Climate Assessment Report
Kitty Hawk Wind Energy Area

Prepared for: Sample Energy Company

Date: January 11, 2015

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Report Overview:

This Climate Assessment Report investigates the potential energy production and several wind assessment characteristics for a single turbine for the Kitty Hawk Wind Energy Area on an annual, quarterly and monthly basis. The estimates in this report are based on WRI's in-house data, which calculates monthly and annual wind climatology and potential energy production values for a representative hub height of 100 meters.

Meteorological reasoning is given to describe distinctive monthly trends (i.e. months of greatest energy production; sharpest month to month decline in production). Weather hazards for turbines (i.e. icing; dust) are also evaluated and ranked by their potential for occurrence.

Additionally, this report evaluates swell heights and coastal wave climatology for the purpose of Operations and Maintenance. The threat for tropical systems and coastal lows (i.e."Nor'easters) to impact this area are also reviewed.

The coordinates 36.25N (36-15N) and 75.25W (72-15W) were used to evaluate the wind and wave data for this area of study.

Map of Site – Kitty Hawk Wind Energy Area

Figure 2.1

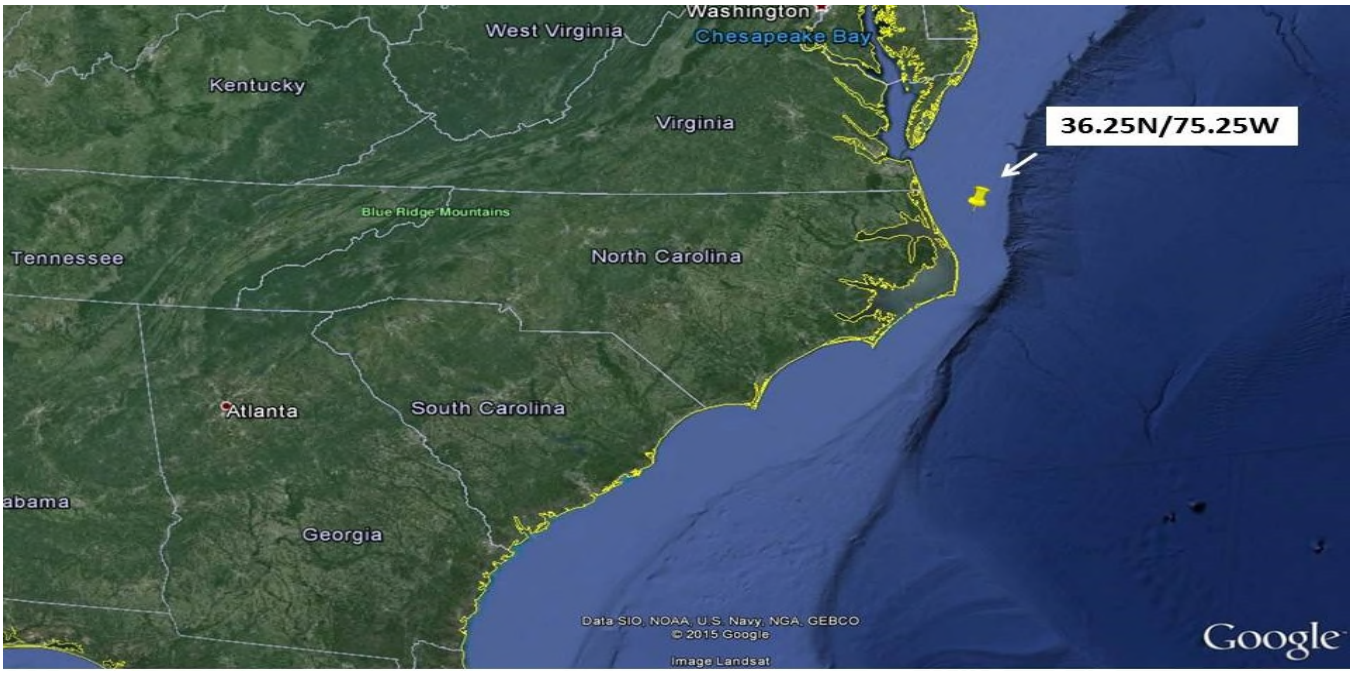
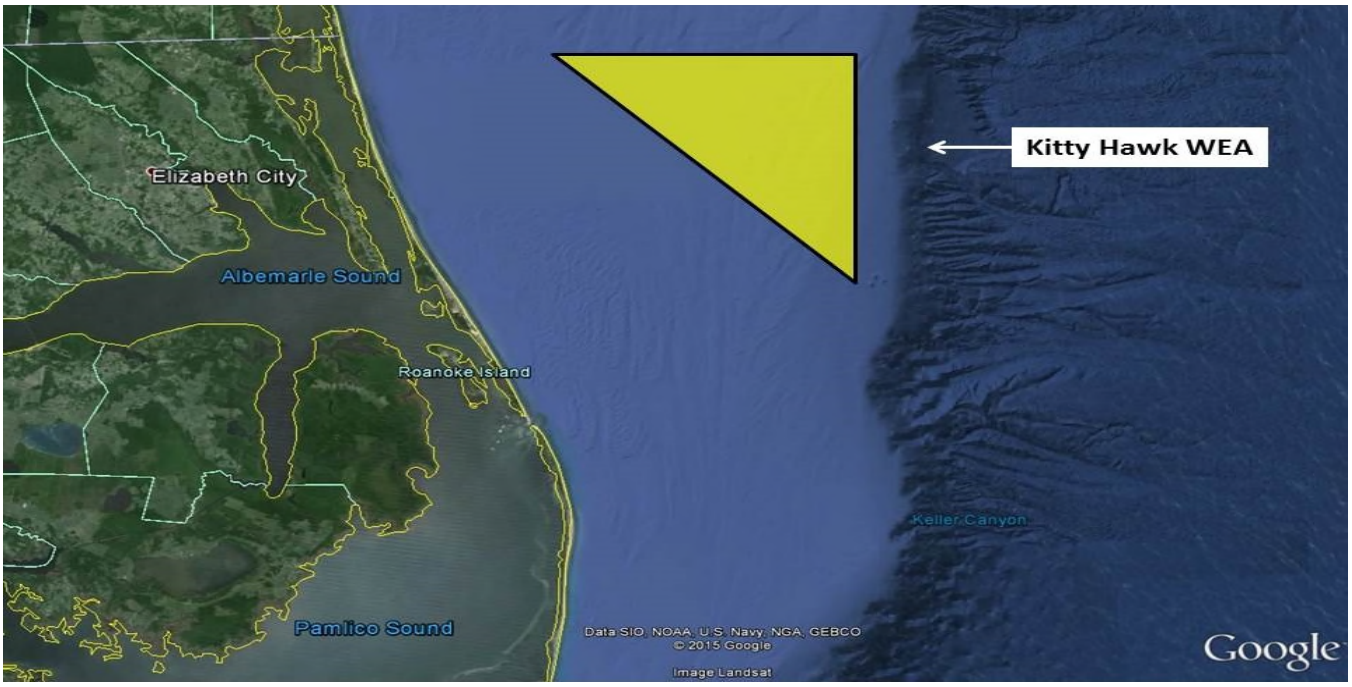
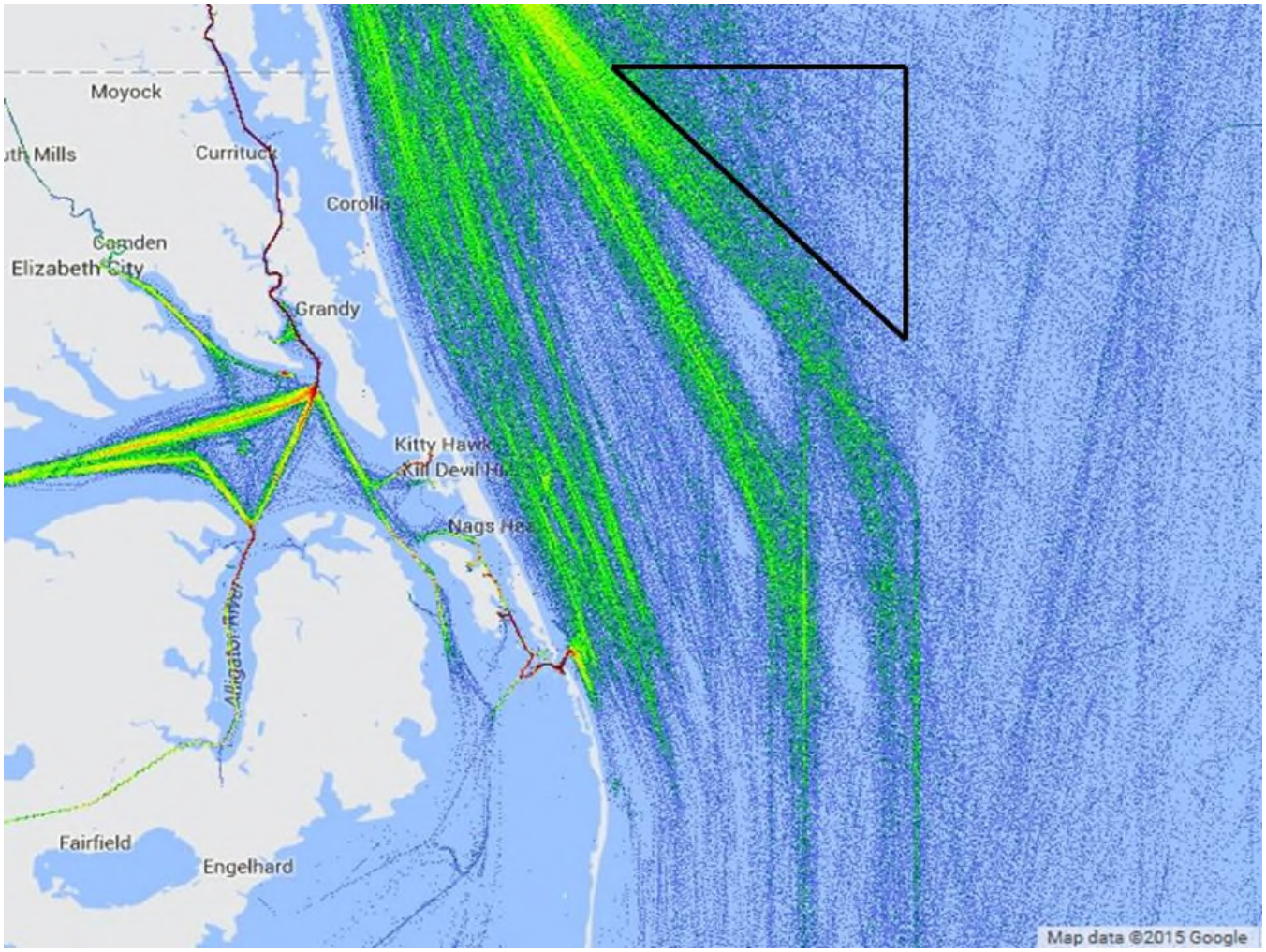


Figure 2.2



AIS Ship Traffic – Kitty Hawk Wind Energy Area

Figure 3.1



For the above map, blue indicates light ship traffic, green indicates moderate shift traffic, and yellow to red indicates heavy ship traffic.

Wind Assessment Characteristics:

Table 4.1

	Annual	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Mean Wind Speed (m/s)	7.99	8.92	8.03	6.70	8.32
Power Density (W/m^2)	614.28	890.33	597.05	316.79	652.94
Weibull *A* (m/s)	9.02	10.07	9.07	7.57	9.39
Weibull *k*	2.07	2.18	2.18	2.05	2.15
Gross Energy Production(MWh)	51,151	19,552	13,260	7,091	14,668
Net Energy Production (MWh)	38,363-43,478	14,664-16,619	9,945-11,271	5,368 – 6,027	11,001-12,468

The above wind assessment estimates are based on WRI's in-house calculated data. The mean wind speed is calculated using the total observations in the dataset. The power density is derived from the site's wind speed frequency distribution and air density. The Weibull function is an analytical curve based on an exponential function that provides a best fit for an annual wind speed distribution. The Weibull function is used because energy production increases exponentially as wind speed increases. The two parameters, *A* and *k* are calculated using the standard deviation of the dataset and can be adjusted to best fit the actual distribution. *A* is a scale parameter related to the mean wind speed, while *k* is dependent on the width of the distribution. Values of *k* typically range from 1 to 3.5, with higher values indicating a narrow distribution.

The Gross Potential Energy is the estimated energy production, which is adjusted using the Weibull analytical curve. The Net Energy Production is obtained by taking into account the typical losses experienced by wind projects (15-25%). The actual losses may vary depending on maintenance levels.

Figure 5.1 – Annual Average Wind Energy Production at 36.25N/75.25W

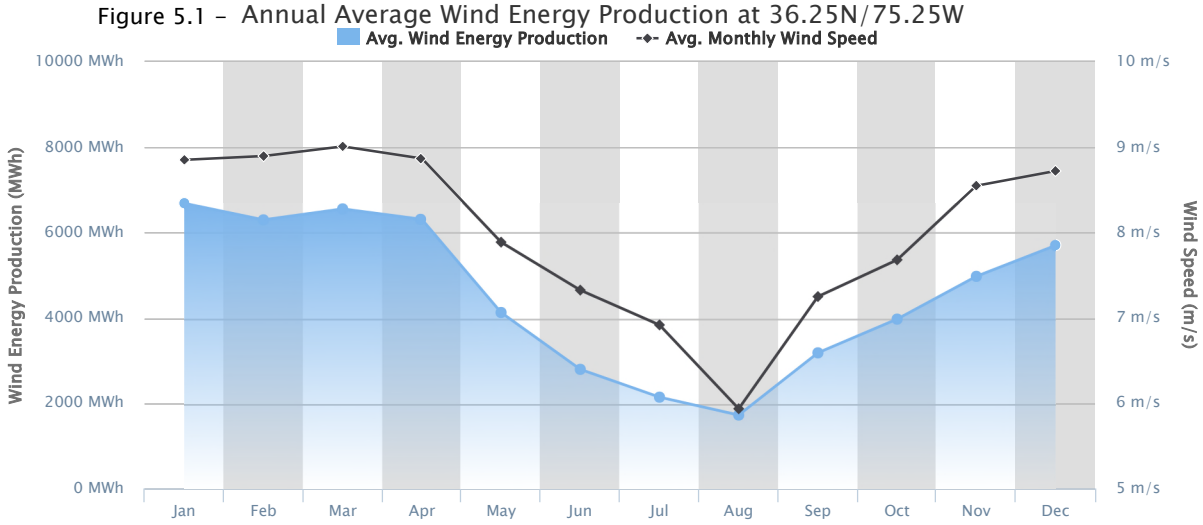


Table 5.1 – Average Wind Energy Production and Wind Speed by Month

Month	Avg. Wind Energy Production (MWH)	Avg. Wind Speed (m/s)
Jan	6690.06	8.85
Feb	6303.07	8.9
Mar	6559.06	9.01
Apr	6315.25	8.87
May	4136.99	7.89
Jun	2808.04	7.33
Jul	2157.74	6.92
Aug	1739.17	5.94
Sep	3193.88	7.25
Oct	3982.41	7.68
Nov	4981.75	8.55
Dec	5703.87	8.72

Figure 5.2 – Annual Average Power Density at 36.25N/75.25W

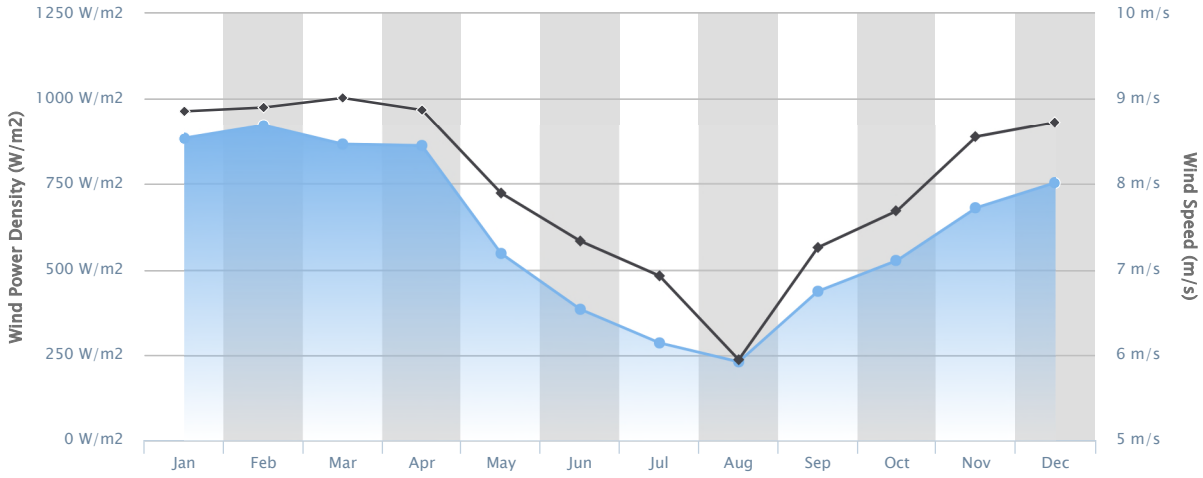


Table 5.2 – Average Power Density and Wind Speed by Month

Month	Avg. Power Density (W/m^2)	Avg. Wind Speed (m/s)
Jan	883.41	8.85
Feb	921.48	8.9
Mar	866.11	9.01
Apr	861.71	8.87
May	546.28	7.89
Jun	383.16	7.33
Jul	284.93	6.92
Aug	229.65	5.94
Sep	435.8	7.25
Oct	525.87	7.68
Nov	679.76	8.55
Dec	753.19	8.72

Figure 5.3 – Annual Wind Speed Frequency at 36.25N/75.25W

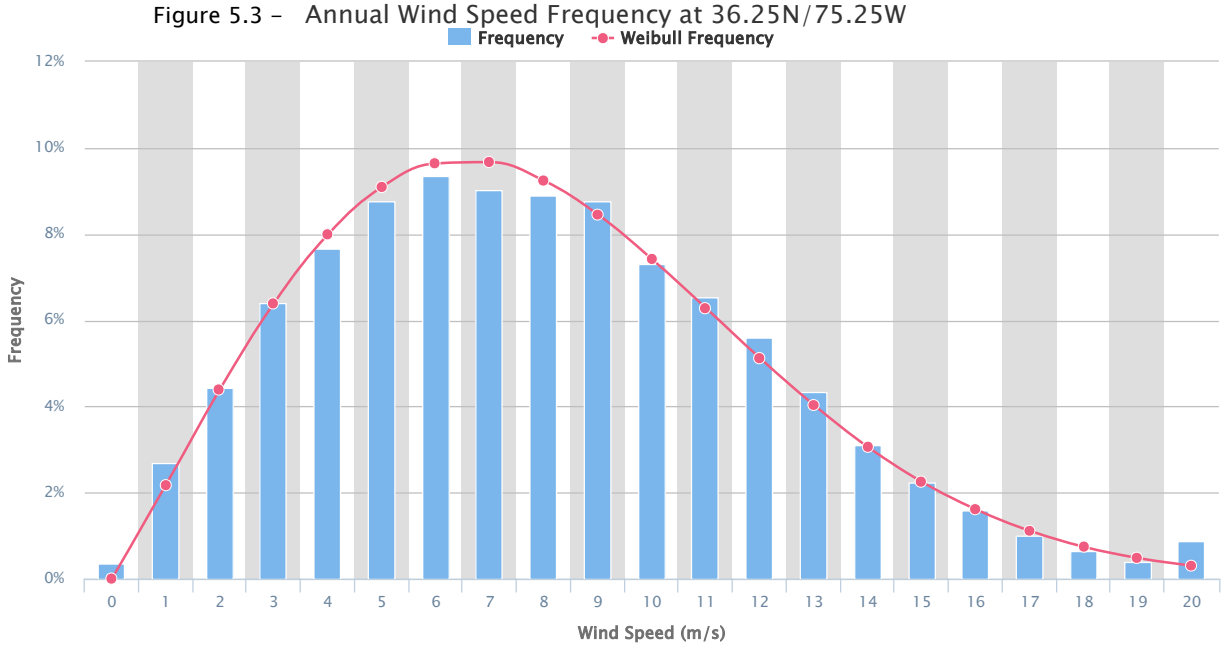


Table 5.3 – Wind Speed Frequency and Weibull Frequency

Wind Speed (m/s)	Frequency (%)	Weibull Frequency (%)
0	0.35%	0%
1	2.7%	2.17%
2	4.44%	4.39%
3	6.42%	6.39%
4	7.67%	7.99%
5	8.77%	9.09%
6	9.34%	9.64%
7	9.04%	9.67%
8	8.88%	9.24%
9	8.76%	8.45%
10	7.31%	7.42%
11	6.52%	6.28%
12	5.59%	5.12%
13	4.35%	4.03%
14	3.12%	3.06%
15	2.24%	2.25%
16	1.59%	1.61%
17	1%	1.11%
18	0.65%	0.74%
19	0.38%	0.48%
20+	0.86%	0.3%

Figure 6.1 – Annual Wind Direction and Speed Frequency at 36.25N/75.25W

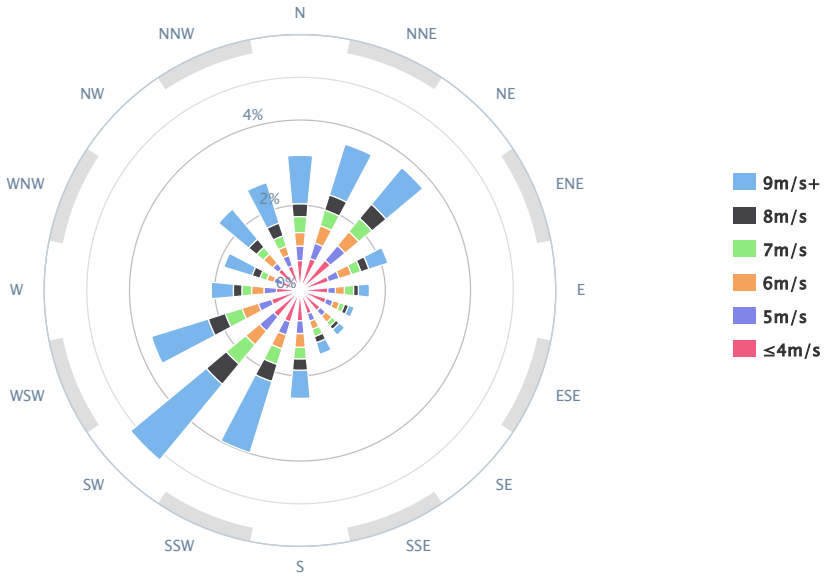


Table 6.1 – Wind Direction and Speed Frequency

	≤ 4m/s	5m/s	6m/s	7m/s	8m/s	9m/s+
N	0.7%	0.34%	0.32%	0.37%	0.3%	1.14%
NNE	0.78%	0.38%	0.43%	0.38%	0.37%	1.25%
NE	0.92%	0.45%	0.42%	0.4%	0.43%	1.12%
ENE	0.7%	0.26%	0.3%	0.23%	0.2%	0.47%
E	0.65%	0.18%	0.21%	0.22%	0.11%	0.26%
ESE	0.64%	0.17%	0.16%	0.12%	0.1%	0.14%
SE	0.61%	0.17%	0.19%	0.12%	0.1%	0.17%
SSE	0.57%	0.18%	0.2%	0.18%	0.15%	0.29%
S	0.71%	0.3%	0.32%	0.27%	0.27%	0.66%
SSW	0.77%	0.32%	0.34%	0.38%	0.42%	1.75%
SW	0.8%	0.43%	0.42%	0.59%	0.61%	2.31%
WSW	0.7%	0.32%	0.4%	0.41%	0.42%	1.4%
W	0.55%	0.29%	0.29%	0.23%	0.2%	0.52%
WNW	0.44%	0.2%	0.17%	0.17%	0.19%	0.7%
NW	0.66%	0.17%	0.28%	0.21%	0.24%	0.92%
NNW	0.6%	0.26%	0.22%	0.26%	0.31%	1%

Figure 6.2 – Annual Wave Direction and Height Frequency at 36.25N/75.25W

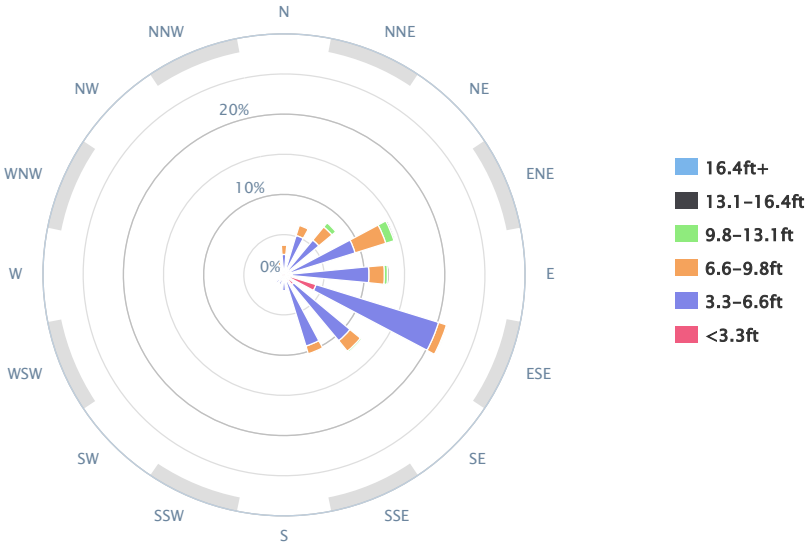


Table 6.2 – Wave Direction and Height Frequency

	<3.3ft	3.3-6.6ft	6.6-9.8ft	9.8-13.1ft	13.1-16.4ft	16.4ft+
N	0.11%	2.41%	1.16%	0.03%	0%	0%
NNE	0.74%	4.36%	1.33%	0.1%	0%	0%
NE	0.41%	5.2%	2.13%	0.65%	0%	0%
ENE	0.9%	8.36%	3.99%	1.08%	0.17%	0%
E	1.04%	9.52%	1.93%	0.38%	0.19%	0%
ESE	4.14%	15.99%	1.04%	0.13%	0.02%	0%
SE	1.56%	9.1%	1.69%	0.21%	0.04%	0%
SSE	0.77%	8.5%	1%	0.11%	0.01%	0%
S	0.09%	1.9%	0.03%	0%	0%	0%
SSW	0.07%	1.19%	0.01%	0%	0%	0%
SW	0.17%	1.1%	0.02%	0%	0%	0%
WSW	0.17%	0.56%	0.01%	0.01%	0%	0%
W	0.08%	0.43%	0.03%	0%	0%	0%
WNW	0.06%	0.56%	0.07%	0%	0%	0%
NW	0.11%	0.98%	0.14%	0%	0%	0%
NNW	0.04%	1.15%	0.49%	0.01%	0%	0%

Table 6.3 - Annual Weather Hazards

Weather Parameters	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Freezing Spray	NONE	NONE	NONE	NONE
Lightning	LOW	MEDIUM	HIGH	LOW
Icing	LOW	NONE	NONE	LOW
Dust	NONE	NONE	NONE	NONE
Vertical Wind	HIGH	MEDIUM	MEDIUM	LOW
Tropical	NONE	LOW	HIGH	MEDIUM
Nor'easter	HIGH	MEDIUM	LOW	MEDIUM
Forecaster Notes	Nor'easter development is greatest during this quarter; this threat coupled with cold front passages yields high threat for vertical motion	Nor'easter threat diminishes after April; tropical threat begins in June; lightning increases as t-storm development increases May/June	Tropical development is greatest during Aug and Sept and tend to curve closer to the coast in Sept; lightning high threat with t-storms	Tropical threat diminishes through October, but can still track toward the coast; Nor'easter development also begins in October

Synopsis of Weather Patterns and Noted Trends in Annual Data:

The Kitty Hawk Wind Energy Area falls within a humid subtropical climate with four distinct seasons. This site receives a wide variety of weather, including high pressure ridges, areas of low pressure, cold fronts, and tropical cyclones. The weather patterns tend to be most active and progressive during the winter months (hence the greatest energy production) and less active and stationary during the summer months (with the exception of increased tropical activity in late summer).

Winter: December-February: During the winter, cold front passages are stronger and more frequent than any time of the year. Strong areas of low pressure known as "Nor'easters" will develop along these fronts from the Gulf of Mexico north along the East Coast or originate from the Continental U.S. (*see enlarged Figure 17.1 on pg 17)*

Additionally, high pressure ridges are strongest this time of year due to abundance of colder air filtering south from Canada. All of these are contributing factors to higher and more frequent wind surges along the coast and therefore greatest energy production during the winter than any other season of the year (*see Annual Charts and Tables pg 4*).

The cut out speed for this turbine model is 25 m/s and we would expect winds to exceed this threshold less than 1% of the time during the winter. The cut in speed for this turbine model is 3 m/s and we would expect winds to fall below this threshold approximately 6% of the time during the winter.

Figure 17.1

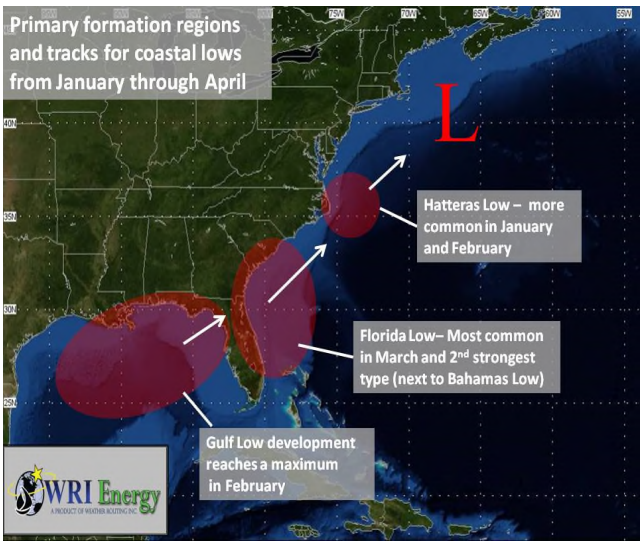
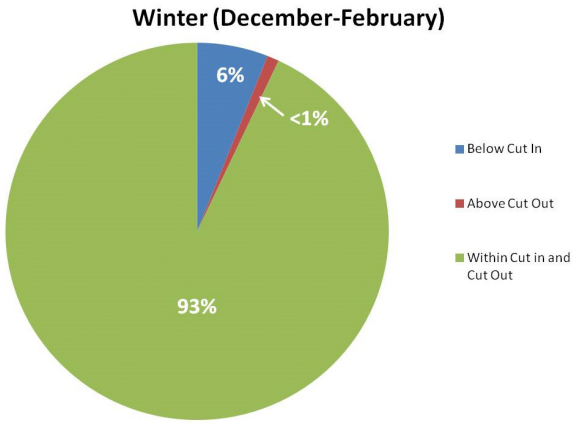


Figure 11.1



Spring: March-May: The sharpest decline in energy production occurs from April into May. This is mainly due to the main low/gale track shifting farther north from the N'rn U.S. into S'rn Canada. Likewise, cold fronts will be a bit weaker and less frequent which, in turn, will result in less "Nor'easter" development along the Carolina coasts. We would expect winds to exceed the cut out threshold less than 1% of the time during the spring. We would expect winds to fall below the cut in threshold approximately 6% of the time during the spring.

Figure 11.2

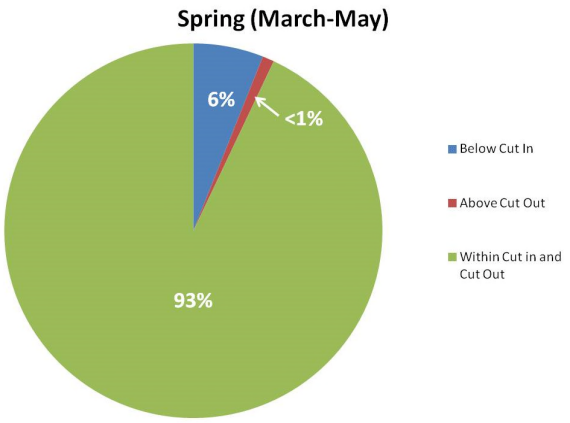
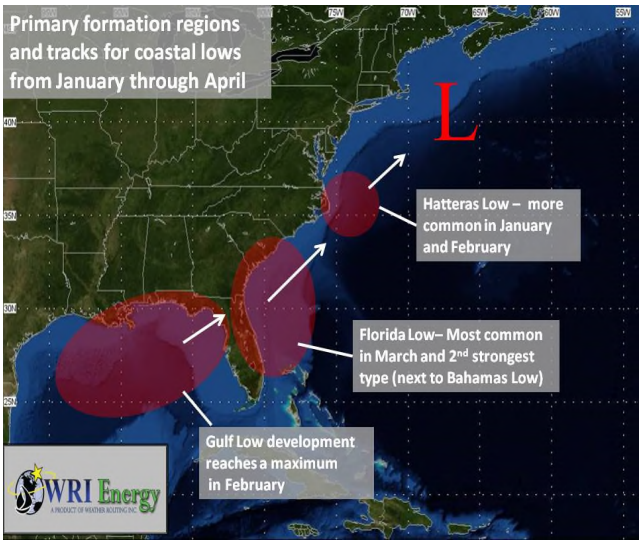


Figure 17.1



Summer: June-August: During the summer, cold front passages are less frequent and weakest, and high pressure ridges are also weakest. This will decrease the pressure gradient overall, resulting in a minimum of wind during the summer months and thereby the least amount of energy production in the summer than any other season of the year. We would expect winds to exceed the cut out threshold less than 1% of the time during the summer. We would expect winds to fall below the cut in threshold approximately 10% of the time during the summer.

Figure 13.1 (*see pg 13 for full graphic)*

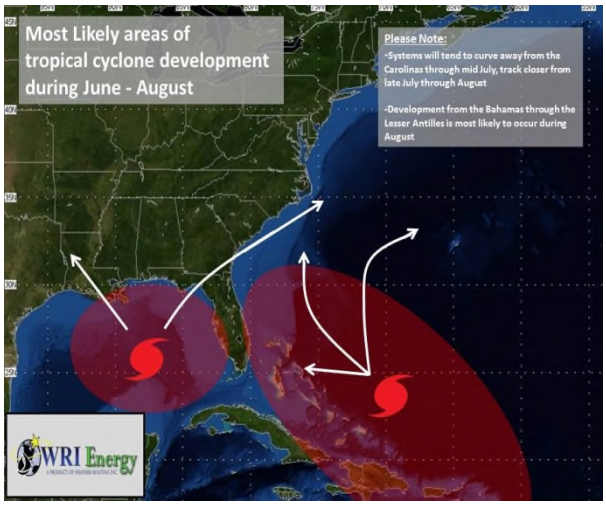
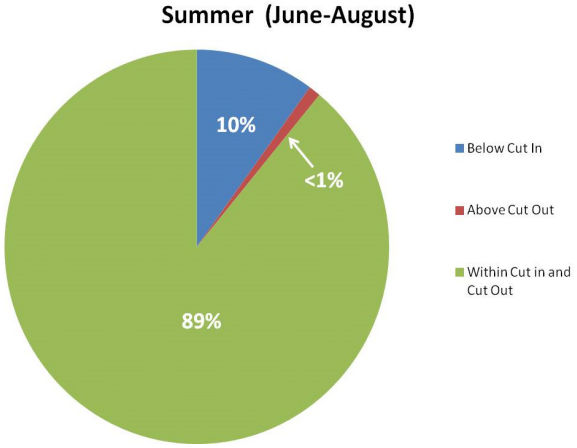


Figure 12.1



Fall: September - November: Looking at the Annual Average Wind Energy Production, we notice the sharpest increase in energy production occurring from August into September. This is due to September being the month of greatest tropical activity along the Carolinas (*see Figure 15.1, pg 15)* and also in part due to the main gale/low track beginning to shift farther south (*see full graphic of Figure 16.1 on pg 16)* .

We would expect winds to exceed the cut out threshold less than 1% of the time during the fall. We would expect winds to fall below the cut in threshold approximately % of the time during the fall.

Figure 12.2

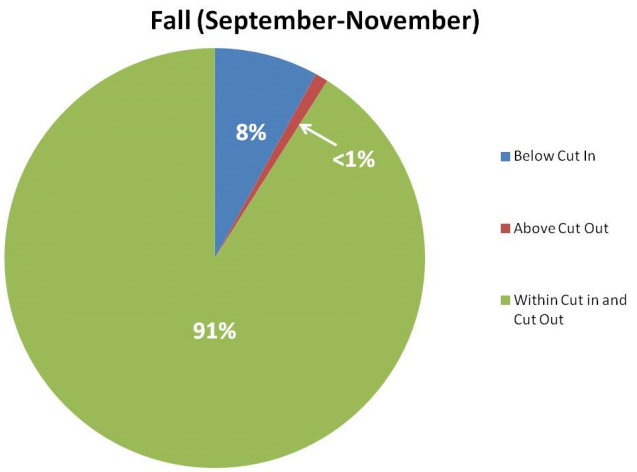


Figure 14.1

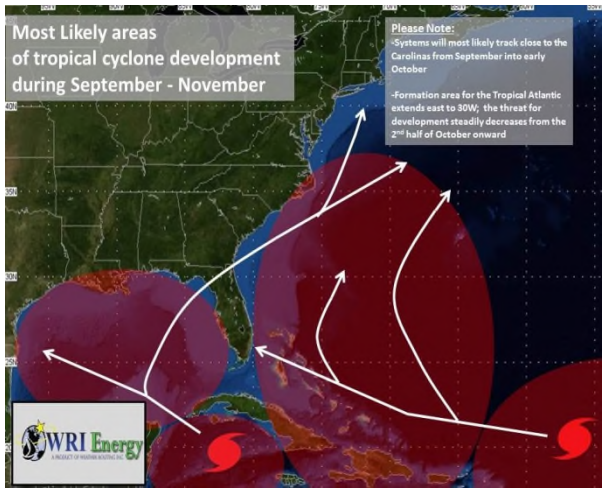
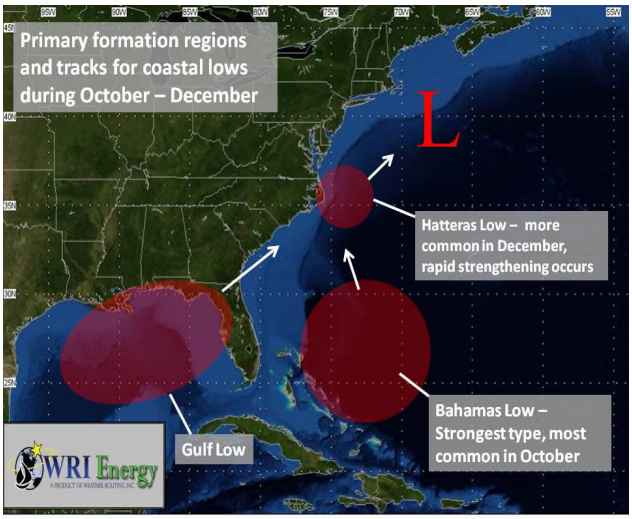


Figure 16.1



Annual Wind Directions: There are varying wind directions throughout the year, with the specific direction being dependent on the weather pattern in place. From the Annual Wind Direction rose (*see pg 5*) we note that SSW-WSW'ly winds and N-NE'ly winds are the most common directions that occur for the Kitty Hawk Wind Energy Area. The SSW-WSW'ly wind direction occurs because North Carolina is often positioned on the W'rn periphery of a high pressure ridge near Bermuda (clockwise wind flow around high pressure). These SSW-WSW'ly winds will peak in strength when this high pressure ridging interacts with an approaching cold front during the winter months.

For N-NE'ly winds, these are most common when high pressure builds over the Northern U.S. after a cold frontal passage. However, these winds will be strongest when a developing gale or storm strengthens (i.e. Nor'easter or tropical cyclone) near or north of Cape Hatteras as it tracks in a general NE-E direction during the winter months (*see Wind Turbine Weather Hazards and Special Weather Phenomena for definition of a Nor'easter).*

The strongest winds the wind turbine would experience would occur during a passing strong tropical system. The directions of these winds will vary and will be highly dependent on the exact track of the system. The winds will be highest when the right front quadrant of the system (relative to the movement of the system) moves over the wind energy area.

Wind Capture Diagrams by Season

Figure 11.1

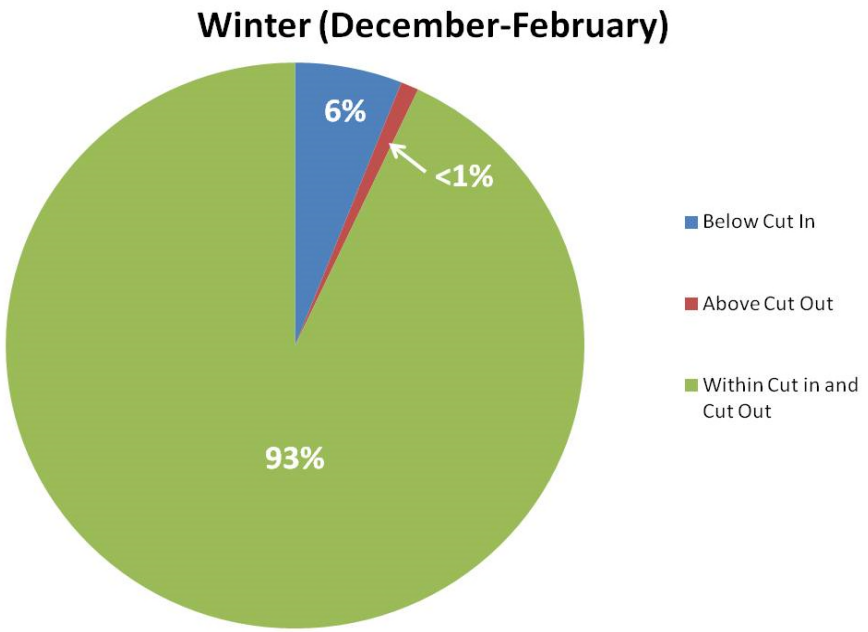
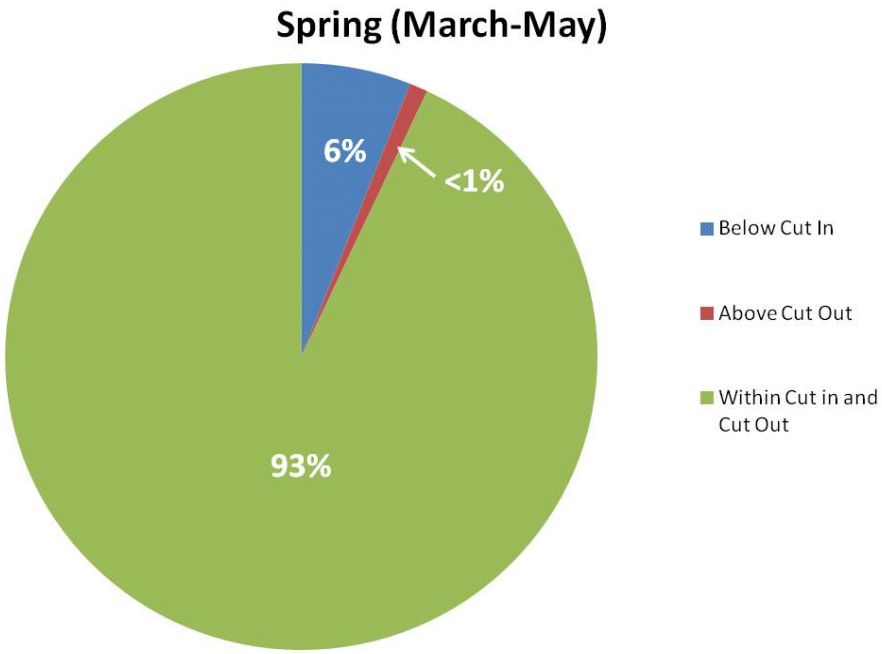


Figure 11.2



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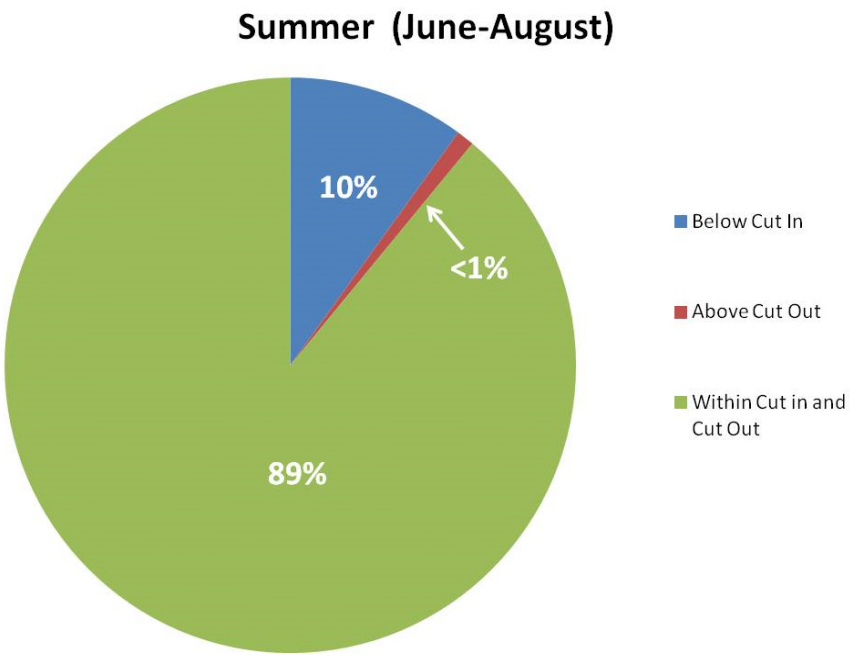
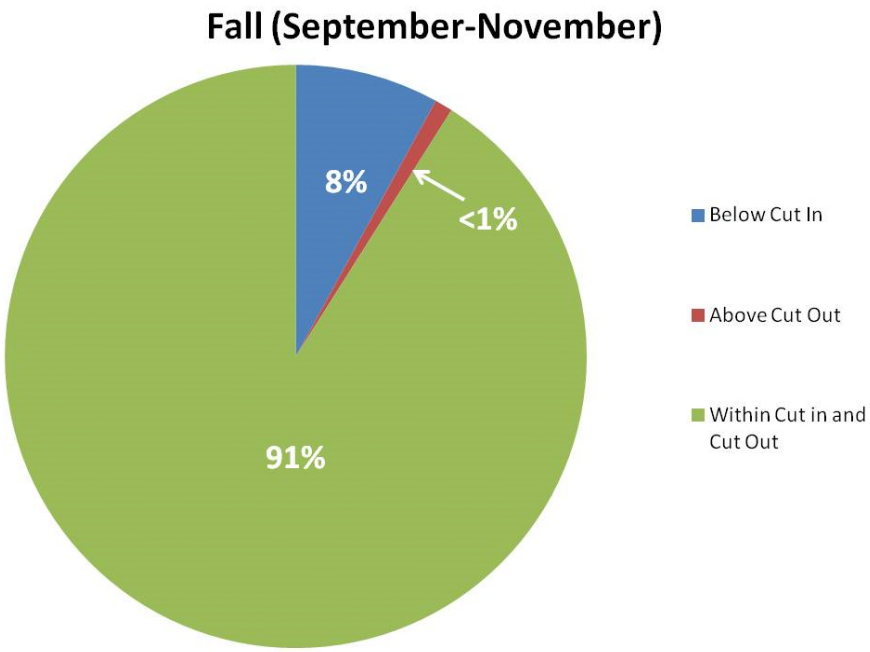
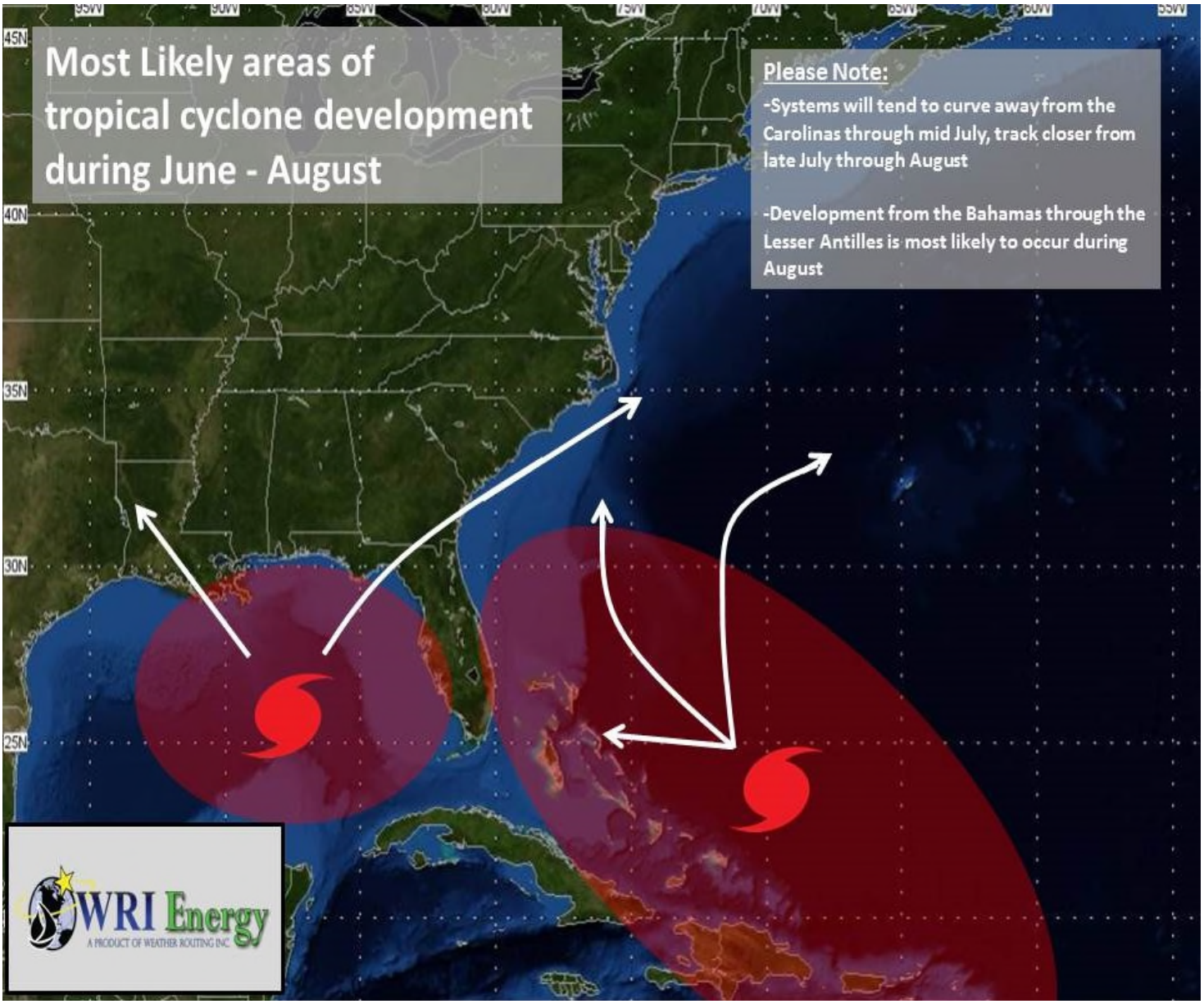


Figure 12.2



Tropical Climatology

Figure 13.1



Tropical Climatology

Figure 14.1

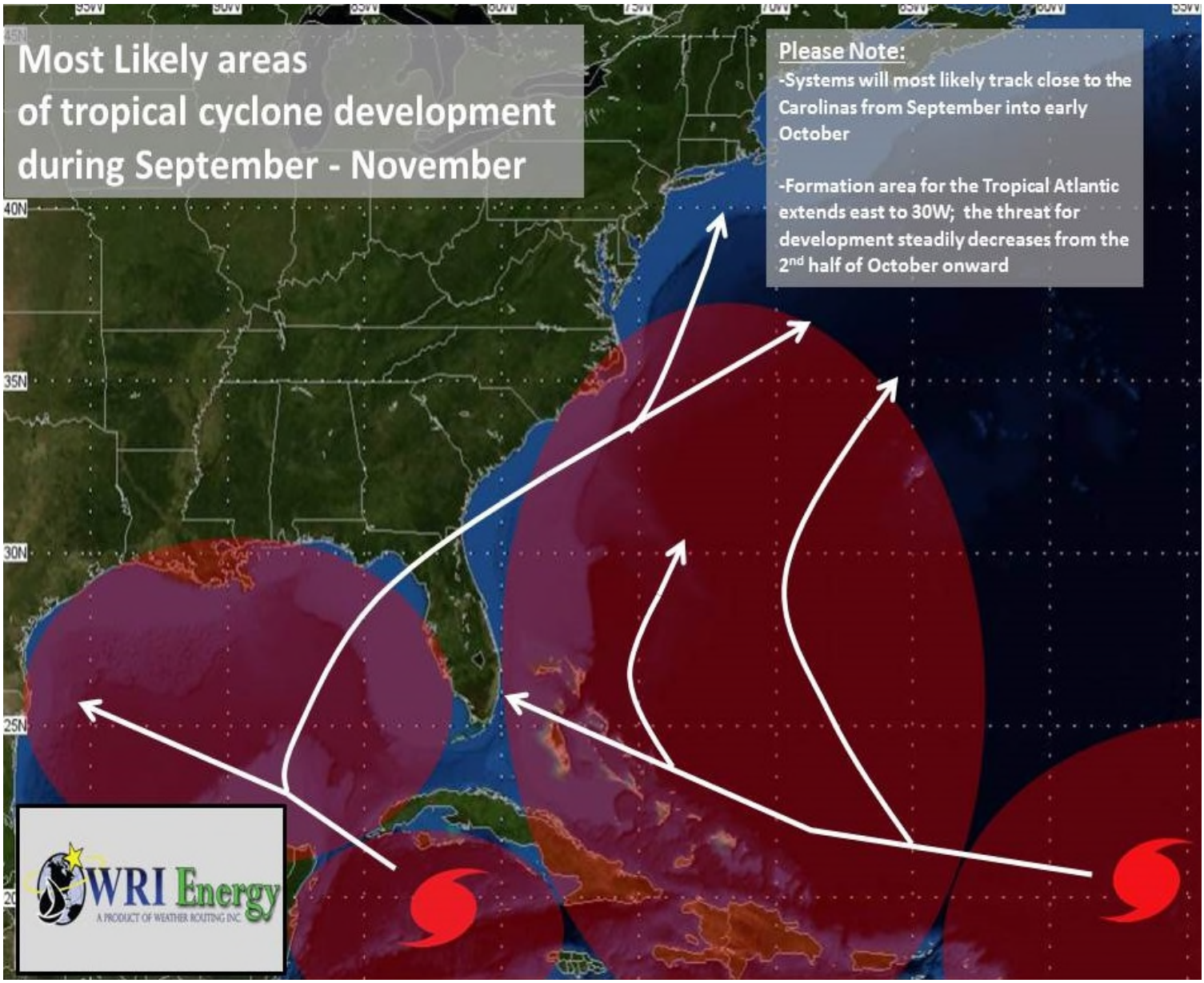


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Figure 15.1

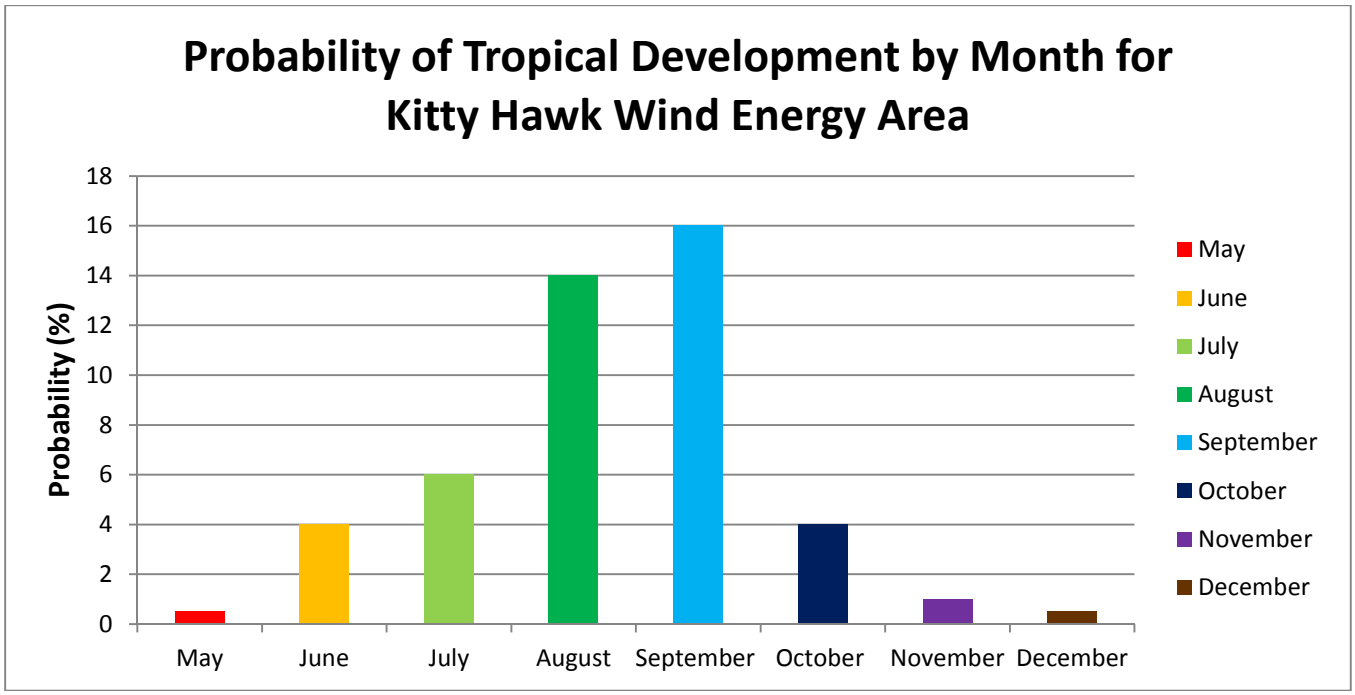
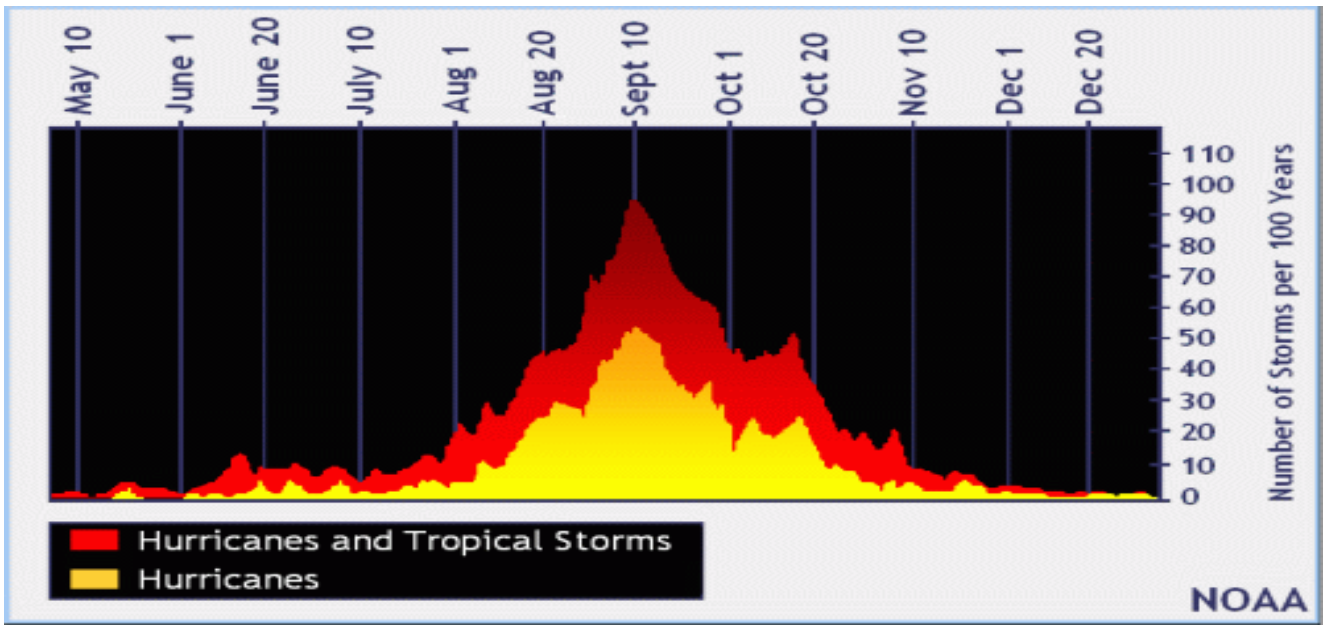
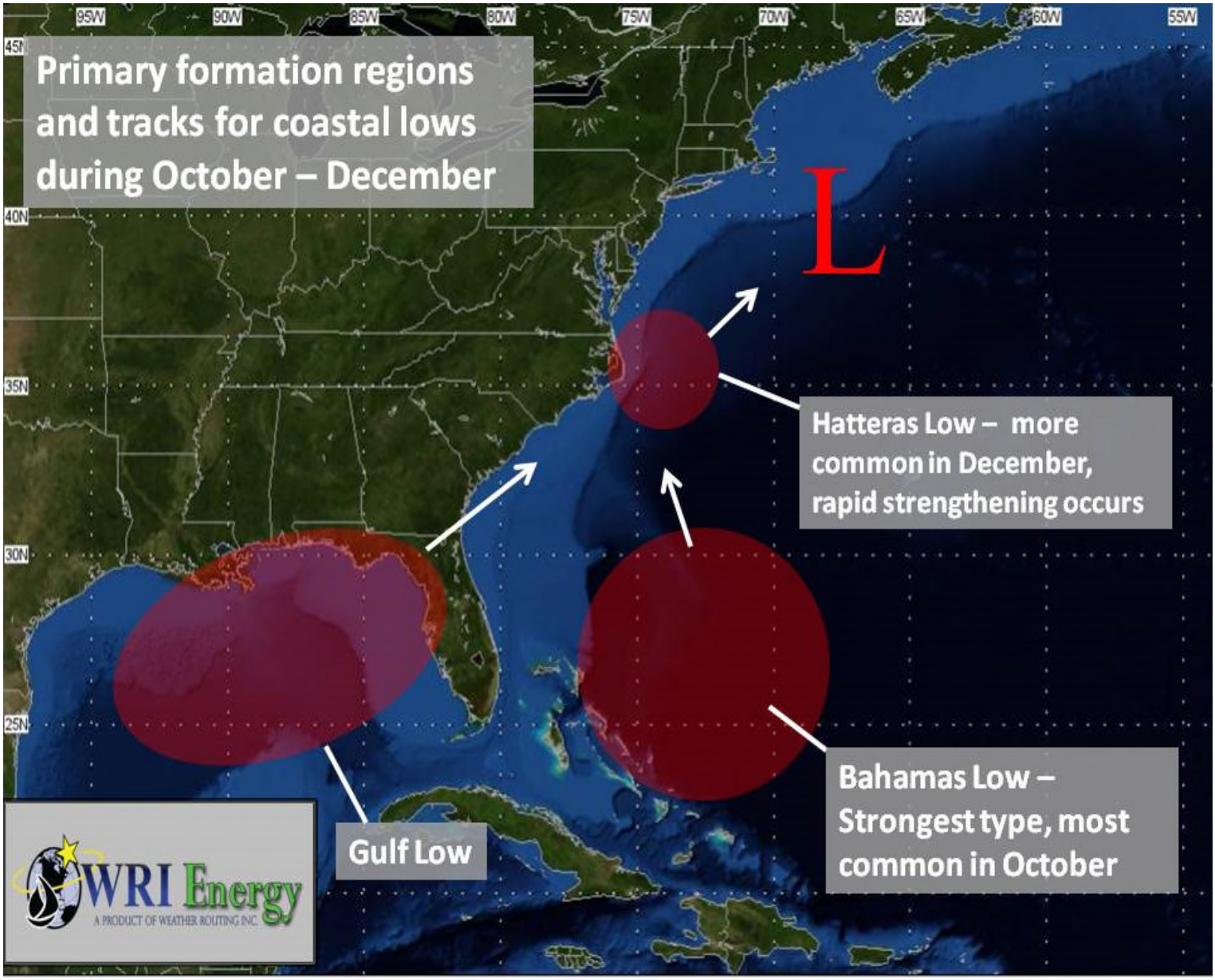


Figure 15.2



Coastal Low Climatology

Figure 16.1



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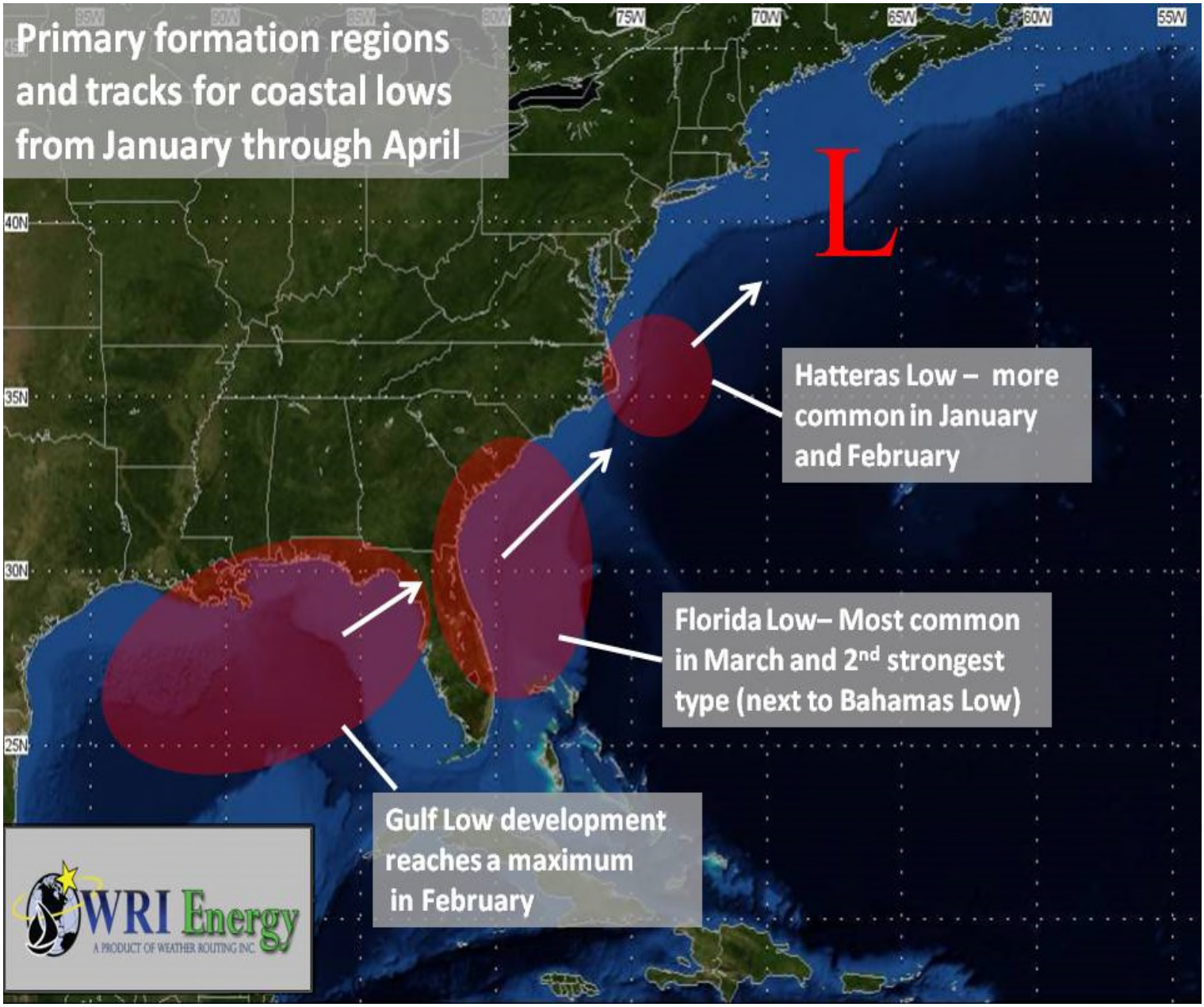


Coastal Low Climatology

Figure 18.1

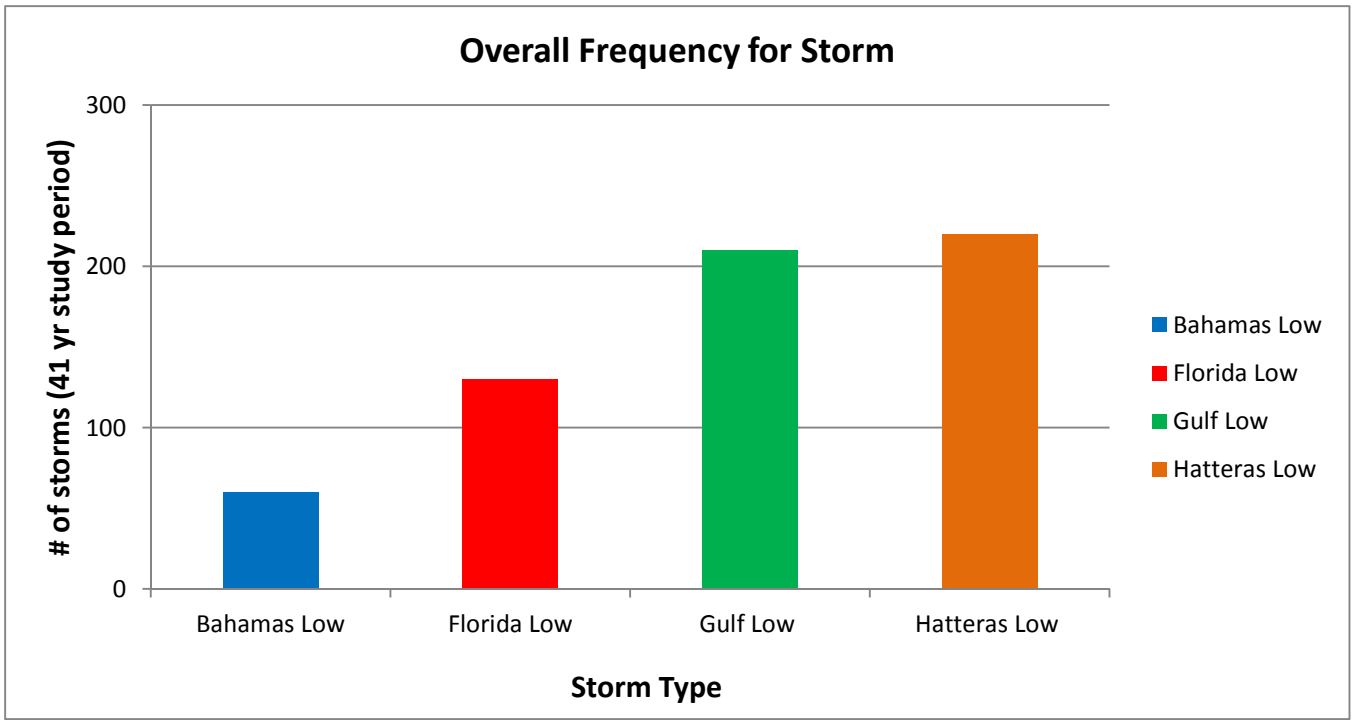
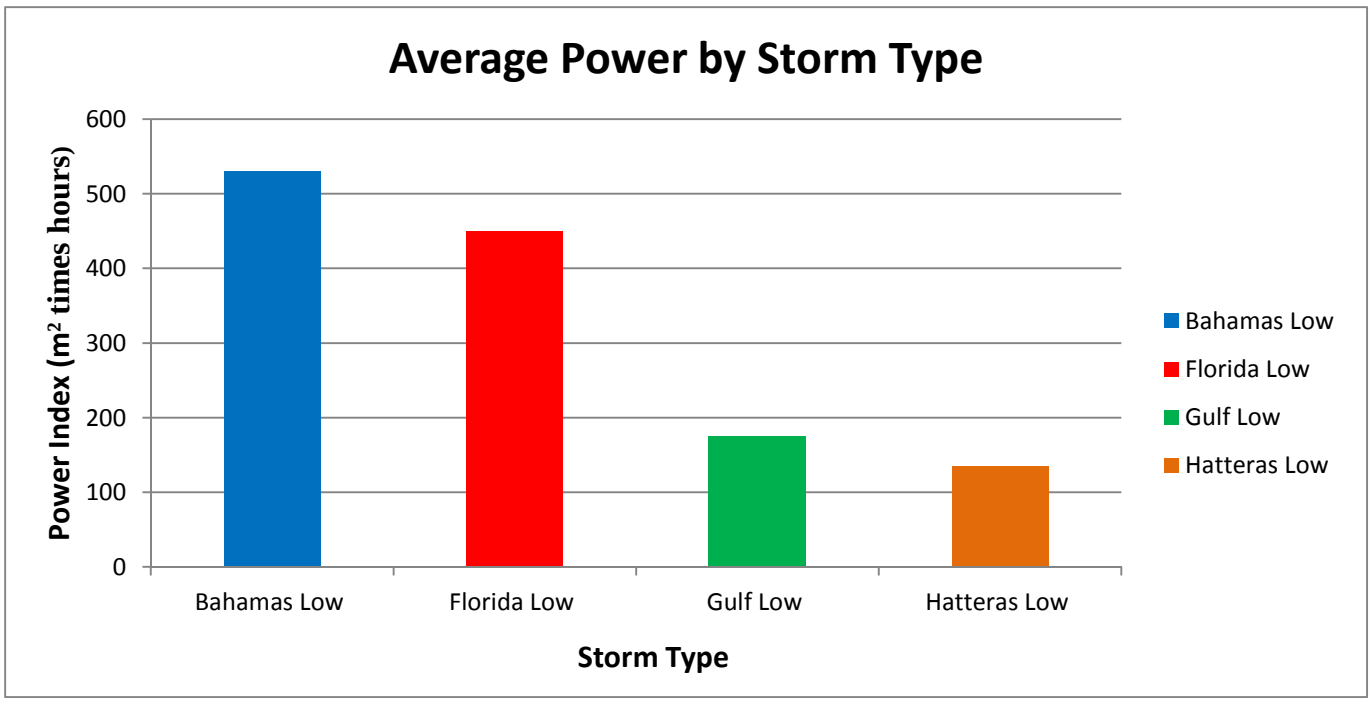


Figure 18.2



Wind Turbine Weather Hazards and Special Weather Phenomena :

In addition to heavy wind and waves, a wind turbine and/or operations and maintenance can be negatively affected by other weather hazards during the year. This potentially includes icing, lightning, dust, freezing spray, and vertical wind shear. Special weather phenomena for the Kitty Hawk Wind Energy Area are tropical cyclones and coastal lows (i.e. Nor'easter)

Icing occurs during a process known as "riming". Rime is a deposit of ice crystals formed by the freezing of super-cooled fog or cloud droplets on objects whose surface temperature is below freezing. Rime will mainly accumulate on the windward (wind-facing) surface of objects (*Lutgens and Tarbuck, 2010).*

Lightning most commonly occurs with the presence of thunderstorm clouds. Thunderstorm development increases as both atmospheric instability and vertical motion increase. Atmospheric instability is a measure of the air temperature at various heights. The greater the difference in temperatures between two heights, the greater the instability of the atmosphere will be. Cloud to ground lightning is the most damaging and dangerous form and represents about 20% of all lightning strokes (*Lutgens and Tarbuck, 2010).*

Freezing spray is a hazard for the operations and maintenance phase of the project, with any ocean vessels or barges being affected when conditions meet the criteria. Freezing spray formation is dependent on an appropriate combination of cold water, wind, cold air and vessel movement.

Vertical wind shear is the difference in wind speed and direction over a relatively short distance in the vertical dimension of the atmosphere or simply "the vertical motion of air". Vertical wind shear is most commonly observed near downbursts caused by thunderstorms, tropical systems and frontal boundaries.

Special Weather Phenomena

A tropical cyclone is the term for a warm core low pressure that originates over the tropical oceans. The hurricane season for the Atlantic runs from June 01st through November 30th. For the Kitty Hawk Wind Energy Area, we expect approximately 0.6-0.7 storms (tropical storm or hurricane) per year (or once every year and a half) within 100 miles of the location (TCFAQ, 2015). These systems are mostly likely to occur in late summer through early autumn and are highly dependent on the presence and timing of cold fronts moving offshore the East Coast U.S.

A nor'easter is defined as a storm when it generates a significant wave height of at least 5 ft (*Jones and Davis, 1995*). The strongest Nor'easters can generate average winds of winds 25-28 m/s (48-55 kts) and average wave heights of 16-23 ft (5-7 M). The primary nor'easter season is from October through April, with February being the stormiest month (*Davis and Dolan, 1993).*

Please see both the *Annual and Monthly Charts and Tables* sections for a breakdown of these hazards throughout the year.

January

Figure 20.1 – Wind Direction and Speed Frequency at 36.25N/75.25W

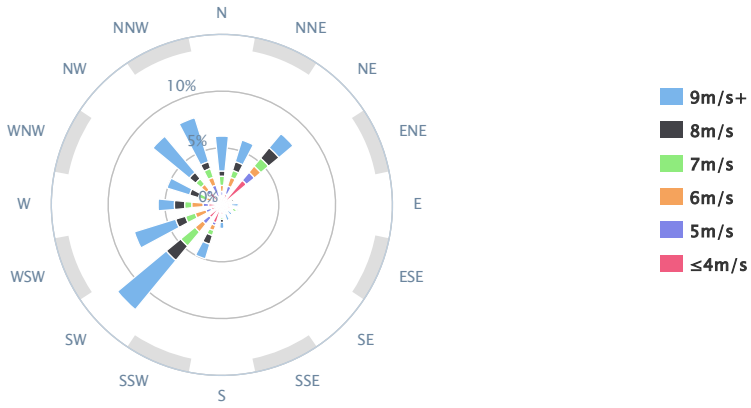


Table 20.1 – Wind Direction and Speed Frequency

	≤ 4m/s	5m/s	6m/s	7m/s	8m/s	9m/s+
N	0.81%	0.36%	0.54%	0.81%	0.45%	3.08%
NNE	1%	0.72%	0.81%	0.63%	0.81%	1.99%
NE	2.81%	0.9%	0.72%	0.9%	1.18%	1.63%
ENE	0.54%	0%	0.27%	0.09%	0.18%	0.09%
E	0.54%	0%	0.18%	0%	0.09%	0.63%
ESE	0.81%	0.09%	0.09%	0.36%	0.09%	0.09%
SE	0.45%	0.09%	0.09%	0%	0.09%	0.45%
SSE	0.54%	0.18%	0.09%	0%	0%	0.63%
S	0.9%	0.18%	0%	0.18%	0.27%	0.54%
SSW	1.63%	0.27%	0.45%	0.45%	0.81%	1.36%
SW	1.45%	0.72%	0.9%	1.63%	1.63%	5.61%
WSW	1%	0.45%	1%	0.9%	0.9%	3.8%
W	1.18%	0.45%	1%	0.63%	0.9%	1.45%
WNW	0.63%	0.36%	0.45%	0.72%	0.81%	2.08%
NW	1.36%	0.36%	0.63%	0.63%	0.72%	4.16%
NNW	0.72%	1.09%	0.72%	0.81%	0.63%	4.07%

Figure 20.2 – Wind Speed Frequency at 36.25N/75.25W

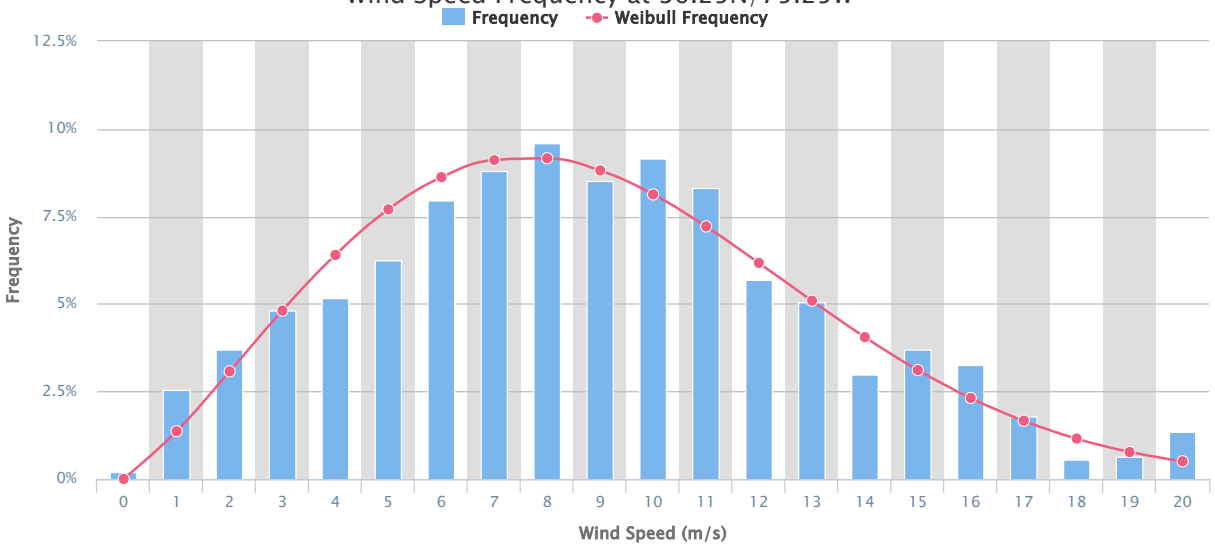


Table 20.2 – Wind Speed Frequency and Weibull Frequency

Wind Speed (m/s)	Frequency (%)	Weibull Frequency (%)
0	0.18%	0%
1	2.53%	1.36%
2	3.71%	3.07%
3	4.8%	4.81%
4	5.16%	6.4%
5	6.24%	7.7%
6	7.96%	8.62%
7	8.78%	9.11%
8	9.59%	9.16%
9	8.51%	8.81%
10	9.14%	8.13%
11	8.33%	7.21%
12	5.7%	6.17%
13	5.07%	5.09%
14	2.99%	4.05%
15	3.71%	3.11%
16	3.26%	2.31%
17	1.81%	1.66%
18	0.54%	1.15%
19	0.63%	0.77%
20+	1.36%	0.5%

Figure 20.3 – Wave Direction and Height Frequency at 36.25N/75.25W

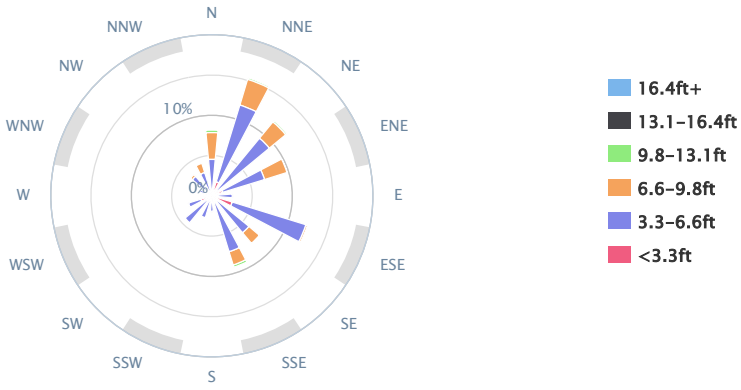


Table 20.3 – Wave Direction and Height Frequency

	<3.3ft	3.3-6.6ft	6.6-9.8ft	9.8-13.1ft	13.1-16.4ft	16.4ft+
N	0.2%	4.33%	3.33%	0.3%	0%	0%
NNE	1.81%	9.98%	3.33%	0.2%	0%	0%
NE	0.71%	8.57%	2.62%	0.2%	0%	0%
ENE	1.41%	5.44%	2.92%	0%	0%	0%
E	0.71%	1.81%	0.1%	0%	0%	0%
ESE	2.62%	9.58%	0.2%	0%	0%	0%
SE	0.81%	5.14%	1.71%	0%	0%	0%
SSE	0.3%	6.96%	1.71%	0.3%	0%	0%
S	0%	1.92%	0.1%	0%	0%	0%
SSW	0.1%	2.72%	0%	0%	0%	0%
SW	0.6%	3.73%	0%	0%	0%	0%
WSW	1.41%	1.61%	0.1%	0%	0%	0%
W	0%	0.91%	0.1%	0%	0%	0%
WNW	0.1%	1.51%	0.1%	0%	0%	0%
NW	0.71%	2.42%	0.3%	0%	0%	0%
NNW	0.1%	2.92%	1.21%	0%	0%	0%

Table 20.4 - Weather Hazards

Weather Parameters	Freezing Spray	Lightning	Icing	Dust	Vertical Wind	Tropical	Nor'easter
Severity	LOW	LOW	MEDIUM	NONE	HIGH	NONE	HIGH
Forecaster Notes	This is only a minimal concern; only affects waters outside of the Gulf Stream		Temp and wind most favorable for riming; this threat is not as severe when compared to northern latitudes		Vertical motion is a high concern due to cold front passages and Nor'easter threat		Development over Gulf of Mexico and along Cape Hatteras is common

February

Figure 21.1 – Wind Direction and Speed Frequency at 36.25N/75.25W

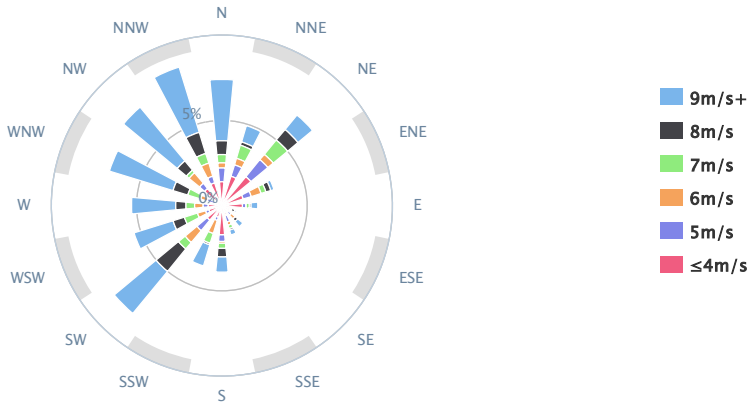


Table 21.1 – Wind Direction and Speed Frequency

	≤ 4m/s	5m/s	6m/s	7m/s	8m/s	9m/s+
N	1.4%	0.8%	0.3%	0.5%	0.8%	3.6%
NNE	1.8%	0.7%	0.4%	0.8%	0.2%	1%
NE	2.2%	1.3%	0.4%	1.1%	0.8%	1.1%
ENE	1.3%	0.5%	0.6%	0.3%	0.3%	0.2%
E	1.2%	0.2%	0%	0.2%	0.1%	0.4%
ESE	0.4%	0%	0.1%	0.1%	0.2%	0.1%
SE	0.5%	0.2%	0.3%	0%	0.2%	0.4%
SSE	0.6%	0.4%	0.2%	0.2%	0.1%	0.3%
S	1.7%	0.4%	0.1%	0.3%	0.5%	0.9%
SSW	0.7%	0.2%	0.8%	0.6%	0.1%	1.3%
SW	1.1%	0.8%	0.9%	0.5%	1.7%	3.2%
WSW	0.8%	0.2%	0.5%	0.8%	0.7%	2.4%
W	0.8%	0.3%	0.5%	0.5%	0.6%	2.6%
WNW	0.4%	0.5%	0.4%	0.8%	0.9%	3.9%
NW	1.3%	0.4%	0.8%	0.2%	0.7%	4.1%
NNW	1.4%	0.4%	0.8%	0.6%	1.3%	4%

Figure 21.2 – Wind Speed Frequency at 36.25N/75.25W

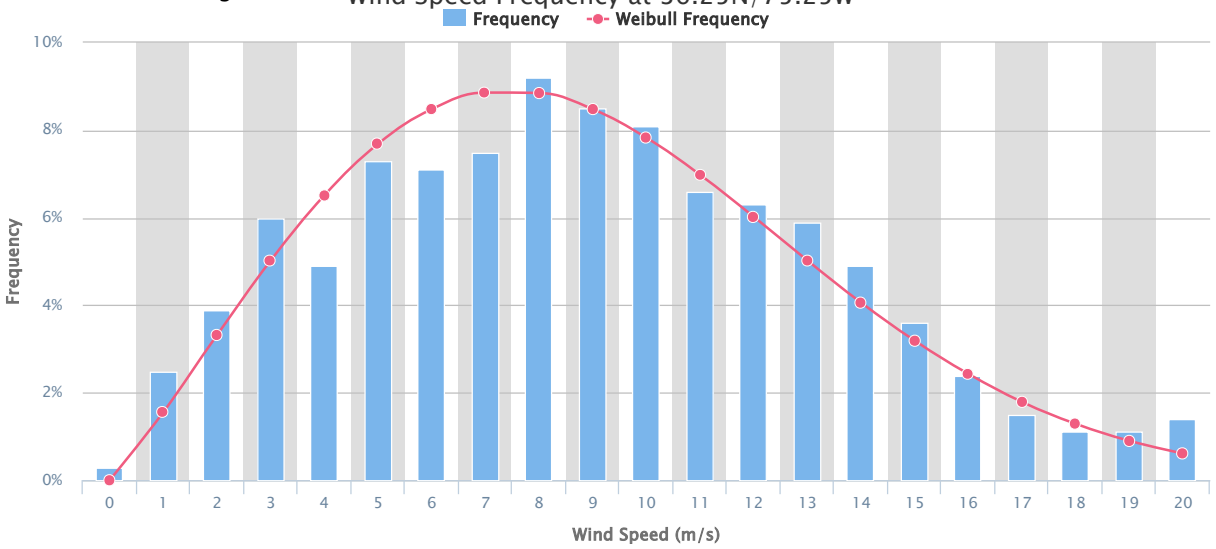


Table 21.2 – Wind Speed Frequency and Weibull Frequency

Wind Speed (m/s)	Frequency (%)	Weibull Frequency (%)
0	0.3%	0%
1	2.5%	1.56%
2	3.9%	3.32%
3	5.99%	5.02%
4	4.9%	6.51%
5	7.29%	7.69%
6	7.09%	8.48%
7	7.49%	8.86%
8	9.19%	8.85%
9	8.49%	8.48%
10	8.09%	7.83%
11	6.59%	6.98%
12	6.29%	6.02%
13	5.89%	5.02%
14	4.9%	4.06%
15	3.6%	3.19%
16	2.4%	2.43%
17	1.5%	1.79%
18	1.1%	1.29%
19	1.1%	0.9%
20+	1.4%	0.61%

Figure 21.3 – Wave Direction and Height Frequency at 36.25N/75.25W

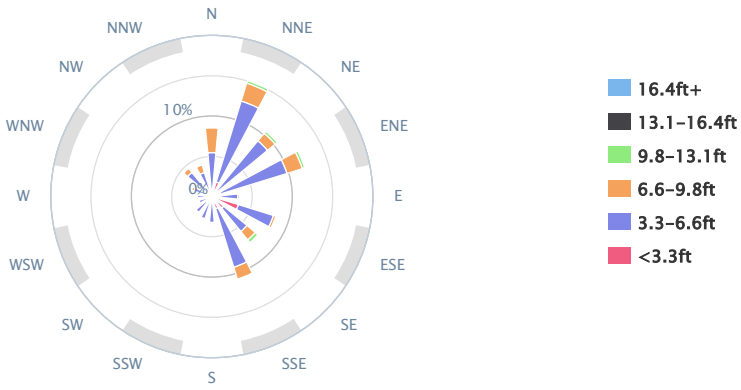


Table 21.3 – Wave Direction and Height Frequency

	<3.3ft	3.3-6.6ft	6.6-9.8ft	9.8-13.1ft	13.1-16.4ft	16.4ft+
N	0.22%	5.2%	3.1%	0.11%	0%	0%
NNE	1.88%	10.51%	2.32%	0.33%	0%	0%
NE	0.66%	8.3%	1.22%	0.33%	0%	0%
ENE	1.11%	8.63%	1.99%	0.33%	0%	0%
E	1%	2.21%	0.22%	0.11%	0%	0%
ESE	3.43%	4.54%	0.33%	0.11%	0%	0%
SE	1.88%	3.76%	1.33%	0.44%	0%	0%
SSE	1.55%	7.63%	1.55%	0%	0%	0%
S	0.11%	3.1%	0.11%	0%	0%	0%
SSW	0.22%	2.65%	0%	0%	0%	0%
SW	0.88%	1.66%	0%	0%	0%	0%
WSW	0.33%	1.33%	0%	0%	0%	0%
W	0%	1.77%	0.11%	0%	0%	0%
WNW	0.33%	1.99%	0.33%	0%	0%	0%
NW	0.22%	3.65%	0.66%	0%	0%	0%
NNW	0.33%	2.77%	1%	0.11%	0%	0%

Table 21.4 - Weather Hazards

Weather Parameters	Freezing Spray	Lightning	Icing	Dust	Vertical Wind	Tropical	Nor'easter
Severity	LOW	LOW	LOW	NONE	HIGH	NONE	HIGH
Forecaster Notes	This is only a minimal concern; only affects waters outside of the Gulf Stream		Icing is a minimal concern		Vertical motion is high due to peak in Nor'easter activity, frequent cold fronts		Development over the Gulf of Mexico and along Cape Hatteras is common

March

Figure 22.1 – Wind Direction and Speed Frequency at 36.25N/75.25W

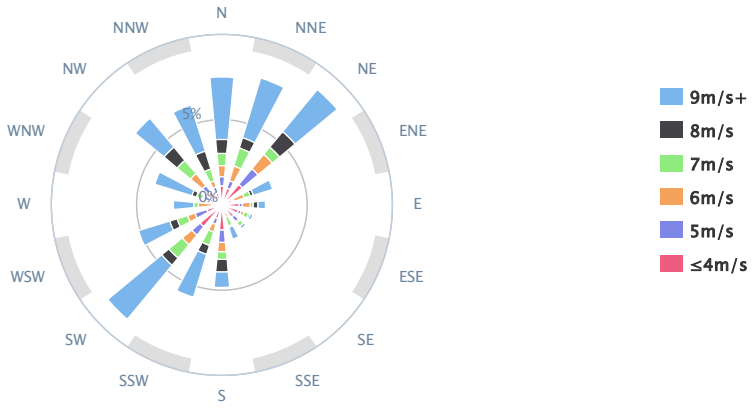


Table 22.1 – Wind Direction and Speed Frequency

	≤ 4m/s	5m/s	6m/s	7m/s	8m/s	9m/s+
N	1.1%	0.55%	0.64%	0.73%	0.82%	3.66%
NNE	1.01%	0.46%	0.91%	1.1%	0.64%	3.66%
NE	1.55%	1.19%	1.1%	0.55%	1.19%	3.2%
ENE	0.64%	0.09%	0.64%	0.37%	0.18%	1.19%
E	1.01%	0.18%	0.46%	0.18%	0.27%	0.46%
ESE	1.01%	0.18%	0.18%	0.27%	0.09%	0.18%
SE	0.91%	0.37%	0.09%	0.27%	0%	0.18%
SSE	0.37%	0.09%	0.27%	0.55%	0.09%	0.73%
S	1.46%	0.73%	0.55%	0.46%	0.73%	0.91%
SSW	0.82%	0.37%	0.46%	0.82%	0.55%	2.65%
SW	1.65%	0.64%	0.73%	1.01%	0.55%	4.11%
WSW	0.91%	0.73%	0.46%	0.64%	0.46%	1.92%
W	0.37%	0.18%	0.82%	0.27%	0%	1.19%
WNW	0.73%	0.37%	0.09%	0.37%	0.27%	2.29%
NW	1.01%	0.46%	0.91%	1.01%	1.01%	2.19%
NNW	0.73%	0.37%	0.37%	0.73%	1.1%	2.83%

Figure 22.2 – Wind Speed Frequency at 36.25N/75.25W

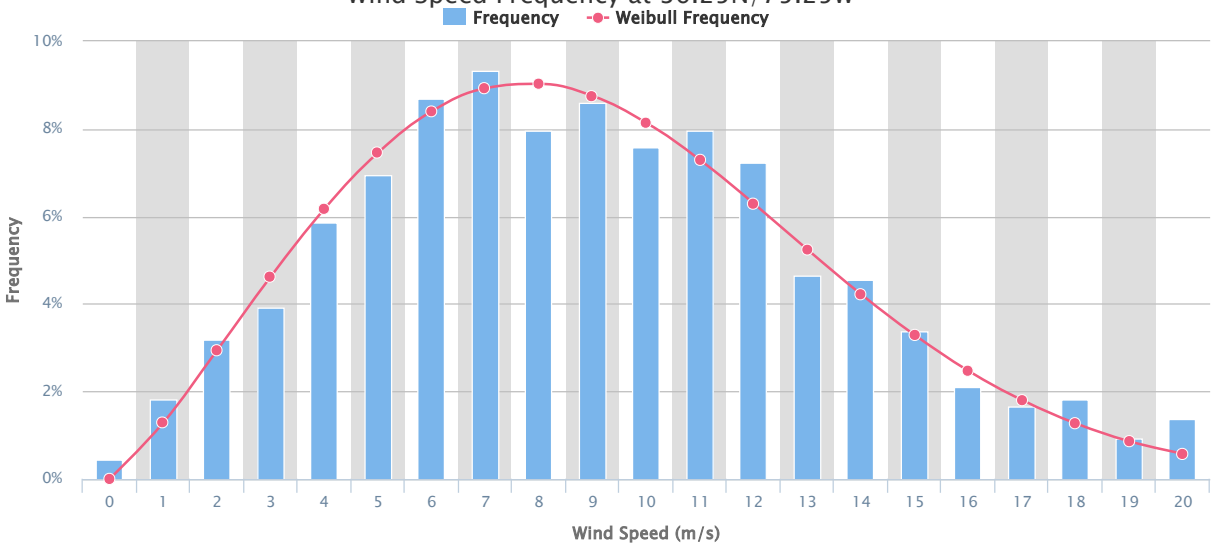


Table 22.2 – Wind Speed Frequency and Weibull Frequency

Wind Speed (m/s)	Frequency (%)	Weibull Frequency (%)
0	0.46%	0%
1	1.83%	1.29%
2	3.2%	2.94%
3	3.93%	4.62%
4	5.85%	6.17%
5	6.95%	7.46%
6	8.68%	8.4%
7	9.32%	8.93%
8	7.95%	9.03%
9	8.59%	8.75%
10	7.59%	8.14%
11	7.95%	7.29%
12	7.22%	6.29%
13	4.66%	5.24%
14	4.57%	4.22%
15	3.38%	3.29%
16	2.1%	2.47%
17	1.65%	1.8%
18	1.83%	1.27%
19	0.91%	0.86%
20+	1.37%	0.57%

Figure 22.3 – Wave Direction and Height Frequency at 36.25N/75.25W

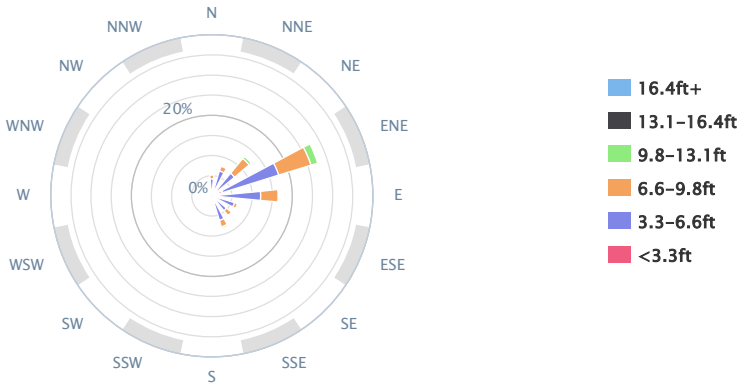


Table 22.3 – Wave Direction and Height Frequency

	<3.3ft	3.3-6.6ft	6.6-9.8ft	9.8-13.1ft	13.1-16.4ft	16.4ft+
N	0.2%	4.03%	0.91%	0%	0%	0%
NNE	1.11%	5.34%	1.21%	0.2%	0%	0%
NE	0.71%	6.55%	4.74%	0.71%	0%	0%
ENE	2.72%	14.62%	8.37%	1.81%	0%	0%
E	1.11%	10.99%	4.33%	0%	0%	0%
ESE	0.5%	5.34%	0.81%	0.1%	0%	0%
SE	0.4%	4.33%	1.61%	0.3%	0%	0%
SSE	0.3%	6.05%	1.71%	0.4%	0%	0%
S	0.2%	2.12%	0%	0%	0%	0%
SSW	0%	1.41%	0%	0%	0%	0%
SW	0%	0.2%	0.1%	0%	0%	0%
WSW	0%	0.2%	0%	0%	0%	0%
W	0%	0.6%	0%	0%	0%	0%
WNW	0.1%	0.4%	0.1%	0%	0%	0%
NW	0.1%	1.11%	0%	0%	0%	0%
NNW	0%	1.61%	0.2%	0%	0%	0%

Table 22.4 - Weather Hazards

Weather Parameters	Freezing Spray	Lightning	Icing	Dust	Vertical Wind	Tropical	Nor'easter
Severity	NONE	LOW	LOW	NONE	HIGH	NONE	HIGH
Forecaster Notes			Icing is a minimal concern		Vertical motion is high due to peak in Nor'easter activity, frequent cold fronts		Development over the Gulf of Mexico and along Cape Hatteras is common; can also form along Florida

April

Figure 23.1 – Wind Direction and Speed Frequency at 36.25N/75.25W

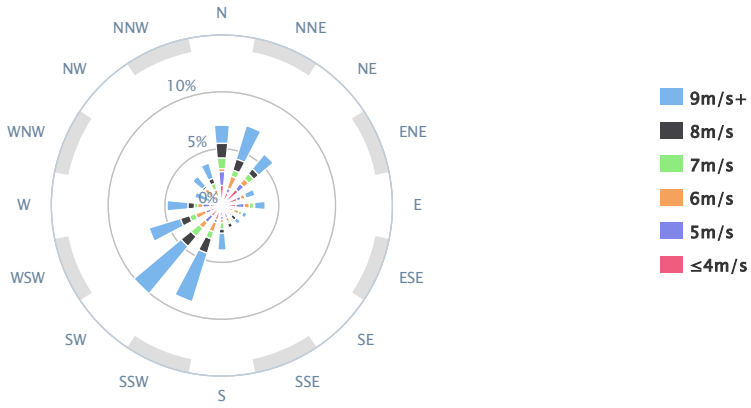


Table 23.1 – Wind Direction and Speed Frequency

	≤ 4m/s	5m/s	6m/s	7m/s	8m/s	9m/s+
N	1.77%	1.21%	0.28%	0.93%	1.3%	1.58%
NNE	1.21%	0.37%	1.12%	0.56%	1.02%	3.07%
NE	1.86%	0.65%	0.56%	0.56%	0.56%	1.67%
ENE	1.39%	0.37%	0.37%	0%	0.09%	0.84%
E	1.21%	0.74%	0.46%	0.37%	0.09%	0.93%
ESE	1.02%	0.09%	0.46%	0.28%	0.09%	0.37%
SE	0.37%	0.28%	0.28%	0.28%	0.46%	0.46%
SSE	0.74%	0.37%	0.37%	0.19%	0.37%	0.09%
S	0.93%	0.28%	0.28%	0.56%	0.37%	1.49%
SSW	1.3%	0.28%	0.84%	0.65%	1.3%	4.46%
SW	1.21%	0.74%	0.65%	0.93%	1.12%	5.39%
WSW	1.02%	0.46%	0.93%	0.56%	0.84%	2.88%
W	1.02%	0.65%	0.46%	0.28%	0.56%	1.86%
WNW	0.65%	0.19%	0.19%	0%	0.09%	1.39%
NW	1.12%	0.09%	0.74%	0.09%	0.19%	1.12%
NNW	0.74%	0.19%	0.56%	0.56%	0.46%	1.39%

Figure 23.2 – Wind Speed Frequency at 36.25N/75.25W

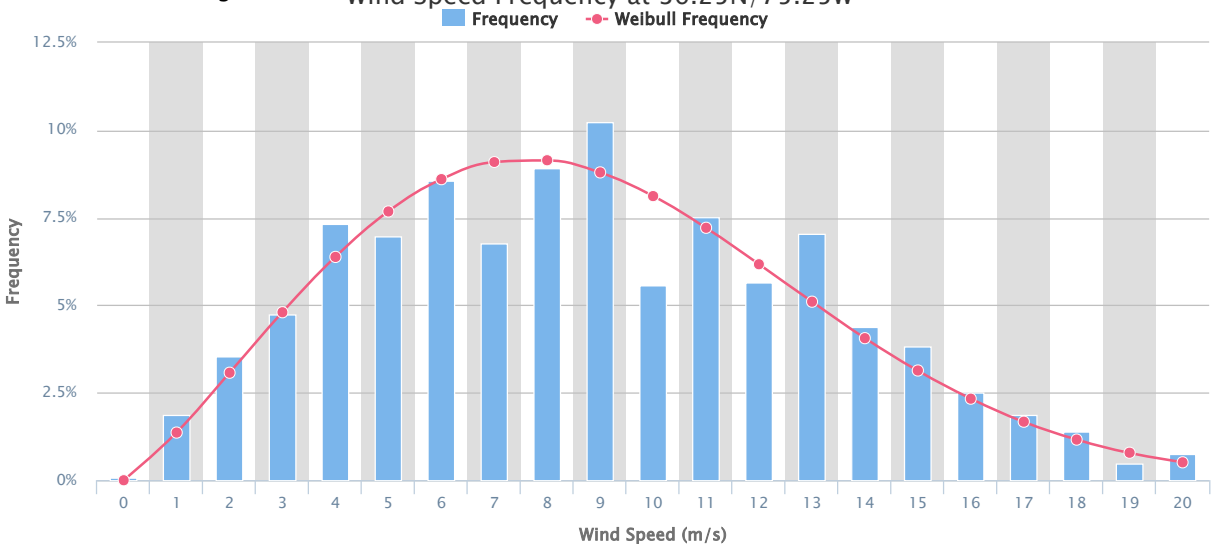


Table 23.2 – Wind Speed Frequency and Weibull Frequency

Wind Speed (m/s)	Frequency (%)	Weibull Frequency (%)
0	0.09%	0%
1	1.86%	1.36%
2	3.53%	3.07%
3	4.74%	4.8%
4	7.34%	6.38%
5	6.97%	7.68%
6	8.55%	8.6%
7	6.78%	9.09%
8	8.92%	9.14%
9	10.22%	8.79%
10	5.58%	8.12%
11	7.53%	7.21%
12	5.67%	6.17%
13	7.06%	5.1%
14	4.37%	4.06%
15	3.81%	3.13%
16	2.51%	2.33%
17	1.86%	1.67%
18	1.39%	1.16%
19	0.46%	0.78%
20+	0.74%	0.51%

Figure 23.3 – Wave Direction and Height Frequency at 36.25N/75.25W

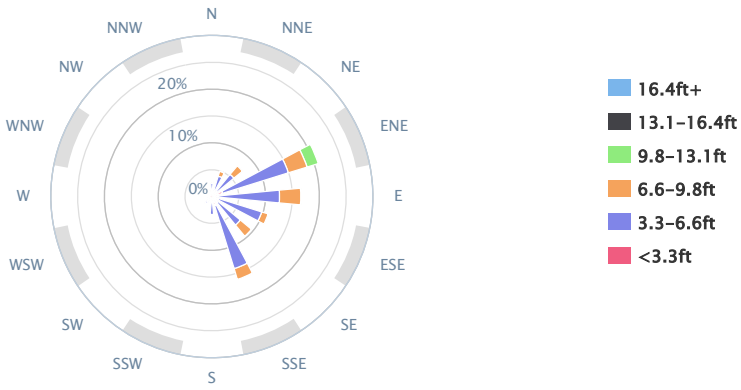


Table 23.3 – Wave Direction and Height Frequency

	<3.3ft	3.3-6.6ft	6.6-9.8ft	9.8-13.1ft	13.1-16.4ft	16.4ft+
N	0.31%	2.19%	0.31%	0%	0%	0%
NNE	0.83%	3.13%	0.94%	0%	0%	0%
NE	0.73%	4.58%	2.08%	0.21%	0%	0%
ENE	2.08%	12.81%	3.65%	2.19%	0%	0%
E	0.63%	11.98%	3.96%	0.1%	0%	0%
ESE	1.25%	8.44%	1.25%	0%	0%	0%
SE	1.35%	5.52%	2.71%	0%	0%	0%
SSE	1.77%	12.29%	2.08%	0.1%	0%	0%
S	0.21%	3.13%	0%	0%	0%	0%
SSW	0.1%	1.15%	0%	0%	0%	0%
SW	0.21%	1.56%	0%	0%	0%	0%
WSW	0.1%	0.73%	0%	0%	0%	0%
W	0.21%	0.42%	0%	0%	0%	0%
WNW	0%	0.52%	0%	0%	0%	0%
NW	0.1%	0.73%	0.21%	0%	0%	0%
NNW	0%	0.63%	0.52%	0%	0%	0%

Table 23.4 - Weather Hazards

Weather Parameters	Freezing Spray	Lightning	Icing	Dust	Vertical Wind	Tropical	Nor'easter
Severity	NONE	LOW	NONE	NONE	MEDIUM	NONE	MEDIUM
Forecaster Notes		Threat begins to increase later April into May as atmospheric instability increases			Threat begins to decrease as Nor'easter threat diminishes through the month		Threat for development gradually decreases through the month

May

Figure 24.1 – Wind Direction and Speed Frequency at 36.25N/75.25W

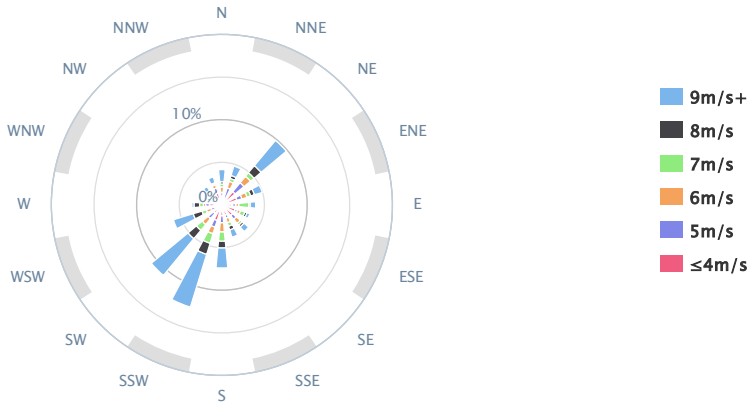


Table 24.1 – Wind Direction and Speed Frequency

	≤ 4m/s	5m/s	6m/s	7m/s	8m/s	9m/s+
N	0.99%	0.45%	0.63%	0.36%	0.27%	1.45%
NNE	0.81%	1.26%	0.81%	0.36%	0.36%	1.17%
NE	1.99%	1.36%	0.99%	0.54%	1.08%	3.88%
ENE	1.81%	0.63%	0.63%	0.45%	0.45%	0.99%
E	1.17%	0.45%	0.36%	1.17%	0.18%	0.63%
ESE	1.63%	0.27%	0.36%	0.54%	0.27%	0.36%
SE	1.63%	0.54%	0.63%	0.27%	0.27%	0.72%
SSE	1.26%	0.36%	0.54%	0.45%	0.45%	0.9%
S	1.26%	0.81%	1.08%	1.08%	0.81%	2.35%
SSW	1.9%	0.81%	0.81%	1.17%	1.36%	6.5%
SW	1.26%	0.81%	0.9%	0.9%	1.26%	5.6%
WSW	0.81%	0.54%	0.54%	0.54%	1.08%	2.44%
W	1.45%	0.45%	0.27%	0.45%	0.63%	0.27%
WNW	0.45%	0.27%	0.18%	0.36%	0.18%	0.36%
NW	1.26%	0.27%	0.27%	0.18%	0.27%	0.54%
NNW	1.45%	0.63%	0.36%	0.18%	0.09%	0.72%

Figure 24.2 – Wind Speed Frequency at 36.25N/75.25W

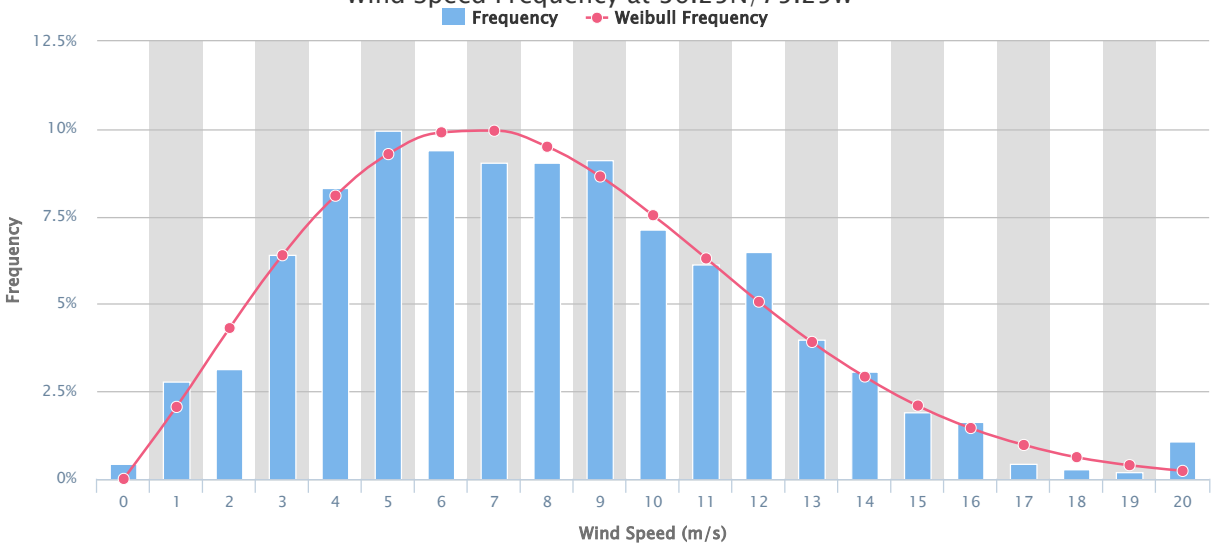


Table 24.2 – Wind Speed Frequency and Weibull Frequency

Wind Speed (m/s)	Frequency (%)	Weibull Frequency (%)
0	0.45%	0%
1	2.8%	2.06%
2	3.16%	4.31%
3	6.41%	6.39%
4	8.31%	8.09%
5	9.94%	9.28%
6	9.39%	9.9%
7	9.03%	9.95%
8	9.03%	9.49%
9	9.12%	8.64%
10	7.14%	7.53%
11	6.14%	6.3%
12	6.5%	5.06%
13	3.97%	3.91%
14	3.07%	2.92%
15	1.9%	2.09%
16	1.63%	1.45%
17	0.45%	0.97%
18	0.27%	0.62%
19	0.18%	0.39%
20+	1.08%	0.23%

Figure 24.3 – Wave Direction and Height Frequency at 36.25N/75.25W

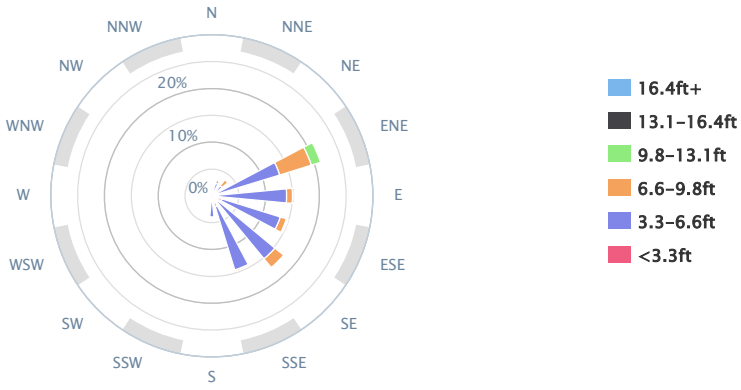


Table 24.3 – Wave Direction and Height Frequency

	<3.3ft	3.3-6.6ft	6.6-9.8ft	9.8-13.1ft	13.1-16.4ft	16.4ft+
N	0.1%	1.41%	0.2%	0%	0%	0%
NNE	0.4%	2.02%	0.6%	0.2%	0%	0%
NE	0.2%	2.22%	1.41%	0.2%	0%	0%
ENE	0.3%	12.9%	6.15%	1.81%	0.2%	0%
E	1.11%	12.8%	1.11%	0.1%	0.3%	0%
ESE	1.92%	11.39%	1.21%	0.2%	0.1%	0%
SE	1.51%	13.71%	2.12%	0%	0%	0%
SSE	2.12%	12.3%	0.3%	0%	0%	0%
S	0%	3.93%	0%	0%	0%	0%
SSW	0%	1.11%	0%	0%	0%	0%
SW	0%	1.11%	0%	0%	0%	0%
WSW	0%	0.2%	0%	0%	0%	0%
W	0.1%	0%	0.1%	0%	0%	0%
WNW	0%	0.3%	0%	0%	0%	0%
NW	0%	0.1%	0.1%	0%	0%	0%
NNW	0%	0.2%	0.1%	0%	0%	0%

Table 24.4 - Weather Hazards

Weather Parameters	Freezing Spray	Lightning	Icing	Dust	Vertical Wind	Tropical	Nor'easter
Severity	NONE	MEDIUM	NONE	NONE	MEDIUM	LOW	LOW
Forecaster Notes		Convection gradually increases in frequency throughout the month			Moderate concern with increasing threat for thunderstorms	Tropical development is rare in May, but has occurred	The threat for strong coastal lows becomes minimal later in the month

June

Figure 25.1 – Wind Direction and Speed Frequency at 36.25N/75.25W

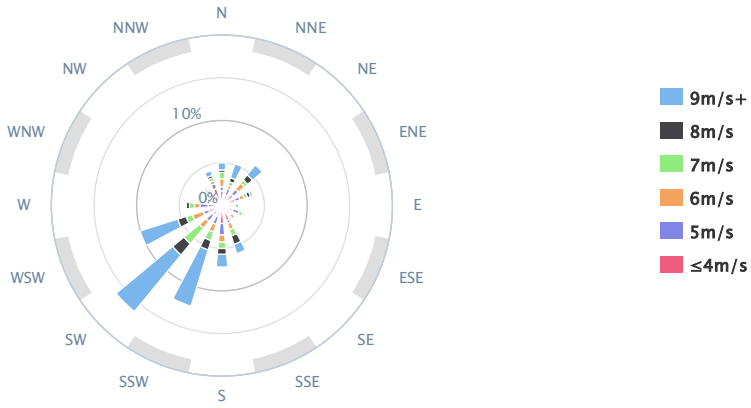


Table 25.1 – Wind Direction and Speed Frequency

	≤ 4m/s	5m/s	6m/s	7m/s	8m/s	9m/s+
N	1.71%	0.47%	0.95%	0.76%	0.28%	0.85%
NNE	1.23%	0.85%	0.38%	0.47%	0.47%	1.71%
NE	1.71%	0.76%	0.95%	0.47%	0.76%	1.52%
ENE	1.61%	0.57%	0.57%	0.38%	0.38%	0.28%
E	0.66%	0.09%	0.47%	0.28%	0%	0.47%
ESE	1.33%	0.76%	0.09%	0.38%	0.19%	0%
SE	1.23%	0.19%	0.57%	0.09%	0%	0.09%
SSE	1.8%	0.38%	0.76%	0.76%	1.04%	1.14%
S	2.09%	1.33%	0.85%	0.76%	0.66%	1.52%
SSW	1.33%	0.95%	0.95%	1.04%	1.14%	6.92%
SW	1.42%	0.95%	1.04%	2.37%	1.71%	8.63%
WSW	1.61%	0.66%	1.33%	0.76%	1.04%	4.64%
W	1.61%	0.95%	0.66%	0.57%	0.38%	0%
WNW	0.47%	0.47%	0.38%	0.19%	0.28%	0.38%
NW	1.42%	0.38%	0.38%	0.19%	0.19%	0.19%
NNW	2.09%	0.57%	0.38%	0.38%	0.28%	0.57%

Figure 25.2 – Wind Speed Frequency at 36.25N/75.25W

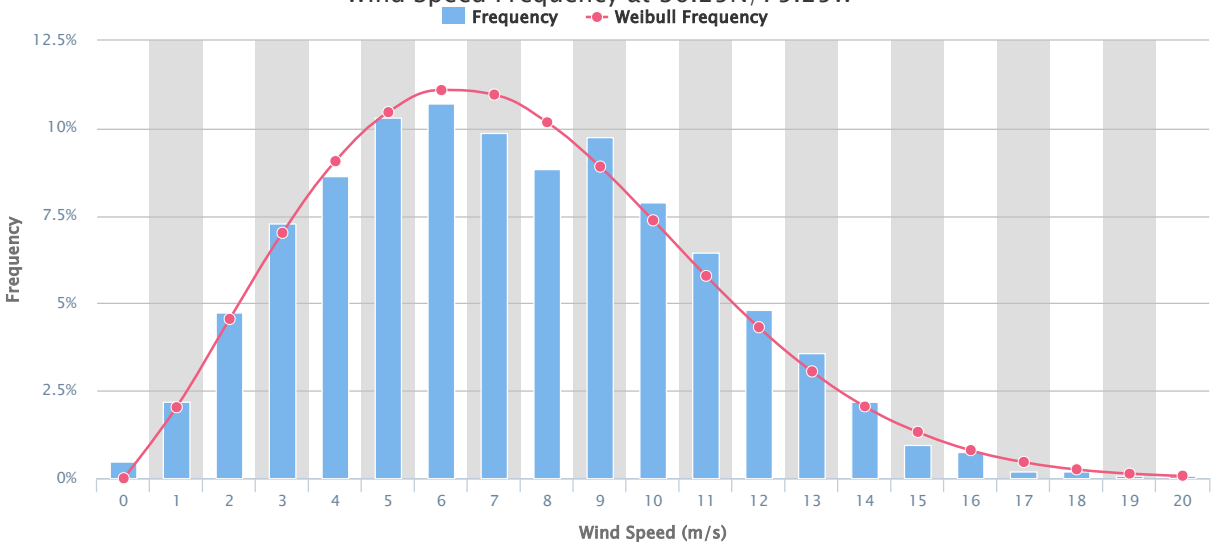


Table 25.2 – Wind Speed Frequency and Weibull Frequency

Wind Speed (m/s)	Frequency (%)	Weibull Frequency (%)
0	0.47%	0%
1	2.18%	2.03%
2	4.74%	4.55%
3	7.3%	7.01%
4	8.63%	9.06%
5	10.33%	10.46%
6	10.71%	11.09%
7	9.86%	10.96%
8	8.82%	10.17%
9	9.76%	8.9%
10	7.87%	7.37%
11	6.45%	5.78%
12	4.83%	4.31%
13	3.6%	3.05%
14	2.18%	2.05%
15	0.95%	1.32%
16	0.76%	0.8%
17	0.19%	0.46%
18	0.19%	0.25%
19	0.09%	0.13%
20+	0.09%	0.07%

Figure 25.3 – Wave Direction and Height Frequency at 36.25N/75.25W

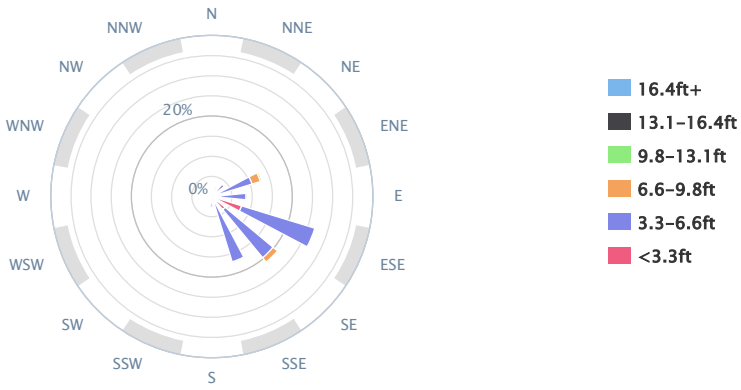


Table 25.3 – Wave Direction and Height Frequency

	<3.3ft	3.3-6.6ft	6.6-9.8ft	9.8-13.1ft	13.1-16.4ft	16.4ft+
N	0.1%	1.46%	0%	0%	0%	0%
NNE	0.63%	1.88%	0.1%	0%	0%	0%
NE	0.31%	3.65%	0.21%	0%	0%	0%
ENE	0.73%	9.69%	2.19%	0.42%	0%	0%
E	1.98%	6.46%	0.42%	0%	0%	0%
ESE	7.71%	19.06%	0%	0%	0%	0%
SE	4.17%	15.52%	1.46%	0.1%	0%	0%
SSE	0.83%	16.15%	0.1%	0.1%	0%	0%
S	0.21%	2.5%	0%	0%	0%	0%
SSW	0%	0.63%	0%	0%	0%	0%
SW	0.1%	0.42%	0%	0%	0%	0%
WSW	0%	0.42%	0%	0%	0%	0%
W	0%	0.1%	0%	0%	0%	0%
WNW	0%	0%	0%	0%	0%	0%
NW	0%	0%	0%	0%	0%	0%
NNW	0%	0.21%	0%	0%	0%	0%

Table 25.4 - Weather Hazards

Weather Parameters	Freezing Spray	Lightning	Icing	Dust	Vertical Wind	Tropical	Nor'easter
Severity	NONE	MEDIUM	NONE	NONE	MEDIUM	LOW	NONE
Forecaster Notes		Convection gradually increases, especially toward the end of the month			Moderate concern due to thunderstorms	Threat of impact is less than 10%, developing systems tend to curve away from the East Coast	

July

Figure 26.1 – Wind Direction and Speed Frequency at 36.25N/75.25W

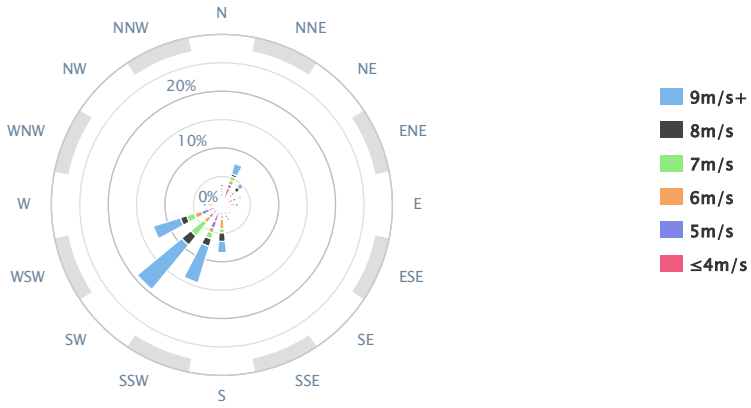


Table 26.1 – Wind Direction and Speed Frequency

	≤ 4m/s	5m/s	6m/s	7m/s	8m/s	9m/s+
N	1.45%	0.63%	0.45%	0.45%	0.18%	0.45%
NNE	3.08%	0.73%	0.73%	0.73%	0.45%	1.9%
NE	1.9%	0.54%	0.54%	0.36%	0.73%	0.91%
ENE	2.09%	0.54%	0.27%	0.09%	0.27%	0.36%
E	2.27%	0.63%	0.09%	0.09%	0%	0%
ESE	1.45%	0.27%	0.27%	0%	0%	0.09%
SE	1.36%	0.27%	0.54%	0.18%	0.18%	0%
SSE	1.9%	0.54%	0.45%	0.09%	0.09%	0.09%
S	1.9%	0.54%	1.72%	0.73%	1.54%	1.99%
SSW	3.08%	1.18%	0.91%	1.09%	1.36%	6.71%
SW	2.09%	0.91%	1.09%	2.99%	2.09%	10.15%
WSW	2.36%	1.36%	1.27%	1.45%	1.18%	4.99%
W	1%	0.54%	0.82%	0.27%	0.09%	0.54%
WNW	0.82%	0.09%	0.45%	0.18%	0.27%	0.09%
NW	1.27%	0.18%	0.09%	0.09%	0.18%	0%
NNW	0.82%	0.36%	0.09%	0%	0.09%	0%

Figure 26.2 – Wind Speed Frequency at 36.25N/75.25W

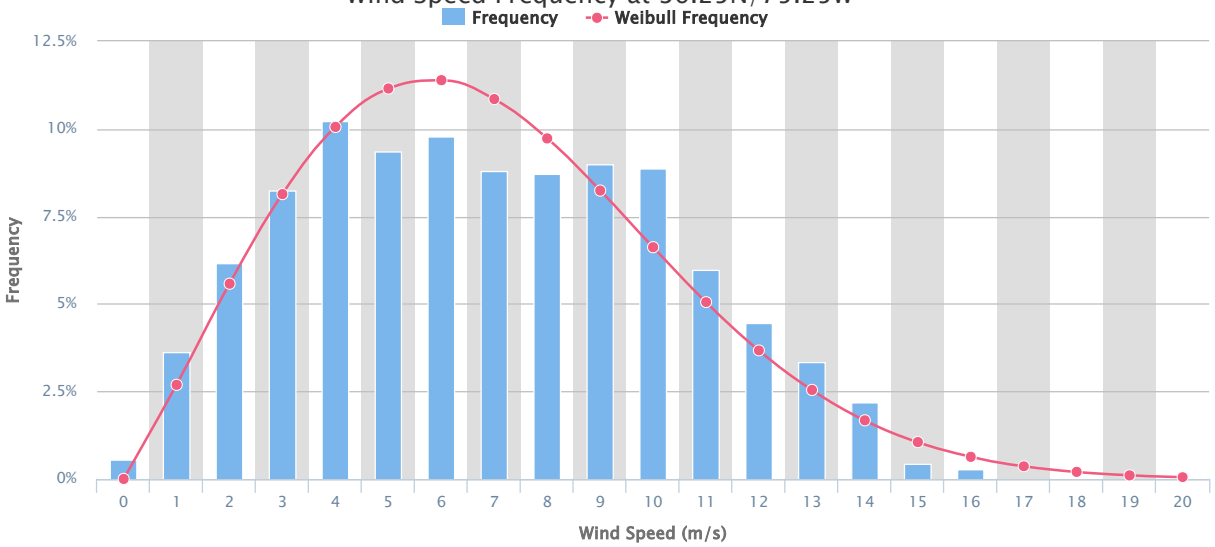


Table 26.2 – Wind Speed Frequency and Weibull Frequency

Wind Speed (m/s)	Frequency (%)	Weibull Frequency (%)
0	0.54%	0%
1	3.63%	2.69%
2	6.17%	5.58%
3	8.25%	8.14%
4	10.24%	10.06%
5	9.34%	11.15%
6	9.79%	11.39%
7	8.79%	10.85%
8	8.7%	9.73%
9	8.98%	8.24%
10	8.88%	6.62%
11	5.98%	5.05%
12	4.44%	3.67%
13	3.35%	2.54%
14	2.18%	1.67%
15	0.45%	1.05%
16	0.27%	0.63%
17	0%	0.36%
18	0%	0.2%
19	0%	0.1%
20+	0%	0.05%

Figure 26.3 – Wave Direction and Height Frequency at 36.25N/75.25W

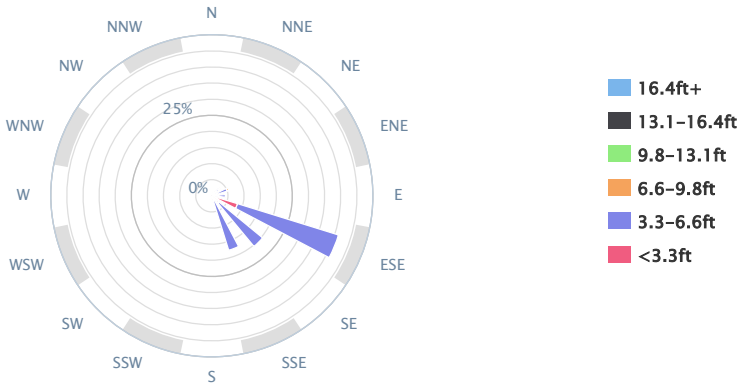


Table 26.3 – Wave Direction and Height Frequency

	<3.3ft	3.3-6.6ft	6.6-9.8ft	9.8-13.1ft	13.1-16.4ft	16.4ft+
N	0%	0.4%	0%	0%	0%	0%
NNE	0%	1.81%	0%	0%	0%	0%
NE	0.1%	2.82%	0.5%	0%	0%	0%
ENE	0.1%	4.84%	0.6%	0%	0%	0%
E	0.6%	3.63%	0%	0%	0%	0%
ESE	8.27%	32.86%	0%	0%	0%	0%
SE	2.92%	17.54%	0%	0%	0%	0%
SSE	1.31%	16.43%	0.2%	0%	0%	0%
S	0%	2.02%	0%	0%	0%	0%
SSW	0%	1.71%	0%	0%	0%	0%
SW	0%	0.71%	0%	0%	0%	0%
WSW	0%	0.4%	0%	0%	0%	0%
W	0%	0.1%	0%	0%	0%	0%
WNW	0%	0%	0%	0%	0%	0%
NW	0%	0%	0%	0%	0%	0%
NNW	0%	0.1%	0%	0%	0%	0%

Table 26.4 - Weather Hazards

Weather Parameters	Freezing Spray	Lightning	Icing	Dust	Vertical Wind	Tropical	Nor'easter
Severity	NONE	HIGH	NONE	NONE	MEDIUM	MEDIUM	NONE
Forecaster Notes		Summertime convection is very active (high atmospheric instability and moisture)			Moderate threat due to thunderstorms	Threat of impact increases slightly, though tend to curve away from the coast through mid-July	

August

Figure 27.1 – Wind Direction and Speed Frequency at 36.25N/75.25W

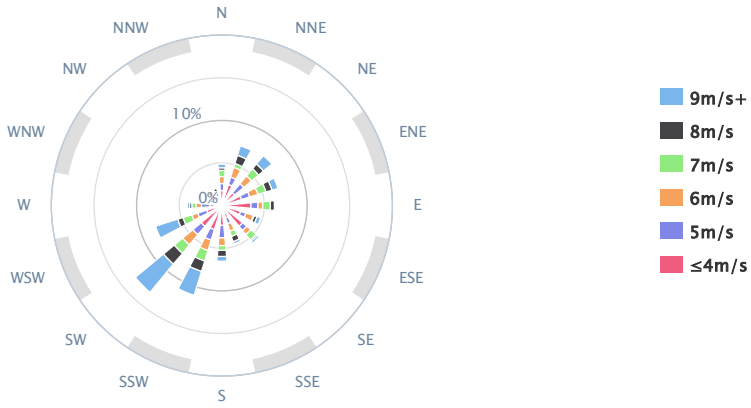


Table 27.1 – Wind Direction and Speed Frequency

	≤ 4m/s	5m/s	6m/s	7m/s	8m/s	9m/s+
N	1.74%	0.83%	0.83%	0.73%	0.28%	0.46%
NNE	2.57%	0.92%	1.19%	0.46%	1.01%	1.19%
NE	1.93%	1.38%	1.19%	1.1%	0.73%	1.28%
ENE	2.39%	1.01%	1.01%	1.01%	0.73%	0.73%
E	3.39%	0.83%	0.55%	0.92%	0.46%	0.18%
ESE	2.29%	0.64%	0.92%	0.09%	0.37%	0.46%
SE	3.12%	0.64%	0.64%	0.83%	0.18%	0.28%
SSE	1.47%	0.73%	0.92%	0.64%	0.64%	0.28%
S	2.29%	1.47%	0.92%	0.55%	0.73%	0.55%
SSW	2.94%	1.28%	1.28%	1.28%	1.28%	2.94%
SW	3.12%	1.28%	1.56%	1.28%	1.65%	4.31%
WSW	1.83%	1.1%	0.73%	1.1%	0.64%	2.75%
W	1.38%	1.01%	0.64%	0.46%	0.28%	0.28%
WNW	1.01%	0.46%	0%	0.28%	0%	0%
NW	1.56%	0.09%	0.46%	0%	0%	0%
NNW	1.1%	0.46%	0.18%	0%	0.37%	0%

Figure 27.2 – Wind Speed Frequency at 36.25N/75.25W

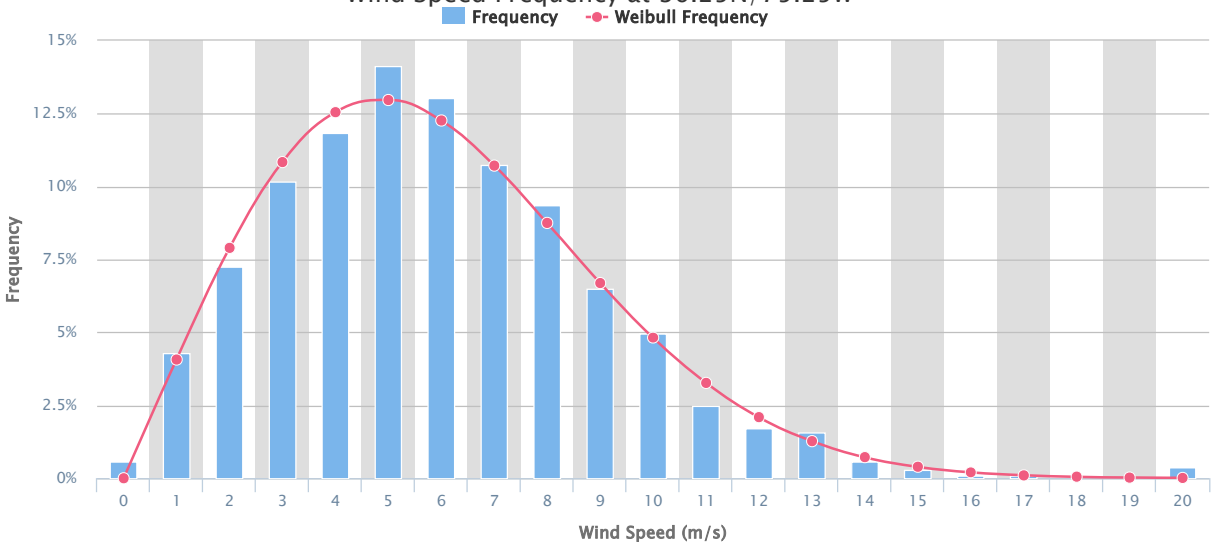


Table 27.2 – Wind Speed Frequency and Weibull Frequency

Wind Speed (m/s)	Frequency (%)	Weibull Frequency (%)
0	0.55%	0%
1	4.31%	4.07%
2	7.25%	7.9%
3	10.18%	10.84%
4	11.83%	12.55%
5	14.13%	12.97%
6	13.03%	12.26%
7	10.73%	10.72%
8	9.36%	8.75%
9	6.51%	6.69%
10	4.95%	4.82%
11	2.48%	3.27%
12	1.74%	2.09%
13	1.56%	1.27%
14	0.55%	0.72%
15	0.28%	0.39%
16	0.09%	0.2%
17	0.09%	0.1%
18	0%	0.05%
19	0%	0.02%
20+	0.37%	0.01%

Figure 27.3 – Wave Direction and Height Frequency at 36.25N/75.25W

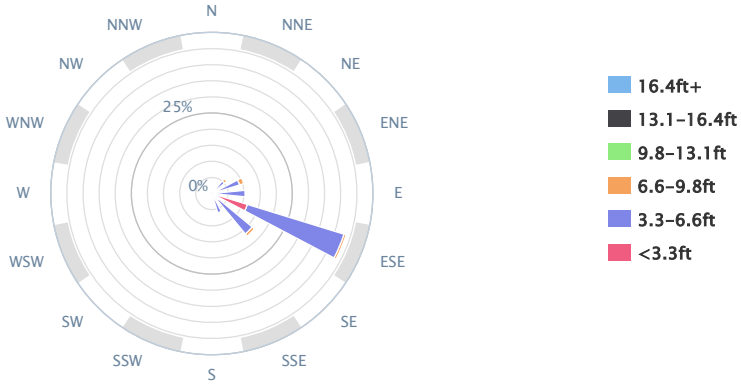


Table 27.3 – Wave Direction and Height Frequency

	<3.3ft	3.3-6.6ft	6.6-9.8ft	9.8-13.1ft	13.1-16.4ft	16.4ft+
N	0%	0.4%	0.1%	0%	0%	0%
NNE	0%	1.61%	0%	0%	0%	0%
NE	0%	5.04%	0.91%	0%	0%	0%
ENE	0.3%	8.67%	1.41%	0%	0%	0%
E	1.01%	9.27%	0.2%	0%	0%	0%
ESE	11.49%	31.35%	0.71%	0%	0%	0%
SE	2.62%	13.61%	0.91%	0.1%	0.2%	0%
SSE	0.5%	5.75%	0.1%	0%	0%	0%
S	0%	1.81%	0%	0%	0%	0%
SSW	0.1%	0.1%	0%	0%	0%	0%
SW	0%	0.91%	0%	0%	0%	0%
WSW	0%	0.1%	0%	0.1%	0%	0%
W	0%	0%	0.1%	0%	0%	0%
WNW	0%	0%	0%	0%	0%	0%
NW	0%	0%	0%	0%	0%	0%
NNW	0%	0.4%	0%	0%	0%	0%

Table 27.4 - Weather Hazards

Weather Parameters	Freezing Spray	Lightning	Icing	Dust	Vertical Wind	Tropical	Nor'easter
Severity	NONE	HIGH	NONE	NONE	MEDIUM	HIGH	NONE
Forecaster Notes		Summertime convection begins to decrease, but the tropics are usually most active during this month			Moderate threat due to thunderstorms	Development from Bahamas to Lesser Antilles increase, chance of impact greater than 10%	

September

Figure 28.1 – Wind Direction and Speed Frequency at 36.25N/75.25W

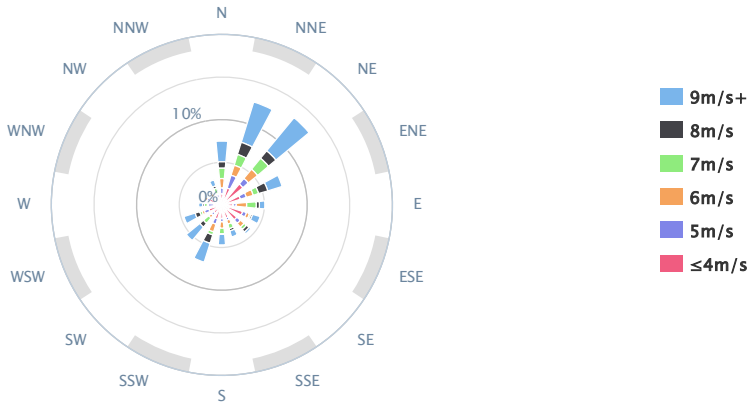


Table 28.1 – Wind Direction and Speed Frequency

	≤ 4m/s	5m/s	6m/s	7m/s	8m/s	9m/s+
N	1.31%	0.66%	1.12%	1.22%	0.75%	2.43%
NNE	2.06%	1.59%	1.22%	1.31%	1.5%	4.96%
NE	3.18%	0.84%	1.4%	1.69%	1.12%	5.06%
ENE	2.25%	0.75%	0.84%	0.66%	1.12%	1.78%
E	1.31%	0.37%	1.22%	1.12%	0.37%	0.66%
ESE	2.53%	0.47%	0.37%	0.19%	0.19%	0.94%
SE	2.25%	0.56%	0.56%	0.37%	0.37%	0.28%
SSE	1.59%	0.28%	0.47%	0.56%	0.28%	0.75%
S	1.59%	0.37%	0.75%	0.66%	0.09%	1.22%
SSW	1.69%	0.66%	0.94%	0.37%	1.03%	2.34%
SW	1.22%	0.37%	0.37%	0.84%	0.56%	2.06%
WSW	1.59%	0.56%	0.28%	0.28%	0.56%	1.4%
W	0.94%	0.66%	0.09%	0.37%	0.19%	0.47%
WNW	1.5%	0.28%	0.28%	0.09%	0%	0.19%
NW	1.03%	0.28%	0.47%	0%	0.19%	0.28%
NNW	0.94%	0.37%	0.09%	0.66%	0.28%	0.75%

Figure 28.2 – Wind Speed Frequency at 36.25N/75.25W

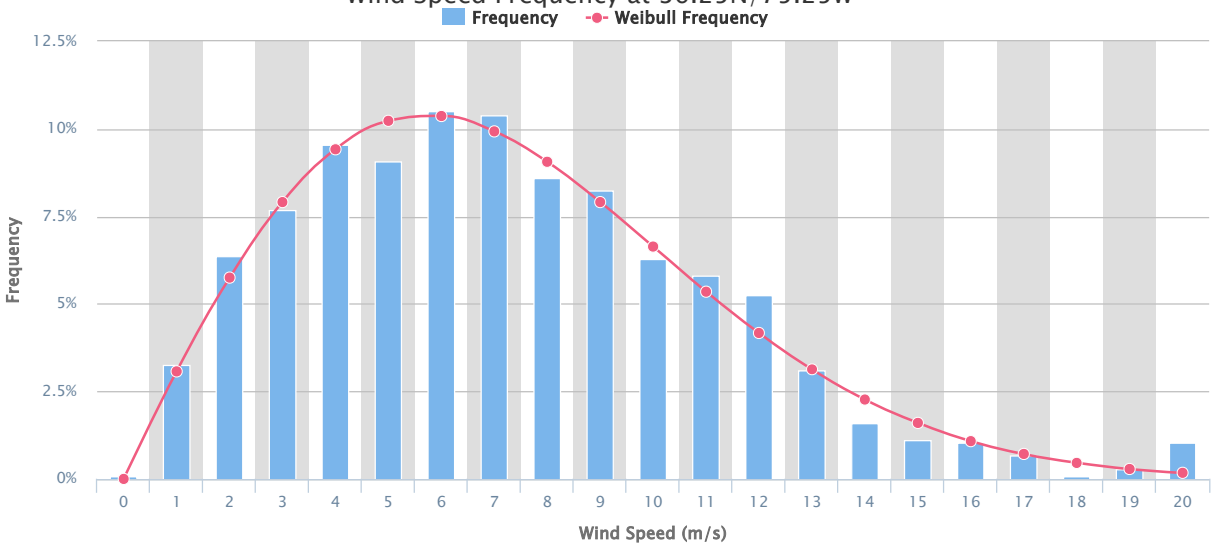


Table 28.2 – Wind Speed Frequency and Weibull Frequency

Wind Speed (m/s)	Frequency (%)	Weibull Frequency (%)
0	0.09%	0%
1	3.28%	3.07%
2	6.37%	5.75%
3	7.68%	7.91%
4	9.55%	9.42%
5	9.08%	10.23%
6	10.49%	10.37%
7	10.39%	9.93%
8	8.61%	9.06%
9	8.24%	7.91%
10	6.27%	6.64%
11	5.81%	5.35%
12	5.24%	4.17%
13	3.09%	3.13%
14	1.59%	2.27%
15	1.12%	1.6%
16	1.03%	1.08%
17	0.66%	0.71%
18	0.09%	0.46%
19	0.28%	0.28%
20+	1.03%	0.17%

Figure 28.3 – Wave Direction and Height Frequency at 36.25N/75.25W

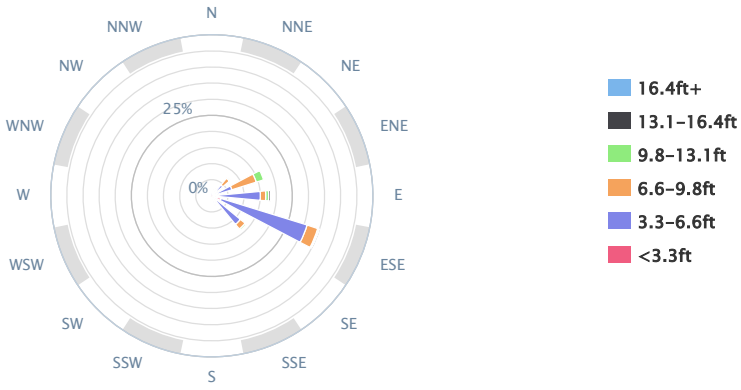


Table 28.3 – Wave Direction and Height Frequency

	<3.3ft	3.3-6.6ft	6.6-9.8ft	9.8-13.1ft	13.1-16.4ft	16.4ft+
N	0%	0.63%	0.21%	0%	0%	0%
NNE	0%	1.88%	0.52%	0.1%	0%	0%
NE	0%	4.38%	2.71%	0.42%	0%	0%
ENE	0%	6.46%	7.92%	2.4%	0%	0%
E	0.1%	14.9%	1.67%	0.94%	0.63%	0%
ESE	2.92%	28.02%	3.44%	0.42%	0%	0%
SE	0.31%	11.15%	1.88%	0.52%	0.1%	0%
SSE	0.1%	2.6%	0.31%	0%	0.1%	0%
S	0%	0.63%	0%	0%	0%	0%
SSW	0%	0.21%	0%	0%	0%	0%
SW	0%	0.42%	0%	0%	0%	0%
WSW	0%	0%	0%	0%	0%	0%
W	0%	0.21%	0%	0%	0%	0%
WNW	0%	0.31%	0%	0%	0%	0%
NW	0%	0.1%	0%	0%	0%	0%
NNW	0%	0.42%	0%	0%	0%	0%

Table 28.4 - Weather Hazards

Weather Parameters	Freezing Spray	Lightning	Icing	Dust	Vertical Wind	Tropical	Nor'easter
Severity	NONE	MEDIUM	NONE	NONE	LOW	HIGH	LOW
Forecaster Notes		Summertime convection begins to decrease, but the tropics are usually most active during this month			Thunderstorm frequency decreases	Development across West Atlantic is greatest, systems more likely to curve toward the East Coast	

October

Figure 29.1 – Wind Direction and Speed Frequency at 36.25N/75.25W

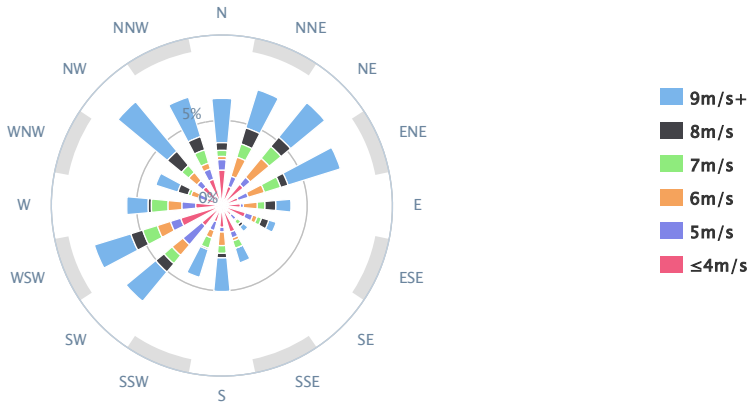


Table 29.1 – Wind Direction and Speed Frequency

	≤ 4m/s	5m/s	6m/s	7m/s	8m/s	9m/s+
N	2.07%	0.63%	0.18%	0.36%	0.45%	2.61%
NNE	1.17%	0.63%	1.17%	0.81%	0.99%	2.34%
NE	1.62%	0.54%	1.44%	0.9%	0.72%	2.61%
ENE	0.99%	0.63%	0.99%	0.99%	0.45%	3.23%
E	1.08%	0.18%	0.81%	0.45%	0.63%	0.9%
ESE	1.44%	0.45%	0.27%	0.27%	0.45%	0.45%
SE	0.72%	0.36%	0.09%	0.27%	0.18%	0.36%
SSE	1.62%	0.36%	0.18%	0.45%	0%	0.9%
S	1.26%	0.27%	0.81%	0.45%	0.27%	1.98%
SSW	0.99%	0.54%	0.45%	0.63%	0.09%	1.71%
SW	1.53%	1.44%	0.81%	0.63%	0.63%	2.25%
WSW	2.52%	0.63%	0.81%	0.9%	0.72%	2.25%
W	1.53%	0.81%	0.81%	0.99%	0.18%	1.26%
WNW	0.9%	0.54%	0.45%	0.18%	0.63%	1.35%
NW	1.44%	0.45%	0.63%	0.54%	1.08%	3.77%
NNW	1.62%	0.63%	0.36%	0.81%	0.81%	2.43%

Figure 29.2 – Wind Speed Frequency at 36.25N/75.25W

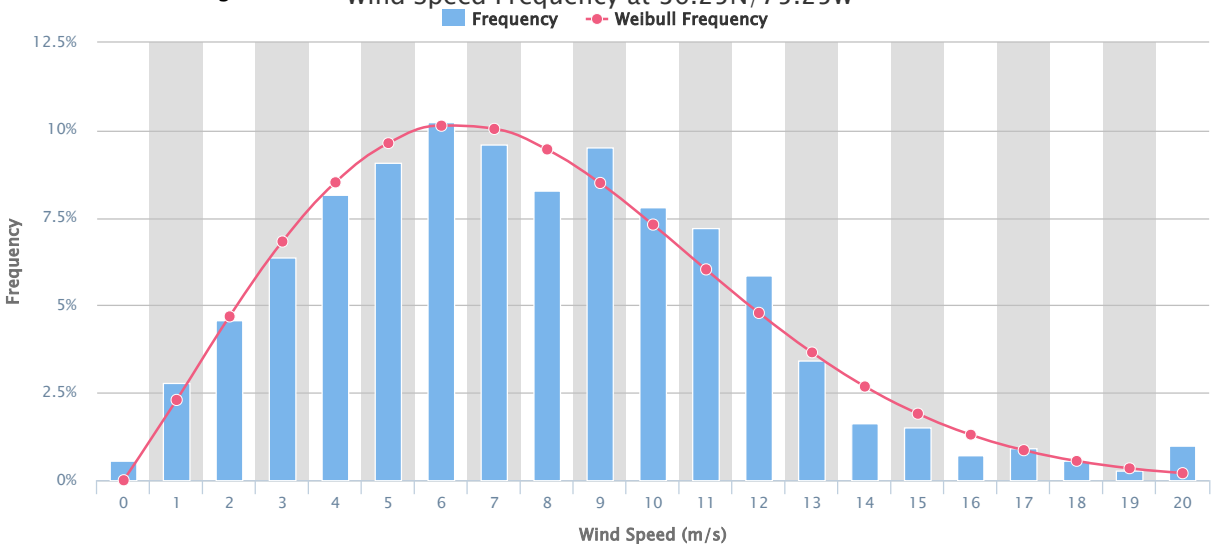


Table 29.2 – Wind Speed Frequency and Weibull Frequency

Wind Speed (m/s)	Frequency (%)	Weibull Frequency (%)
0	0.54%	0%
1	2.79%	2.29%
2	4.58%	4.68%
3	6.38%	6.82%
4	8.18%	8.51%
5	9.07%	9.63%
6	10.24%	10.13%
7	9.61%	10.04%
8	8.27%	9.45%
9	9.52%	8.49%
10	7.82%	7.3%
11	7.19%	6.02%
12	5.84%	4.78%
13	3.41%	3.65%
14	1.62%	2.68%
15	1.53%	1.9%
16	0.72%	1.3%
17	0.9%	0.86%
18	0.54%	0.55%
19	0.27%	0.34%
20+	0.99%	0.2%

Figure 29.3 – Wave Direction and Height Frequency at 36.25N/75.25W

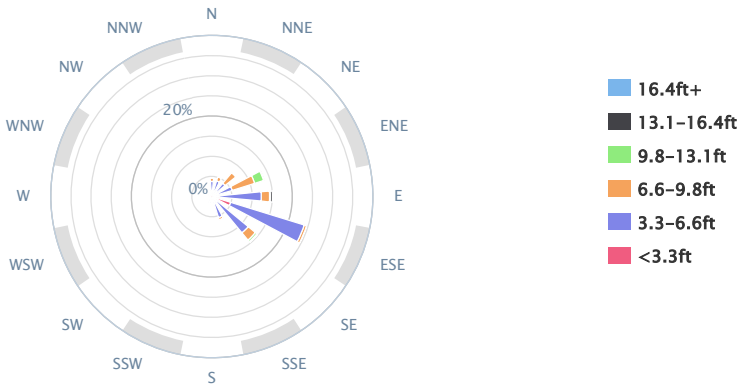


Table 29.3 – Wave Direction and Height Frequency

	<3.3ft	3.3-6.6ft	6.6-9.8ft	9.8-13.1ft	13.1-16.4ft	16.4ft+
N	0.1%	3.63%	0.81%	0%	0%	0%
NNE	0.4%	3.63%	1.01%	0%	0%	0%
NE	0.3%	3.93%	3.43%	0.1%	0%	0%
ENE	0.71%	4.54%	5.85%	2.32%	0.3%	0%
E	1.81%	10.48%	2.02%	0.2%	0.5%	0%
ESE	4.84%	19.15%	0.6%	0%	0%	0%
SE	1.01%	10.69%	2.32%	0.5%	0.2%	0%
SSE	0.3%	5.14%	0.6%	0.1%	0%	0%
S	0%	0.81%	0%	0%	0%	0%
SSW	0%	1.61%	0.1%	0%	0%	0%
SW	0.1%	0.71%	0.1%	0%	0%	0%
WSW	0%	0.6%	0%	0%	0%	0%
W	0.2%	0.3%	0%	0%	0%	0%
WNW	0%	0.81%	0%	0%	0%	0%
NW	0%	1.21%	0.1%	0%	0%	0%
NNW	0%	1.31%	0.3%	0%	0%	0%

Table 29.4 - Weather Hazards

Weather Parameters	Freezing Spray	Lightning	Icing	Dust	Vertical Wind	Tropical	Nor'easter
Severity	NONE	LOW	NONE	NONE	LOW	MEDIUM	MEDIUM
Forecaster Notes		Both thunderstorms and tropical threat has decreased				While overall development decreases, systems can curve toward the East Coast	Development near Bahamas can occur, which generates the stronger Nor'easters

November

Figure 30.1 – Wind Direction and Speed Frequency at 36.25N/75.25W

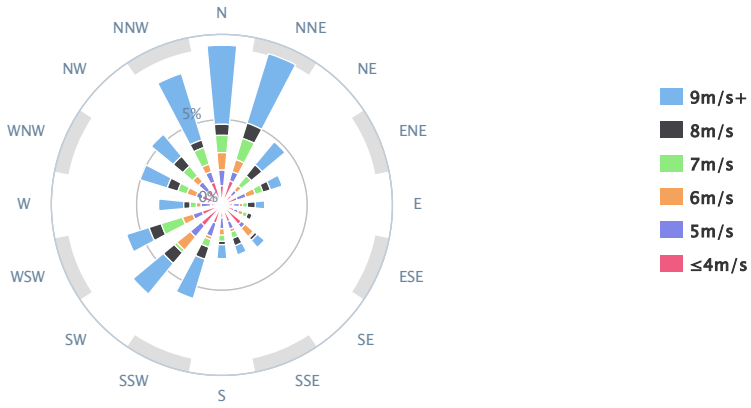


Table 30.1 – Wind Direction and Speed Frequency

	≤ 4m/s	5m/s	6m/s	7m/s	8m/s	9m/s+
N	1.11%	0.93%	1.02%	1.02%	0.65%	4.64%
NNE	1.48%	0.56%	0.74%	1.3%	0.93%	4.27%
NE	0.74%	0.37%	0.37%	0.74%	0.83%	1.76%
ENE	0.93%	0.56%	0.56%	0.46%	0.46%	0.74%
E	0.65%	0.37%	0.19%	0.28%	0.46%	0.56%
ESE	0.74%	0.28%	0.28%	0.28%	0.28%	0.09%
SE	1.48%	0.28%	0.65%	0.09%	0.19%	0.56%
SSE	1.02%	0.46%	0.19%	0.37%	0.46%	0.56%
S	0.74%	0.65%	0.37%	0.37%	0.19%	0.83%
SSW	1.11%	0.83%	0.19%	0.46%	0.74%	2.41%
SW	1.58%	0.83%	1.02%	0.19%	0.83%	2.32%
WSW	1.21%	0.56%	0.65%	1.3%	0.74%	1.39%
W	0.65%	0.56%	0.28%	0.37%	0.37%	1.48%
WNW	1.21%	0.37%	0.56%	0.56%	0.65%	1.67%
NW	1.11%	0.65%	0.46%	0.74%	0.74%	1.67%
NNW	1.39%	0.65%	0.46%	1.02%	0.46%	4.08%

Figure 30.2 – Wind Speed Frequency at 36.25N/75.25W

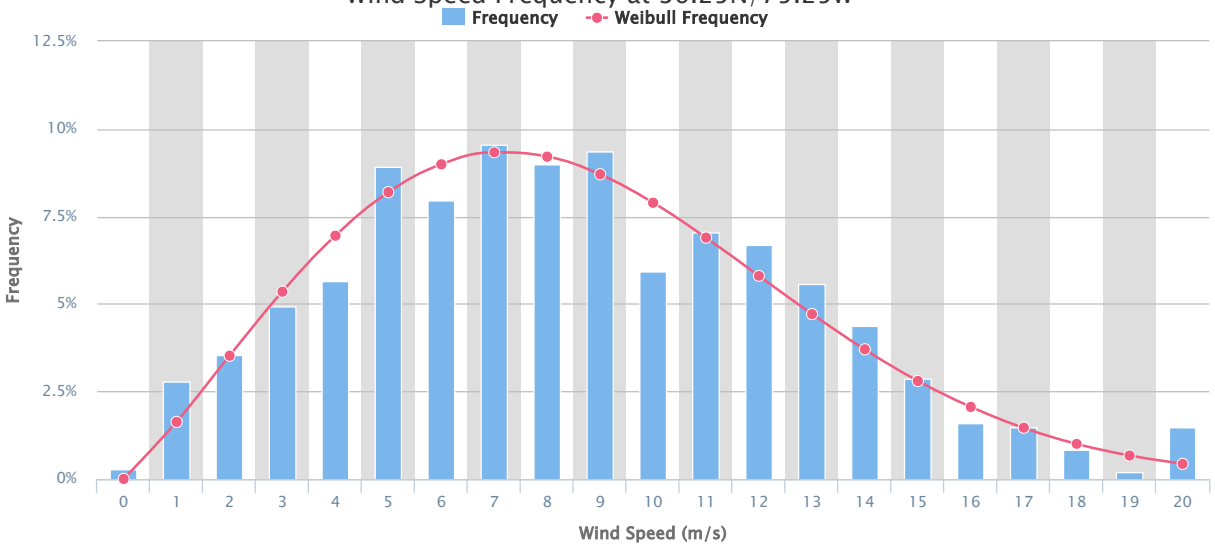


Table 30.2 – Wind Speed Frequency and Weibull Frequency

Wind Speed (m/s)	Frequency (%)	Weibull Frequency (%)
0	0.28%	0%
1	2.78%	1.63%
2	3.53%	3.52%
3	4.92%	5.35%
4	5.66%	6.95%
5	8.91%	8.19%
6	7.98%	8.99%
7	9.55%	9.33%
8	9%	9.21%
9	9.37%	8.7%
10	5.94%	7.89%
11	7.05%	6.89%
12	6.68%	5.8%
13	5.57%	4.71%
14	4.36%	3.7%
15	2.88%	2.8%
16	1.58%	2.06%
17	1.48%	1.46%
18	0.83%	1%
19	0.19%	0.67%
20+	1.48%	0.43%

Figure 30.3 – Wave Direction and Height Frequency at 36.25N/75.25W

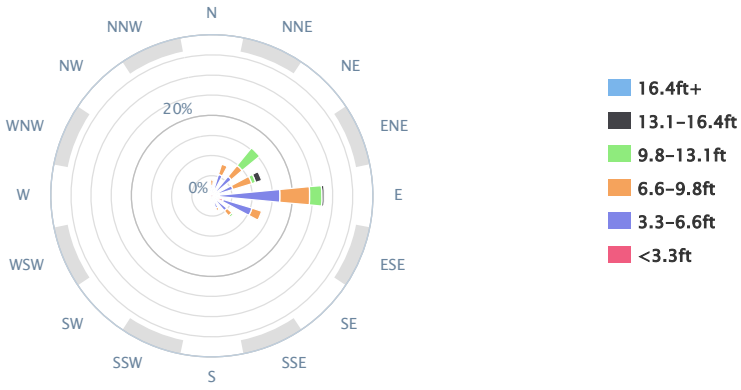


Table 30.3 – Wave Direction and Height Frequency

	<3.3ft	3.3-6.6ft	6.6-9.8ft	9.8-13.1ft	13.1-16.4ft	16.4ft+
N	0%	2.5%	1.46%	0%	0%	0%
NNE	0.83%	4.69%	2.71%	0.21%	0%	0%
NE	0.83%	5.42%	3.54%	5.63%	0%	0%
ENE	0.73%	4.69%	4.9%	1.04%	1.56%	0%
E	1.67%	15.21%	7.4%	3.02%	0.63%	0%
ESE	2.92%	7.5%	2.5%	0.21%	0.1%	0%
SE	0.1%	4.69%	1.67%	0.52%	0%	0%
SSE	0.1%	3.02%	0.73%	0.1%	0%	0%
S	0.21%	0.42%	0.1%	0%	0%	0%
SSW	0.31%	0.73%	0%	0%	0%	0%
SW	0.1%	0.73%	0%	0%	0%	0%
WSW	0%	0.52%	0%	0%	0%	0%
W	0.1%	0.31%	0%	0%	0%	0%
WNW	0%	0.1%	0%	0%	0%	0%
NW	0.1%	0.83%	0.1%	0%	0%	0%
NNW	0%	1.67%	0.63%	0%	0%	0%

Table 30.4 - Weather Hazards

Weather Parameters	Freezing Spray	Lightning	Icing	Dust	Vertical Wind	Tropical	Nor'easter
Severity	NONE	LOW	NONE	NONE	LOW	LOW	MEDIUM
Forecaster Notes						Tropical impacts are unlikely, development confined to waters well east of East Coast	Development occurs over the Gulf of Mexico

December

Figure 31.1 – Wind Direction and Speed Frequency at 36.25N/75.25W

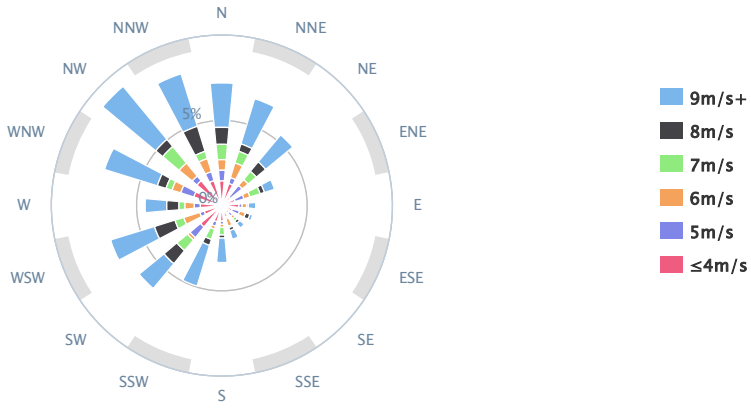


Table 31.1 – Wind Direction and Speed Frequency

	≤ 4m/s	5m/s	6m/s	7m/s	8m/s	9m/s+
N	1.44%	0.63%	0.63%	0.9%	0.99%	2.6%
NNE	1.35%	0.36%	0.9%	0.72%	0.45%	2.78%
NE	0.63%	0.9%	0.45%	0.63%	0.72%	2.06%
ENE	0.81%	0.54%	0.36%	0.63%	0.27%	0.63%
E	0.99%	0.18%	0.27%	0.09%	0%	0.45%
ESE	0.63%	0.45%	0.36%	0%	0.27%	0.18%
SE	0.54%	0.27%	0.18%	0.18%	0.18%	0.36%
SSE	0.72%	0.09%	0.45%	0.09%	0.18%	0.54%
S	0.9%	0.18%	0.18%	0.45%	0.18%	1.44%
SSW	0.99%	0.27%	0.18%	0.63%	0.36%	2.51%
SW	1.62%	0.81%	0.18%	0.81%	0.99%	1.89%
WSW	1.08%	0.27%	0.99%	0.54%	1.26%	2.69%
W	1.26%	0.36%	0.54%	0.36%	0.72%	1.26%
WNW	1.71%	0.81%	0.54%	0.36%	0.54%	3.23%
NW	1.89%	0.36%	0.99%	1.26%	0.54%	4.04%
NNW	1.53%	0.54%	0.81%	0.45%	1.53%	3.23%

Figure 31.2 – Wind Speed Frequency at 36.25N/75.25W

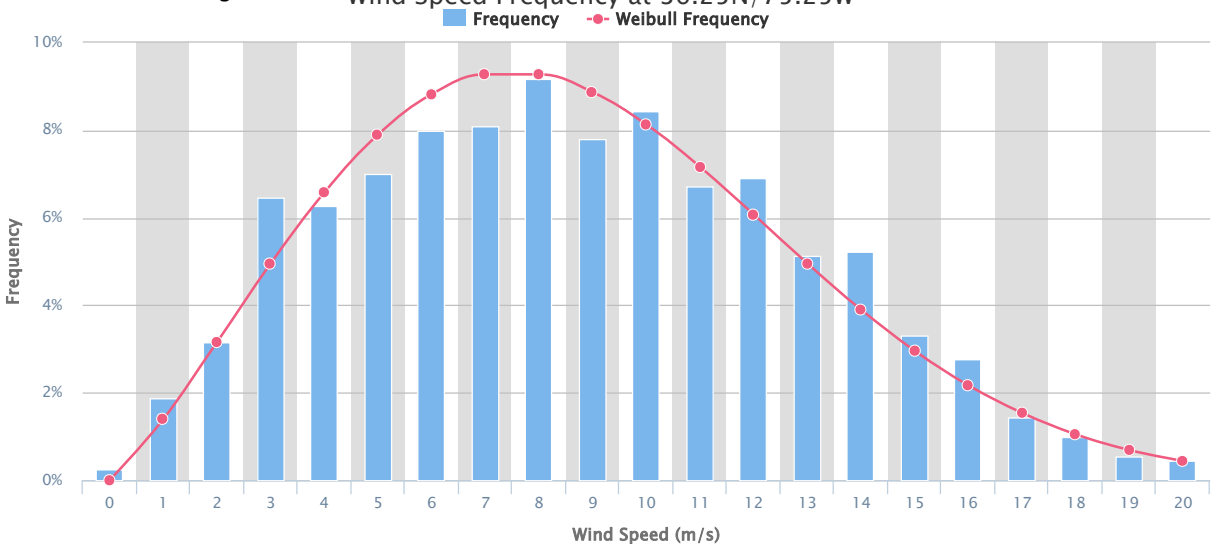


Table 31.2 – Wind Speed Frequency and Weibull Frequency

Wind Speed (m/s)	Frequency (%)	Weibull Frequency (%)
0	0.27%	0%
1	1.89%	1.4%
2	3.14%	3.16%
3	6.46%	4.95%
4	6.28%	6.58%
5	7%	7.9%
6	7.99%	8.82%
7	8.08%	9.28%
8	9.16%	9.28%
9	7.81%	8.87%
10	8.44%	8.13%
11	6.73%	7.16%
12	6.91%	6.07%
13	5.12%	4.95%
14	5.21%	3.9%
15	3.32%	2.96%
16	2.78%	2.17%
17	1.44%	1.54%
18	0.99%	1.05%
19	0.54%	0.69%
20+	0.45%	0.44%

Figure 31.3 – Wave Direction and Height Frequency at 36.25N/75.25W

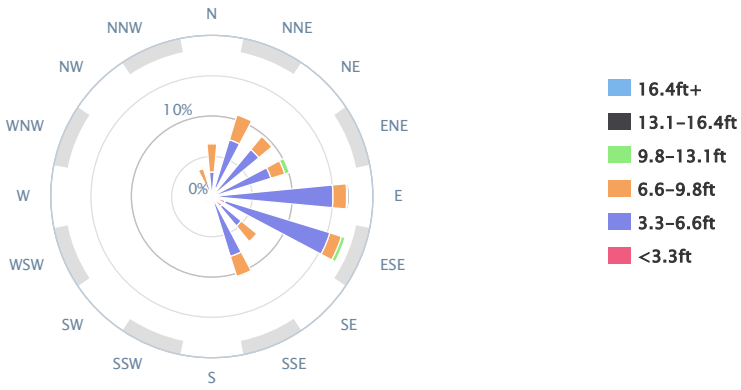


Table 31.3 – Wave Direction and Height Frequency

	<3.3ft	3.3-6.6ft	6.6-9.8ft	9.8-13.1ft	13.1-16.4ft	16.4ft+
N	0.1%	2.92%	3.53%	0%	0%	0%
NNE	1.11%	6.25%	3.23%	0%	0%	0%
NE	0.4%	7.16%	2.12%	0.1%	0%	0%
ENE	0.6%	7.06%	1.81%	0.6%	0%	0%
E	0.81%	14.21%	1.71%	0.1%	0.2%	0%
ESE	1.71%	13.61%	1.51%	0.5%	0%	0%
SE	1.61%	3.13%	2.52%	0.1%	0%	0%
SSE	0.1%	7.66%	2.62%	0.2%	0%	0%
S	0.1%	0.5%	0%	0%	0%	0%
SSW	0%	0.3%	0%	0%	0%	0%
SW	0.1%	1.01%	0%	0%	0%	0%
WSW	0.2%	0.71%	0%	0%	0%	0%
W	0.3%	0.5%	0%	0%	0%	0%
WNW	0.2%	0.81%	0.3%	0%	0%	0%
NW	0.1%	1.71%	0.2%	0%	0%	0%
NNW	0.1%	1.61%	1.92%	0%	0%	0%

Table 31.4 - Weather Hazards

Weather Parameters	Freezing Spray	Lightning	Icing	Dust	Vertical Wind	Tropical	Nor'easter
Severity	NONE	LOW	LOW	NONE	MEDIUM	LOW	MEDIUM
Forecaster Notes			Icing is a minimal concern toward the end of the month		Moderate concern as Nor'easter threat increases toward the end of the month		Development occurs over the Gulf of Mexico and near Hatteras

Conclusions:

The above energy production estimates for the Kitty Hawk Offshore site are consistent with expected industry standards for this turbine model at a representative hub height of 100 meters. The power density value falls within a Wind Power Class of 6 (NREL, 2007), which is typical of many areas along the East Coast greater than 25NM from the coast. It is important to note that actual losses in energy production due to gearbox, bearing and generator efficiencies will vary depending on the overall maintenance of the equipment.

For construction of the turbine, we would recommend this to be done during the summer time. This will offer the best weather in terms of lowest average winds and swells. Likewise, doing this will potentially minimize losses in energy production. For this location, we would strongly recommend de-icing measures to be taken during months when the severity of Icing is medium or high. Additionally, this offshore site lies within the north-south shipping lanes along the East Coast U.S. The density of ships transiting these waters is considered to be light (*please reference Figure 3.1 on Page 3*)

In addition to the above assessment characteristics for energy production and wind and wave climatology data, WRI Energy's Dashboard is an important tool for daily real-time monitoring of the wind farm site. Forecasted wind speeds/gusts and directions with respect to the cut-in/cut-out values, and waves can be viewed out to 10 days, with hourly forecasts available out through 3 days. Additionally, information on icing potential, visibility, precipitation/squall threat, and temperature are provided with these forecasts. Potential energy output is derived for hourly and three hourly increments. Access to graphical weather charts and severe weather monitoring, including daily tropical summaries in season, are also available.

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