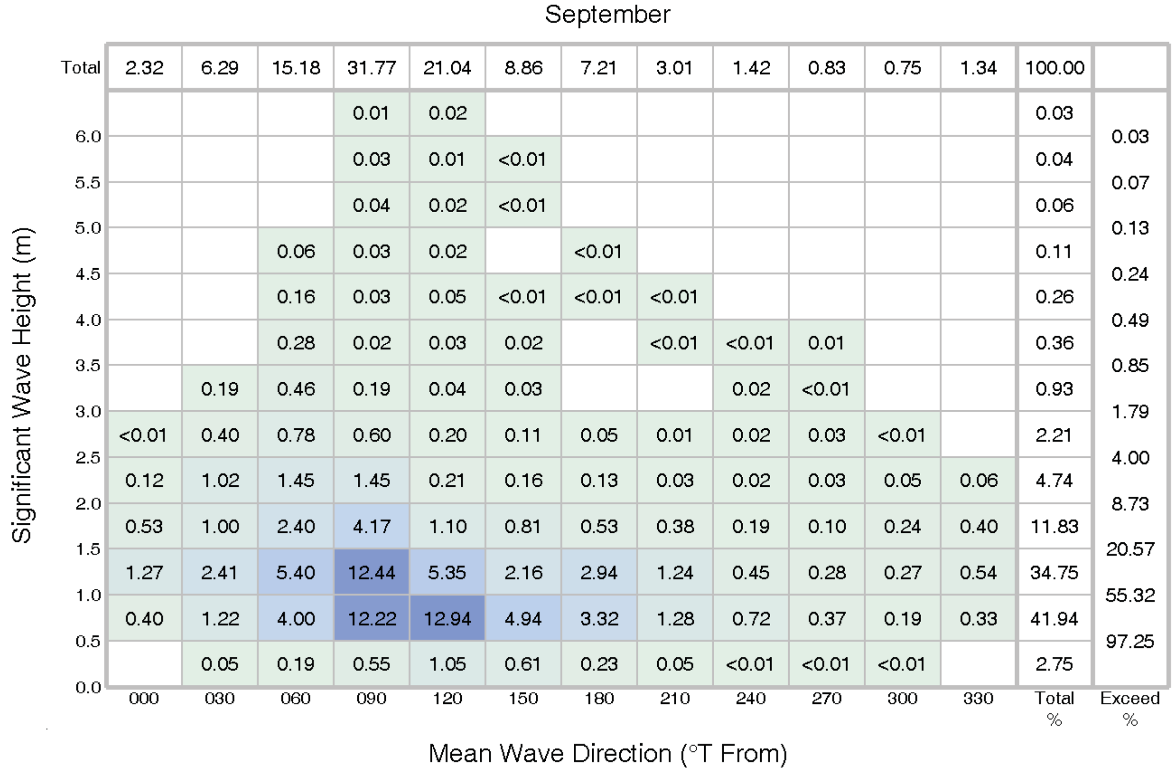
| Significant Wave Height (m) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 0.77 | 2.35 | 6.44 | 13.35 | 20.51 | 19.40 | 20.17 | 12.21 | 2.49 | 1.00 | 0.77 | 0.54 | 100.00 | |
| 5.0–5.5 | | | | | <0.01 | 0.01 | | | | | | | 0.02 | 0.02 |
| 4.5–5.0 | | | <0.01 | 0.01 | 0.01 | 0.01 | | | | | | | 0.04 | 0.05 |
| 4.0–4.5 | | | | <0.01 | <0.01 | <0.01 | <0.01 | | | | | | 0.02 | 0.07 |
| 3.5–4.0 | | | | <0.01 | 0.01 | | 0.01 | | | | | | 0.03 | 0.10 |
| 3.0–3.5 | | | | <0.01 | 0.02 | | <0.01 | <0.01 | | | | | 0.03 | 0.13 |
| 2.5–3.0 | | | | | 0.03 | <0.01 | | 0.02 | | | | | 0.05 | 0.18 |
| 2.0–2.5 | | | 0.01 | | 0.05 | 0.03 | <0.01 | 0.08 | | | | | 0.17 | 0.35 |
| 1.5–2.0 | 0.04 | 0.05 | 0.62 | 0.39 | 0.18 | 0.14 | 0.61 | 0.44 | 0.03 | | <0.01 | <0.01 | 2.51 | 2.86 |
| 1.0–1.5 | 0.23 | 0.69 | 0.96 | 1.84 | 1.02 | 1.16 | 4.92 | 3.93 | 0.47 | 0.18 | 0.15 | 0.14 | 15.68 | 18.54 |
| 0.5–1.0 | 0.45 | 1.50 | 4.06 | 9.31 | 15.18 | 13.31 | 13.34 | 7.09 | 1.91 | 0.77 | 0.56 | 0.30 | 67.79 | 86.33 |
| 0.0–0.5 | 0.05 | 0.11 | 0.79 | 1.78 | 4.01 | 4.74 | 1.27 | 0.65 | 0.08 | 0.06 | 0.05 | 0.09 | 13.67 | |

Figure 2-105 Percentage Occurrence of Significant Wave Height and 30° Direction Bin - July



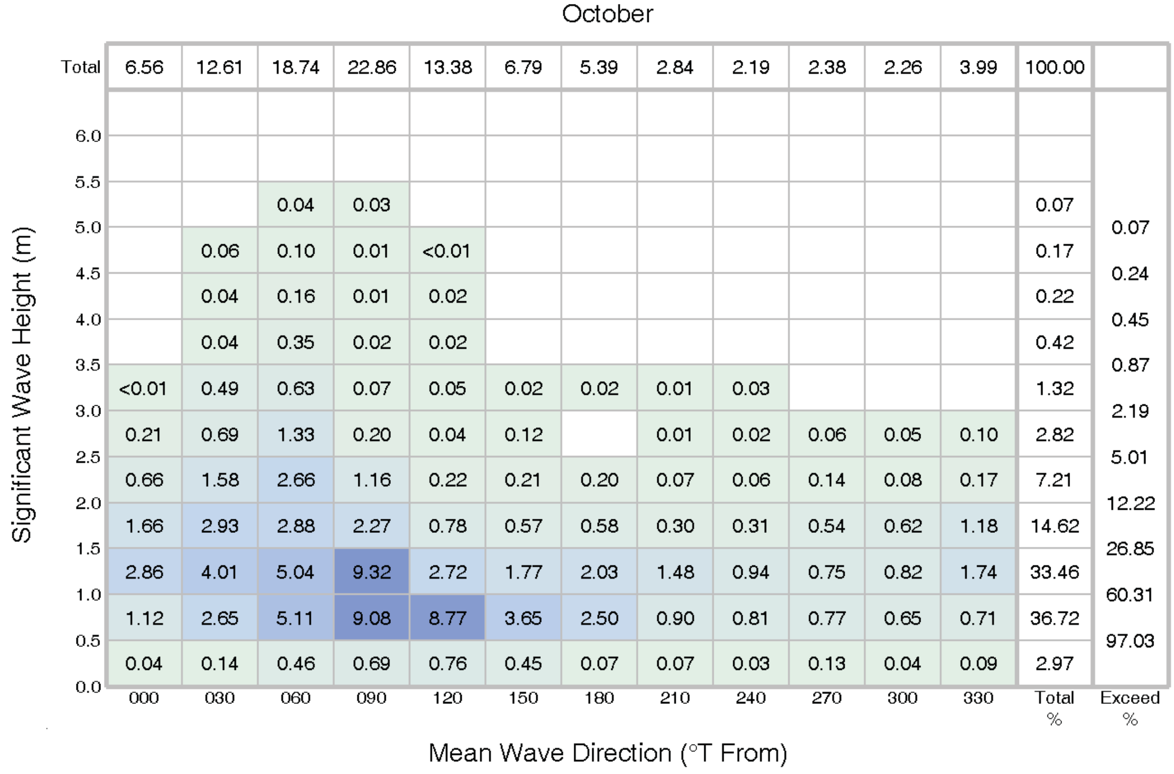
| Significant Wave Height (m) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 0.92 | 3.77 | 10.28 | 21.99 | 24.32 | 16.03 | 14.04 | 5.93 | 1.26 | 0.55 | 0.42 | 0.48 | 100.00 | |
| 5.0–5.5 | | | | 0.01 | 0.03 | | | | | | | | 0.04 | 0.04 |
| 4.5–5.0 | | | 0.13 | 0.01 | 0.02 | <0.01 | | | | | | | 0.16 | 0.20 |
| 4.0–4.5 | | | 0.05 | 0.01 | 0.02 | | | | | | | | 0.07 | 0.27 |
| 3.5–4.0 | | | 0.20 | 0.02 | 0.02 | 0.01 | <0.01 | | | | | | 0.25 | 0.52 |
| 3.0–3.5 | | | 0.27 | 0.03 | 0.04 | 0.01 | 0.02 | <0.01 | 0.01 | | | | 0.38 | 0.89 |
| 2.5–3.0 | | 0.07 | 0.25 | 0.13 | 0.11 | <0.01 | | <0.01 | 0.01 | 0.01 | | | 0.59 | 1.49 |
| 2.0–2.5 | | 0.19 | 0.49 | 0.23 | 0.10 | 0.03 | 0.04 | 0.01 | | 0.03 | 0.02 | <0.01 | 1.13 | 2.62 |
| 1.5–2.0 | 0.18 | 0.71 | 0.85 | 1.31 | 0.33 | 0.21 | 0.39 | 0.27 | 0.05 | 0.02 | 0.04 | 0.05 | 4.40 | 7.03 |
| 1.0–1.5 | 0.36 | 1.55 | 3.35 | 6.39 | 2.23 | 2.16 | 4.62 | 2.19 | 0.29 | 0.16 | 0.12 | 0.19 | 23.60 | 30.62 |
| 0.5–1.0 | 0.35 | 1.19 | 4.44 | 12.86 | 18.79 | 11.65 | 8.49 | 3.25 | 0.89 | 0.34 | 0.24 | 0.22 | 62.71 | 93.34 |
| 0.0–0.5 | 0.04 | 0.07 | 0.25 | 1.00 | 2.66 | 1.95 | 0.48 | 0.21 | | | | 0.01 | 6.66 | |

Figure 2-106 Percentage Occurrence of Significant Wave Height and 30° Direction Bin - August



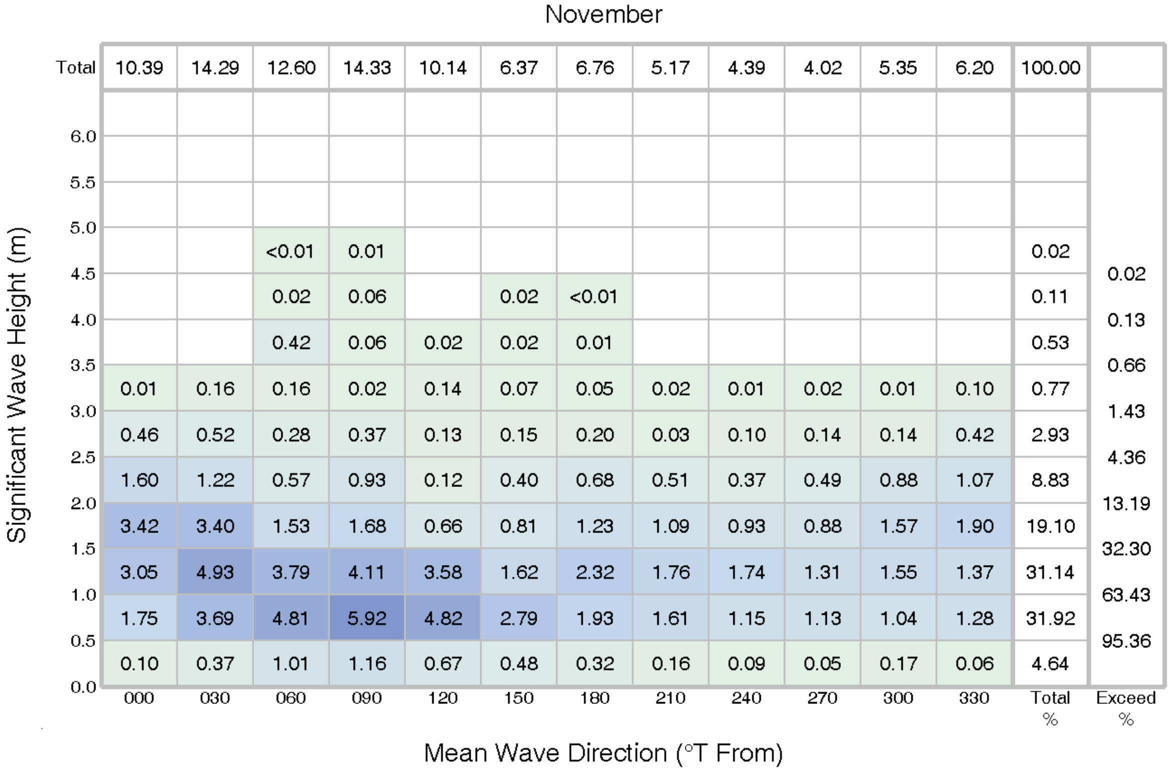
| Significant Wave Height (m) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 2.32 | 6.29 | 15.18 | 31.77 | 21.04 | 8.86 | 7.21 | 3.01 | 1.42 | 0.83 | 0.75 | 1.34 | 100.00 | |
| 6.0 | | | | 0.01 | 0.02 | | | | | | | | 0.03 | 0.03 |
| 5.5 | | | | 0.03 | 0.01 | <0.01 | | | | | | | 0.04 | 0.07 |
| 5.0 | | | | 0.04 | 0.02 | <0.01 | | | | | | | 0.06 | 0.13 |
| 4.5 | | | 0.06 | 0.03 | 0.02 | | <0.01 | | | | | | 0.11 | 0.24 |
| 4.0 | | | 0.16 | 0.03 | 0.05 | <0.01 | <0.01 | <0.01 | | | | | 0.26 | 0.49 |
| 3.5 | | | 0.28 | 0.02 | 0.03 | 0.02 | | <0.01 | <0.01 | 0.01 | | | 0.36 | 0.85 |
| 3.0 | | 0.19 | 0.46 | 0.19 | 0.04 | 0.03 | | | 0.02 | <0.01 | | | 0.93 | 1.79 |
| 2.5 | <0.01 | 0.40 | 0.78 | 0.60 | 0.20 | 0.11 | 0.05 | 0.01 | 0.02 | 0.03 | <0.01 | | 2.21 | 4.00 |
| 2.0 | 0.12 | 1.02 | 1.45 | 1.45 | 0.21 | 0.16 | 0.13 | 0.03 | 0.02 | 0.03 | 0.05 | 0.06 | 4.74 | 8.73 |
| 1.5 | 0.53 | 1.00 | 2.40 | 4.17 | 1.10 | 0.81 | 0.53 | 0.38 | 0.19 | 0.10 | 0.24 | 0.40 | 11.83 | 20.57 |
| 1.0 | 1.27 | 2.41 | 5.40 | 12.44 | 5.35 | 2.16 | 2.94 | 1.24 | 0.45 | 0.28 | 0.27 | 0.54 | 34.75 | 55.32 |
| 0.5 | 0.40 | 1.22 | 4.00 | 12.22 | 12.94 | 4.94 | 3.32 | 1.28 | 0.72 | 0.37 | 0.19 | 0.33 | 41.94 | 97.25 |
| 0.0 | | 0.05 | 0.19 | 0.55 | 1.05 | 0.61 | 0.23 | 0.05 | <0.01 | <0.01 | <0.01 | | 2.75 | |

**Figure 2-107 Percentage Occurrence of Significant Wave Height and 30° Direction Bin - September**



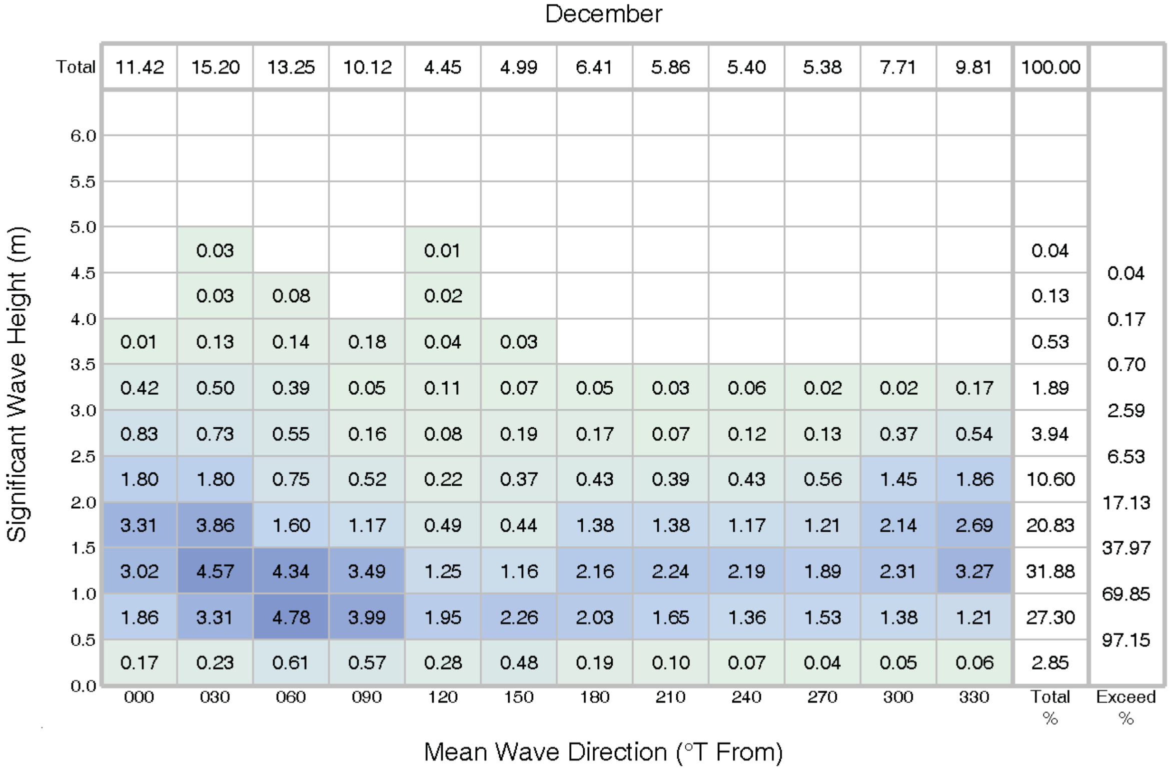
| Significant Wave Height (m) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 6.56 | 12.61 | 18.74 | 22.86 | 13.38 | 6.79 | 5.39 | 2.84 | 2.19 | 2.38 | 2.26 | 3.99 | 100.00 | |
| 6.0 | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | |
| 5.0 | | | 0.04 | 0.03 | | | | | | | | | 0.07 | 0.07 |
| 4.5 | | 0.06 | 0.10 | 0.01 | <0.01 | | | | | | | | 0.17 | 0.24 |
| 4.0 | | 0.04 | 0.16 | 0.01 | 0.02 | | | | | | | | 0.22 | 0.45 |
| 3.5 | | 0.04 | 0.35 | 0.02 | 0.02 | | | | | | | | 0.42 | 0.87 |
| 3.0 | <0.01 | 0.49 | 0.63 | 0.07 | 0.05 | 0.02 | 0.02 | 0.01 | 0.03 | | | | 1.32 | 2.19 |
| 2.5 | 0.21 | 0.69 | 1.33 | 0.20 | 0.04 | 0.12 | | 0.01 | 0.02 | 0.06 | 0.05 | 0.10 | 2.82 | 5.01 |
| 2.0 | 0.66 | 1.58 | 2.66 | 1.16 | 0.22 | 0.21 | 0.20 | 0.07 | 0.06 | 0.14 | 0.08 | 0.17 | 7.21 | 12.22 |
| 1.5 | 1.66 | 2.93 | 2.88 | 2.27 | 0.78 | 0.57 | 0.58 | 0.30 | 0.31 | 0.54 | 0.62 | 1.18 | 14.62 | 26.85 |
| 1.0 | 2.86 | 4.01 | 5.04 | 9.32 | 2.72 | 1.77 | 2.03 | 1.48 | 0.94 | 0.75 | 0.82 | 1.74 | 33.46 | 60.31 |
| 0.5 | 1.12 | 2.65 | 5.11 | 9.08 | 8.77 | 3.65 | 2.50 | 0.90 | 0.81 | 0.77 | 0.65 | 0.71 | 36.72 | 97.03 |
| 0.0 | 0.04 | 0.14 | 0.46 | 0.69 | 0.76 | 0.45 | 0.07 | 0.07 | 0.03 | 0.13 | 0.04 | 0.09 | 2.97 | |

**Figure 2-108 Percentage Occurrence of Significant Wave Height and 30° Direction Bin - October**



| Significant Wave Height (m) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 10.39 | 14.29 | 12.60 | 14.33 | 10.14 | 6.37 | 6.76 | 5.17 | 4.39 | 4.02 | 5.35 | 6.20 | 100.00 | |
| 6.0 | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | |
| 4.5 | | | <0.01 | 0.01 | | | | | | | | | 0.02 | 0.02 |
| 4.0 | | | 0.02 | 0.06 | | 0.02 | <0.01 | | | | | | 0.11 | 0.13 |
| 3.5 | | | 0.42 | 0.06 | 0.02 | 0.02 | 0.01 | | | | | | 0.53 | 0.66 |
| 3.0 | 0.01 | 0.16 | 0.16 | 0.02 | 0.14 | 0.07 | 0.05 | 0.02 | 0.01 | 0.02 | 0.01 | 0.10 | 0.77 | 1.43 |
| 2.5 | 0.46 | 0.52 | 0.28 | 0.37 | 0.13 | 0.15 | 0.20 | 0.03 | 0.10 | 0.14 | 0.14 | 0.42 | 2.93 | 4.36 |
| 2.0 | 1.60 | 1.22 | 0.57 | 0.93 | 0.12 | 0.40 | 0.68 | 0.51 | 0.37 | 0.49 | 0.88 | 1.07 | 8.83 | 13.19 |
| 1.5 | 3.42 | 3.40 | 1.53 | 1.68 | 0.66 | 0.81 | 1.23 | 1.09 | 0.93 | 0.88 | 1.57 | 1.90 | 19.10 | 32.30 |
| 1.0 | 3.05 | 4.93 | 3.79 | 4.11 | 3.58 | 1.62 | 2.32 | 1.76 | 1.74 | 1.31 | 1.55 | 1.37 | 31.14 | 63.43 |
| 0.5 | 1.75 | 3.69 | 4.81 | 5.92 | 4.82 | 2.79 | 1.93 | 1.61 | 1.15 | 1.13 | 1.04 | 1.28 | 31.92 | 95.36 |
| 0.0 | 0.10 | 0.37 | 1.01 | 1.16 | 0.67 | 0.48 | 0.32 | 0.16 | 0.09 | 0.05 | 0.17 | 0.06 | 4.64 | |

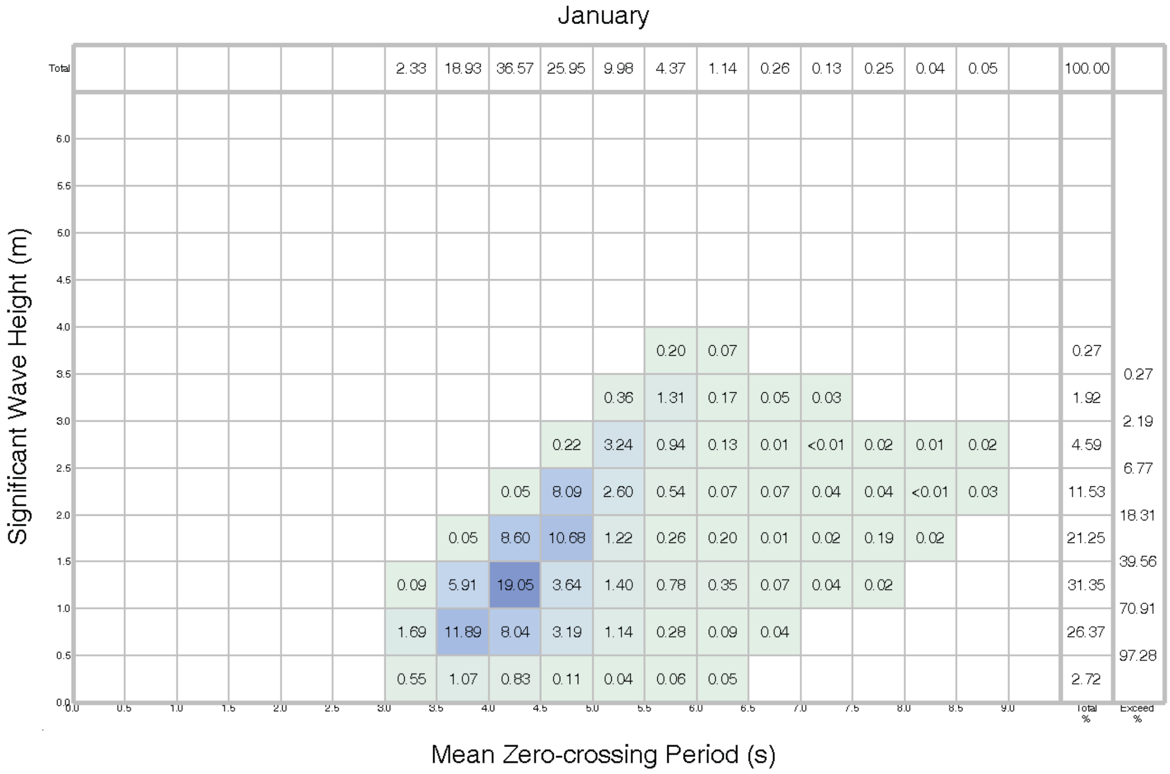
**Figure 2-109 Percentage Occurrence of Significant Wave Height and 30° Direction Bin - November**



| Significant Wave Height (m) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 11.42 | 15.20 | 13.25 | 10.12 | 4.45 | 4.99 | 6.41 | 5.86 | 5.40 | 5.38 | 7.71 | 9.81 | 100.00 | |
| 6.0 | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | |
| 4.5 | | 0.03 | | | 0.01 | | | | | | | | 0.04 | 0.04 |
| 4.0 | | 0.03 | 0.08 | | 0.02 | | | | | | | | 0.13 | 0.17 |
| 3.5 | 0.01 | 0.13 | 0.14 | 0.18 | 0.04 | 0.03 | | | | | | | 0.53 | 0.70 |
| 3.0 | 0.42 | 0.50 | 0.39 | 0.05 | 0.11 | 0.07 | 0.05 | 0.03 | 0.06 | 0.02 | 0.02 | 0.17 | 1.89 | 2.59 |
| 2.5 | 0.83 | 0.73 | 0.55 | 0.16 | 0.08 | 0.19 | 0.17 | 0.07 | 0.12 | 0.13 | 0.37 | 0.54 | 3.94 | 6.53 |
| 2.0 | 1.80 | 1.80 | 0.75 | 0.52 | 0.22 | 0.37 | 0.43 | 0.39 | 0.43 | 0.56 | 1.45 | 1.86 | 10.60 | 17.13 |
| 1.5 | 3.31 | 3.86 | 1.60 | 1.17 | 0.49 | 0.44 | 1.38 | 1.38 | 1.17 | 1.21 | 2.14 | 2.69 | 20.83 | 37.97 |
| 1.0 | 3.02 | 4.57 | 4.34 | 3.49 | 1.25 | 1.16 | 2.16 | 2.24 | 2.19 | 1.89 | 2.31 | 3.27 | 31.88 | 69.85 |
| 0.5 | 1.86 | 3.31 | 4.78 | 3.99 | 1.95 | 2.26 | 2.03 | 1.65 | 1.36 | 1.53 | 1.38 | 1.21 | 27.30 | 97.15 |
| 0.0 | 0.17 | 0.23 | 0.61 | 0.57 | 0.28 | 0.48 | 0.19 | 0.10 | 0.07 | 0.04 | 0.05 | 0.06 | 2.85 | |

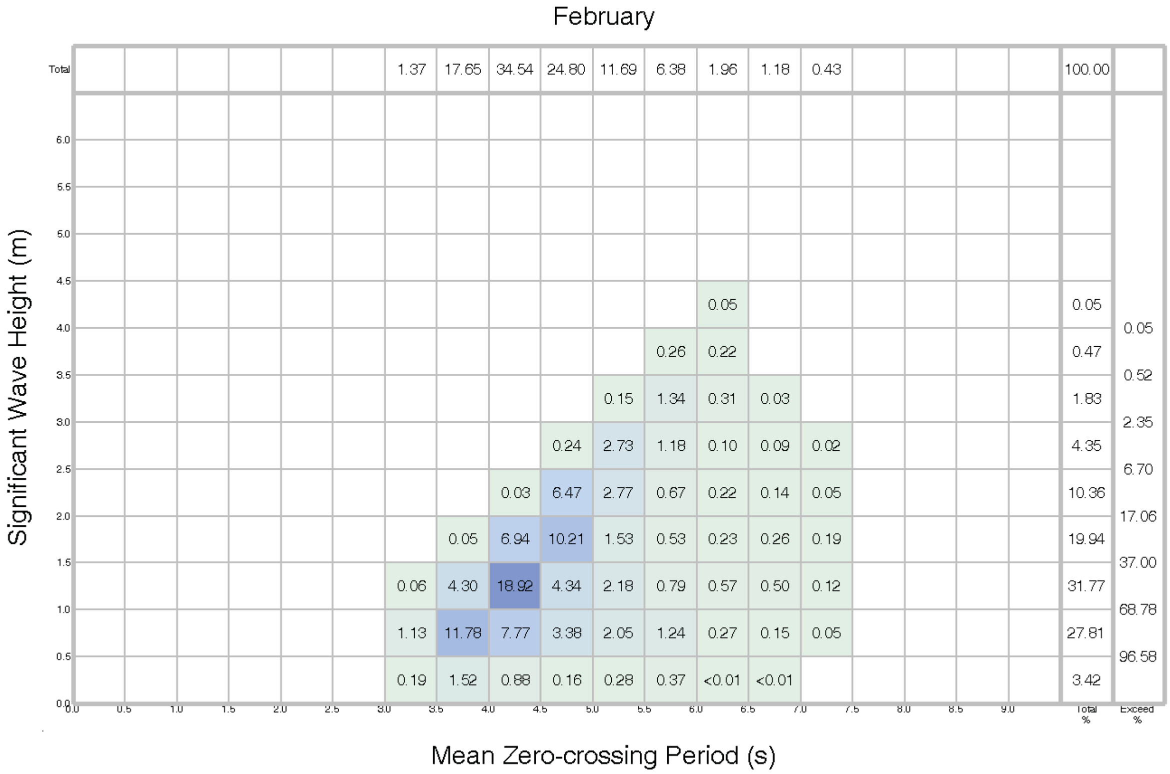
**Figure 2-110 Percentage Occurrence of Significant Wave Height and 30° Direction Bin - December**

### 2.4.3 Joint Frequency Distribution of Significant Wave Height and Zero Up-Crossing Period


January

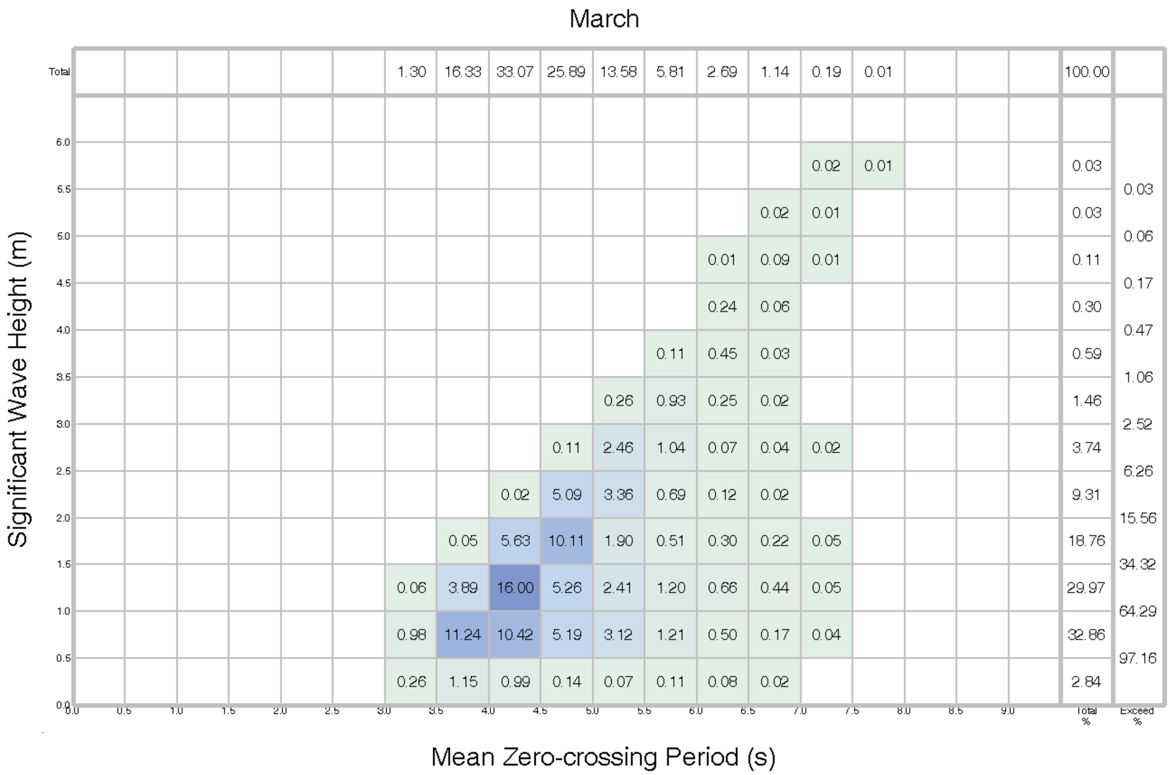
|  | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total |  |  |  |  |  |  | 2.33 | 18.93 | 36.57 | 25.95 | 9.98 | 4.37 | 1.14 | 0.26 | 0.13 | 0.25 | 0.04 | 0.05 |  | 100.00 |  |
| 6.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3.5 |  |  |  |  |  |  |  |  |  |  |  | 0.20 | 0.07 |  |  |  |  |  |  | 0.27 | 0.27 |
| 3.0 |  |  |  |  |  |  |  |  |  |  | 0.36 | 1.31 | 0.17 | 0.05 | 0.03 |  |  |  |  | 1.92 | 2.19 |
| 2.5 |  |  |  |  |  |  |  |  |  | 0.22 | 3.24 | 0.94 | 0.13 | 0.01 | <0.01 | 0.02 | 0.01 | 0.02 |  | 4.59 | 6.77 |
| 2.0 |  |  |  |  |  |  |  |  | 0.05 | 8.09 | 2.60 | 0.54 | 0.07 | 0.07 | 0.04 | 0.04 | <0.01 | 0.03 |  | 11.53 | 18.31 |
| 1.5 |  |  |  |  |  |  |  | 0.05 | 8.60 | 10.68 | 1.22 | 0.26 | 0.20 | 0.01 | 0.02 | 0.19 | 0.02 |  |  | 21.25 | 39.56 |
| 1.0 |  |  |  |  |  |  | 0.09 | 5.91 | 19.05 | 3.64 | 1.40 | 0.78 | 0.35 | 0.07 | 0.04 | 0.02 |  |  |  | 31.35 | 70.91 |
| 0.5 |  |  |  |  |  |  | 1.69 | 11.89 | 8.04 | 3.19 | 1.14 | 0.28 | 0.09 | 0.04 |  |  |  |  |  | 26.37 | 97.28 |
| 0.0 |  |  |  |  |  |  | 0.55 | 1.07 | 0.83 | 0.11 | 0.04 | 0.06 | 0.05 |  |  |  |  |  |  | 2.72 |  |

Figure 2-111 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period - January


February

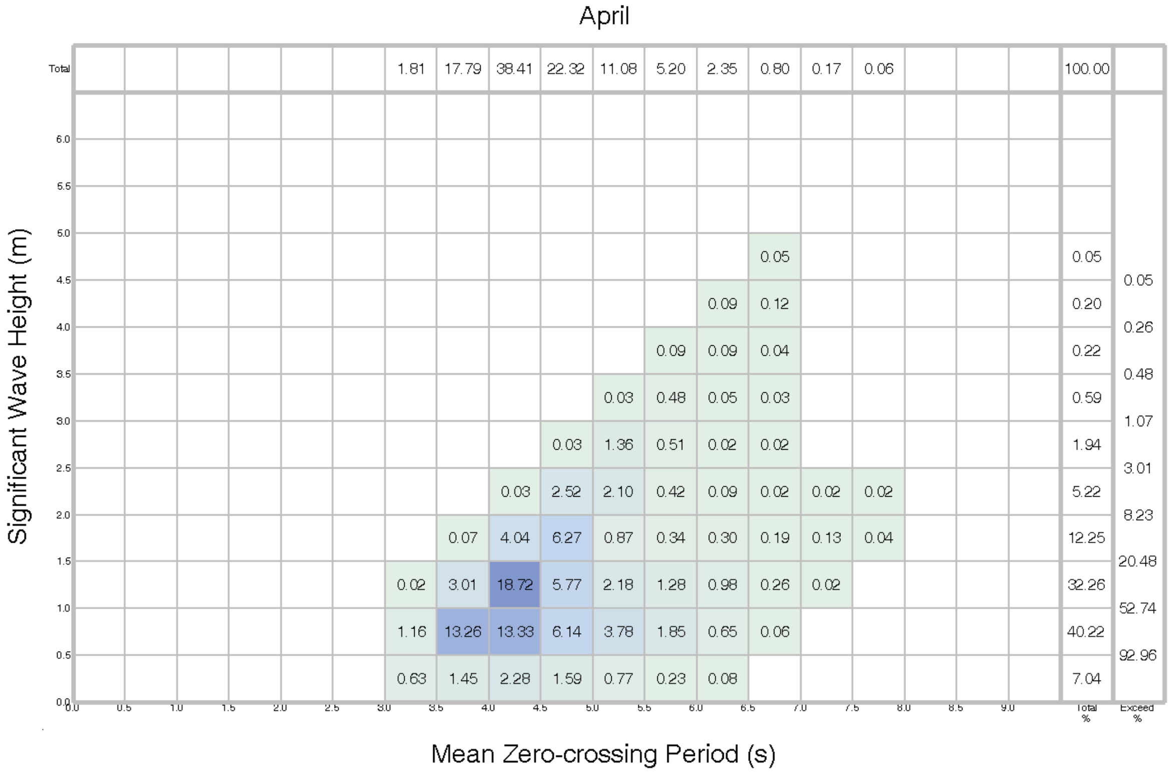
|  | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total |  |  |  |  |  |  | 1.37 | 17.65 | 34.54 | 24.80 | 11.69 | 6.38 | 1.96 | 1.18 | 0.43 |  |  |  |  | 100.00 |  |
| 6.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.0 |  |  |  |  |  |  |  |  |  |  |  |  | 0.05 |  |  |  |  |  |  | 0.05 | 0.05 |
| 3.5 |  |  |  |  |  |  |  |  |  |  |  | 0.26 | 0.22 |  |  |  |  |  |  | 0.47 | 0.52 |
| 3.0 |  |  |  |  |  |  |  |  |  |  | 0.15 | 1.34 | 0.31 | 0.03 |  |  |  |  |  | 1.83 | 2.35 |
| 2.5 |  |  |  |  |  |  |  |  |  | 0.24 | 2.73 | 1.18 | 0.10 | 0.09 | 0.02 |  |  |  |  | 4.35 | 6.70 |
| 2.0 |  |  |  |  |  |  |  |  | 0.03 | 6.47 | 2.77 | 0.67 | 0.22 | 0.14 | 0.05 |  |  |  |  | 10.36 | 17.06 |
| 1.5 |  |  |  |  |  |  |  | 0.05 | 6.94 | 10.21 | 1.53 | 0.53 | 0.23 | 0.26 | 0.19 |  |  |  |  | 19.94 | 37.00 |
| 1.0 |  |  |  |  |  |  | 0.06 | 4.30 | 18.92 | 4.34 | 2.18 | 0.79 | 0.57 | 0.50 | 0.12 |  |  |  |  | 31.77 | 68.78 |
| 0.5 |  |  |  |  |  |  | 1.13 | 11.78 | 7.77 | 3.38 | 2.05 | 1.24 | 0.27 | 0.15 | 0.05 |  |  |  |  | 27.81 | 96.58 |
| 0.0 |  |  |  |  |  |  | 0.19 | 1.52 | 0.88 | 0.16 | 0.28 | 0.37 | <0.01 | <0.01 |  |  |  |  |  | 3.42 |  |

Figure 2-112 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period - February



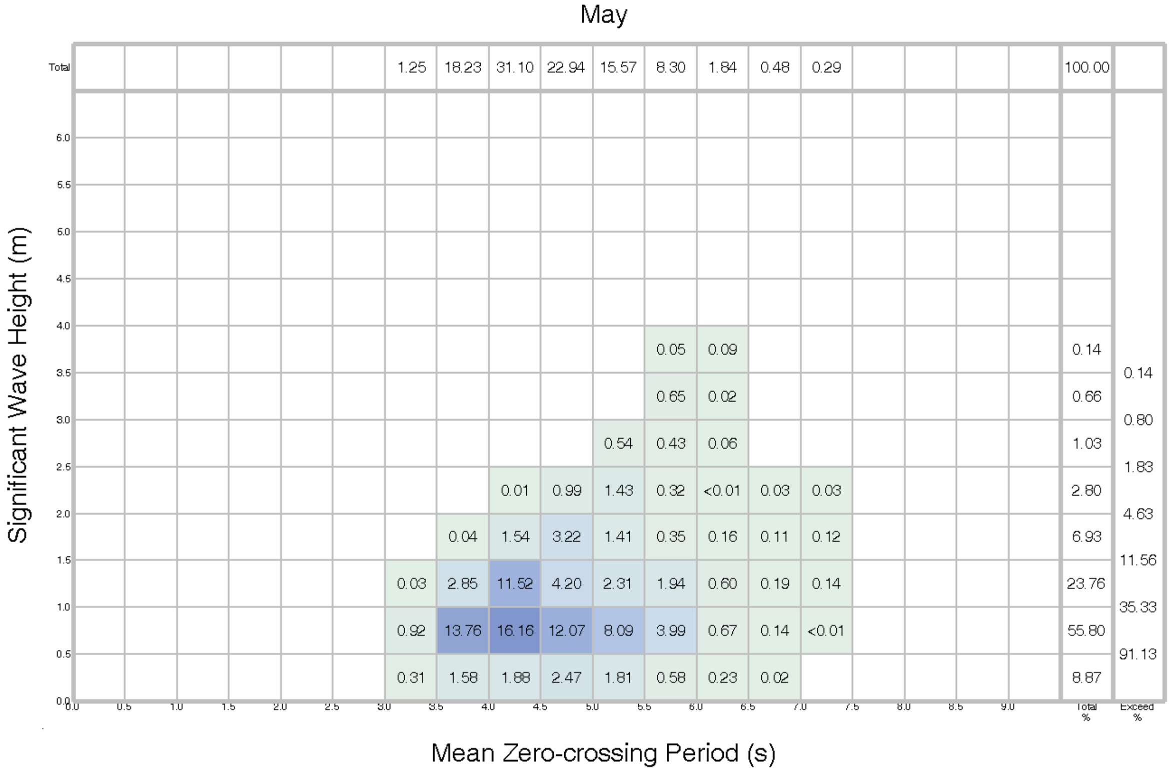
| | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | 1.30 | 16.33 | 33.07 | 25.89 | 13.58 | 5.81 | 2.69 | 1.14 | 0.19 | 0.01 | | | | 100.00 | |
| 6.0 | | | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | 0.02 | 0.01 | | | | 0.03 | 0.03 |
| 5.0 | | | | | | | | | | | | | | 0.02 | 0.01 | | | | | 0.03 | 0.06 |
| 4.5 | | | | | | | | | | | | | 0.01 | 0.09 | 0.01 | | | | | 0.11 | 0.17 |
| 4.0 | | | | | | | | | | | | | 0.24 | 0.06 | | | | | | 0.30 | 0.47 |
| 3.5 | | | | | | | | | | | | 0.11 | 0.45 | 0.03 | | | | | | 0.59 | 1.06 |
| 3.0 | | | | | | | | | | | 0.26 | 0.93 | 0.25 | 0.02 | | | | | | 1.46 | 2.52 |
| 2.5 | | | | | | | | | | 0.11 | 2.46 | 1.04 | 0.07 | 0.04 | 0.02 | | | | | 3.74 | 6.26 |
| 2.0 | | | | | | | | | 0.02 | 5.09 | 3.36 | 0.69 | 0.12 | 0.02 | | | | | | 9.31 | 15.56 |
| 1.5 | | | | | | | | 0.05 | 5.63 | 10.11 | 1.90 | 0.51 | 0.30 | 0.22 | 0.05 | | | | | 18.76 | 34.32 |
| 1.0 | | | | | | | 0.06 | 3.89 | 16.00 | 5.26 | 2.41 | 1.20 | 0.66 | 0.44 | 0.05 | | | | | 29.97 | 64.29 |
| 0.5 | | | | | | | 0.98 | 11.24 | 10.42 | 5.19 | 3.12 | 1.21 | 0.50 | 0.17 | 0.04 | | | | | 32.86 | 97.16 |
| 0.0 | | | | | | | 0.26 | 1.15 | 0.99 | 0.14 | 0.07 | 0.11 | 0.08 | 0.02 | | | | | | 2.84 | |

**Figure 2-113 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period - March**



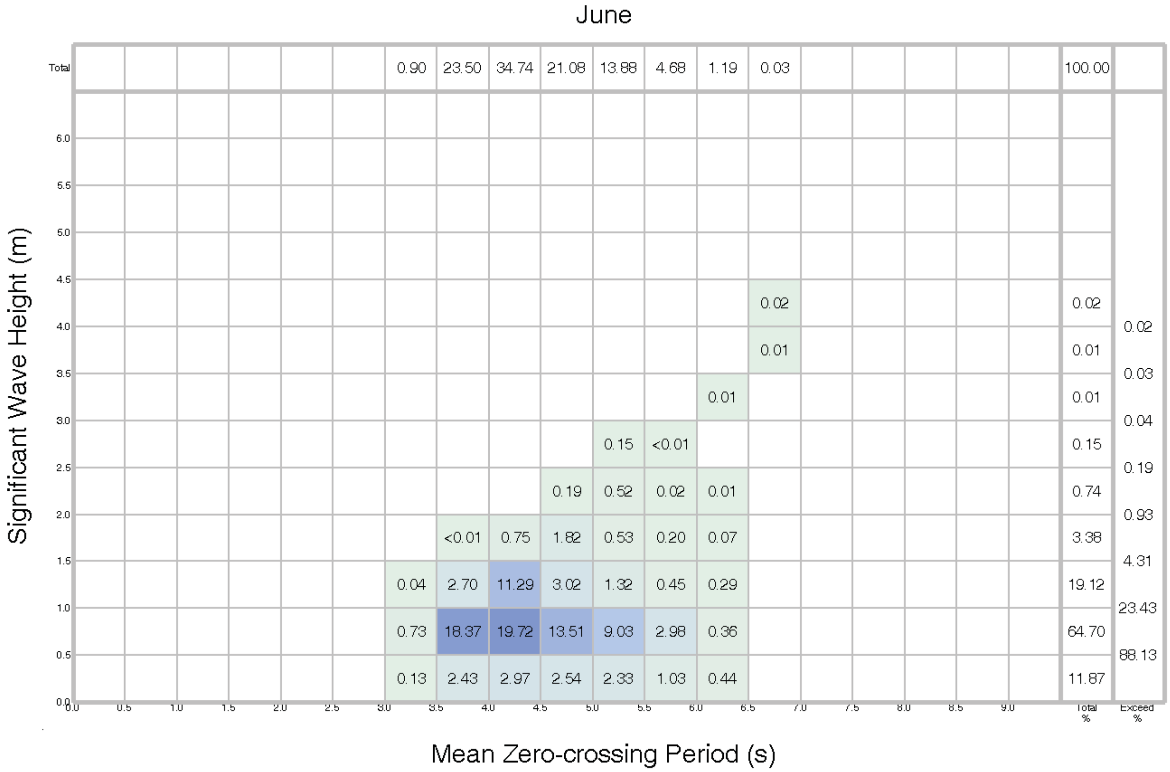
| | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | 1.81 | 17.79 | 38.41 | 22.32 | 11.08 | 5.20 | 2.35 | 0.80 | 0.17 | 0.06 | | | | 100.00 | |
| 6.0 | | | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | | | | |
| 4.5 | | | | | | | | | | | | | | 0.05 | | | | | | 0.05 | 0.05 |
| 4.0 | | | | | | | | | | | | | 0.09 | 0.12 | | | | | | 0.20 | 0.26 |
| 3.5 | | | | | | | | | | | | 0.09 | 0.09 | 0.04 | | | | | | 0.22 | 0.48 |
| 3.0 | | | | | | | | | | | 0.03 | 0.48 | 0.05 | 0.03 | | | | | | 0.59 | 1.07 |
| 2.5 | | | | | | | | | | 0.03 | 1.36 | 0.51 | 0.02 | 0.02 | | | | | | 1.94 | 3.01 |
| 2.0 | | | | | | | | | 0.03 | 2.52 | 2.10 | 0.42 | 0.09 | 0.02 | 0.02 | 0.02 | | | | 5.22 | 8.23 |
| 1.5 | | | | | | | | 0.07 | 4.04 | 6.27 | 0.87 | 0.34 | 0.30 | 0.19 | 0.13 | 0.04 | | | | 12.25 | 20.48 |
| 1.0 | | | | | | | 0.02 | 3.01 | 18.72 | 5.77 | 2.18 | 1.28 | 0.98 | 0.26 | 0.02 | | | | | 32.26 | 52.74 |
| 0.5 | | | | | | | 1.16 | 13.26 | 13.33 | 6.14 | 3.78 | 1.85 | 0.65 | 0.06 | | | | | | 40.22 | 92.96 |
| 0.0 | | | | | | | 0.63 | 1.45 | 2.28 | 1.59 | 0.77 | 0.23 | 0.08 | | | | | | | 7.04 | |

**Figure 2-114 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period - April**



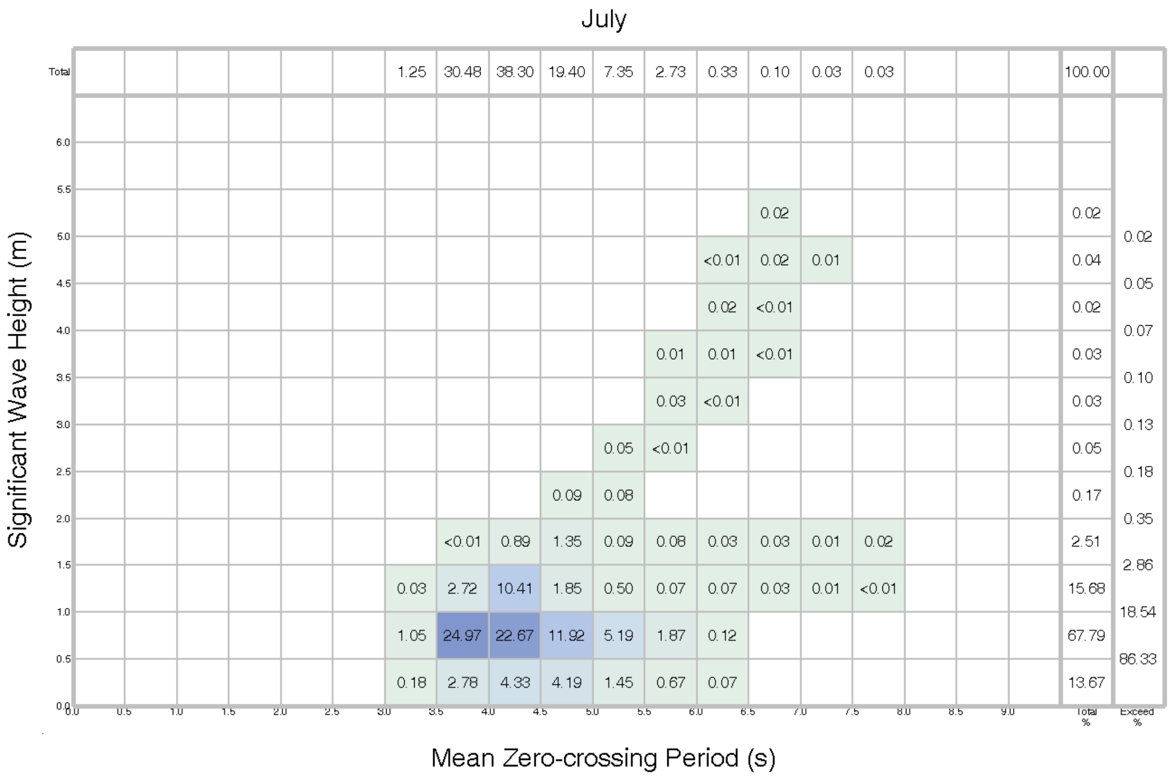
| Significant Wave Height (m) | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | 1.25 | 18.23 | 31.10 | 22.94 | 15.57 | 8.30 | 1.84 | 0.48 | 0.29 | | | | | 100.00 | |
| 6.0 | | | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | | | | |
| 4.5 | | | | | | | | | | | | | | | | | | | | | |
| 4.0 | | | | | | | | | | | | | | | | | | | | | |
| 3.5 | | | | | | | | | | | | 0.05 | 0.09 | | | | | | | 0.14 | 0.14 |
| 3.0 | | | | | | | | | | | | 0.65 | 0.02 | | | | | | | 0.66 | 0.80 |
| 2.5 | | | | | | | | | | | 0.54 | 0.43 | 0.06 | | | | | | | 1.03 | 1.83 |
| 2.0 | | | | | | | | | 0.01 | 0.99 | 1.43 | 0.32 | <0.01 | 0.03 | 0.03 | | | | | 2.80 | 4.63 |
| 1.5 | | | | | | | | 0.04 | 1.54 | 3.22 | 1.41 | 0.35 | 0.16 | 0.11 | 0.12 | | | | | 6.93 | 11.56 |
| 1.0 | | | | | | | 0.03 | 2.85 | 11.52 | 4.20 | 2.31 | 1.94 | 0.60 | 0.19 | 0.14 | | | | | 23.76 | 35.33 |
| 0.5 | | | | | | | 0.92 | 13.76 | 16.16 | 12.07 | 8.09 | 3.99 | 0.67 | 0.14 | <0.01 | | | | | 55.80 | 91.13 |
| 0.0 | | | | | | | 0.31 | 1.58 | 1.88 | 2.47 | 1.81 | 0.58 | 0.23 | 0.02 | | | | | | 8.87 | |

**Figure 2-115 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period - May**



| Significant Wave Height (m) | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | 0.90 | 23.50 | 34.74 | 21.08 | 13.88 | 4.68 | 1.19 | 0.03 | | | | | | 100.00 | |
| 6.0 | | | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | | | | |
| 4.5 | | | | | | | | | | | | | | | | | | | | | |
| 4.0 | | | | | | | | | | | | | | 0.02 | | | | | | 0.02 | 0.02 |
| 3.5 | | | | | | | | | | | | | | 0.01 | | | | | | 0.01 | 0.03 |
| 3.0 | | | | | | | | | | | | | 0.01 | | | | | | | 0.01 | 0.04 |
| 2.5 | | | | | | | | | | | 0.15 | <0.01 | | | | | | | | 0.15 | 0.19 |
| 2.0 | | | | | | | | | | 0.19 | 0.52 | 0.02 | 0.01 | | | | | | | 0.74 | 0.93 |
| 1.5 | | | | | | | | <0.01 | 0.75 | 1.82 | 0.53 | 0.20 | 0.07 | | | | | | | 3.38 | 4.31 |
| 1.0 | | | | | | | 0.04 | 2.70 | 11.29 | 3.02 | 1.32 | 0.45 | 0.29 | | | | | | | 19.12 | 23.43 |
| 0.5 | | | | | | | 0.73 | 18.37 | 19.72 | 13.51 | 9.03 | 2.98 | 0.36 | | | | | | | 64.70 | 88.13 |
| 0.0 | | | | | | | 0.13 | 2.43 | 2.97 | 2.54 | 2.33 | 1.03 | 0.44 | | | | | | | 11.87 | |

**Figure 2-116 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period - June**

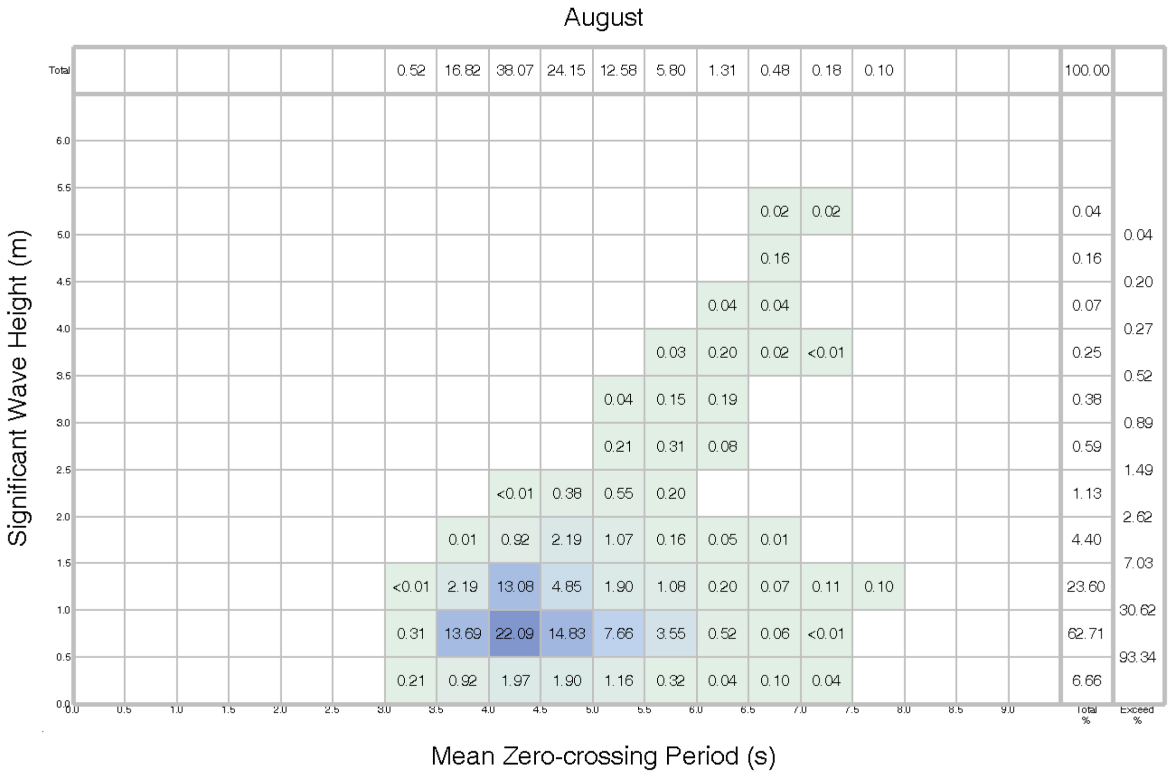


July

| Significant Wave Height (m) | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | 1.25 | 30.48 | 38.30 | 19.40 | 7.35 | 2.73 | 0.33 | 0.10 | 0.03 | 0.03 | | | | 100.00 | |
| 6.0 | | | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | 0.02 | | | | | | 0.02 | 0.02 |
| 4.5 | | | | | | | | | | | | | <0.01 | 0.02 | 0.01 | | | | | 0.04 | 0.05 |
| 4.0 | | | | | | | | | | | | | 0.02 | <0.01 | | | | | | 0.02 | 0.07 |
| 3.5 | | | | | | | | | | | | 0.01 | 0.01 | <0.01 | | | | | | 0.03 | 0.10 |
| 3.0 | | | | | | | | | | | | 0.03 | <0.01 | | | | | | | 0.03 | 0.13 |
| 2.5 | | | | | | | | | | | 0.05 | <0.01 | | | | | | | | 0.05 | 0.18 |
| 2.0 | | | | | | | | | | 0.09 | 0.08 | | | | | | | | | 0.17 | 0.35 |
| 1.5 | | | | | | | | <0.01 | 0.89 | 1.35 | 0.09 | 0.08 | 0.03 | 0.03 | 0.01 | 0.02 | | | | 2.51 | 2.86 |
| 1.0 | | | | | | | 0.03 | 2.72 | 10.41 | 1.85 | 0.50 | 0.07 | 0.07 | 0.03 | 0.01 | <0.01 | | | | 15.68 | 18.54 |
| 0.5 | | | | | | | 1.05 | 24.97 | 22.67 | 11.92 | 5.19 | 1.87 | 0.12 | | | | | | | 67.79 | 86.33 |
| 0.0 | | | | | | | 0.18 | 2.78 | 4.33 | 4.19 | 1.45 | 0.67 | 0.07 | | | | | | | 13.67 | |

Mean Zero-crossing Period (s)

Figure 2-117 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period - July

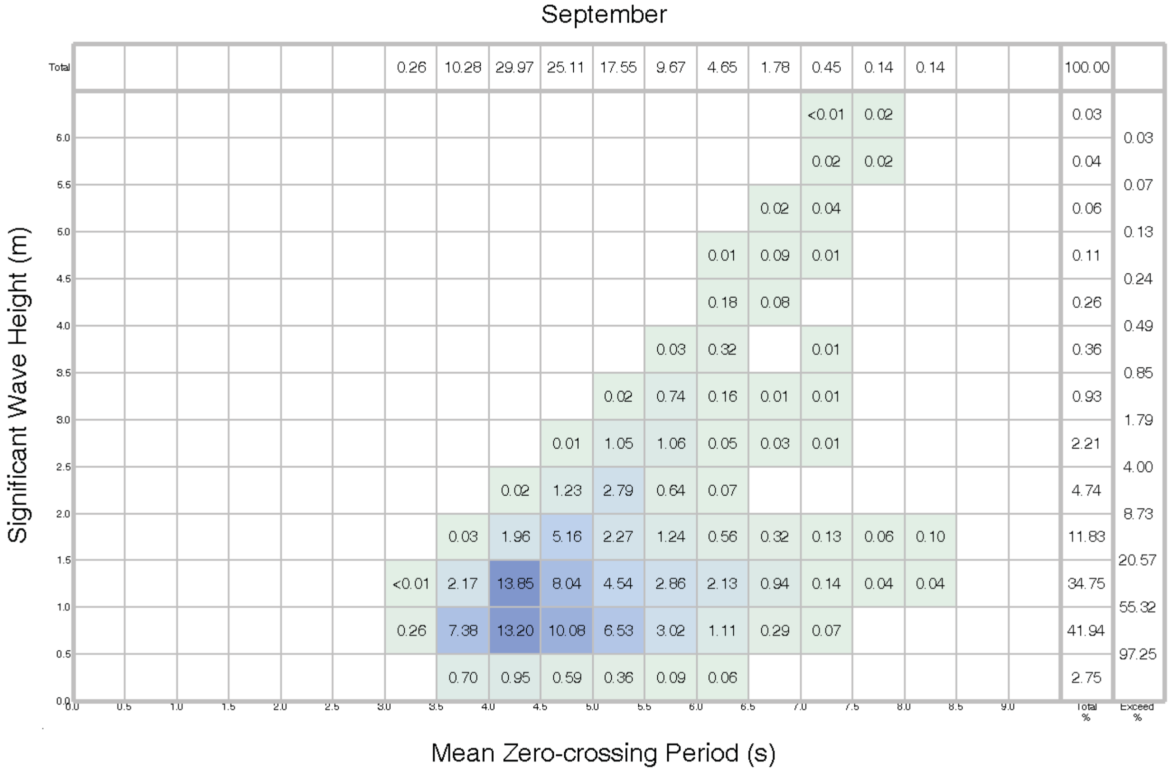


August

| Significant Wave Height (m) | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | 0.52 | 16.82 | 38.07 | 24.15 | 12.58 | 5.80 | 1.31 | 0.48 | 0.18 | 0.10 | | | | 100.00 | |
| 6.0 | | | | | | | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | 0.02 | 0.02 | | | | | 0.04 | 0.04 |
| 4.5 | | | | | | | | | | | | | | 0.16 | | | | | | 0.16 | 0.20 |
| 4.0 | | | | | | | | | | | | | 0.04 | 0.04 | | | | | | 0.07 | 0.27 |
| 3.5 | | | | | | | | | | | | 0.03 | 0.20 | 0.02 | <0.01 | | | | | 0.25 | 0.52 |
| 3.0 | | | | | | | | | | | 0.04 | 0.15 | 0.19 | | | | | | | 0.38 | 0.89 |
| 2.5 | | | | | | | | | | | 0.21 | 0.31 | 0.08 | | | | | | | 0.59 | 1.49 |
| 2.0 | | | | | | | | | <0.01 | 0.38 | 0.55 | 0.20 | | | | | | | | 1.13 | 2.62 |
| 1.5 | | | | | | | | 0.01 | 0.92 | 2.19 | 1.07 | 0.16 | 0.05 | 0.01 | | | | | | 4.40 | 7.03 |
| 1.0 | | | | | | | <0.01 | 2.19 | 13.08 | 4.85 | 1.90 | 1.08 | 0.20 | 0.07 | 0.11 | 0.10 | | | | 23.60 | 30.62 |
| 0.5 | | | | | | | 0.31 | 13.69 | 22.09 | 14.83 | 7.66 | 3.55 | 0.52 | 0.06 | <0.01 | | | | | 62.71 | 93.34 |
| 0.0 | | | | | | | 0.21 | 0.92 | 1.97 | 1.90 | 1.16 | 0.32 | 0.04 | 0.10 | 0.04 | | | | | 6.66 | |

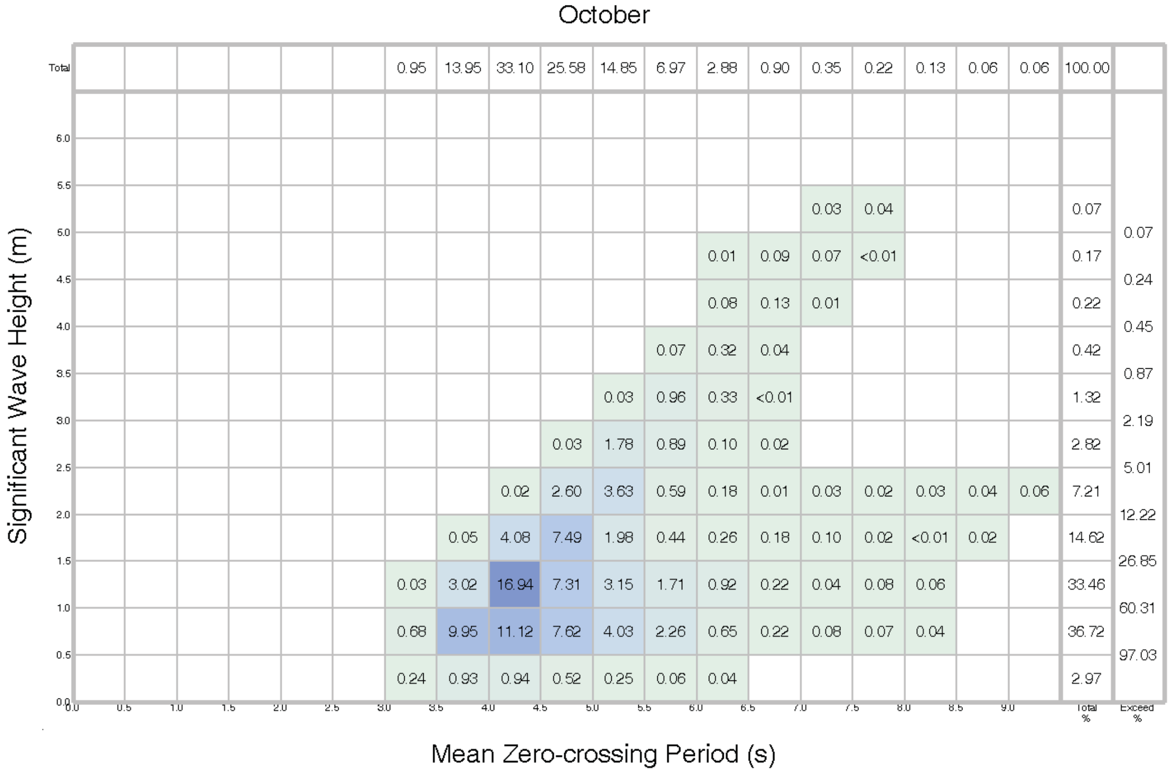
Mean Zero-crossing Period (s)

Figure 2-118 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period - August



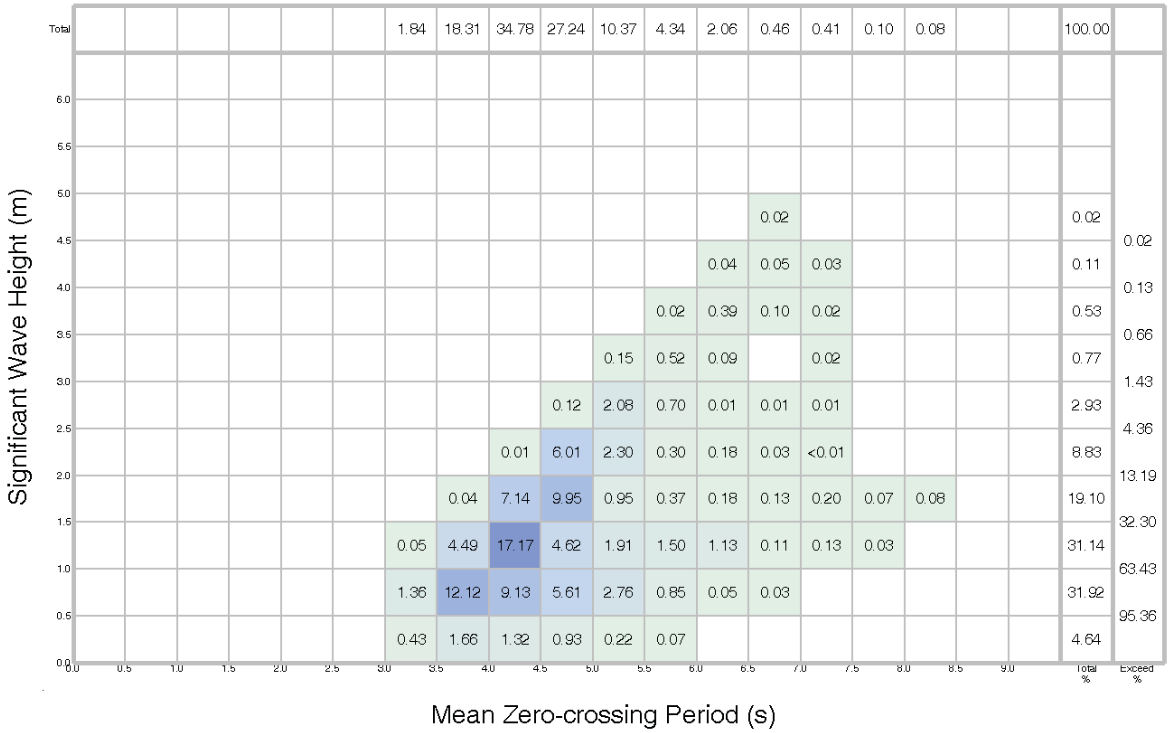
|  | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total |  |  |  |  |  |  | 0.26 | 10.28 | 29.97 | 25.11 | 17.55 | 9.67 | 4.65 | 1.78 | 0.45 | 0.14 | 0.14 |  |  | 100.00 |  |
| 6.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | <0.01 | 0.02 |  |  |  | 0.03 | 0.03 |
| 5.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.02 | 0.02 |  |  |  | 0.04 | 0.07 |
| 5.0 |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.02 | 0.04 |  |  |  |  | 0.06 | 0.13 |
| 4.5 |  |  |  |  |  |  |  |  |  |  |  |  | 0.01 | 0.09 | 0.01 |  |  |  |  | 0.11 | 0.24 |
| 4.0 |  |  |  |  |  |  |  |  |  |  |  |  | 0.18 | 0.08 |  |  |  |  |  | 0.26 | 0.49 |
| 3.5 |  |  |  |  |  |  |  |  |  |  |  | 0.03 | 0.32 |  | 0.01 |  |  |  |  | 0.36 | 0.85 |
| 3.0 |  |  |  |  |  |  |  |  |  |  | 0.02 | 0.74 | 0.16 | 0.01 | 0.01 |  |  |  |  | 0.93 | 1.79 |
| 2.5 |  |  |  |  |  |  |  |  |  | 0.01 | 1.05 | 1.06 | 0.05 | 0.03 | 0.01 |  |  |  |  | 2.21 | 4.00 |
| 2.0 |  |  |  |  |  |  |  |  | 0.02 | 1.23 | 2.79 | 0.64 | 0.07 |  |  |  |  |  |  | 4.74 | 8.73 |
| 1.5 |  |  |  |  |  |  |  | 0.03 | 1.96 | 5.16 | 2.27 | 1.24 | 0.56 | 0.32 | 0.13 | 0.06 | 0.10 |  |  | 11.83 | 20.57 |
| 1.0 |  |  |  |  |  |  | <0.01 | 2.17 | 13.85 | 8.04 | 4.54 | 2.86 | 2.13 | 0.94 | 0.14 | 0.04 | 0.04 |  |  | 34.75 | 55.32 |
| 0.5 |  |  |  |  |  |  | 0.26 | 7.38 | 13.20 | 10.08 | 6.53 | 3.02 | 1.11 | 0.29 | 0.07 |  |  |  |  | 41.94 | 97.25 |
| 0.0 |  |  |  |  |  |  |  | 0.70 | 0.95 | 0.59 | 0.36 | 0.09 | 0.06 |  |  |  |  |  |  | 2.75 |  |

Figure 2-119 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period - September



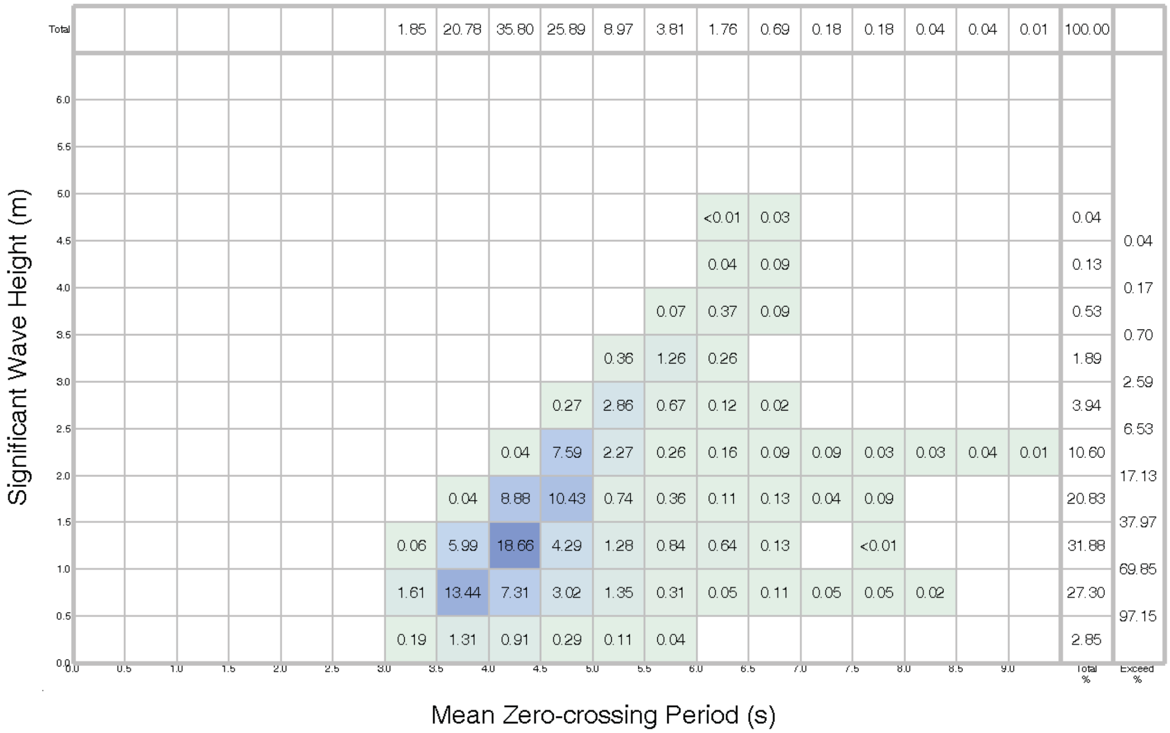
|  | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total |  |  |  |  |  |  | 0.95 | 13.95 | 33.10 | 25.58 | 14.85 | 6.97 | 2.88 | 0.90 | 0.35 | 0.22 | 0.13 | 0.06 | 0.06 | 100.00 |  |
| 6.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.03 | 0.04 |  |  |  | 0.07 | 0.07 |
| 4.5 |  |  |  |  |  |  |  |  |  |  |  |  | 0.01 | 0.09 | 0.07 | <0.01 |  |  |  | 0.17 | 0.24 |
| 4.0 |  |  |  |  |  |  |  |  |  |  |  |  | 0.08 | 0.13 | 0.01 |  |  |  |  | 0.22 | 0.45 |
| 3.5 |  |  |  |  |  |  |  |  |  |  |  | 0.07 | 0.32 | 0.04 |  |  |  |  |  | 0.42 | 0.87 |
| 3.0 |  |  |  |  |  |  |  |  |  |  | 0.03 | 0.96 | 0.33 | <0.01 |  |  |  |  |  | 1.32 | 2.19 |
| 2.5 |  |  |  |  |  |  |  |  |  | 0.03 | 1.78 | 0.89 | 0.10 | 0.02 |  |  |  |  |  | 2.82 | 5.01 |
| 2.0 |  |  |  |  |  |  |  |  | 0.02 | 2.60 | 3.63 | 0.59 | 0.18 | 0.01 | 0.03 | 0.02 | 0.03 | 0.04 | 0.06 | 7.21 | 12.22 |
| 1.5 |  |  |  |  |  |  |  | 0.05 | 4.08 | 7.49 | 1.98 | 0.44 | 0.26 | 0.18 | 0.10 | 0.02 | <0.01 | 0.02 |  | 14.62 | 26.85 |
| 1.0 |  |  |  |  |  |  | 0.03 | 3.02 | 16.94 | 7.31 | 3.15 | 1.71 | 0.92 | 0.22 | 0.04 | 0.08 | 0.06 |  |  | 33.46 | 60.31 |
| 0.5 |  |  |  |  |  |  | 0.68 | 9.95 | 11.12 | 7.62 | 4.03 | 2.26 | 0.65 | 0.22 | 0.08 | 0.07 | 0.04 |  |  | 36.72 | 97.03 |
| 0.0 |  |  |  |  |  |  | 0.24 | 0.93 | 0.94 | 0.52 | 0.25 | 0.06 | 0.04 |  |  |  |  |  |  | 2.97 |  |

Figure 2-120 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period - October



| Significant Wave Height (m) | 0.0–0.5 | 0.5–1.0 | 1.0–1.5 | 1.5–2.0 | 2.0–2.5 | 2.5–3.0 | 3.0–3.5 | 3.5–4.0 | 4.0–4.5 | 4.5–5.0 | 5.0–5.5 | 5.5–6.0 | 6.0–6.5 | 6.5–7.0 | 7.0–7.5 | 7.5–8.0 | 8.0–8.5 | 8.5–9.0 | 9.0–9.5 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | 1.84 | 18.31 | 34.78 | 27.24 | 10.37 | 4.34 | 2.06 | 0.46 | 0.41 | 0.10 | 0.08 | | | 100.00 | |
| 5.5–6.0 | | | | | | | | | | | | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | | | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | | | | | 0.02 | | | | | | 0.02 | 0.02 |
| 4.0–4.5 | | | | | | | | | | | | | 0.04 | 0.05 | 0.03 | | | | | 0.11 | 0.13 |
| 3.5–4.0 | | | | | | | | | | | | 0.02 | 0.39 | 0.10 | 0.02 | | | | | 0.53 | 0.66 |
| 3.0–3.5 | | | | | | | | | | | 0.15 | 0.52 | 0.09 | | 0.02 | | | | | 0.77 | 1.43 |
| 2.5–3.0 | | | | | | | | | | 0.12 | 2.08 | 0.70 | 0.01 | 0.01 | 0.01 | | | | | 2.93 | 4.36 |
| 2.0–2.5 | | | | | | | | | 0.01 | 6.01 | 2.30 | 0.30 | 0.18 | 0.03 | <0.01 | | | | | 8.83 | 13.19 |
| 1.5–2.0 | | | | | | | | 0.04 | 7.14 | 9.95 | 0.95 | 0.37 | 0.18 | 0.13 | 0.20 | 0.07 | 0.08 | | | 19.10 | 32.30 |
| 1.0–1.5 | | | | | | | 0.05 | 4.49 | 17.17 | 4.62 | 1.91 | 1.50 | 1.13 | 0.11 | 0.13 | 0.03 | | | | 31.14 | 63.43 |
| 0.5–1.0 | | | | | | | 1.36 | 12.12 | 9.13 | 5.61 | 2.76 | 0.85 | 0.05 | 0.03 | | | | | | 31.92 | 95.36 |
| 0.0–0.5 | | | | | | | 0.43 | 1.66 | 1.32 | 0.93 | 0.22 | 0.07 | | | | | | | | 4.64 | |

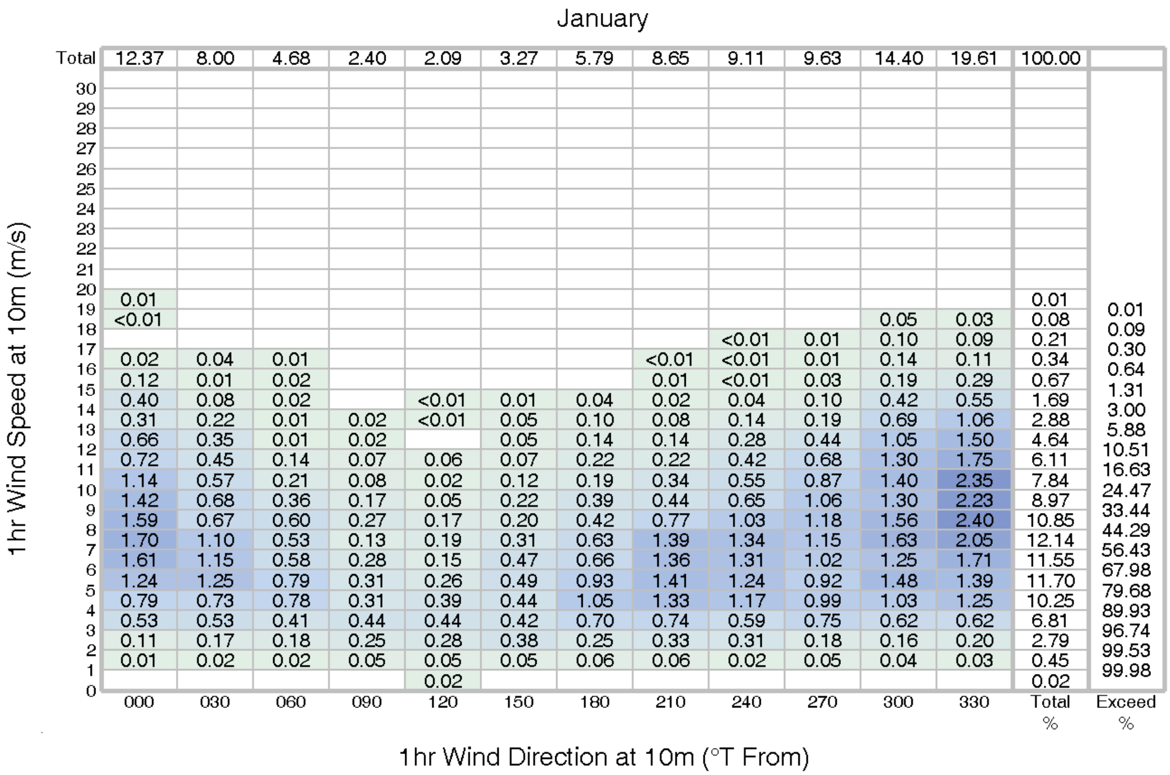
**Figure 2-121 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period - November**



| Significant Wave Height (m) | 0.0–0.5 | 0.5–1.0 | 1.0–1.5 | 1.5–2.0 | 2.0–2.5 | 2.5–3.0 | 3.0–3.5 | 3.5–4.0 | 4.0–4.5 | 4.5–5.0 | 5.0–5.5 | 5.5–6.0 | 6.0–6.5 | 6.5–7.0 | 7.0–7.5 | 7.5–8.0 | 8.0–8.5 | 8.5–9.0 | 9.0–9.5 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | 1.85 | 20.78 | 35.80 | 25.89 | 8.97 | 3.81 | 1.76 | 0.69 | 0.18 | 0.18 | 0.04 | 0.04 | 0.01 | 100.00 | |
| 5.5–6.0 | | | | | | | | | | | | | | | | | | | | | |
| 5.0–5.5 | | | | | | | | | | | | | | | | | | | | | |
| 4.5–5.0 | | | | | | | | | | | | | <0.01 | 0.03 | | | | | | 0.04 | 0.04 |
| 4.0–4.5 | | | | | | | | | | | | | 0.04 | 0.09 | | | | | | 0.13 | 0.17 |
| 3.5–4.0 | | | | | | | | | | | | 0.07 | 0.37 | 0.09 | | | | | | 0.53 | 0.70 |
| 3.0–3.5 | | | | | | | | | | | 0.36 | 1.26 | 0.26 | | | | | | | 1.89 | 2.59 |
| 2.5–3.0 | | | | | | | | | | 0.27 | 2.86 | 0.67 | 0.12 | 0.02 | | | | | | 3.94 | 6.53 |
| 2.0–2.5 | | | | | | | | | 0.04 | 7.59 | 2.27 | 0.26 | 0.16 | 0.09 | 0.09 | 0.03 | 0.03 | 0.04 | 0.01 | 10.60 | 17.13 |
| 1.5–2.0 | | | | | | | | 0.04 | 8.88 | 10.43 | 0.74 | 0.36 | 0.11 | 0.13 | 0.04 | 0.09 | | | | 20.83 | 37.97 |
| 1.0–1.5 | | | | | | | 0.06 | 5.99 | 18.66 | 4.29 | 1.28 | 0.84 | 0.64 | 0.13 | | <0.01 | | | | 31.88 | 69.85 |
| 0.5–1.0 | | | | | | | 1.61 | 13.44 | 7.31 | 3.02 | 1.35 | 0.31 | 0.05 | 0.11 | 0.05 | 0.05 | 0.02 | | | 27.30 | 97.15 |
| 0.0–0.5 | | | | | | | 0.19 | 1.31 | 0.91 | 0.29 | 0.11 | 0.04 | | | | | | | | 2.85 | |

**Figure 2-122 Percentage Occurrence of Significant Wave Height and Zero Up-Crossing Period - December**

### 2.4.4 Joint Frequency of Wind Speed by 30° Direction Bin

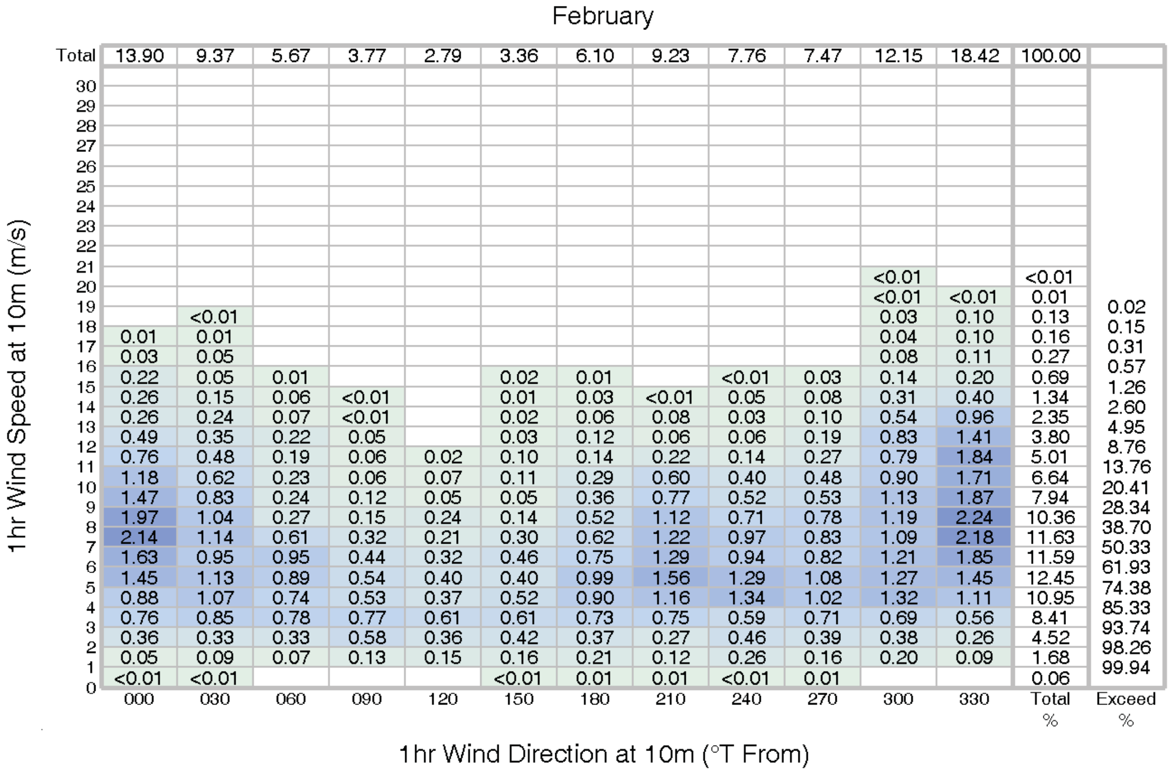


January

| 1hr Wind Speed at 10m (m/s) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 12.37 | 8.00 | 4.68 | 2.40 | 2.09 | 3.27 | 5.79 | 8.65 | 9.11 | 9.63 | 14.40 | 19.61 | 100.00 | |
| 30 | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | |
| 19 | 0.01 | | | | | | | | | | | | 0.01 | 0.01 |
| 18 | <0.01 | | | | | | | | | | 0.05 | 0.03 | 0.08 | 0.09 |
| 17 | | | | | | | | | <0.01 | 0.01 | 0.10 | 0.09 | 0.21 | 0.30 |
| 16 | 0.02 | 0.04 | 0.01 | | | | | <0.01 | <0.01 | 0.01 | 0.14 | 0.11 | 0.34 | 0.64 |
| 15 | 0.12 | 0.01 | 0.02 | | | | | 0.01 | <0.01 | 0.03 | 0.19 | 0.29 | 0.67 | 1.31 |
| 14 | 0.40 | 0.08 | 0.02 | | <0.01 | 0.01 | 0.04 | 0.02 | 0.04 | 0.10 | 0.42 | 0.55 | 1.69 | 3.00 |
| 13 | 0.31 | 0.22 | 0.01 | 0.02 | <0.01 | 0.05 | 0.10 | 0.08 | 0.14 | 0.19 | 0.69 | 1.06 | 2.88 | 5.88 |
| 12 | 0.66 | 0.35 | 0.01 | 0.02 | | 0.05 | 0.14 | 0.14 | 0.28 | 0.44 | 1.05 | 1.50 | 4.64 | 10.51 |
| 11 | 0.72 | 0.45 | 0.14 | 0.07 | 0.06 | 0.07 | 0.22 | 0.22 | 0.42 | 0.68 | 1.30 | 1.75 | 6.11 | 16.63 |
| 10 | 1.14 | 0.57 | 0.21 | 0.08 | 0.02 | 0.12 | 0.19 | 0.34 | 0.55 | 0.87 | 1.40 | 2.35 | 7.84 | 24.47 |
| 9 | 1.42 | 0.68 | 0.36 | 0.17 | 0.05 | 0.22 | 0.39 | 0.44 | 0.65 | 1.06 | 1.30 | 2.23 | 8.97 | 33.44 |
| 8 | 1.59 | 0.67 | 0.60 | 0.27 | 0.17 | 0.20 | 0.42 | 0.77 | 1.03 | 1.18 | 1.56 | 2.40 | 10.85 | 44.29 |
| 7 | 1.70 | 1.10 | 0.53 | 0.13 | 0.19 | 0.31 | 0.63 | 1.39 | 1.34 | 1.15 | 1.63 | 2.05 | 12.14 | 56.43 |
| 6 | 1.61 | 1.15 | 0.58 | 0.28 | 0.15 | 0.47 | 0.66 | 1.36 | 1.31 | 1.02 | 1.25 | 1.71 | 11.55 | 67.98 |
| 5 | 1.24 | 1.25 | 0.79 | 0.31 | 0.26 | 0.49 | 0.93 | 1.41 | 1.24 | 0.92 | 1.48 | 1.39 | 11.70 | 79.68 |
| 4 | 0.79 | 0.73 | 0.78 | 0.31 | 0.39 | 0.44 | 1.05 | 1.33 | 1.17 | 0.99 | 1.03 | 1.25 | 10.25 | 89.93 |
| 3 | 0.53 | 0.53 | 0.41 | 0.44 | 0.44 | 0.42 | 0.70 | 0.74 | 0.59 | 0.75 | 0.62 | 0.62 | 6.81 | 96.74 |
| 2 | 0.11 | 0.17 | 0.18 | 0.25 | 0.28 | 0.38 | 0.25 | 0.33 | 0.31 | 0.18 | 0.16 | 0.20 | 2.79 | 99.53 |
| 1 | 0.01 | 0.02 | 0.02 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 | 0.02 | 0.05 | 0.04 | 0.03 | 0.45 | 99.98 |
| 0 | | | | | 0.02 | | | | | | | | 0.02 | |

1hr Wind Direction at 10m (°T From)

**Figure 2-123 Percentage Occurrence of Wind Speed and 30° Direction Bin - January**

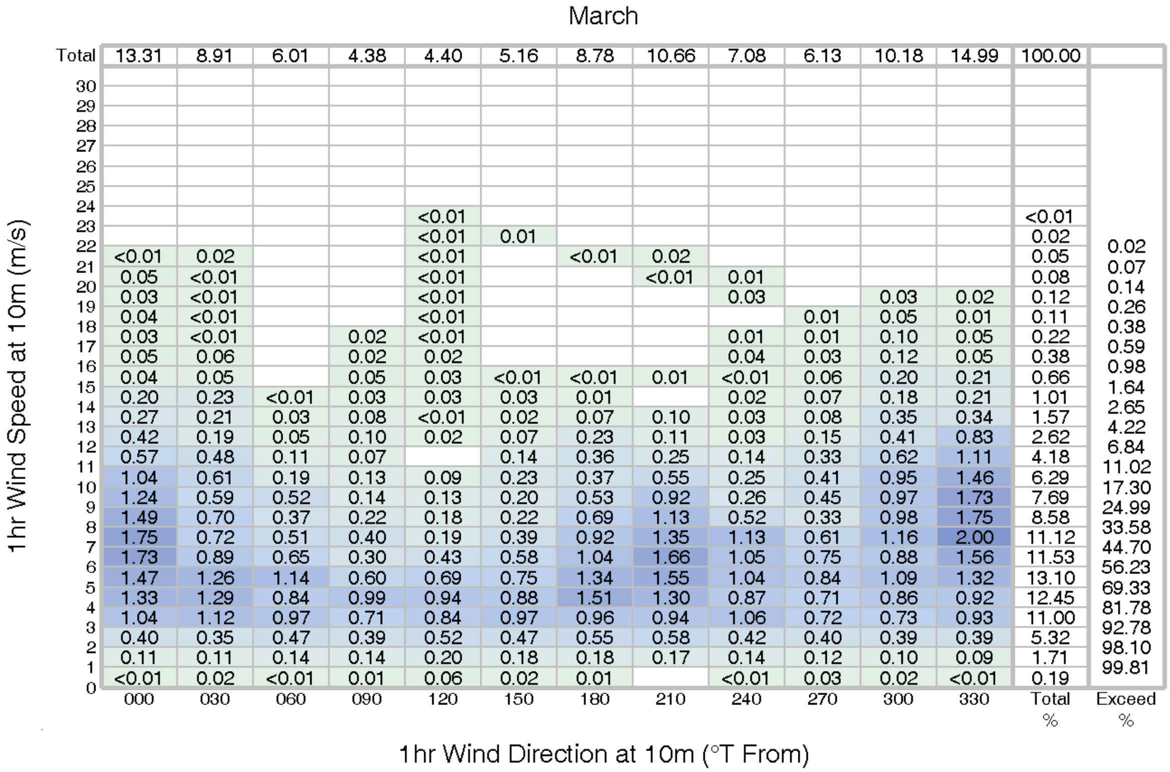


February

| 1hr Wind Speed at 10m (m/s) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 13.90 | 9.37 | 5.67 | 3.77 | 2.79 | 3.36 | 6.10 | 9.23 | 7.76 | 7.47 | 12.15 | 18.42 | 100.00 | |
| 30 | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | <0.01 | | <0.01 | |
| 19 | | | | | | | | | | | <0.01 | <0.01 | 0.01 | 0.02 |
| 18 | | <0.01 | | | | | | | | | 0.03 | 0.10 | 0.13 | 0.15 |
| 17 | 0.01 | 0.01 | | | | | | | | | 0.04 | 0.10 | 0.16 | 0.31 |
| 16 | 0.03 | 0.05 | | | | | | | | | 0.08 | 0.11 | 0.27 | 0.57 |
| 15 | 0.22 | 0.05 | 0.01 | | | 0.02 | 0.01 | | <0.01 | 0.03 | 0.14 | 0.20 | 0.69 | 1.26 |
| 14 | 0.26 | 0.15 | 0.06 | <0.01 | | 0.01 | 0.03 | <0.01 | 0.05 | 0.08 | 0.31 | 0.40 | 1.34 | 2.60 |
| 13 | 0.26 | 0.24 | 0.07 | <0.01 | | 0.02 | 0.06 | 0.08 | 0.03 | 0.10 | 0.54 | 0.96 | 2.35 | 4.95 |
| 12 | 0.49 | 0.35 | 0.22 | 0.05 | | 0.03 | 0.12 | 0.06 | 0.06 | 0.19 | 0.83 | 1.41 | 3.80 | 8.76 |
| 11 | 0.76 | 0.48 | 0.19 | 0.06 | 0.02 | 0.10 | 0.14 | 0.22 | 0.14 | 0.27 | 0.79 | 1.84 | 5.01 | 13.76 |
| 10 | 1.18 | 0.62 | 0.23 | 0.06 | 0.07 | 0.11 | 0.29 | 0.60 | 0.40 | 0.48 | 0.90 | 1.71 | 6.64 | 20.41 |
| 9 | 1.47 | 0.83 | 0.24 | 0.12 | 0.05 | 0.05 | 0.36 | 0.77 | 0.52 | 0.53 | 1.13 | 1.87 | 7.94 | 28.34 |
| 8 | 1.97 | 1.04 | 0.27 | 0.15 | 0.24 | 0.14 | 0.52 | 1.12 | 0.71 | 0.78 | 1.19 | 2.24 | 10.36 | 38.70 |
| 7 | 2.14 | 1.14 | 0.61 | 0.32 | 0.21 | 0.30 | 0.62 | 1.22 | 0.97 | 0.83 | 1.09 | 2.18 | 11.63 | 50.33 |
| 6 | 1.63 | 0.95 | 0.95 | 0.44 | 0.32 | 0.46 | 0.75 | 1.29 | 0.94 | 0.82 | 1.21 | 1.85 | 11.59 | 61.93 |
| 5 | 1.45 | 1.13 | 0.89 | 0.54 | 0.40 | 0.40 | 0.99 | 1.56 | 1.29 | 1.08 | 1.27 | 1.45 | 12.45 | 74.38 |
| 4 | 0.88 | 1.07 | 0.74 | 0.53 | 0.37 | 0.52 | 0.90 | 1.16 | 1.34 | 1.02 | 1.32 | 1.11 | 10.95 | 85.33 |
| 3 | 0.76 | 0.85 | 0.78 | 0.77 | 0.61 | 0.61 | 0.73 | 0.75 | 0.59 | 0.71 | 0.69 | 0.56 | 8.41 | 93.74 |
| 2 | 0.36 | 0.33 | 0.33 | 0.58 | 0.36 | 0.42 | 0.37 | 0.27 | 0.46 | 0.39 | 0.38 | 0.26 | 4.52 | 98.26 |
| 1 | 0.05 | 0.09 | 0.07 | 0.13 | 0.15 | 0.16 | 0.21 | 0.12 | 0.26 | 0.16 | 0.20 | 0.09 | 1.68 | 99.94 |
| 0 | <0.01 | <0.01 | | | | <0.01 | 0.01 | 0.01 | <0.01 | 0.01 | | | 0.06 | |

1hr Wind Direction at 10m (°T From)

**Figure 2-124 Percentage Occurrence of Wind Speed and 30° Direction Bin - February**

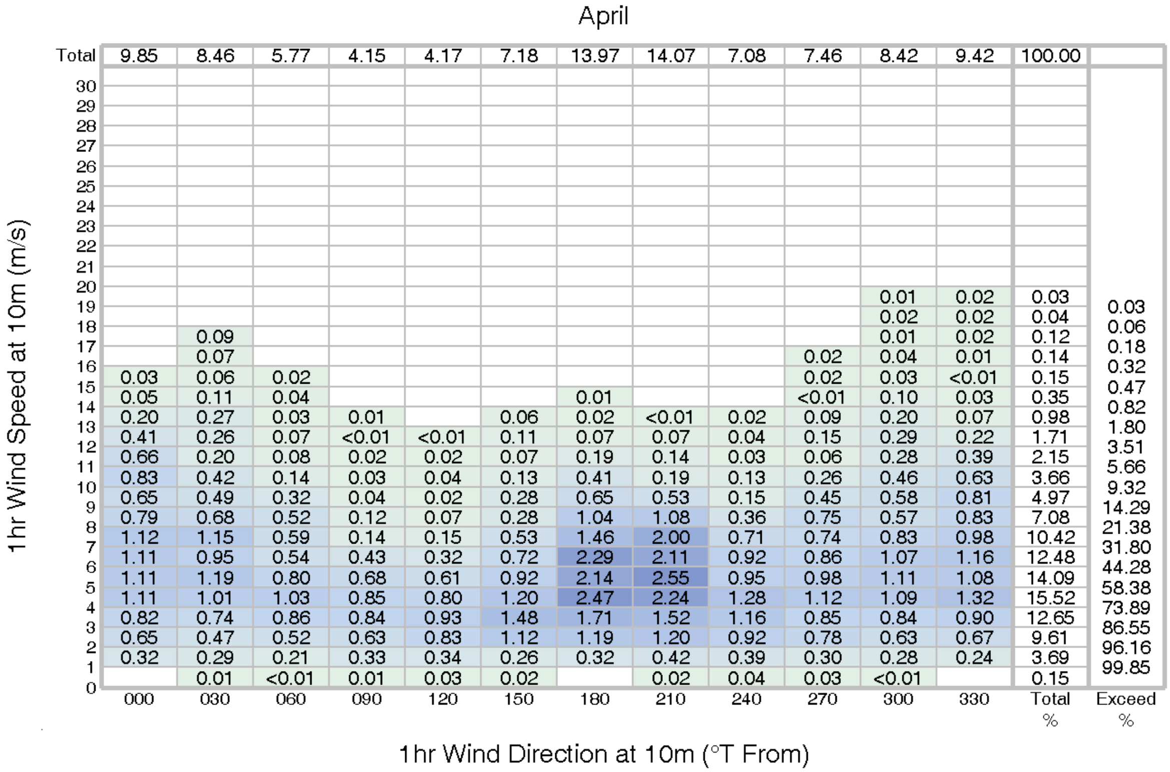


March

| 1hr Wind Speed at 10m (m/s) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 13.31 | 8.91 | 6.01 | 4.38 | 4.40 | 5.16 | 8.78 | 10.66 | 7.08 | 6.13 | 10.18 | 14.99 | 100.00 | |
| 30 | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | |
| 23 | | | | | <0.01 | | | | | | | | <0.01 | |
| 22 | | | | | <0.01 | 0.01 | | | | | | | 0.02 | 0.02 |
| 21 | <0.01 | 0.02 | | | <0.01 | | <0.01 | 0.02 | | | | | 0.05 | 0.07 |
| 20 | 0.05 | <0.01 | | | <0.01 | | | <0.01 | 0.01 | | | | 0.08 | 0.14 |
| 19 | 0.03 | <0.01 | | | <0.01 | | | | 0.03 | | 0.03 | 0.02 | 0.12 | 0.26 |
| 18 | 0.04 | <0.01 | | | <0.01 | | | | | 0.01 | 0.05 | 0.01 | 0.11 | 0.38 |
| 17 | 0.03 | <0.01 | | 0.02 | <0.01 | | | | 0.01 | 0.01 | 0.10 | 0.05 | 0.22 | 0.59 |
| 16 | 0.05 | 0.06 | | 0.02 | 0.02 | | | | 0.04 | 0.03 | 0.12 | 0.05 | 0.38 | 0.98 |
| 15 | 0.04 | 0.05 | | 0.05 | 0.03 | <0.01 | <0.01 | 0.01 | <0.01 | 0.06 | 0.20 | 0.21 | 0.66 | 1.64 |
| 14 | 0.20 | 0.23 | <0.01 | 0.03 | 0.03 | 0.03 | 0.01 | | 0.02 | 0.07 | 0.18 | 0.21 | 1.01 | 2.65 |
| 13 | 0.27 | 0.21 | 0.03 | 0.08 | <0.01 | 0.02 | 0.07 | 0.10 | 0.03 | 0.08 | 0.35 | 0.34 | 1.57 | 4.22 |
| 12 | 0.42 | 0.19 | 0.05 | 0.10 | 0.02 | 0.07 | 0.23 | 0.11 | 0.03 | 0.15 | 0.41 | 0.83 | 2.62 | 6.84 |
| 11 | 0.57 | 0.48 | 0.11 | 0.07 | | 0.14 | 0.36 | 0.25 | 0.14 | 0.33 | 0.62 | 1.11 | 4.18 | 11.02 |
| 10 | 1.04 | 0.61 | 0.19 | 0.13 | 0.09 | 0.23 | 0.37 | 0.55 | 0.25 | 0.41 | 0.95 | 1.46 | 6.29 | 17.30 |
| 9 | 1.24 | 0.59 | 0.52 | 0.14 | 0.13 | 0.20 | 0.53 | 0.92 | 0.26 | 0.45 | 0.97 | 1.73 | 7.69 | 24.99 |
| 8 | 1.49 | 0.70 | 0.37 | 0.22 | 0.18 | 0.22 | 0.69 | 1.13 | 0.52 | 0.33 | 0.98 | 1.75 | 8.58 | 33.58 |
| 7 | 1.75 | 0.72 | 0.51 | 0.40 | 0.19 | 0.39 | 0.92 | 1.35 | 1.13 | 0.61 | 1.16 | 2.00 | 11.12 | 44.70 |
| 6 | 1.73 | 0.89 | 0.65 | 0.30 | 0.43 | 0.58 | 1.04 | 1.66 | 1.05 | 0.75 | 0.88 | 1.56 | 11.53 | 56.23 |
| 5 | 1.47 | 1.26 | 1.14 | 0.60 | 0.69 | 0.75 | 1.34 | 1.55 | 1.04 | 0.84 | 1.09 | 1.32 | 13.10 | 69.33 |
| 4 | 1.33 | 1.29 | 0.84 | 0.99 | 0.94 | 0.88 | 1.51 | 1.30 | 0.87 | 0.71 | 0.86 | 0.92 | 12.45 | 81.78 |
| 3 | 1.04 | 1.12 | 0.97 | 0.71 | 0.84 | 0.97 | 0.96 | 0.94 | 1.06 | 0.72 | 0.73 | 0.93 | 11.00 | 92.78 |
| 2 | 0.40 | 0.35 | 0.47 | 0.39 | 0.52 | 0.47 | 0.55 | 0.58 | 0.42 | 0.40 | 0.39 | 0.39 | 5.32 | 98.10 |
| 1 | 0.11 | 0.11 | 0.14 | 0.14 | 0.20 | 0.18 | 0.18 | 0.17 | 0.14 | 0.12 | 0.10 | 0.09 | 1.71 | 99.81 |
| 0 | <0.01 | 0.02 | <0.01 | 0.01 | 0.06 | 0.02 | 0.01 | | <0.01 | 0.03 | 0.02 | <0.01 | 0.19 | |

1hr Wind Direction at 10m (°T From)

**Figure 2-125 Percentage Occurrence of Wind Speed and 30° Direction Bin - March**

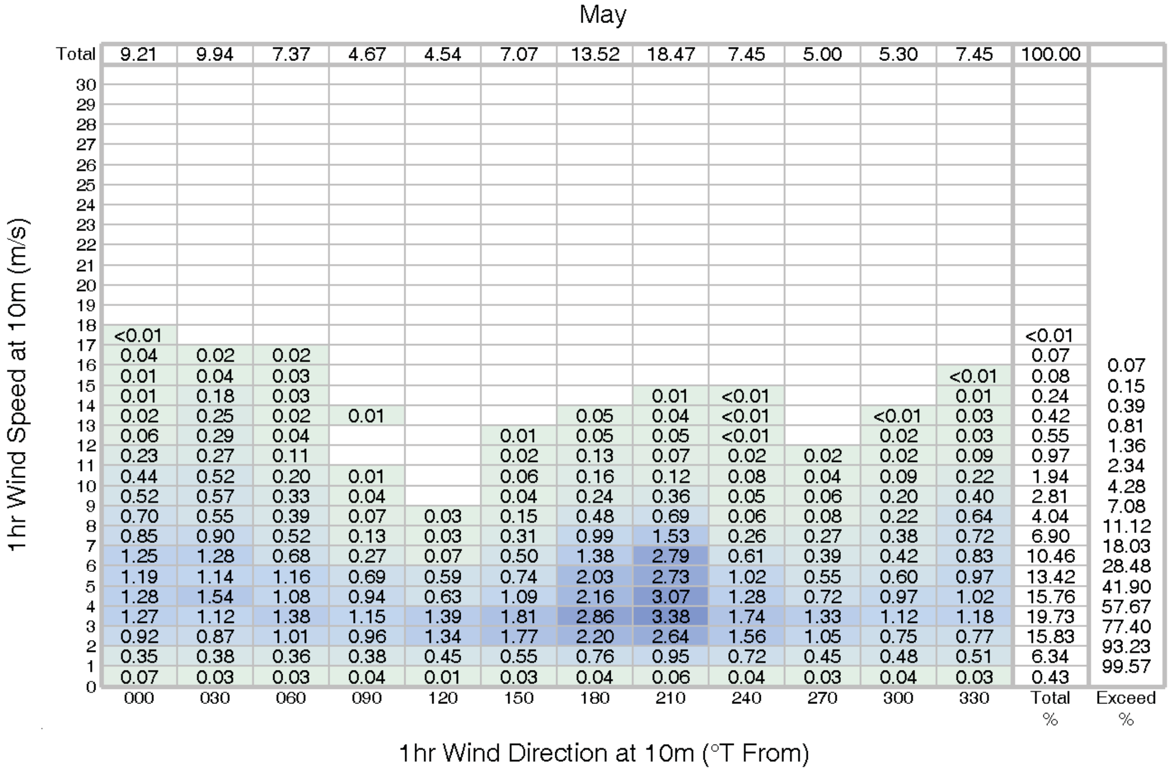


April

| 1hr Wind Speed at 10m (m/s) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 9.85 | 8.46 | 5.77 | 4.15 | 4.17 | 7.18 | 13.97 | 14.07 | 7.08 | 7.46 | 8.42 | 9.42 | 100.00 | |
| 30 | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | 0.01 | 0.02 | 0.03 | 0.03 |
| 18 | | | | | | | | | | | 0.02 | 0.02 | 0.04 | 0.06 |
| 17 | | 0.09 | | | | | | | | | 0.01 | 0.02 | 0.12 | 0.18 |
| 16 | | 0.07 | | | | | | | | 0.02 | 0.04 | 0.01 | 0.14 | 0.32 |
| 15 | 0.03 | 0.06 | 0.02 | | | | | | | 0.02 | 0.03 | <0.01 | 0.15 | 0.47 |
| 14 | 0.05 | 0.11 | 0.04 | | | | 0.01 | | | <0.01 | 0.10 | 0.03 | 0.35 | 0.82 |
| 13 | 0.20 | 0.27 | 0.03 | 0.01 | | 0.06 | 0.02 | <0.01 | 0.02 | 0.09 | 0.20 | 0.07 | 0.98 | 1.80 |
| 12 | 0.41 | 0.26 | 0.07 | <0.01 | <0.01 | 0.11 | 0.07 | 0.07 | 0.04 | 0.15 | 0.29 | 0.22 | 1.71 | 3.51 |
| 11 | 0.66 | 0.20 | 0.08 | 0.02 | 0.02 | 0.07 | 0.19 | 0.14 | 0.03 | 0.06 | 0.28 | 0.39 | 2.15 | 5.66 |
| 10 | 0.83 | 0.42 | 0.14 | 0.03 | 0.04 | 0.13 | 0.41 | 0.19 | 0.13 | 0.26 | 0.46 | 0.63 | 3.66 | 9.32 |
| 9 | 0.65 | 0.49 | 0.32 | 0.04 | 0.02 | 0.28 | 0.65 | 0.53 | 0.15 | 0.45 | 0.58 | 0.81 | 4.97 | 14.29 |
| 8 | 0.79 | 0.68 | 0.52 | 0.12 | 0.07 | 0.28 | 1.04 | 1.08 | 0.36 | 0.75 | 0.57 | 0.83 | 7.08 | 21.38 |
| 7 | 1.12 | 1.15 | 0.59 | 0.14 | 0.15 | 0.53 | 1.46 | 2.00 | 0.71 | 0.74 | 0.83 | 0.98 | 10.42 | 31.80 |
| 6 | 1.11 | 0.95 | 0.54 | 0.43 | 0.32 | 0.72 | 2.29 | 2.11 | 0.92 | 0.86 | 1.07 | 1.16 | 12.48 | 44.28 |
| 5 | 1.11 | 1.19 | 0.80 | 0.68 | 0.61 | 0.92 | 2.14 | 2.55 | 0.95 | 0.98 | 1.11 | 1.08 | 14.09 | 58.38 |
| 4 | 1.11 | 1.01 | 1.03 | 0.85 | 0.80 | 1.20 | 2.47 | 2.24 | 1.28 | 1.12 | 1.09 | 1.32 | 15.52 | 73.89 |
| 3 | 0.82 | 0.74 | 0.86 | 0.84 | 0.93 | 1.48 | 1.71 | 1.52 | 1.16 | 0.85 | 0.84 | 0.90 | 12.65 | 86.55 |
| 2 | 0.65 | 0.47 | 0.52 | 0.63 | 0.83 | 1.12 | 1.19 | 1.20 | 0.92 | 0.78 | 0.63 | 0.67 | 9.61 | 96.16 |
| 1 | 0.32 | 0.29 | 0.21 | 0.33 | 0.34 | 0.26 | 0.32 | 0.42 | 0.39 | 0.30 | 0.28 | 0.24 | 3.69 | 99.85 |
| 0 | | 0.01 | <0.01 | 0.01 | 0.03 | 0.02 | | 0.02 | 0.04 | 0.03 | <0.01 | | 0.15 | |

1hr Wind Direction at 10m (°T From)

**Figure 2-126 Percentage Occurrence of Wind Speed and 30° Direction Bin - April**

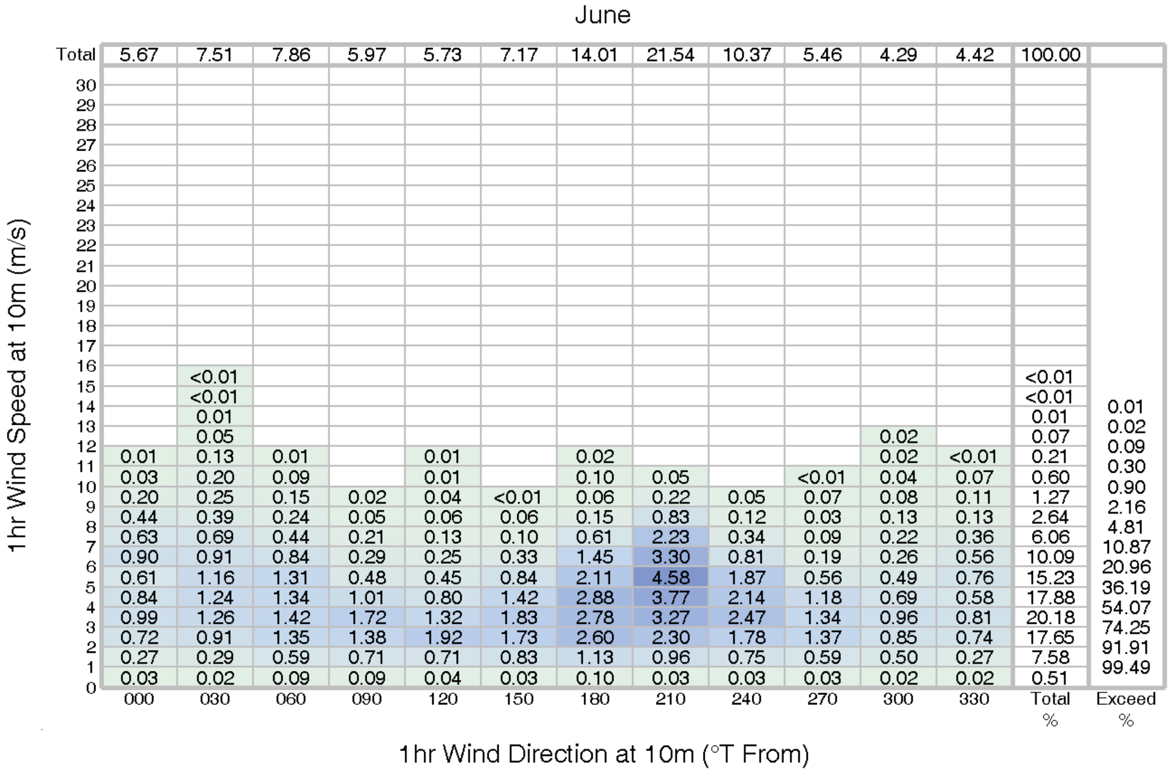


May

| 1hr Wind Speed at 10m (m/s) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 9.21 | 9.94 | 7.37 | 4.67 | 4.54 | 7.07 | 13.52 | 18.47 | 7.45 | 5.00 | 5.30 | 7.45 | 100.00 | |
| 29–30 | | | | | | | | | | | | | | |
| 28–29 | | | | | | | | | | | | | | |
| 27–28 | | | | | | | | | | | | | | |
| 26–27 | | | | | | | | | | | | | | |
| 25–26 | | | | | | | | | | | | | | |
| 24–25 | | | | | | | | | | | | | | |
| 23–24 | | | | | | | | | | | | | | |
| 22–23 | | | | | | | | | | | | | | |
| 21–22 | | | | | | | | | | | | | | |
| 20–21 | | | | | | | | | | | | | | |
| 19–20 | | | | | | | | | | | | | | |
| 18–19 | | | | | | | | | | | | | | |
| 17–18 | <0.01 | | | | | | | | | | | | <0.01 | |
| 16–17 | 0.04 | 0.02 | 0.02 | | | | | | | | | | 0.07 | 0.07 |
| 15–16 | 0.01 | 0.04 | 0.03 | | | | | | | | | <0.01 | 0.08 | 0.15 |
| 14–15 | 0.01 | 0.18 | 0.03 | | | | | 0.01 | <0.01 | | | 0.01 | 0.24 | 0.39 |
| 13–14 | 0.02 | 0.25 | 0.02 | 0.01 | | | 0.05 | 0.04 | <0.01 | | <0.01 | 0.03 | 0.42 | 0.81 |
| 12–13 | 0.06 | 0.29 | 0.04 | | | 0.01 | 0.05 | 0.05 | <0.01 | | 0.02 | 0.03 | 0.55 | 1.36 |
| 11–12 | 0.23 | 0.27 | 0.11 | | | 0.02 | 0.13 | 0.07 | 0.02 | 0.02 | 0.02 | 0.09 | 0.97 | 2.34 |
| 10–11 | 0.44 | 0.52 | 0.20 | 0.01 | | 0.06 | 0.16 | 0.12 | 0.08 | 0.04 | 0.09 | 0.22 | 1.94 | 4.28 |
| 9–10 | 0.52 | 0.57 | 0.33 | 0.04 | | 0.04 | 0.24 | 0.36 | 0.05 | 0.06 | 0.20 | 0.40 | 2.81 | 7.08 |
| 8–9 | 0.70 | 0.55 | 0.39 | 0.07 | 0.03 | 0.15 | 0.48 | 0.69 | 0.06 | 0.08 | 0.22 | 0.64 | 4.04 | 11.12 |
| 7–8 | 0.85 | 0.90 | 0.52 | 0.13 | 0.03 | 0.31 | 0.99 | 1.53 | 0.26 | 0.27 | 0.38 | 0.72 | 6.90 | 18.03 |
| 6–7 | 1.25 | 1.28 | 0.68 | 0.27 | 0.07 | 0.50 | 1.38 | 2.79 | 0.61 | 0.39 | 0.42 | 0.83 | 10.46 | 28.48 |
| 5–6 | 1.19 | 1.14 | 1.16 | 0.69 | 0.59 | 0.74 | 2.03 | 2.73 | 1.02 | 0.55 | 0.60 | 0.97 | 13.42 | 41.90 |
| 4–5 | 1.28 | 1.54 | 1.08 | 0.94 | 0.63 | 1.09 | 2.16 | 3.07 | 1.28 | 0.72 | 0.97 | 1.02 | 15.76 | 57.67 |
| 3–4 | 1.27 | 1.12 | 1.38 | 1.15 | 1.39 | 1.81 | 2.86 | 3.38 | 1.74 | 1.33 | 1.12 | 1.18 | 19.73 | 77.40 |
| 2–3 | 0.92 | 0.87 | 1.01 | 0.96 | 1.34 | 1.77 | 2.20 | 2.64 | 1.56 | 1.05 | 0.75 | 0.77 | 15.83 | 93.23 |
| 1–2 | 0.35 | 0.38 | 0.36 | 0.38 | 0.45 | 0.55 | 0.76 | 0.95 | 0.72 | 0.45 | 0.48 | 0.51 | 6.34 | 99.57 |
| 0–1 | 0.07 | 0.03 | 0.03 | 0.04 | 0.01 | 0.03 | 0.04 | 0.06 | 0.04 | 0.03 | 0.04 | 0.03 | 0.43 | |

1hr Wind Direction at 10m (°T From)

**Figure 2-127 Percentage Occurrence of Wind Speed and 30° Direction Bin - May**

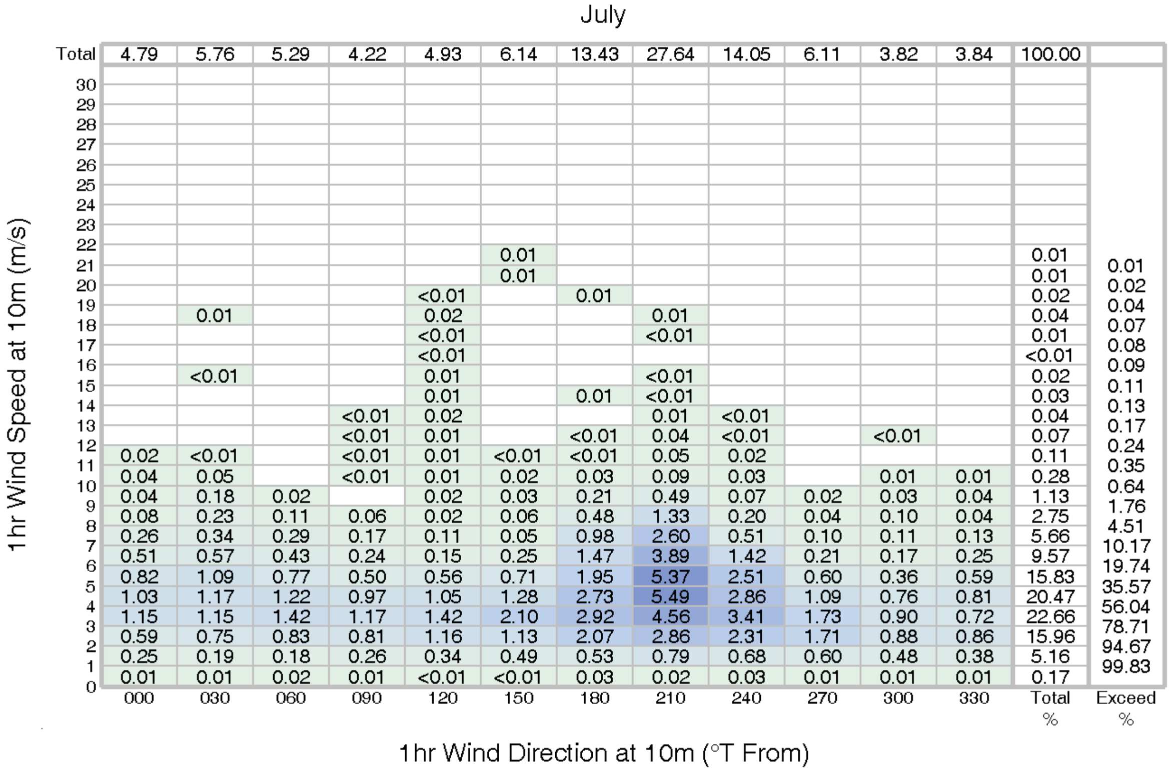


June

| 1hr Wind Speed at 10m (m/s) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 5.67 | 7.51 | 7.86 | 5.97 | 5.73 | 7.17 | 14.01 | 21.54 | 10.37 | 5.46 | 4.29 | 4.42 | 100.00 | |
| 29–30 | | | | | | | | | | | | | | |
| 28–29 | | | | | | | | | | | | | | |
| 27–28 | | | | | | | | | | | | | | |
| 26–27 | | | | | | | | | | | | | | |
| 25–26 | | | | | | | | | | | | | | |
| 24–25 | | | | | | | | | | | | | | |
| 23–24 | | | | | | | | | | | | | | |
| 22–23 | | | | | | | | | | | | | | |
| 21–22 | | | | | | | | | | | | | | |
| 20–21 | | | | | | | | | | | | | | |
| 19–20 | | | | | | | | | | | | | | |
| 18–19 | | | | | | | | | | | | | | |
| 17–18 | | | | | | | | | | | | | | |
| 16–17 | | | | | | | | | | | | | | |
| 15–16 | | <0.01 | | | | | | | | | | | <0.01 | |
| 14–15 | | <0.01 | | | | | | | | | | | <0.01 | 0.01 |
| 13–14 | | 0.01 | | | | | | | | | | | 0.01 | 0.02 |
| 12–13 | | 0.05 | | | | | | | | | 0.02 | | 0.07 | 0.09 |
| 11–12 | 0.01 | 0.13 | 0.01 | | 0.01 | | 0.02 | | | | 0.02 | <0.01 | 0.21 | 0.30 |
| 10–11 | 0.03 | 0.20 | 0.09 | | 0.01 | | 0.10 | 0.05 | | <0.01 | 0.04 | 0.07 | 0.60 | 0.90 |
| 9–10 | 0.20 | 0.25 | 0.15 | 0.02 | 0.04 | <0.01 | 0.06 | 0.22 | 0.05 | 0.07 | 0.08 | 0.11 | 1.27 | 2.16 |
| 8–9 | 0.44 | 0.39 | 0.24 | 0.05 | 0.06 | 0.06 | 0.15 | 0.83 | 0.12 | 0.03 | 0.13 | 0.13 | 2.64 | 4.81 |
| 7–8 | 0.63 | 0.69 | 0.44 | 0.21 | 0.13 | 0.10 | 0.61 | 2.23 | 0.34 | 0.09 | 0.22 | 0.36 | 6.06 | 10.87 |
| 6–7 | 0.90 | 0.91 | 0.84 | 0.29 | 0.25 | 0.33 | 1.45 | 3.30 | 0.81 | 0.19 | 0.26 | 0.56 | 10.09 | 20.96 |
| 5–6 | 0.61 | 1.16 | 1.31 | 0.48 | 0.45 | 0.84 | 2.11 | 4.58 | 1.87 | 0.56 | 0.49 | 0.76 | 15.23 | 36.19 |
| 4–5 | 0.84 | 1.24 | 1.34 | 1.01 | 0.80 | 1.42 | 2.88 | 3.77 | 2.14 | 1.18 | 0.69 | 0.58 | 17.88 | 54.07 |
| 3–4 | 0.99 | 1.26 | 1.42 | 1.72 | 1.32 | 1.83 | 2.78 | 3.27 | 2.47 | 1.34 | 0.96 | 0.81 | 20.18 | 74.25 |
| 2–3 | 0.72 | 0.91 | 1.35 | 1.38 | 1.92 | 1.73 | 2.60 | 2.30 | 1.78 | 1.37 | 0.85 | 0.74 | 17.65 | 91.91 |
| 1–2 | 0.27 | 0.29 | 0.59 | 0.71 | 0.71 | 0.83 | 1.13 | 0.96 | 0.75 | 0.59 | 0.50 | 0.27 | 7.58 | 99.49 |
| 0–1 | 0.03 | 0.02 | 0.09 | 0.09 | 0.04 | 0.03 | 0.10 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.51 | |

1hr Wind Direction at 10m (°T From)

**Figure 2-128 Percentage Occurrence of Wind Speed and 30° Direction Bin - June**

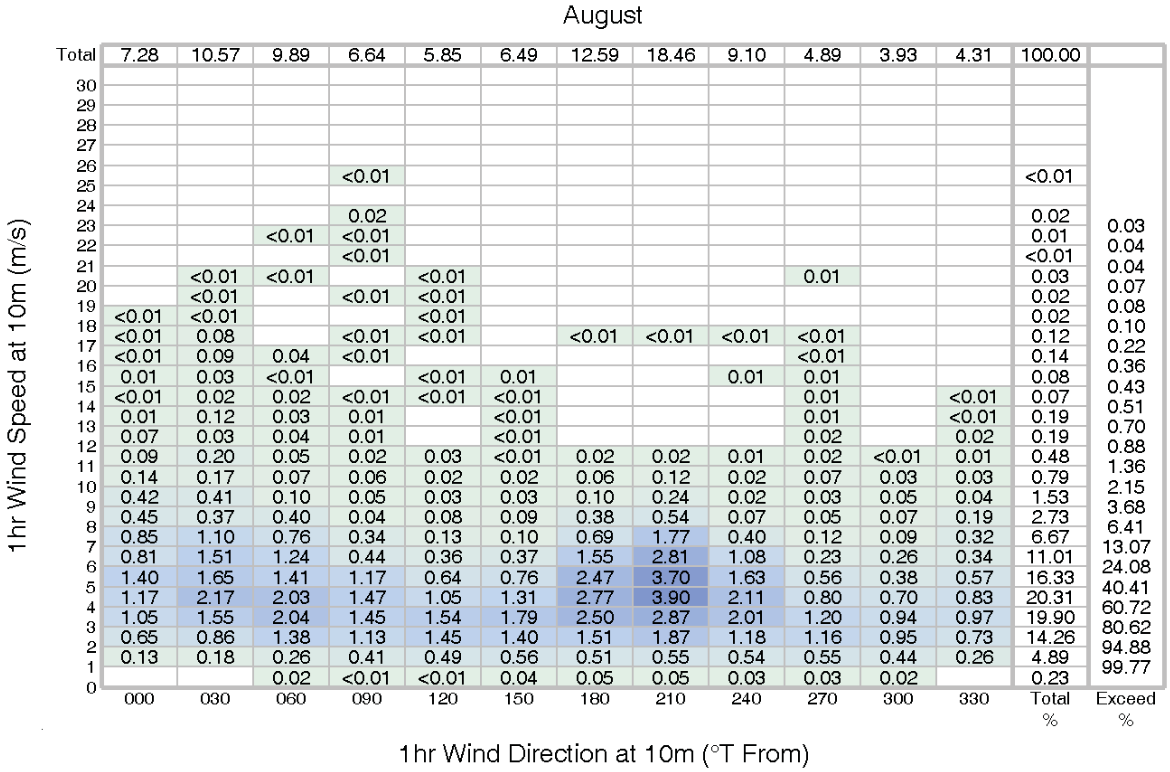


July

| 1hr Wind Speed at 10m (m/s) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 4.79 | 5.76 | 5.29 | 4.22 | 4.93 | 6.14 | 13.43 | 27.64 | 14.05 | 6.11 | 3.82 | 3.84 | 100.00 | |
| 30 | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | |
| 21 | | | | | | 0.01 | | | | | | | 0.01 | 0.01 |
| 20 | | | | | | 0.01 | | | | | | | 0.01 | 0.02 |
| 19 | | | | | <0.01 | | 0.01 | | | | | | 0.02 | 0.04 |
| 18 | | 0.01 | | | 0.02 | | | 0.01 | | | | | 0.04 | 0.07 |
| 17 | | | | | <0.01 | | | <0.01 | | | | | 0.01 | 0.08 |
| 16 | | | | | <0.01 | | | | | | | | <0.01 | 0.09 |
| 15 | | <0.01 | | | 0.01 | | | <0.01 | | | | | 0.02 | 0.11 |
| 14 | | | | | 0.01 | | 0.01 | <0.01 | | | | | 0.03 | 0.13 |
| 13 | | | | <0.01 | 0.02 | | | 0.01 | <0.01 | | | | 0.04 | 0.17 |
| 12 | | | | <0.01 | 0.01 | | <0.01 | 0.04 | <0.01 | | <0.01 | | 0.07 | 0.24 |
| 11 | 0.02 | <0.01 | | <0.01 | 0.01 | <0.01 | <0.01 | 0.05 | 0.02 | | | | 0.11 | 0.35 |
| 10 | 0.04 | 0.05 | | <0.01 | 0.01 | 0.02 | 0.03 | 0.09 | 0.03 | | 0.01 | 0.01 | 0.28 | 0.64 |
| 9 | 0.04 | 0.18 | 0.02 | | 0.02 | 0.03 | 0.21 | 0.49 | 0.07 | 0.02 | 0.03 | 0.04 | 1.13 | 1.76 |
| 8 | 0.08 | 0.23 | 0.11 | 0.06 | 0.02 | 0.06 | 0.48 | 1.33 | 0.20 | 0.04 | 0.10 | 0.04 | 2.75 | 4.51 |
| 7 | 0.26 | 0.34 | 0.29 | 0.17 | 0.11 | 0.05 | 0.98 | 2.60 | 0.51 | 0.10 | 0.11 | 0.13 | 5.66 | 10.17 |
| 6 | 0.51 | 0.57 | 0.43 | 0.24 | 0.15 | 0.25 | 1.47 | 3.89 | 1.42 | 0.21 | 0.17 | 0.25 | 9.57 | 19.74 |
| 5 | 0.82 | 1.09 | 0.77 | 0.50 | 0.56 | 0.71 | 1.95 | 5.37 | 2.51 | 0.60 | 0.36 | 0.59 | 15.83 | 35.57 |
| 4 | 1.03 | 1.17 | 1.22 | 0.97 | 1.05 | 1.28 | 2.73 | 5.49 | 2.86 | 1.09 | 0.76 | 0.81 | 20.47 | 56.04 |
| 3 | 1.15 | 1.15 | 1.42 | 1.17 | 1.42 | 2.10 | 2.92 | 4.56 | 3.41 | 1.73 | 0.90 | 0.72 | 22.66 | 78.71 |
| 2 | 0.59 | 0.75 | 0.83 | 0.81 | 1.16 | 1.13 | 2.07 | 2.86 | 2.31 | 1.71 | 0.88 | 0.86 | 15.96 | 94.67 |
| 1 | 0.25 | 0.19 | 0.18 | 0.26 | 0.34 | 0.49 | 0.53 | 0.79 | 0.68 | 0.60 | 0.48 | 0.38 | 5.16 | 99.83 |
| 0 | 0.01 | 0.01 | 0.02 | 0.01 | <0.01 | <0.01 | 0.03 | 0.02 | 0.03 | 0.01 | 0.01 | 0.01 | 0.17 | |

1hr Wind Direction at 10m (°T From)

Figure 2-129 Percentage Occurrence of Wind Speed and 30° Direction Bin - July

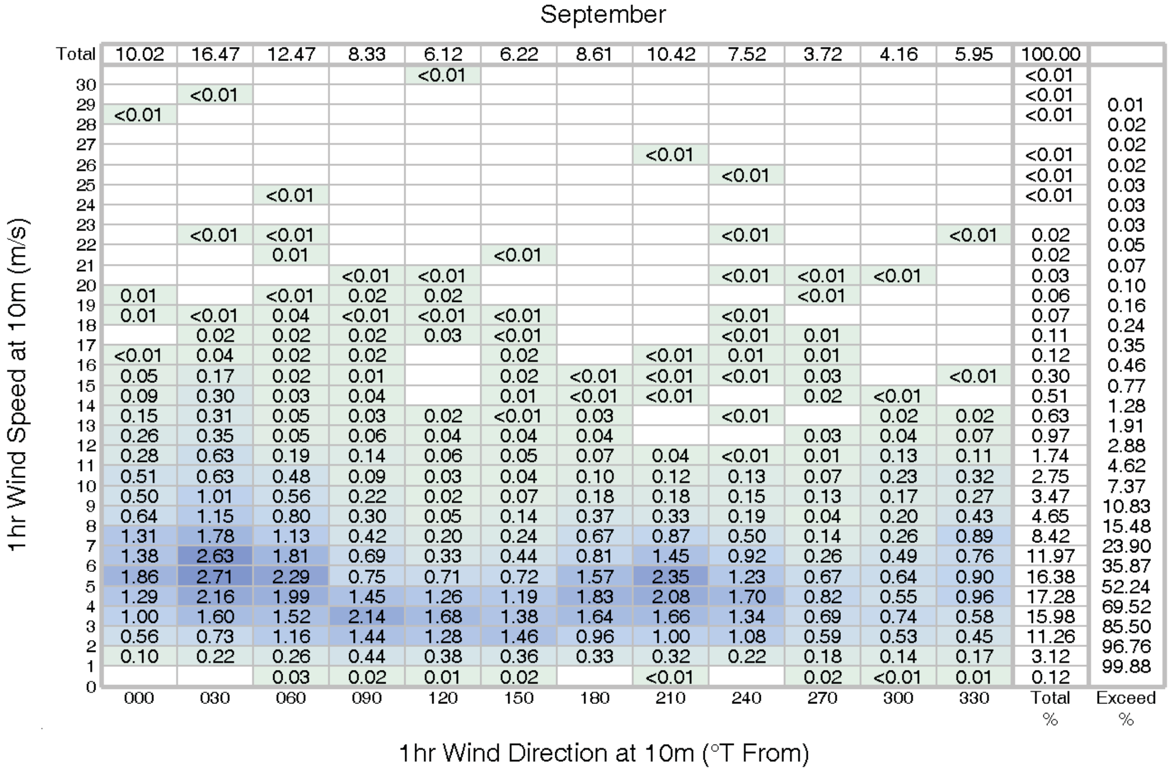


August

| 1hr Wind Speed at 10m (m/s) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 7.28 | 10.57 | 9.89 | 6.64 | 5.85 | 6.49 | 12.59 | 18.46 | 9.10 | 4.89 | 3.93 | 4.31 | 100.00 | |
| 30 | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | |
| 25 | | | | <0.01 | | | | | | | | | <0.01 | |
| 24 | | | | | | | | | | | | | | |
| 23 | | | | 0.02 | | | | | | | | | 0.02 | 0.03 |
| 22 | | | <0.01 | <0.01 | | | | | | | | | 0.01 | 0.04 |
| 21 | | | | <0.01 | | | | | | | | | <0.01 | 0.04 |
| 20 | | <0.01 | <0.01 | | <0.01 | | | | | 0.01 | | | 0.03 | 0.07 |
| 19 | | <0.01 | | <0.01 | <0.01 | | | | | | | | 0.02 | 0.08 |
| 18 | <0.01 | <0.01 | | | <0.01 | | | | | | | | 0.02 | 0.10 |
| 17 | <0.01 | 0.08 | | <0.01 | <0.01 | | <0.01 | <0.01 | <0.01 | <0.01 | | | 0.12 | 0.22 |
| 16 | <0.01 | 0.09 | 0.04 | <0.01 | | | | | | <0.01 | | | 0.14 | 0.36 |
| 15 | 0.01 | 0.03 | <0.01 | | <0.01 | 0.01 | | | 0.01 | 0.01 | | | 0.08 | 0.43 |
| 14 | <0.01 | 0.02 | 0.02 | <0.01 | <0.01 | <0.01 | | | | 0.01 | | <0.01 | 0.07 | 0.51 |
| 13 | 0.01 | 0.12 | 0.03 | 0.01 | | <0.01 | | | | 0.01 | | <0.01 | 0.19 | 0.70 |
| 12 | 0.07 | 0.03 | 0.04 | 0.01 | | <0.01 | | | | 0.02 | | 0.02 | 0.19 | 0.88 |
| 11 | 0.09 | 0.20 | 0.05 | 0.02 | 0.03 | <0.01 | 0.02 | 0.02 | 0.01 | 0.02 | <0.01 | 0.01 | 0.48 | 1.36 |
| 10 | 0.14 | 0.17 | 0.07 | 0.06 | 0.02 | 0.02 | 0.06 | 0.12 | 0.02 | 0.07 | 0.03 | 0.03 | 0.79 | 2.15 |
| 9 | 0.42 | 0.41 | 0.10 | 0.05 | 0.03 | 0.03 | 0.10 | 0.24 | 0.02 | 0.03 | 0.05 | 0.04 | 1.53 | 3.68 |
| 8 | 0.45 | 0.37 | 0.40 | 0.04 | 0.08 | 0.09 | 0.38 | 0.54 | 0.07 | 0.05 | 0.07 | 0.19 | 2.73 | 6.41 |
| 7 | 0.85 | 1.10 | 0.76 | 0.34 | 0.13 | 0.10 | 0.69 | 1.77 | 0.40 | 0.12 | 0.09 | 0.32 | 6.67 | 13.07 |
| 6 | 0.81 | 1.51 | 1.24 | 0.44 | 0.36 | 0.37 | 1.55 | 2.81 | 1.08 | 0.23 | 0.26 | 0.34 | 11.01 | 24.08 |
| 5 | 1.40 | 1.65 | 1.41 | 1.17 | 0.64 | 0.76 | 2.47 | 3.70 | 1.63 | 0.56 | 0.38 | 0.57 | 16.33 | 40.41 |
| 4 | 1.17 | 2.17 | 2.03 | 1.47 | 1.05 | 1.31 | 2.77 | 3.90 | 2.11 | 0.80 | 0.70 | 0.83 | 20.31 | 60.72 |
| 3 | 1.05 | 1.55 | 2.04 | 1.45 | 1.54 | 1.79 | 2.50 | 2.87 | 2.01 | 1.20 | 0.94 | 0.97 | 19.90 | 80.62 |
| 2 | 0.65 | 0.86 | 1.38 | 1.13 | 1.45 | 1.40 | 1.51 | 1.87 | 1.18 | 1.16 | 0.95 | 0.73 | 14.26 | 94.88 |
| 1 | 0.13 | 0.18 | 0.26 | 0.41 | 0.49 | 0.56 | 0.51 | 0.55 | 0.54 | 0.55 | 0.44 | 0.26 | 4.89 | 99.77 |
| 0 | | | 0.02 | <0.01 | <0.01 | 0.04 | 0.05 | 0.05 | 0.03 | 0.03 | 0.02 | | 0.23 | |

1hr Wind Direction at 10m (°T From)

Figure 2-130 Percentage Occurrence of Wind Speed and 30° Direction Bin - August

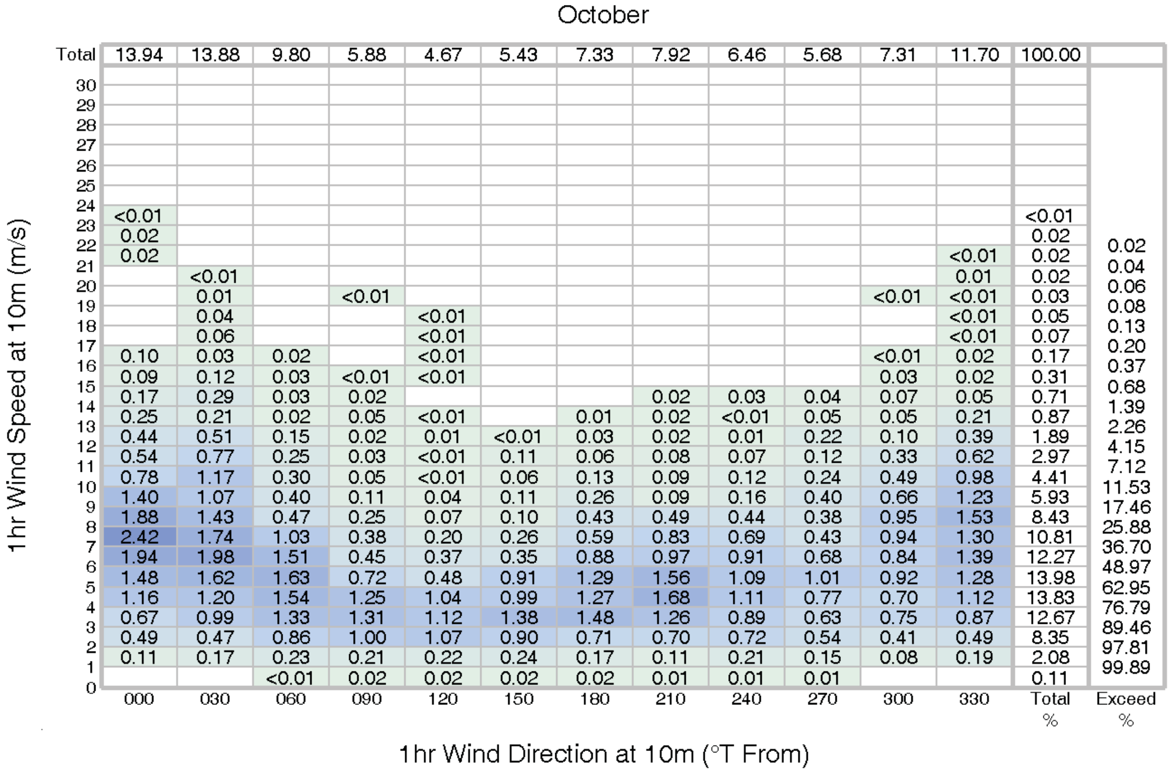


September

| 1hr Wind Speed at 10m (m/s) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 10.02 | 16.47 | 12.47 | 8.33 | 6.12 | 6.22 | 8.61 | 10.42 | 7.52 | 3.72 | 4.16 | 5.95 | 100.00 | |
| 30 | | | | | <0.01 | | | | | | | | <0.01 | |
| 29 | | <0.01 | | | | | | | | | | | <0.01 | 0.01 |
| 28 | <0.01 | | | | | | | | | | | | <0.01 | 0.02 |
| 27 | | | | | | | | | | | | | | 0.02 |
| 26 | | | | | | | | <0.01 | | | | | <0.01 | 0.02 |
| 25 | | | | | | | | | <0.01 | | | | <0.01 | 0.03 |
| 24 | | | <0.01 | | | | | | | | | | <0.01 | 0.03 |
| 23 | | | | | | | | | | | | | | 0.03 |
| 22 | | <0.01 | <0.01 | | | | | | <0.01 | | | <0.01 | 0.02 | 0.05 |
| 21 | | | 0.01 | | | <0.01 | | | | | | | 0.02 | 0.07 |
| 20 | | | | <0.01 | <0.01 | | | | <0.01 | <0.01 | <0.01 | | 0.03 | 0.10 |
| 19 | 0.01 | | <0.01 | 0.02 | 0.02 | | | | | <0.01 | | | 0.06 | 0.16 |
| 18 | 0.01 | <0.01 | 0.04 | <0.01 | <0.01 | <0.01 | | | <0.01 | | | | 0.07 | 0.24 |
| 17 | | 0.02 | 0.02 | 0.02 | 0.03 | <0.01 | | | <0.01 | 0.01 | | | 0.11 | 0.35 |
| 16 | <0.01 | 0.04 | 0.02 | 0.02 | | 0.02 | | <0.01 | 0.01 | 0.01 | | | 0.12 | 0.46 |
| 15 | 0.05 | 0.17 | 0.02 | 0.01 | | 0.02 | <0.01 | <0.01 | <0.01 | 0.03 | | <0.01 | 0.30 | 0.77 |
| 14 | 0.09 | 0.30 | 0.03 | 0.04 | | 0.01 | <0.01 | <0.01 | | 0.02 | <0.01 | | 0.51 | 1.28 |
| 13 | 0.15 | 0.31 | 0.05 | 0.03 | 0.02 | <0.01 | 0.03 | | <0.01 | | 0.02 | 0.02 | 0.63 | 1.91 |
| 12 | 0.26 | 0.35 | 0.05 | 0.06 | 0.04 | 0.04 | 0.04 | | | 0.03 | 0.04 | 0.07 | 0.97 | 2.88 |
| 11 | 0.28 | 0.63 | 0.19 | 0.14 | 0.06 | 0.05 | 0.07 | 0.04 | <0.01 | 0.01 | 0.13 | 0.11 | 1.74 | 4.62 |
| 10 | 0.51 | 0.63 | 0.48 | 0.09 | 0.03 | 0.04 | 0.10 | 0.12 | 0.13 | 0.07 | 0.23 | 0.32 | 2.75 | 7.37 |
| 9 | 0.50 | 1.01 | 0.56 | 0.22 | 0.02 | 0.07 | 0.18 | 0.18 | 0.15 | 0.13 | 0.17 | 0.27 | 3.47 | 10.83 |
| 8 | 0.64 | 1.15 | 0.80 | 0.30 | 0.05 | 0.14 | 0.37 | 0.33 | 0.19 | 0.04 | 0.20 | 0.43 | 4.65 | 15.48 |
| 7 | 1.31 | 1.78 | 1.13 | 0.42 | 0.20 | 0.24 | 0.67 | 0.87 | 0.50 | 0.14 | 0.26 | 0.89 | 8.42 | 23.90 |
| 6 | 1.38 | 2.63 | 1.81 | 0.69 | 0.33 | 0.44 | 0.81 | 1.45 | 0.92 | 0.26 | 0.49 | 0.76 | 11.97 | 35.87 |
| 5 | 1.86 | 2.71 | 2.29 | 0.75 | 0.71 | 0.72 | 1.57 | 2.35 | 1.23 | 0.67 | 0.64 | 0.90 | 16.38 | 52.24 |
| 4 | 1.29 | 2.16 | 1.99 | 1.45 | 1.26 | 1.19 | 1.83 | 2.08 | 1.70 | 0.82 | 0.55 | 0.96 | 17.28 | 69.52 |
| 3 | 1.00 | 1.60 | 1.52 | 2.14 | 1.68 | 1.38 | 1.64 | 1.66 | 1.34 | 0.69 | 0.74 | 0.58 | 15.98 | 85.50 |
| 2 | 0.56 | 0.73 | 1.16 | 1.44 | 1.28 | 1.46 | 0.96 | 1.00 | 1.08 | 0.59 | 0.53 | 0.45 | 11.26 | 96.76 |
| 1 | 0.10 | 0.22 | 0.26 | 0.44 | 0.38 | 0.36 | 0.33 | 0.32 | 0.22 | 0.18 | 0.14 | 0.17 | 3.12 | 99.88 |
| 0 | | | 0.03 | 0.02 | 0.01 | 0.02 | | <0.01 | | 0.02 | <0.01 | 0.01 | 0.12 | |

1hr Wind Direction at 10m (°T From)

Figure 2-131 Percentage Occurrence of Wind Speed and 30° Direction Bin - September

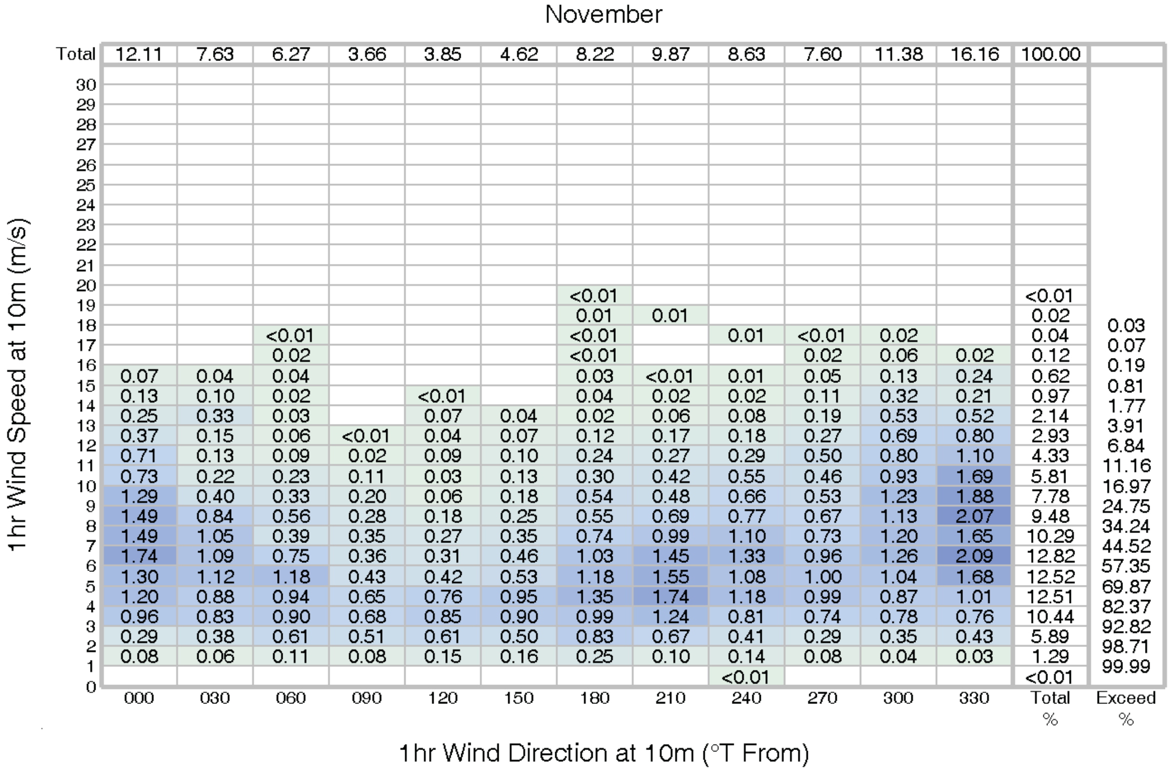


October

| 1hr Wind Speed at 10m (m/s) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 13.94 | 13.88 | 9.80 | 5.88 | 4.67 | 5.43 | 7.33 | 7.92 | 6.46 | 5.68 | 7.31 | 11.70 | 100.00 | |
| 30 | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | |
| 23 | <0.01 | | | | | | | | | | | | <0.01 | |
| 22 | 0.02 | | | | | | | | | | | | 0.02 | 0.02 |
| 21 | 0.02 | | | | | | | | | | | <0.01 | 0.02 | 0.04 |
| 20 | | <0.01 | | | | | | | | | | 0.01 | 0.02 | 0.06 |
| 19 | | 0.01 | | <0.01 | | | | | | | <0.01 | <0.01 | 0.03 | 0.08 |
| 18 | | 0.04 | | | <0.01 | | | | | | | <0.01 | 0.05 | 0.13 |
| 17 | | 0.06 | | | <0.01 | | | | | | | <0.01 | 0.07 | 0.20 |
| 16 | 0.10 | 0.03 | 0.02 | | <0.01 | | | | | | <0.01 | 0.02 | 0.17 | 0.37 |
| 15 | 0.09 | 0.12 | 0.03 | <0.01 | <0.01 | | | | | | 0.03 | 0.02 | 0.31 | 0.68 |
| 14 | 0.17 | 0.29 | 0.03 | 0.02 | | | | 0.02 | 0.03 | 0.04 | 0.07 | 0.05 | 0.71 | 1.39 |
| 13 | 0.25 | 0.21 | 0.02 | 0.05 | <0.01 | | 0.01 | 0.02 | <0.01 | 0.05 | 0.05 | 0.21 | 0.87 | 2.26 |
| 12 | 0.44 | 0.51 | 0.15 | 0.02 | 0.01 | <0.01 | 0.03 | 0.02 | 0.01 | 0.22 | 0.10 | 0.39 | 1.89 | 4.15 |
| 11 | 0.54 | 0.77 | 0.25 | 0.03 | <0.01 | 0.11 | 0.06 | 0.08 | 0.07 | 0.12 | 0.33 | 0.62 | 2.97 | 7.12 |
| 10 | 0.78 | 1.17 | 0.30 | 0.05 | <0.01 | 0.06 | 0.13 | 0.09 | 0.12 | 0.24 | 0.49 | 0.98 | 4.41 | 11.53 |
| 9 | 1.40 | 1.07 | 0.40 | 0.11 | 0.04 | 0.11 | 0.26 | 0.09 | 0.16 | 0.40 | 0.66 | 1.23 | 5.93 | 17.46 |
| 8 | 1.88 | 1.43 | 0.47 | 0.25 | 0.07 | 0.10 | 0.43 | 0.49 | 0.44 | 0.38 | 0.95 | 1.53 | 8.43 | 25.88 |
| 7 | 2.42 | 1.74 | 1.03 | 0.38 | 0.20 | 0.26 | 0.59 | 0.83 | 0.69 | 0.43 | 0.94 | 1.30 | 10.81 | 36.70 |
| 6 | 1.94 | 1.98 | 1.51 | 0.45 | 0.37 | 0.35 | 0.88 | 0.97 | 0.91 | 0.68 | 0.84 | 1.39 | 12.27 | 48.97 |
| 5 | 1.48 | 1.62 | 1.63 | 0.72 | 0.48 | 0.91 | 1.29 | 1.56 | 1.09 | 1.01 | 0.92 | 1.28 | 13.98 | 62.95 |
| 4 | 1.16 | 1.20 | 1.54 | 1.25 | 1.04 | 0.99 | 1.27 | 1.68 | 1.11 | 0.77 | 0.70 | 1.12 | 13.83 | 76.79 |
| 3 | 0.67 | 0.99 | 1.33 | 1.31 | 1.12 | 1.38 | 1.48 | 1.26 | 0.89 | 0.63 | 0.75 | 0.87 | 12.67 | 89.46 |
| 2 | 0.49 | 0.47 | 0.86 | 1.00 | 1.07 | 0.90 | 0.71 | 0.70 | 0.72 | 0.54 | 0.41 | 0.49 | 8.35 | 97.81 |
| 1 | 0.11 | 0.17 | 0.23 | 0.21 | 0.22 | 0.24 | 0.17 | 0.11 | 0.21 | 0.15 | 0.08 | 0.19 | 2.08 | 99.89 |
| 0 | | | <0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | | | 0.11 | |

1hr Wind Direction at 10m (°T From)

Figure 2-132 Percentage Occurrence of Wind Speed and 30° Direction Bin - October

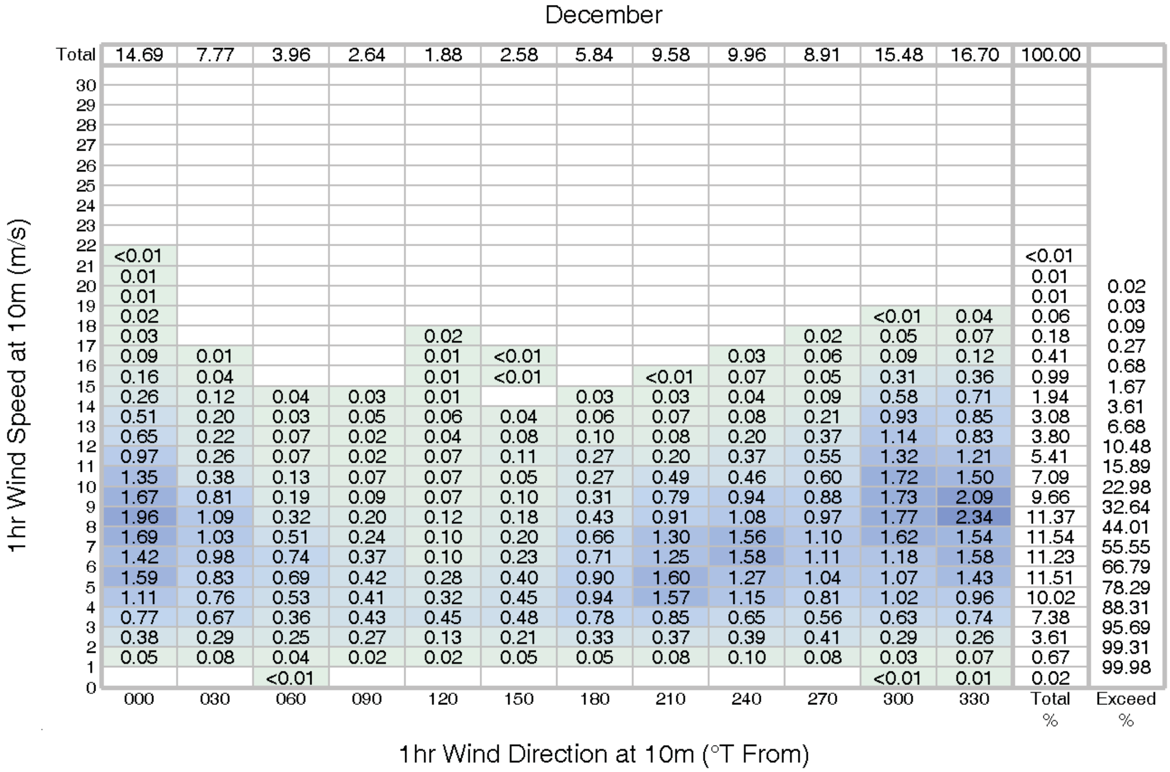


November

| 1hr Wind Speed at 10m (m/s) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 12.11 | 7.63 | 6.27 | 3.66 | 3.85 | 4.62 | 8.22 | 9.87 | 8.63 | 7.60 | 11.38 | 16.16 | 100.00 | |
| 29–30 | | | | | | | | | | | | | | |
| 28–29 | | | | | | | | | | | | | | |
| 27–28 | | | | | | | | | | | | | | |
| 26–27 | | | | | | | | | | | | | | |
| 25–26 | | | | | | | | | | | | | | |
| 24–25 | | | | | | | | | | | | | | |
| 23–24 | | | | | | | | | | | | | | |
| 22–23 | | | | | | | | | | | | | | |
| 21–22 | | | | | | | | | | | | | | |
| 20–21 | | | | | | | | | | | | | | |
| 19–20 | | | | | | | <0.01 | | | | | | <0.01 | |
| 18–19 | | | | | | | 0.01 | 0.01 | | | | | 0.02 | 0.03 |
| 17–18 | | | <0.01 | | | | <0.01 | | 0.01 | <0.01 | 0.02 | | 0.04 | 0.07 |
| 16–17 | | | 0.02 | | | | <0.01 | | | 0.02 | 0.06 | 0.02 | 0.12 | 0.19 |
| 15–16 | 0.07 | 0.04 | 0.04 | | | | 0.03 | <0.01 | 0.01 | 0.05 | 0.13 | 0.24 | 0.62 | 0.81 |
| 14–15 | 0.13 | 0.10 | 0.02 | | <0.01 | | 0.04 | 0.02 | 0.02 | 0.11 | 0.32 | 0.21 | 0.97 | 1.77 |
| 13–14 | 0.25 | 0.33 | 0.03 | | 0.07 | 0.04 | 0.02 | 0.06 | 0.08 | 0.19 | 0.53 | 0.52 | 2.14 | 3.91 |
| 12–13 | 0.37 | 0.15 | 0.06 | <0.01 | 0.04 | 0.07 | 0.12 | 0.17 | 0.18 | 0.27 | 0.69 | 0.80 | 2.93 | 6.84 |
| 11–12 | 0.71 | 0.13 | 0.09 | 0.02 | 0.09 | 0.10 | 0.24 | 0.27 | 0.29 | 0.50 | 0.80 | 1.10 | 4.33 | 11.16 |
| 10–11 | 0.73 | 0.22 | 0.23 | 0.11 | 0.03 | 0.13 | 0.30 | 0.42 | 0.55 | 0.46 | 0.93 | 1.69 | 5.81 | 16.97 |
| 9–10 | 1.29 | 0.40 | 0.33 | 0.20 | 0.06 | 0.18 | 0.54 | 0.48 | 0.66 | 0.53 | 1.23 | 1.88 | 7.78 | 24.75 |
| 8–9 | 1.49 | 0.84 | 0.56 | 0.28 | 0.18 | 0.25 | 0.55 | 0.69 | 0.77 | 0.67 | 1.13 | 2.07 | 9.48 | 34.24 |
| 7–8 | 1.49 | 1.05 | 0.39 | 0.35 | 0.27 | 0.35 | 0.74 | 0.99 | 1.10 | 0.73 | 1.20 | 1.65 | 10.29 | 44.52 |
| 6–7 | 1.74 | 1.09 | 0.75 | 0.36 | 0.31 | 0.46 | 1.03 | 1.45 | 1.33 | 0.96 | 1.26 | 2.09 | 12.82 | 57.35 |
| 5–6 | 1.30 | 1.12 | 1.18 | 0.43 | 0.42 | 0.53 | 1.18 | 1.55 | 1.08 | 1.00 | 1.04 | 1.68 | 12.52 | 69.87 |
| 4–5 | 1.20 | 0.88 | 0.94 | 0.65 | 0.76 | 0.95 | 1.35 | 1.74 | 1.18 | 0.99 | 0.87 | 1.01 | 12.51 | 82.37 |
| 3–4 | 0.96 | 0.83 | 0.90 | 0.68 | 0.85 | 0.90 | 0.99 | 1.24 | 0.81 | 0.74 | 0.78 | 0.76 | 10.44 | 92.82 |
| 2–3 | 0.29 | 0.38 | 0.61 | 0.51 | 0.61 | 0.50 | 0.83 | 0.67 | 0.41 | 0.29 | 0.35 | 0.43 | 5.89 | 98.71 |
| 1–2 | 0.08 | 0.06 | 0.11 | 0.08 | 0.15 | 0.16 | 0.25 | 0.10 | 0.14 | 0.08 | 0.04 | 0.03 | 1.29 | 99.99 |
| 0–1 | | | | | | | | | <0.01 | | | | <0.01 | |

1hr Wind Direction at 10m (°T From)

Figure 2-133 Percentage Occurrence of Wind Speed and 30° Direction Bin - November



December

| 1hr Wind Speed at 10m (m/s) | 000 | 030 | 060 | 090 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | Total % | Exceed % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 14.69 | 7.77 | 3.96 | 2.64 | 1.88 | 2.58 | 5.84 | 9.58 | 9.96 | 8.91 | 15.48 | 16.70 | 100.00 | |
| 29–30 | | | | | | | | | | | | | | |
| 28–29 | | | | | | | | | | | | | | |
| 27–28 | | | | | | | | | | | | | | |
| 26–27 | | | | | | | | | | | | | | |
| 25–26 | | | | | | | | | | | | | | |
| 24–25 | | | | | | | | | | | | | | |
| 23–24 | | | | | | | | | | | | | | |
| 22–23 | | | | | | | | | | | | | | |
| 21–22 | <0.01 | | | | | | | | | | | | <0.01 | |
| 20–21 | 0.01 | | | | | | | | | | | | 0.01 | 0.02 |
| 19–20 | 0.01 | | | | | | | | | | | | 0.01 | 0.03 |
| 18–19 | 0.02 | | | | | | | | | | <0.01 | 0.04 | 0.06 | 0.09 |
| 17–18 | 0.03 | | | | 0.02 | | | | | 0.02 | 0.05 | 0.07 | 0.18 | 0.27 |
| 16–17 | 0.09 | 0.01 | | | 0.01 | <0.01 | | | 0.03 | 0.06 | 0.09 | 0.12 | 0.41 | 0.68 |
| 15–16 | 0.16 | 0.04 | | | 0.01 | <0.01 | | <0.01 | 0.07 | 0.05 | 0.31 | 0.36 | 0.99 | 1.67 |
| 14–15 | 0.26 | 0.12 | 0.04 | 0.03 | 0.01 | | 0.03 | 0.03 | 0.04 | 0.09 | 0.58 | 0.71 | 1.94 | 3.61 |
| 13–14 | 0.51 | 0.20 | 0.03 | 0.05 | 0.06 | 0.04 | 0.06 | 0.07 | 0.08 | 0.21 | 0.93 | 0.85 | 3.08 | 6.68 |
| 12–13 | 0.65 | 0.22 | 0.07 | 0.02 | 0.04 | 0.08 | 0.10 | 0.08 | 0.20 | 0.37 | 1.14 | 0.83 | 3.80 | 10.48 |
| 11–12 | 0.97 | 0.26 | 0.07 | 0.02 | 0.07 | 0.11 | 0.27 | 0.20 | 0.37 | 0.55 | 1.32 | 1.21 | 5.41 | 15.89 |
| 10–11 | 1.35 | 0.38 | 0.13 | 0.07 | 0.07 | 0.05 | 0.27 | 0.49 | 0.46 | 0.60 | 1.72 | 1.50 | 7.09 | 22.98 |
| 9–10 | 1.67 | 0.81 | 0.19 | 0.09 | 0.07 | 0.10 | 0.31 | 0.79 | 0.94 | 0.88 | 1.73 | 2.09 | 9.66 | 32.64 |
| 8–9 | 1.96 | 1.09 | 0.32 | 0.20 | 0.12 | 0.18 | 0.43 | 0.91 | 1.08 | 0.97 | 1.77 | 2.34 | 11.37 | 44.01 |
| 7–8 | 1.69 | 1.03 | 0.51 | 0.24 | 0.10 | 0.20 | 0.66 | 1.30 | 1.56 | 1.10 | 1.62 | 1.54 | 11.54 | 55.55 |
| 6–7 | 1.42 | 0.98 | 0.74 | 0.37 | 0.10 | 0.23 | 0.71 | 1.25 | 1.58 | 1.11 | 1.18 | 1.58 | 11.23 | 66.79 |
| 5–6 | 1.59 | 0.83 | 0.69 | 0.42 | 0.28 | 0.40 | 0.90 | 1.60 | 1.27 | 1.04 | 1.07 | 1.43 | 11.51 | 78.29 |
| 4–5 | 1.11 | 0.76 | 0.53 | 0.41 | 0.32 | 0.45 | 0.94 | 1.57 | 1.15 | 0.81 | 1.02 | 0.96 | 10.02 | 88.31 |
| 3–4 | 0.77 | 0.67 | 0.36 | 0.43 | 0.45 | 0.48 | 0.78 | 0.85 | 0.65 | 0.56 | 0.63 | 0.74 | 7.38 | 95.69 |
| 2–3 | 0.38 | 0.29 | 0.25 | 0.27 | 0.13 | 0.21 | 0.33 | 0.37 | 0.39 | 0.41 | 0.29 | 0.26 | 3.61 | 99.31 |
| 1–2 | 0.05 | 0.08 | 0.04 | 0.02 | 0.02 | 0.05 | 0.05 | 0.08 | 0.10 | 0.08 | 0.03 | 0.07 | 0.67 | 99.98 |
| 0–1 | | | <0.01 | | | | | | | | <0.01 | 0.01 | 0.02 | |

1hr Wind Direction at 10m (°T From)

Figure 2-134 Percentage Occurrence of Wind Speed and 30° Direction Bin - December

## 2.5 Water Levels

### 2.5.1 Storm Surge

Extreme storm surge (positive and negative) criteria was dervive using the winter storm and hurricane Oceanweather data and subtracting the tides. Tides was calculated using the TMD (Tidal Model Driver) over the EastCoast2001 model.

| Extreme Winter Storm Surge | Return Period | | | | | |
|---|---|---|---|---|---|---|
| | 1-year | 50-years | 100-years | 500-years | 1000-years | 10000-years |
| Positive Surge [m] | 0.44 | 0.96 | 1.03 | 1.22 | 1.30 | 1.57 |
| Negative Surge [m] | -0.34 | -1.06 | -1.19 | -1.49 | -1.62 | -2.04 |

**Table 2-45 Extreme Winter Storm Surge (positive and negative)**

| Extreme Hurricane Surge | Return Period | | | | | |
|---|---|---|---|---|---|---|
| | 1-year | 50-years | 100-years | 500-years | 1000-years | 10000-years |
| Positive Surge [m] | 0.24 | 1.39 | 1.58 | 2.02 | 2.21 | 2.84 |
| Negative Surge [m] | -0.29 | -0.55 | -0.59 | -0.7 | -0.74 | -0.89 |

**Table 2-46 Extreme Hurricane Surge (positive and negative)**

### 2.5.2 Tides

To produce the tidal descriptors in Table 2-47, the water elevation time series obtained with TMD (Section 3.1.3). Tides are in relative to lowest astronomical tide (LAT).

| TIDAL LEVELS | LAT (m) |
|---|---|
| **Highest Still Water Level (HSWL)** | 2.98 |
| **Highest Astronomical Tide (HAT)** | 1.46 |
| **Mean Higher High Water (MHHW)** | 1.22 |
| **Mean Sea Level (MSL)** | 0.67 |
| **Mean Lower Low Water (MLLW)** | 0.16 |
| **Mean Low Water Spring (MLWS)** | 0.06 |
| **Lowest Astronomical Tide (LAT)** | 0 |
| **Lowest Stll Water Level (LSWL)** | -1.06 |

**Table 2-47 Tidal Levels in Relative to LAT**

### 2.5.3 Chart Datum vs Land Survey Datum

The nearest identified station between chart datums is Duck. Duck is located offshore North Carolina at 36° 11’ N, 75° 44.8’ W, and is approximately 81 km from the target sites. Based on comparison, TMD and at Duck, we believe it is reasonable to use the relationship in Table 2-48 to relate offshore data to the North American Vertical Datum 1988 (NAVD 88). Table 2-48 is in relative to mean low low water (MLLW).

| TIDAL LEVELS | Duck | TMD |
|---|---|---|
| | MLLW (m) | MLLW (m) |
| **NAVD 88** | 0.67 | |
| **Mean Higher High Water (MHHW)** | 1.12 | 1.06 |
| **Mean High Water (MHW)** | 1.03 | 0.98 |
| **Diurnal Tide Level (DTL)** | 0.56 | 0.53 |
| **Mean Sea Level (MSL)** | 0.54 | 0.51 |
| **Mean Tide Level (MTL)** | 0.54 | 0.50 |
| **Mean Low Water (MLW)** | 0.04 | 0.02 |
| **Lowest Astronomical Tide (LAT)** | 0 | 0 |

**Table 2-48 Chart Datum Comparison**

## 2.6 Marine Growth

There are two forms of marine growth, or fouling as well as seaweed and kelp. Hard fouling consist of mussels, branacles and tubeworms and soft fouling consists of organisims such as hydroids, anemones and coral. Types of marine growth vary with depth and location.

Marine growth varies depending on the water body in the Lower Chesapeake Bay. Marine growth is typically about 1 to 3 inches thick and is thickest in the splash zone down to about -10ft. Within that zone, the growth is predominantly hard shells and barnacles, some algae. Dense growth of barnacles and hard shells are typically in upper 15ft of water and decrease to less dense hard shells below that 15ft.

The marine growth varies from area to area. For refrence, marine growth at three different locations are provided here, UK sector Table 2-49 (ISO 19901-1[1]), Gulf of Mexico Table 2-50 (Heideman and George)[7], and offshore southern and central California Table 2-51 (ISO 19901-1[1]).

| Depth | Type of growth | | |
|---|---|---|---|
| | Hard | Soft | Algae/Kelps |
| 0 m to 15 m | 0.2 m | 0.07 m | 3.0 m |
| 15 m to 30 m | 0.2 m | 0.3 m | Unknown |
| 30 m to sea floor | 0.01 m | 0.3 m | No growth |

**Table 2-49 Terminal Thickness of Marine Growth UK sector**

| Depth | Thickness (mm) |
|---|---|
| MHHW | 38 |
| -10 m from MLLW | 38 |
| -50 m from MLLW | 10 |
| -100 m from MLLW | 10 |
| -140 m from MLLW | 0 |

**Table 2-50 Hard Shell Marine Growth for Gulf of Mexico**

| Depth | Thickness (mm) |
|---|---|
| Unspecified | 200 |

**Table 2-51 Marine Growth Offshore California**

## 2.7 Air Temperature and Density

Air temperature and density were derive from 29-years (1984 to 2012) measured NDBC buoy CHLV2 data.

| COMBINED PERIOD (1984 to 2012) | Air Temperature [C] | | | Air Density [kg/m^3] | | |
|---|---|---|---|---|---|---|
| | MIN | MAX | STD DEV. | MIN | MAX | STD DEV. |
| January | -16.70 | 21.20 | 4.91 | 1.18 | 1.36 | 0.03 |
| February | -9.50 | 21.10 | 4.27 | 1.18 | 1.34 | 0.03 |
| March | -6.50 | 24.90 | 4.23 | 1.17 | 1.34 | 0.03 |
| April | 0.00 | 29.10 | 3.86 | 1.16 | 1.28 | 0.02 |
| May | 8.00 | 31.30 | 3.54 | 1.16 | 1.26 | 0.02 |
| June | 12.10 | 32.20 | 2.85 | 1.14 | 1.22 | 0.01 |
| July | 17.20 | 33.10 | 1.99 | 1.14 | 1.21 | 0.01 |
| August | 16.50 | 32.30 | 1.89 | 1.12 | 1.20 | 0.01 |
| September | 12.60 | 30.80 | 2.39 | 1.14 | 1.23 | 0.01 |
| October | 5.90 | 29.30 | 3.44 | 1.15 | 1.28 | 0.02 |
| November | -0.20 | 24.40 | 3.95 | 1.18 | 1.31 | 0.02 |
| December | -8.80 | 23.00 | 4.59 | 1.18 | 1.33 | 0.03 |
| All Year | -16.70 | 33.10 | 7.91 | 1.12 | 1.36 | 0.04 |

**Table 2-52 Air Temperature and Density**

## 2.8 Seawater Temperature, Salinity and Density

Seawater temperature, salinity, and density were derived from 7-years (2006 to 2012) Rutgers University's ESPreSSO (Experimental System for Predicting Shelf and Slope Optics) hindcast data from gridpoint 36.8587°N, 75.5139°W.

| COMBINED PERIOD (2006 to 2012) | Seawater Temperature [C] | | | Seawater Salinity [PSU] | | | Seawater Density [kg/m^3] | | |
|---|---|---|---|---|---|---|---|---|---|
| | MIN | MAX | STD DEV. | MIN | MAX | STD DEV. | MIN | MAX | STD DEV. |
| January | 4.66 | 13.46 | 1.82 | 27.43 | 33.68 | 1.15 | 1020.72 | 1025.97 | 0.96 |
| February | 3.75 | 9.75 | 1.36 | 26.08 | 33.90 | 0.97 | 1020.24 | 1026.33 | 0.73 |
| March | 4.26 | 15.39 | 1.63 | 27.63 | 33.55 | 1.14 | 1021.21 | 1026.23 | 0.99 |
| April | 7.17 | 15.83 | 1.78 | 24.04 | 33.14 | 1.37 | 1018.04 | 1025.58 | 1.26 |
| May | 9.56 | 22.24 | 2.34 | 24.81 | 33.42 | 1.75 | 1017.59 | 1025.43 | 1.63 |
| June | 18.12 | 26.92 | 1.72 | 24.67 | 32.89 | 1.68 | 1015.95 | 1023.07 | 1.46 |
| July | 20.14 | 28.32 | 1.21 | 24.19 | 34.42 | 1.97 | 1014.92 | 1022.57 | 1.60 |
| August | 22.57 | 29.87 | 1.17 | 26.61 | 34.47 | 1.68 | 1016.32 | 1022.17 | 1.41 |
| September | 19.37 | 26.97 | 1.26 | 28.07 | 32.48 | 0.83 | 1017.91 | 1022.80 | 0.83 |
| October | 15.96 | 24.70 | 1.75 | 28.58 | 32.77 | 0.88 | 1019.20 | 1023.57 | 0.86 |
| November | 10.86 | 20.47 | 1.67 | 27.26 | 32.98 | 0.90 | 1020.55 | 1024.52 | 0.71 |
| December | 7.03 | *15.83* | 1.55 | 26.32 | 33.04 | 0.88 | 1019.53 | 1025.27 | 0.79 |
| All Year | 3.75 | 29.87 | 6.84 | 24.04 | 34.47 | 1.55 | 1014.92 | 1026.33 | 2.32 |

**Table 2-53 Seawater Temperature, Salinity and Density at Near Surface**

## 2.9 Seawater Mechanical and Thermal Properties

Overall statistics of kinematic viscosity, specific heat capacity and thermal conductivity of seawater (Table 2-54) were calculated following Sharqawy et al. (2010)[6] using the ESPreSSO modelled temperature and salinity data near the surface (~0.1MPa of pressure).

| Property | MIN | MAX | MEAN | STD DEV. |
|---|---|---|---|---|
| Kinematic Viscosity [$m^2/s$] | 8.3614e-07 | 1.6307e-06 | 1.1736e-06 | 2.0497e-07 |
| Specific Heat Capacity [J/kg-K] | 4001 | 4056.5 | 4018.9 | 9.1989 |
| Thermal Conductivity [W/m-K] | 0.5763 | 0.61563 | 0.5960 | 0.0103 |

**Table 2-54 Thermal and Mechanical Properties of Seawater Near The Surface.**

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[6] Sharqawy, Mostafa H., John H. Lienhard V and Syed M. Zubair. "The thermophysical properties of seawater: A review of existing correlations and data." Desalination and Water Treatment, 16 (April 2010) 354–380.

## 2.10 Effects of Climate Change for The Next 25 Years

Climate-related changes have already been observed globally and in the United States. It has been well accepted that greenhouse gas concentrations in the atmosphere will continue to increase unless the billions of tons of our annual emissions decrease substantially. Continued emissions of greenhouse gases will lead to further climate changes. Future changes are expected to include a warmer atmosphere, a warmer and more acidic ocean, higher sea levels, and larger changes in precipitation patterns. The Global Climate Change Impacts in the United States report the U.S. Global Change Research Program (2009) indicated that likely future changes for the United States and surrounding coastal waters include more intense hurricanes with related increases in wind, rain, and storm surges (but not necessarily an increase in the number of these storms that make landfall), as well as drier conditions in the Southwest and Caribbean. These changes will affect human health, water supply, agriculture, coastal areas, and many other aspects of society and the natural environment. The effects to the wind farm projects for the next 25 years would be on extreme wind speed, wave height, currents and water level, which are associated with tropical cyclones in the area.

In response to future anthropogenic climate warming, tropical cyclones could potentially change in a number of important ways, including frequency, intensity, size, duration, tracks, area of genesis or occurrence, precipitation, and storm surge characteristics.

### 2.10.1 Change in Extreme Wind Speed due to Climate Change Over The Next 25 Years

The following is quoted from Weather and Climate Extremes in a Changing Climate report lead by William J. Gutowski, Jr. "In summary, theory and high-resolution idealized models indicate increasing intensity and frequency of the strongest hurricanes and typhoons in a CO2-warmed climate. Parts of the Atlantic basin may have small decreases in the upper limit intensity, according to one multimodel study of theoretical potential intensity. Expected changes in tropical cyclone intensity and their confidence are therefore assessed as follows: in the Atlantic and North Pacific basins, some increase of maximum surface wind speeds of the strongest hurricanes and typhoons is likely. We estimate the likely range for the intensity increase (in terms of maximum surface winds) to be about **1 to 8% per °C** tropical sea surface warming over most tropical cyclone regions. This range encompasses the broad range of available credible estimates, from the relatively low 1.3% per °C area average estimate by Vecchi (personal communication, 2007) of Vecchi and Soden (2007) to the higher estimate (5% per °C) of Emanuel (1987, 2005), and includes some additional subjective margin of error in this range. The ensemble sensitivity estimate from the dynamical hurricane modeling study of Knutson and Tuleya (2004) of 3.7% per °C is near the middle of the above range. Furthermore, the available evidence suggests that maximum intensities may decrease in some regions, particularly in parts of the Atlantic basin, even though sea surfaces are expected to warm in all regions." (Gutowski, 2008)[7]

During the past 30 years, annual sea surface temperature in the main Atlantic hurricane development region increased nearly 2°F. Projections are that sea surface temperatures in the main Atlantic hurricane development region will increase at even faster rates (see Figure 2-135), there is a good

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[7] Gutowski, W.J., G.C. Hegerl, G.J. Holland, T.R. Knutson, L.O. Mearns, R.J. Stouffer, P.J. Webster, M.F. Wehner, and F.W. Zwiers, 2008: Causes of observed changes in extremes and projections of future changes. In: Weather and Climate Extremes in a Changing Climate: Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands [Karl, T.R., G.A. Meehl, C.D. Miller, S.J. Hassol, A.M. Waple, and W.L. Murray (eds.)]. Synthesis and Assessment Product 3.3. U.S. Climate Change Science Program, Washington, DC, pp. 81-116.

chance that 1°C or 1.8°F temperature increase would happen in the next 25 years, so the extreme wind speed would increase by 1 to 8 percent. (Karl, 2008)[8]

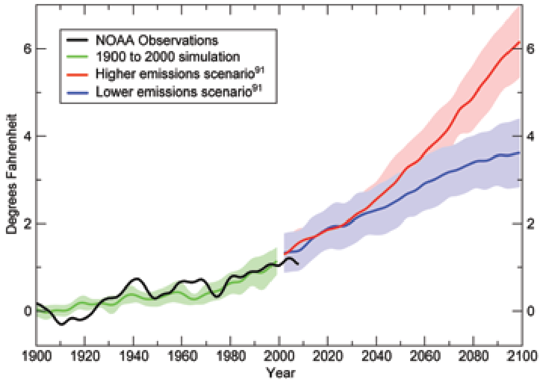

**Figure 2-135 Observed (black) and projected temperatures (blue = lower scenario; red = higher scenario) in the Atlantic hurricane formation region. Increased intensity of hurricanes is linked to rising sea surface temperatures in the region of the ocean where hurricanes form. The shaded areas show the likely ranges while the lines show the central projections from a set of climate models. (Karl, 2008)[6]**

### 2.10.2 Change in Extreme Wave Height due to Climate Change Over The Next 25 Years

The heights and periods of the waves generated are governed by the wind velocity and the duration or time that the wind blows. The third important factor is the fetch, the distance over which the wind blows. The fetch distance restricts the time during which individual waves are moving under the action of the wind and therefore governs the time during which energy can be transferred from wind to waves. For fetch limited condition, U.S. Army Corps of Engineers Shore Protection Manual (SPM) model gives:

$$Hs = 1.616 \times 10^{-2} U_A F^{1/2} = 1.616 \times 10^{-2} \times 0.71 U^{1.23} F^{1/2}$$

Where UA is an "adjusted wind speed", U is the actual wind speed and F is fetch. The significant wave height Hs would increase by 1.2% to 9.9% in the next 25 years give the 1 to 8% wind speed increase, assume wind fetch does not change.

### 2.10.3 Change in Extreme Currents due to Climate Change Over The Next 25 Years

The extreme currents would also increase due to increase of extreme wind speed. In deep water along open coastlines, API 2A-WSD recommended that surface storm current can be roughly estimated to have speeds up to 2-3 percent of the one-hour sustained wind speed during tropical storms and hurricanes and up to 1% of the one-hour sustained wind speed during winter storms or extratropical cyclones. As the storm approaches shallow water and the coastline, the current can increase.

### 2.10.4 Sea Level Rise due to Climate Change Over The Next 25 Years

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[8] Karl, T.R., G.A. Meehl, T.C. Peterson, K.E. Kunkel, W.J. Gutowski Jr., and D.R. Easterling, 2008: Executive summary. In: *Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands* [Karl, T.R., G.A. Meehl, C.D. Miller, S.J. Hassol, A.M. Waple, and W.L. Murray (eds.)]. Synthesis and Assessment Product 3.3. U.S. Climate Change Science Program, Washington, DC, pp. 1-9.

Several recent studies (Boon, 2012; Ezer and Corlett, 2012a, 2012b; Ezer, Atkinson et al, 2013; Sallenger et al., 2012)[9][10][11][12][13] indicate that the rates of sea level rise (SLR) have been accelerating along the coastal mid-Atlantic region. Over the past few decades the pace of relative sea level rise in the Chesapeake Bay has been 2 to 3 times faster than that of the global average (from 1.8 mm/y for 1961-2003 to 3.1 mm/y for 1993-2003), a trend that may continue during the coming decades. As a result, low-lying coastal communities in the mid-Atlantic region, such as the Hampton Roads area in the Chesapeake Bay, have seen a significant increase in the frequency of flooding in recent years (Mitchell et al., 2013)[14]. Future projections of SLR depend on estimates of past SLR rates and potential SLR acceleration. For example, the U.S. Army Corps of Engineers introduces 3 SLR scenarios based on assessment of the National Research Council (NRC), they include SLR of 0.5m (NRC-I scenario), 1.0m (NRC-II) and 1.5m (NRC-III) between 1986 and 2100. In Figure 2-136, Ezer and Corlett compared various SLR projection scenarios for 4 Chesapeake Bay locations with long records, Baltimore and Annapolis in the northern Chesapeake Bay and Kiptopeke and Sewells Point in the southern Chesapeake Bay and close to the study area. Based on the projection, there will be 3 to 9cm sea level rise at the study site in the next 25 years.

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[9] Boon, J. D. (2012) Evidence of sea level acceleration at U.S. and Canadian tide stations, Atlantic coast, North America, J. Coast. Res., 28(6), 1437–1445, doi:10.2112/JCOASTRES-D-12-00102.1.

[10] Ezer, T., and W. B. Corlett (2012a), Is sea level rise accelerating in the Chesapeake Bay? A demonstration of a novel new approach for analyzing sea level data, Geophys. Res. Lett., 39, L19605, doi:10.1029/2012GL053435.

[11] Ezer, T., and W. B. Corlett (2012b), Analysis of relative sea level variations and trends in the Chesapeake Bay: Is there evidence for acceleration in sea level rise? Proc. Oceans'12 MTS/IEEE, October 14–19, IEEE Xplore, doi:10.1109/OCEANS.2012.6404794.

[12] Ezer, T., L. P. Atkinson, W. B. Corlett and J. L. Blanco (2013), Gulf Stream's induced sea level rise and variability along the U.S. mid-Atlantic coast, J. Geophys. Res. Oceans, 118, 685–697, doi:10.1002/jgrc.20091.

[13] Sallenger A.H., Doran K. S., and Howd, P., 2012, Hotspot of accelerated sea-level rise on the Atlantic coast of North America, Nature Climate Change 2: 884-888.

[14] Mitchell, M., C. Hershner, J. Herman, D. Schatt, E. Eggington, and S. Stiles (2013), Recurrent flooding study for Tidewater Virginia, Report SJR 76, 2012, 141 pp., Virginia Institute of Marine Science, Gloucester Point, Va.

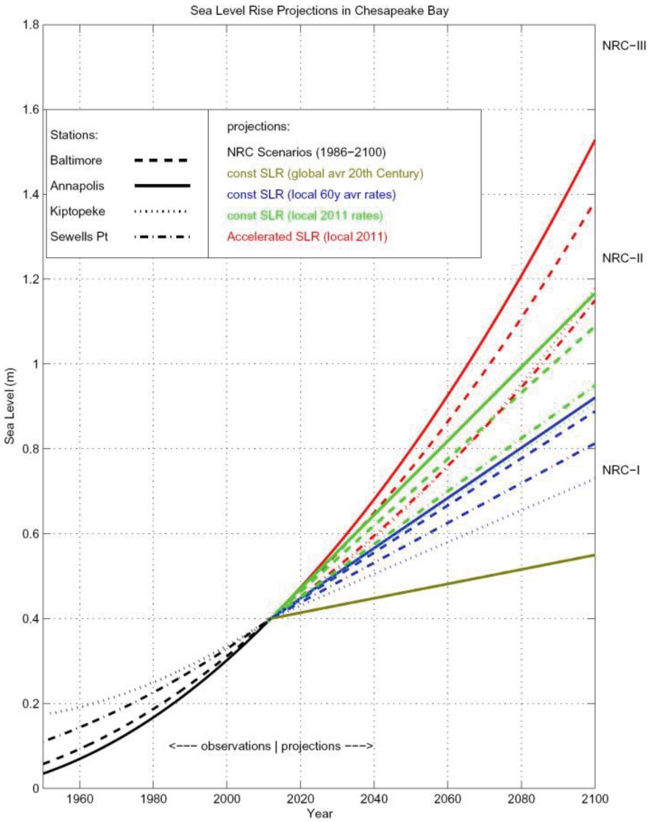

**Figure 2-136 Sea Level Projections in Chesapeake Bay (from Ezer and Corlett, 2012b)**

## 2.11 Snow and Sea Ice

Since the wind farm site is at such a low altitude, snow and ice would not be an effecting design factors. For detail description with respect to ice loads follow IEC 61400-3[3], Annex E.

## 2.12 Corrosion

Offshore wind turbines are exposed to very corrosive marine environment and require unique corrosion protection. Should keep in consideration the matrial selection, design, corrosion protection systems, and suitable inspection and repair programs. Corrosion protection systems are grouped on two main areas, coating systems and cathodic protection. For the atmospheric and splash zones, appropriate coating system according to a recognised code or standard should be applied. Extra attention should be given to the splash zone. The submerged and buried zones, appropriate protection intended to last the design life of the structure or renewal or repair should be possible. If renewal, dedicated survey intervals should be developed to detect any coating breakdown. Submerged zone should always have a cathodic protection system. For a more detail description follow the specefications under IEC 61400-3[3], Annex H.

# 3 CRITERIA REVIEW

## 3.1 Data Sources

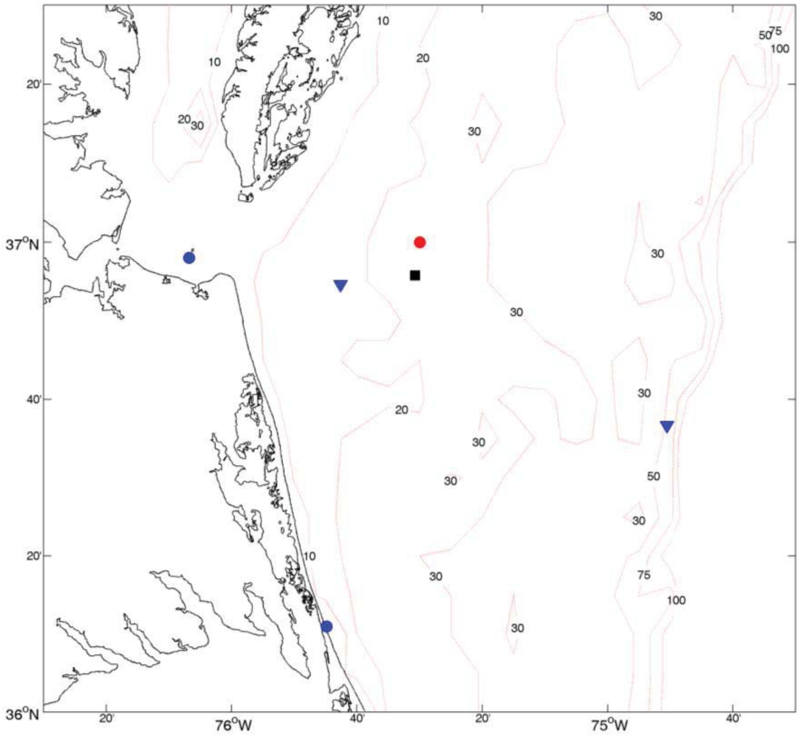

**Figure 3-1 Data sources (blue triangles: NDBC Buoys; red dots: Oceanweather gridpoints; blue dot: tidal gauge) and target site (black square).**

**Table 3-1 Public Domain Metocean Data**

| Data Sources | Location | Wind | Wave | Current | Water Level | Air Temperature | Seawater |
|---|---|---|---|---|---|---|---|
| Oceanweather EE002791 | 37.000°N 75.500°W | 1957~2003 | 1957~2003 | N | 1957~2003 | N | N |
| Oceanweather EO002791 | 37.000°N 75.500°W | 1980~2005 | 1980~2005 | N | N | N | N |
| Oceanweather ET002791 | 37.000°N 75.500°W | 1924~2005 | 1924~2005 | N | 1924~2005 | N | N |
| NDBC Station 44014 | 36.611°N 74.842°W | 1990~Present | 1990~Present | 3/1/97~3/31/97<br>3/1/10~present |  | 1990~Present | Temperature 1990~Present |
| NDBC Station CHLV2 | 36.910°N 75.710°W | 8/21/84~Present | N | N | N | 8/21/84~Present | Temperature 8/21/84~Present |
| NDBC Tidal Gauge 8651370 | 36.183°N 75.747°W | 6/1/91-Present | N | N | 6/01/78-Present | 6/1/91-Present | Temperature 11/12/92-Present |
| NOAA Tidal Gauge 8638863 | 36.967°N 76.113°W | 6/1/91-Present | N | N | 1/26/75-Present | 6/1/91-Present | Temperature 6/1/91-Present |
| ESPreSSO | 36.859°N 75.514°W | N | N | 1/3/06-12/31/12 | N | N | Temperature 1/3/06-12/31/12 |

### 3.1.1 Wind/Wave Data Sources

Wind and wave criteria would be derived from the Oceanweather hindcast database Global Reanalysis of Ocean Waves U.S East Coast (GROW-FINE EC28km) and measured wind and wave data at the NDBC stations in the area. The existing data in the area are shown in Figure 3-1 and Table 3-1. Cross checking and comparison would be performed.

Extreme value analyses would be carried out on the hindcast and measured data sets of wind speed and significant wave height to produce extreme criteria associated with the specified return periods. Directional extremes would be derived by scaling the omni-directional values by relative severity factors for each directional sector.

Wind speeds at elevations greater than 10m ASL with duration other than 1hour will be derived using the equations recommended in ISO19901-1:2005.

The crest height and maximum wave height with a probability of exceedence of 63%, 50%, 10% and 1% would be derived from analysis fo storm events using our EXWAN software which addresses the short term probability distribution function for these parameters in the storm rather than an individual seastate which can lead to underestimation. Associated wave period parameters would be calculated from derived empirical relationships between wave height and period.

Near-bed horizontal wave orbital velocity will be derived from Hs and Tp using stream function wave theory.

The number of individual wave heights and periods that a structure is likely to encounter during a given return period will be derived by numerical simulation. A summary of the method is given below:

- Estimate the wave spectrum from Hs and Tp.
- Simulate a Gaussian time series from the wave spectrum.
- Transform the Gaussian time series to non-Gaussian using an appropriate transformation function.

Estimate individual wave heights and periods from the non-Gaussian time series.

### 3.1.2 Current Data

The currents criteria would be derived from the Rutgers University's ESPreSSO (Experimental System for Predicting Shelf and Slope Optics) hindcast from 2006 (http://www.myroms.org/espresso/). The ESPreSSO model covers the Mid-Atlantic Bight from the center of Cape Cod southward to Cape Hatteras, from the coast to beyond the shelf break and shelf/slope front. The model domain is shown in Figure 3-2.

The prototype system is a 5-km horizontal, 36-level ROMS model with Incremental Strong Constraint 4DVAR assimilation of AVHRR and daily composite SST (remss) and along track altimeter SSH anomalies (RADS). The initial conditions were MOCHA Mid-Atlantic Bight climatology dynamically adjusted by ROMS IS4DVAR. Meteorological forcing is NCEP/NAM 12-km 3-hourly forecast data. Boundary conditions are from HYCOM NCODA forecast system. Tide boundary conditions are from the ADCIRC tidal model. River discharges from major rivers are also considered.

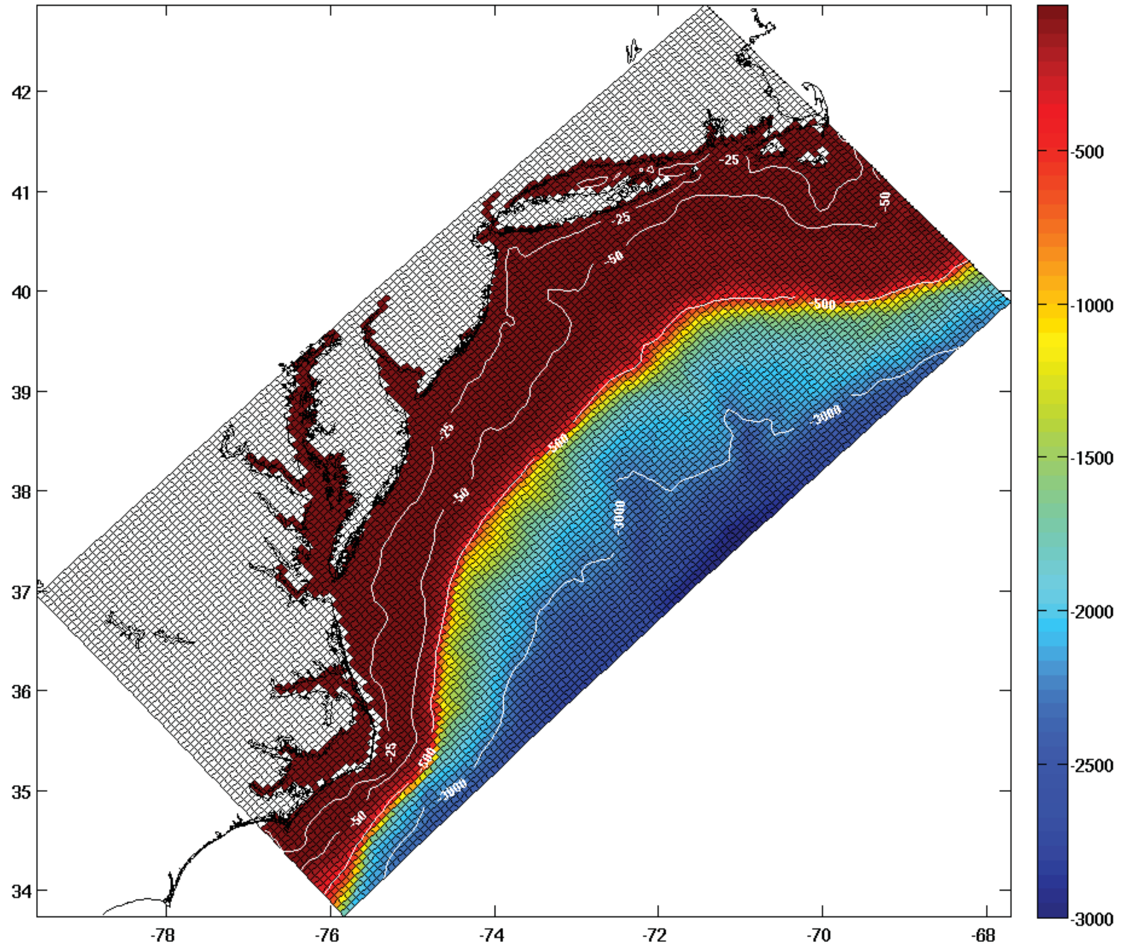

**Figure 3-2 EXPreSSO Model Domain Grids**

The model data would be verified/calibrated using the any available measurements in the area (HF Radar surface current measurement, near surface currents at NDBC buoy 44014, etc).

Extreme value analyses would be carried out on the hindcast current data to produce extreme criteria associated with the specified return periods. Directional extremes would be derived by scaling the omni-directional values by relative severity factors for each directional sector.

### 3.1.3 Water Level

Tidal information would be derived from Oregon State University East Coast 1/30° model. The harmonic constituents in this model were derived from TOPEX/POSEIDON satellite altimeter data which were inverted and assimilated into a global barotropic tidal model. The model has been validated using 179 shallow water tide gauge data. The model constituents would be accessed using TMD (Tide Model Driver), a MATLAB package that allows the user to create tidal predictions from the harmonic constituents for a specified location and duration. Surge would be derived from Oceanweather hindcast database Global Reanalysis of Ocean Waves U.S East Coast (GROW-FINE EC28km).

### 3.1.4 Air Temperature

Air temperature statistics would be derived from NDBC station CHLV2 measured data.

### 3.1.5 Seawater Temperature

Seawater temperature statistics would be derived from measured surface temperature data in the area and ESPreSSO model temperature hindcast through the depth. The existing measurements in the area are shown in Figure 3-1 and Table 3-1. Cross checking and comparison would be performed.

### 3.1.6 Seawater Salinity and Density

Seawater salinity statistics would be derived from ESPreSSO model temperature hindcast through the depth. The seawater density would be calculated from salinity and temperature and depth.

### 3.1.7 Effects of Climate Change

The effects of climate change would be quantified based on literature review and long term measurements in the tidal gauges in the study area.

# 4 TECHNICAL REFERENCE

## 4.1 Extreme Value Analysis

Extreme omni-directional wind, wave and current speeds were derived using the Peaks-Over-Threshold (POT) Method. The POT values were derived by fitting the Weibull, Fisher-Tippett 1, and Exponential functions to the rate of exceedance using the method of least squares, Maximum Likelihood and Method of Moments. Extreme directional wind speeds were derived by scaling the omni-directional extreme values using relative severity factors derived from the relative magnitude of the maximum 1-hour mean wind speed in each direction sector.

### 4.1.1 Probability Distributions

The functions[15,16,17,18,19,20] used in this study for the estimation of extreme values are the:

- Fisher-Tippett distribution, Type 1.
- Weibull 3-parameter
- Exponential

The FT1 and Exponential functions are two parameter distributions. The Weibull function may be described by two or three parameters: $\alpha$ is the location parameter and the limiting value of the distribution, $\beta$ is the scale parameter and defines the spread of the distribution, and $\gamma$ is the shape parameter and describes the asymmetry of the distribution. The Generalised Pareto is also a three parameter distribution: a location parameter, $x_t$, a scale parameter, $\beta$, and a shape parameter, $\gamma$. The following paragraphs describe the distributions and present expressions for the moments estimators and for plotting on probability paper.

Fisher-Tippett Type 1 Distribution

This function is also known as a Gumbel, double exponential, Jenkinson Type 2, extreme value and extremal type 1 distribution.

$$P(x) = \exp\{-\exp[-(x - \alpha)/\beta]\} \qquad \beta > 0$$

where $P(x)$ is the cumulative probability that $X \leq x$ and $\alpha$ is the mode of the distribution.

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[15] Carter, D.J.T. and Challenor, P.G. (1981). *Estimating Return Values of Wave Height*. IOS Report No. 116.

[16] Carter, D.J.T. et al (1986). *Estimating Wave Climate Parameters for Engineering Applications*.
Offshore Technology Report No. OTH 86 228. London: HMSO.

[17] Coastal Engineering Research Center, US Army Engineer Waterways Experiment Station (1985). *Computer Program: WAVDIST (MACE 17) Extremal Significant Wave Height Distributions*. Coastal Engineering Technical Note CETN-I-40, December 1985.

[18] Davison, A.C. and Smith, R.L. (1990). *Models for Exceedences over High Thresholds*. J. R. Statist. Soc. B, 52, No. 3, 393-442.

[19] Johnson, N.L. and Kotz, S. *Continuous Univariate Distributions - 1*.

[20] National Environmental Research Council (1975). *Flood Studies Report Volume 1: Hydrological Studies*.

The function may be re-arranged to give

$$x = \alpha - \beta [ \ln(-\ln P(x)) ]$$

It can be seen that plotting -ln(-ln$P(x)$) against $x$ will give a straight line.

The mean and variance of the F-T 1 distribution are as follows:

mean = $\alpha + \gamma\beta$

variance = $\beta^2 \pi^2 / 6$

where $\gamma$ = Euler's constant = 0.5772.

The moments estimators are therefore given by

$\boldsymbol{\alpha}$ = mean - $\gamma\boldsymbol{\beta}$

$\boldsymbol{\beta}$ = $\sqrt{\text{variance}}\sqrt{6}/\pi$

Weibull Distribution

$$P(x) = 1 - \exp\{ -[ (x - \alpha)/\beta ]^{\gamma} \} \qquad x > \alpha;\ \beta, \gamma > 0$$

$$P(x) = 0 \qquad x < \alpha$$

where $\alpha$ is the lower limiting value of the distribution.

Re-arranging gives

$$x = \alpha + \beta [-\ln(1 - P(x)) ]^{1/\gamma}$$

$$\ln[ -\ln(1 - P(x)) ] = \gamma\ln(x - \alpha) - \gamma\ln\beta$$

so a plot of ln[ -ln(1 - $P(x)$) ] against ln($x - \alpha$) is a straight line.

For a three parameter Weibull distribution the mean, variance and skewness are given by

Mean = $\beta\Gamma(1 + 1/\gamma) + \alpha$

variance = $\beta^2 [ \Gamma(1 + 2/\gamma) - \Gamma^2(1 + 1/\gamma) ]$

skewness = $\beta^3 [ \Gamma(1 + 3/\gamma) - 3\Gamma(1 + 2/\gamma) * \Gamma(1 + 1/\gamma) + 2\Gamma^3(1 + 1/\gamma) ]$

where $\Gamma$ is the gamma function and the moments estimators are obtained by

$\alpha$ = mean - [ $\beta\Gamma((1 + 1/\gamma)$ ]

$\beta$ = { variance/[ $\Gamma(1 + 2/\gamma) - \Gamma^2(1 + 1/\gamma)$ ] }$^{0.5}$

Skewness = [ $\Gamma(1 + 3/\gamma) - 3\Gamma(1 + 2/\gamma) * \Gamma(1 + 1/\gamma) + 2\Gamma^3(1 + 1/\gamma)$ ] /[ $\Gamma(1 + 2/\gamma) - \Gamma^2(1 + 1/\gamma)$ ]$^{3/2}$

which is solved iteratively for $\gamma$

Note that skewness = coefficient of skewness * variance$^{3/2}$.

For a two parameter Weibull distribution, $\alpha = 0$ and the mean and variance are given by

mean = $\beta\Gamma(1 + 1/\gamma)$

variance = $\beta^2$[ $\Gamma(1 + 2/\gamma) - \Gamma^2(1 + 1/\gamma)$ ]

and the moments estimators are obtained by

$\beta$ = mean/$\Gamma(1 + 1/\gamma)$

variance/mean$^2$ = [ $\Gamma(1 + 2/\gamma) - \Gamma^2(1 + 1/\gamma)$ ]/[ $\Gamma(1 + 1/\gamma)$ ]$^2$

which is solved iteratively for $\gamma$

Exponential Distribution

$P(x) = 1 - \exp[-(x - \alpha)/\beta]$

The mean and variance are given by

Mean = $\alpha + \beta$

variance = $\beta^2$

The moments estimators are therefore

$\alpha$ = mean - $\beta$

$\beta$ = $\sqrt{}$variance

### 4.1.2 Peaks Over Threshold Analysis

The peak over threshold technique (Coastal Engineering Research Center, 1985[2]) consists of declustering the data by selecting storm peak events that exceeded a predetermined threshold within a forty-eight hour moving window. The observations are assumed to be independent and identically distributed. The number of peaks exceeding a given level, divided by the number of years of record, gives the rate of exceedance which can then be used to find the expected number of occurrences in a period of specified length of time. The probability distribution of the peak values which depends on the threshold over which the peaks are counted is then combined with the rate of occurrence of peaks to give the unconditional distribution of peak values from which extreme values corresponding to given return periods can be calculated, i.e.

$$P(x.y) = P(x/y)\,P(y)$$

where $P(x.y)$ = the unconditional probability distribution of peak values with time.
$P(x/y)$ = the conditional probability distribution of peak values.
$P(y)$ = the probability distribution of storms with time.

The return periods of extreme values are calculated as follows:

$$RP = 1 / \{ \lambda [ 1 - P(x/y) ] \}$$

where $\lambda$ is the Poisson parameter and $P(x/y)$ the conditional probability distribution of peak values.

The number of storms occurring per unit time is assumed to be a random variable that may be represented by the Poisson distribution. The Poisson distribution is characterised by a mean value, $\lambda$, which is the average number of storms per year. The value of $\lambda$ is calculated as the number of storms divided by the period of record in years. The probability density of the Poisson distribution is given by the following formula:

$$p(i) = (\lambda^{i} \exp^{-i}) / i!$$

where $i = 0, 1, 2, \ldots n$.

### 4.1.3 Cumulative Frequency Distribution

Cumulative frequency extrapolation involves grouping all the parameter values in the data set using specified class intervals and then forming a cumulative frequency distribution (cfd) by summing the number of observations greater than or equal to the lower bound of the class interval. The Fisher-Tippett distributions, Types 1 and 3 and the Weibull and Exponential distributions are then fitted to the data, using the method of least squares, in order to extrapolate to the required probability of non exceedence. The advantage of this method is that it can be used with as little as one year of data. However, the probability levels calculated for the cumulative frequency method assume that the measurements used to form the distribution are independent. Therefore, by ignoring the correlation between consecutive values of the metocean parameter, this method may result in underestimation of extreme values. Note that in some cases the Fisher-Tippett 3 function has values of the location parameter (the upper limiting value of the distribution) which are very high. As the value of this parameter becomes larger the distribution tends more towards the F-T1, therefore, the function fitted to the cfd’s represents a Fisher Tippett Type 1 rather than a Fisher-Tippett Type 3.

The relationship between probability of non-exceedence and return period is as follows:

$$P(x) = 1 - 1/(365.25mRP)$$

where P(x) = the probability of non-exceedence.
m = the number of observations in a day.
RP = the return period (years).

### 4.1.4 Associated Tp with Extreme Waves

Data from GFC were used to create an omni-directional joint frequency distribution of Tp, and Tz conditional on Hs. The mode of each conditional distribution was then estimated for each primary parameter class interval. A power law regression equation was then used to define the relationship between the two parameters.

### 4.1.5 Associated Hc and Hmax

Crest and maximum wave height were calculated using in-house software (EXWAN – EXtreme Wave ANalysis).

The probability distributions of maximum wave or crest height for a storm are given by:

$$P(H_{max} < h) = exp\left\{\int_0^T log\{F_{Hs(t)}(h)\}dt / T_{m02}(t)\right\}$$

where:

| | |
|---|---|
| $P(H_{max} < h)$ | is the non-exceedance probability of the maximum wave or crest height in a storm; |
| $F_{Hs(t)}(h)$ | is the short-term non-exceedance probability of wave or crest height, $h$, for a significant wave height, $Hs$, at time, $t$; |
| $T_{m02}(t)$ | is the spectral estimate of the mean zero up-crossing wave period at time, $t$; |
| $T$ | is the duration of the storm. |

This approach was developed by Borgman[21] and has been adopted by the EXWAN software as a means of determining the maximum wave and crest height from each storm. The GOMOS data contained an estimate of *Tp* and this parameter was used to derive $T_{m02}$ by multiplying by 0.74.

In order to calculate $F_{Hs(t)}(h)$ for each time step within each storm the Forristall 3-D approach was used for crest height. This formulation is based on the 2-parameter Weibull distribution:

$$F_{Hs}(h) = 1 - exp\left\{-\frac{(4\,h/Hs)^A}{B}\right\}$$

where, $A$ and $B$ are parameters that were empirically fitted.

Forristall[22] derived estimates of extreme crest heights for given sea states in given water depths by using simulations of JONSWAP spectra by empirically fitted the following for *A* and *B*:

$$A = 2 - 1.7912S - 0.5302U_r + 0.2824U_r^2$$
$$B = \{4(0.3536 + 0.2568S + 0.0800U_r)\}^A$$

---

[21] Borgman, L., 1973. *Probabilities for highest wave in hurricane*. J. Waterways, Harbors, and Coastal Eng, Div. ASCE **99**, 185-207.

[22] Forristall, G.Z. (2000). *Wave crest distributions: observations and second order theory*. J. Phys. Ocean, **30**, 1931-1943.

where:

the Ursell number, $U_r = \frac{Hs}{k_1^2 d^3}$ ;

the wave steepness, $S = \frac{2\pi H_s}{gT_{m01}^2}$ ;

$T_{m01} = m_0/m_1$, the ratio of the zeroth to the first moments of the wave spectrum;
$k_1$ is the deep water wave number corresponding to $T_{m01}$;
$d$ is the water depth.

The maximum wave height was calculated using EXWAN and the 2-parameter Weibull distribution proposed by Forristall. The values used for A and B were 2.13 and 8.42, respectively. As with the crest heights, the ratio of maximum wave height to the highest Hs recorded in each storm was calculated. The regression equation of Hmax vs. Hs and Hc vs. Hs were then developed and used to derive the respective maximum wave heights in the Criteria Reference.

# 5 BIBLIOGRAPHY

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