Meteorological Data Assessment Report for BOEM Oregon Call Areas

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Prepared on behalf of:

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For Submittal to:

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1.0 INTRODUCTION

Kearns and West (KW) has retained Tetra Tech Inc. (Tetra Tech) to perform the meteorological data assessment for the Bureau of Ocean Energy Management (BOEM) Pacific Office for two Oregon Call Areas. This meteorological data assessment is part of a study to inform BOEM in its potential designation of future Wind Energy Areas off the coast of Oregon.

Visibility has been defined as the measure of the distance at which an object or light can be clearly discerned. It depends on the transparency of the surrounding air and the size of the object. Degradation of visibility is caused by the scattering and/or absorption of light by gases and particles in the air. Estimation of visibility is affected by many subjective as well as physical factors. “Visibility involves more than specifying how light is absorbed and scattered by the atmosphere. Visibility is a psychophysical process of perceiving the environment through the use of the eye-brain system” (Malm, 1999). Although there are other contributing factors to assessing visibility, as pointed out by Malm, visibility can be measured objectively. This is referred to as the meteorological optical range, which does not have the dependency on the size of the object or the observer’s perspective. This meteorological data analysis will assist in understanding the meteorological conditions experienced in the Oregon Call Areas and how they may influence the visibility of a wind energy project during different conditions.

The Call Areas of this study, Brookings and Coos Bay, are each situated 13.8 miles west of the Oregon coast. The analysis was based on a 10-year period of existing hourly meteorological observations from National Weather Service/Federal Aviation Administration measurement sites representative of the area where each Call Area is located. Visibility was analyzed for the different seasons, daylight versus nighttime hours, and various weather conditions.

This report consists of four sections including this Introduction. Section 2 contains information regarding the Call Area’s locations, and meteorological stations selected for the analysis, and the data collection and processing methodology. Section 3 presents the meteorological conditions assessment for the Brookings Call Area and the Coos Bay Call Area. References cited in the report are presented in Section 4.

2.0 METEOROLOGICAL DATA COLLECTION AND PROCESSING

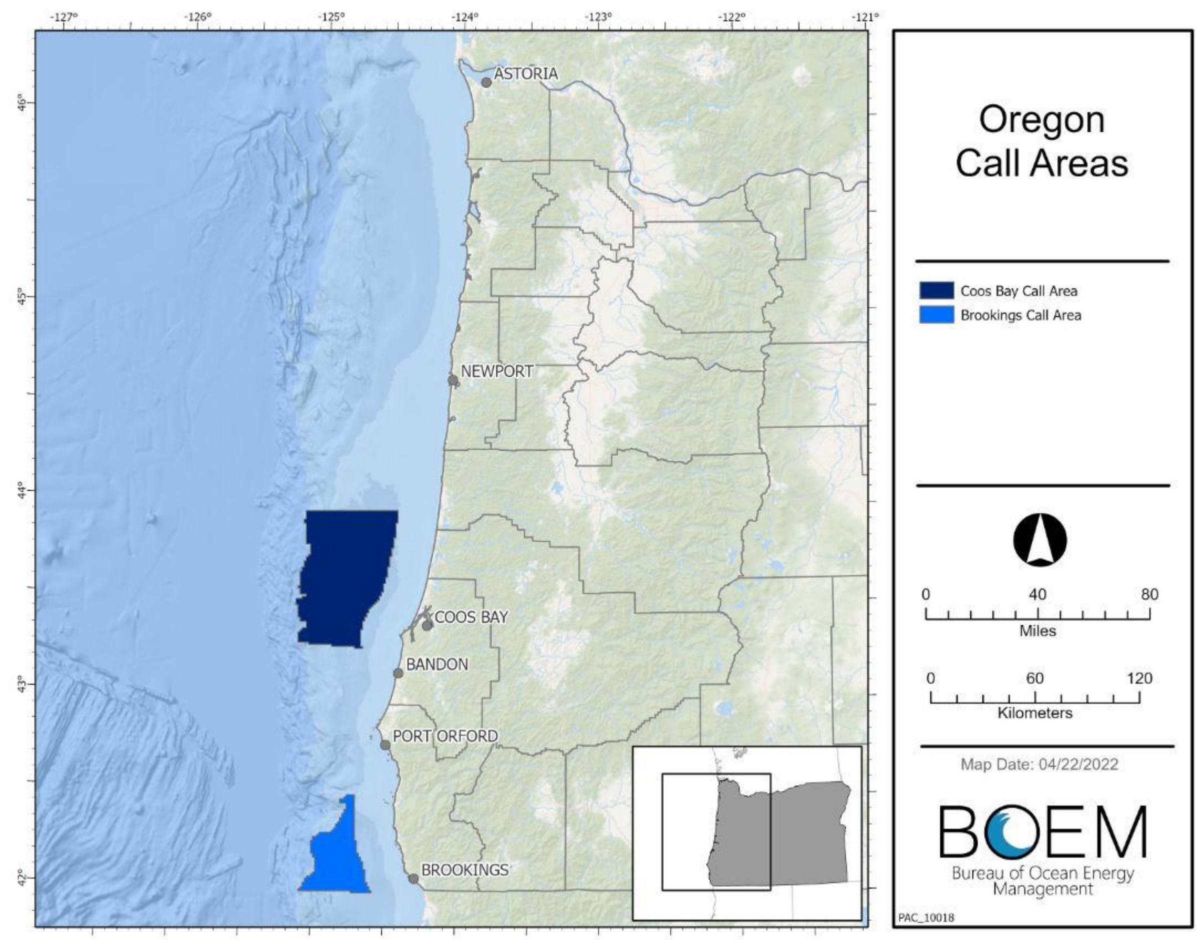
An assessment of the meteorological conditions associated with each of the Brookings and Coos Bay Call Areas was conducted. This section describes the location of each Call Area, as well as the meteorological observation station selected for each analysis. A discussion of the data collection and processing methodology is also described.

2.1 CALL AREA DESCRIPTIONS

The eastern boundary of the Brookings Call Area begins 13.8 miles offshore from Gold Beach and Brookings in southern Oregon and extends to about 46 miles offshore. The area is not rectangular and extends approximately 46 miles from north to south at its longest point and 22 miles from east to west at its widest point. The entire area covers approximately 448 square miles.

The Coos Bay Call Area is located offshore south-central Oregon. The boundary begins 13.8 miles offshore Charleston, Oregon, and extends to about 65 miles offshore. The Coos Bay Call Area is approximately three times larger in area than the Brookings Call Area. The area extends about 67 miles in the north-south direction and about 41 miles in the east-west direction. The entire area covers approximately 1,364 square miles. Figure 1 presents a map created by BOEM (BOEM, 2022) showing the Oregon Call Area locations.

Figure 1. Location of the Oregon Call Areas

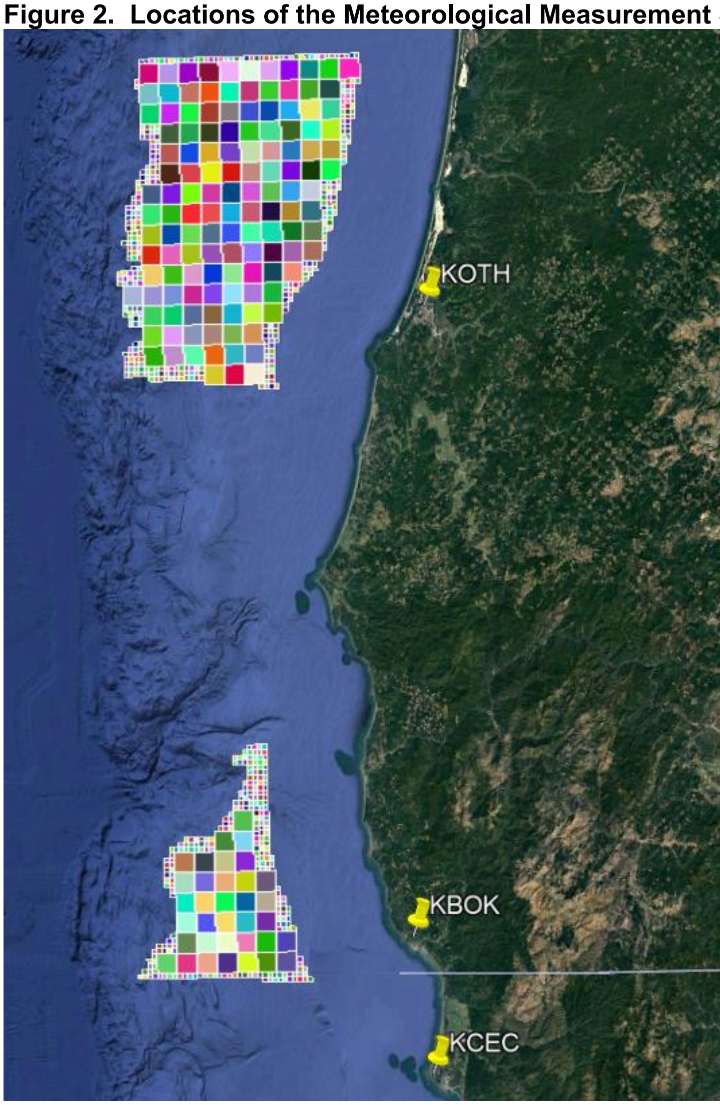


2.2 METEOROLOGICAL MEASUREMENT SITES

The meteorological assessment utilized hourly surface observation data collected at the National Airspace System (NAS) measurement sites located onshore near each of the Call Areas. The Automated Weather Observing Station (AWOS) at Brookings Airport in Curry County, Oregon (call sign KBOK) was selected to represent the meteorological conditions for the Brookings Call Area, and the AWOS station at North Bend Municipal Airport (call sign KOTH) was selected to represent the meteorological conditions for the Coos Bay Call Area. Figure 2 shows the location of each meteorological site selected for each Call Area. Surface observations for each station were downloaded for the most recent 10-year period (January 1, 2012–December 31, 2021) from the National Center for Environmental Information (formerly known as the National Climatic Data Center). Extinction coefficient data from Crescent City, CA (call sign KCEC) was used to establish a relationship between reported visibility and relative humidity (RH) (NOAA, 1998).

The surface observation data was retrieved in DS-3505 Integrated Surface Database (NOAA, 2018). The data set includes both automated and sometimes manual observations records as well as summaries of daily and monthly records. Observations reported in the data sets include wind speed, wind direction, temperature, dew point temperature, cloud cover, cloud ceiling height, visibility, weather codes denoting sky conditions and precipitation type, and precipitation amounts.

Figure 2. Locations of the Meteorological Measurement Sites



2.3 METEOROLOGICAL CONDITIONS AND VISIBILITY ASSESSMENT METHODOLOGY

Meteorological Conditions

The meteorological data analysis was conducted to assist in understanding the meteorological conditions experienced in the Oregon Call Areas and how they may influence the visibility of a wind energy project during both daylight and nighttime hours. Seasonal and annual metrics were analyzed. Daylight hours and nighttime hours were defined by civil twilight, which corresponds to dawn in the morning and dusk in the evening and is defined as the period when the geometric center of the sun is 6 degrees or less below the horizon prior to sunrise or after sunset. During civil twilight there is sufficient light to conduct outdoor activities without the need for artificial lighting. The time of civil twilight changes over the course of the year. Data from the website *timeanddate.com* was used to define these times.

Seasons are defined as meteorological seasons by months as follows:

- Winter: December, January, February
- Spring: March, April, May
- Summer: June, July, August
- Autumn: September, October, November

Wind roses depict the frequencies that the wind is blowing from for each of the sixteen compass point directions. The length of each sector shows the overall frequency of winds from that direction. Wind speed ranges are shown by different colors within each sector, with speeds increasing outward from the center.

Wind roses were developed at each meteorological site to show the annual frequency distribution of wind speed and direction, as well as the seasonal frequency distributions of wind. This is an important metric because the prevailing winds provide information about where the air masses affecting the local weather have originated from. Understanding the meteorology of a location is essential because there are many aspects of the air masses (humidity, pollutant concentrations, etc.) that affect the visibility at a particular location.

Hourly surface observations were evaluated for clear, cloudy, rainy, foggy and hazy conditions during daylight and nighttime hours. The available AWOS station data were sufficient to make these condition determinations and were made based upon the following criteria:

- Clear conditions were defined as having an unlimited cloud ceiling height. Unlimited ceiling heights are associated with clear and scattered sky cover (up to 50% of the sky).
- Cloudy conditions were defined as broken or overcast sky cover, greater than 50% of the sky.
- Rainy conditions were defined as any ‘trace’ or measurable precipitation amount. The DS-3505 data set includes weather codes that define the type (rain, snow, sleet, etc.) and intensity of different precipitation types.
- Foggy and hazy conditions are defined by weather codes. The KOTH station data did not provide these weather codes. However, visibility is always less than 0.5 miles during foggy conditions and visibility is between 0.3 miles to 6 miles when hazy conditions are present, therefore visibility was used as a surrogate for these conditions.

It is important to note that these meteorological conditions are not always mutually exclusive. It is possible to have multiple conditions occurring at the same time. For example, fog and rain occur when it is cloudy or light rain can occur during fog events. In addition, haze can occur when it is sunny with clear skies. Conditions were prioritized to avoid double counting conditions for a given hour to maintain a 100% count. For each hour the conditions were assigned based on the following prioritization criteria:

1. Clear conditions are based on unlimited ceiling height and can include haze. An hour was counted as hazy before being counted as sunny.

2. Cloudy conditions are based on limited ceiling height and can also include rain and fog. The classification order was foggy, rainy, and then cloudy.

Visibility

Visibility is defined by the World Meteorological Organization as the length of a path in the atmosphere required to reduce the intensity of light to 5 percent of its original value (WMO 2011). This 5 percent change value is considered the threshold contrast, and the outer limits at which an observer can still identify an object. An increase or decrease in light intensity is caused by the scattering or absorption of light. Over the length of a path, the perception of light will be diminished or attenuated by scattering and absorption of light from gases and particles in the atmosphere. The sum of all light scattering by gases and particles and all light absorption by gases and particles is quantified as the extinction coefficient (b_{ext}).

The Beer-Lambert law expressed in terms of attenuation coefficient relates the extinction coefficient to visibility and contrast according to the following equation:

$$I/I_0 = e^{(-bext * x)} \quad \text{(Eqn. 1)}$$

Where,

I = intensity at distance x
I_0 = intensity at the observer
I/I_0 = contrast
x = visibility distance

For a defined contrast of 5 percent, the equation simplifies to:

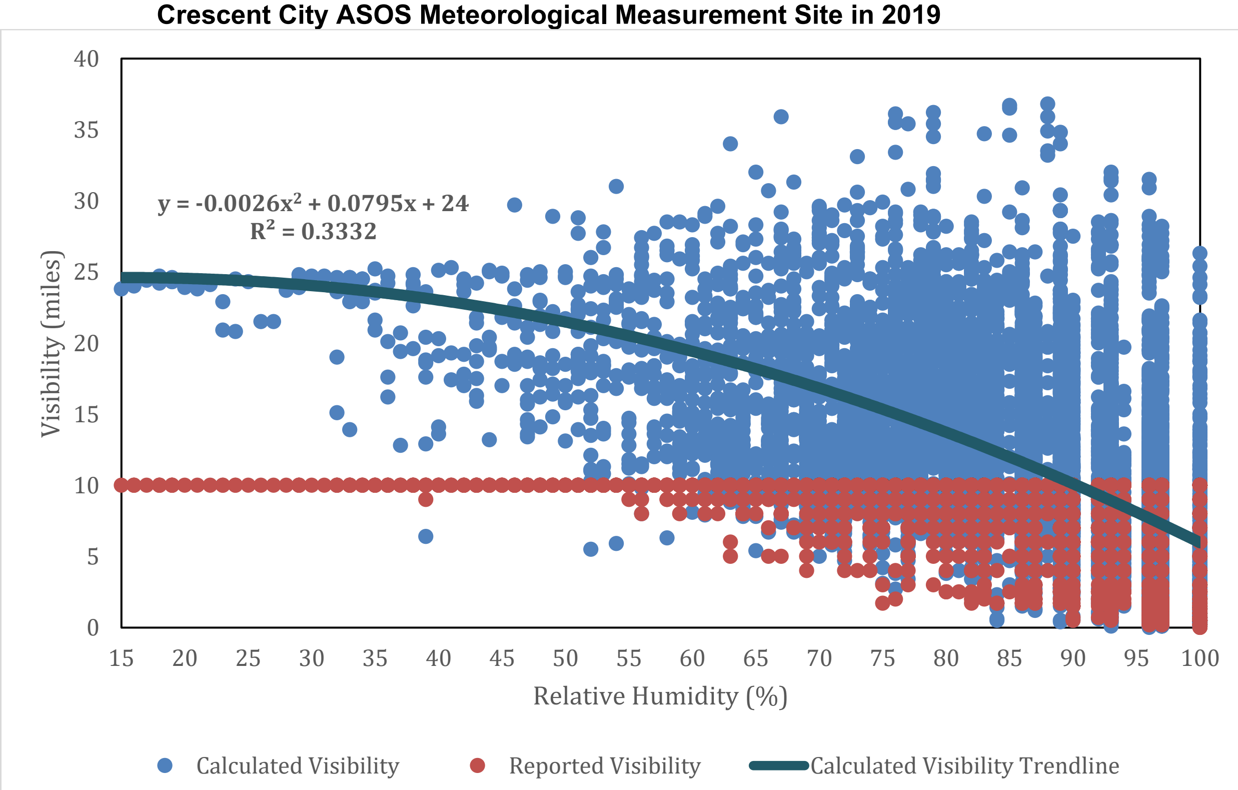
$$x = -\ln(0.05)/b_{ext} \quad \text{(Eqn. 2)}$$

Although absorption and scattering due to gases play a role in determining visibility, the greatest contributor to reduced visibility (by means of a large extinction coefficient) is scattering by fine particulate matter between 0.1 to 1.0 microns (Malm,1999). As with ambient air (gases), scattering by fine particulates is increased by high relative humidity. Hygroscopic particles grow as water condenses on them, increasing their ability to scatter light.

Visibility observations reported in the DS-3505 surface data have an upper limit distance of 10 statute miles. For the hourly reports, visibility distances less than 10 miles are binned and reported in categories of less than ¼ mile, ¼ mile, ½ mile, ¾ mile, 1 mile, 1¼ miles, 1½ miles, 1¾ miles, 2 miles, 2½ miles, 3 miles, 3½ miles, 4 miles, 5 miles, 6 miles, 7 miles, 8 miles, 9 miles, and 10 miles or greater. All visibility measurements greater than or equal to 10 miles are combined into a single category and reported as 10 miles. Therefore, for this analysis a methodology was developed to evaluate visibility beyond 10 miles. The methodology involved using raw 1-minute Automated Surface Observation System (ASOS) data with light extinction measurements. The 1-minute raw ASOS data is found in the 6405 data set that is available for download from the NCEI. These 1-minute light extinction measurements are used as the basis of the reported DS-3505 visibility data. However, light extinction coefficient data was not available for either KBOK or KOTH observation sites. Therefore, light extinction coefficient data from a nearby ASOS site along the northern California coast (KCEC: Crescent City, CA) is used instead. First, the 1-minute data was averaged to hourly averages, and visibility was calculated using Equation 2. Next, the relationship between visibility and relative humidity (RH) was determined. RH was calculated from the ambient temperature and the dew point temperature reported in the DS-3505 surface observations using the August-Roche-Magnus approximation. The relationship was applied using the RH data at the AWOS stations (KBOK and KOTH) to compute visibility in the vicinity of each of the Oregon Call Areas. The relationship between visibility and

RH established at KCEC is appropriate to use at the other locations in the study areas because visibility estimates are generally spatially representative due to being strongly driven by secondarily formed fine particles, which are generally uniform in a given region. As the humidity increases, the fine particles grow hygroscopically resulting in an increase in the scattering of light by these particles. The advantage of using these light extinction coefficient data for predicting visibility is that the raw 1-minute data is not binned and already includes the effects of the wide range of other variables on visibility. Since RH is the meteorological variable most closely related to visibility, the hourly average RH was compared to the hourly average calculated visibility to discern any trends. Figure 3 presents the distribution of visibility calculated from the light extinction measurements for various RH. While there is a significant amount of scatter, there is a clear inverse relationship between visibility and RH. The polynomial equation that defines the average trend line is determined based on the 2019 Crescent City data. The Crescent City data from 2019 was chosen because it most closely represented the visibility distances reported at the Oregon meteorological stations. The application of the equation will be used at each of the Brookings and North Bend meteorological stations to estimate the extent of the visibility at each location for each of the 10 years of meteorological data in the study. The percentage of daylight and nighttime hours with visibility up to 13.8 statute miles, and beyond 13.8 miles is also summarized.

Figure 3. Relationship between Hourly Average Visibility and RH, based on measurements at Crescent City ASOS Meteorological Measurement Site in 2019



3.0 METEOROLOGICAL CONDITIONS AND VISIBILITY ASSESSMENT RESULTS

3.1 BROOKINGS CALL AREA

Ten years (2012-2021) of DS-3505 surface observation data at Brookings Airport were analyzed. Wind roses were developed to show the annual frequency distribution of wind speed and direction, as well as the seasonal frequency distributions of the winds. Figure 4 presents the annual distribution of the wind measurements at Brookings Airport for the 10-year period. Wind roses depict the frequencies that the wind is blowing from each of the sixteen compass point directions. Both wind direction and wind speed are depicted in a wind rose plot. The frequency of winds from that direction is represented by the length in each sector, while the wind speed ranges are shown by different colors within each sector, with speeds increasing outward from the center. Figure 4 shows that winds are predominantly from the south-southeast and southeast and followed by winds from the northwest. The winds from the northwest tend to be stronger than those from the southeast sectors. Seasonal wind roses are presented in Figure 5 and show that the winds from the southeast sector are present all year long, while spring brings a northwesterly component that continues through the summer.

Figure 4. Ten-year (2012-2021) Wind Rose of Measurements at Brookings Airport

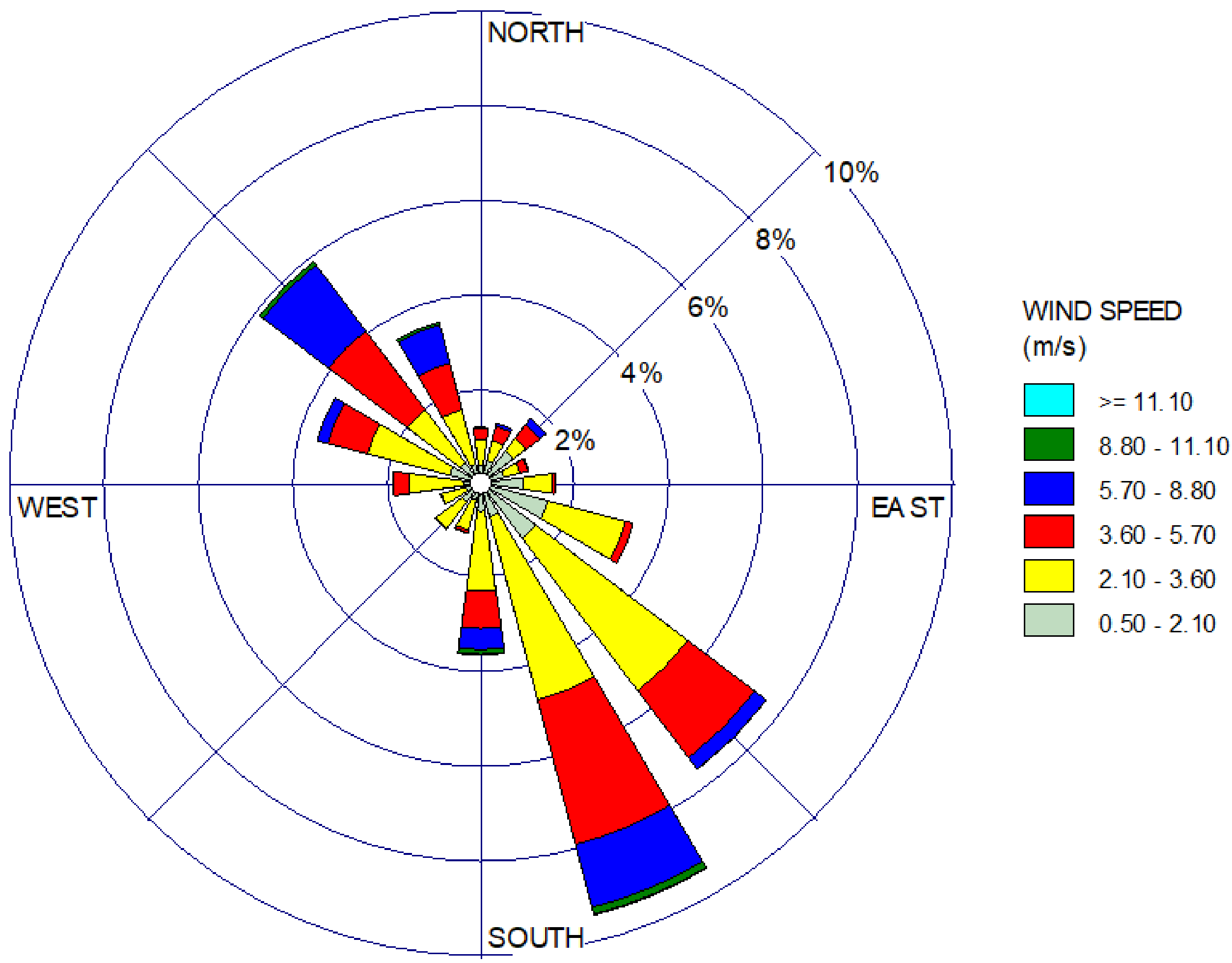
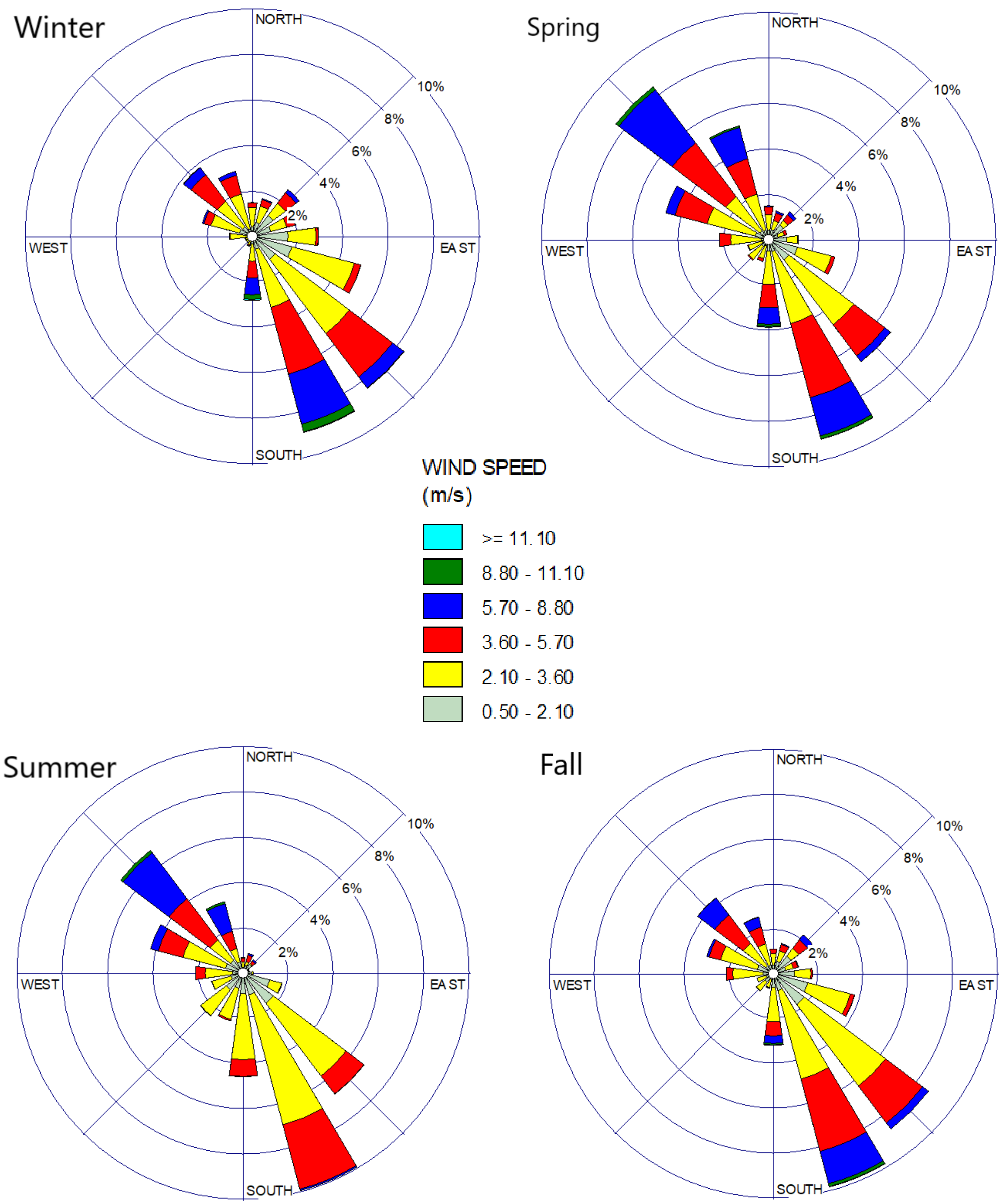


Figure 5. Seasonal 10-year (2012-2021) Wind Roses of Measurements at Brookings Airport



Since the closet point of the Brookings Call area to land is 13.8 miles, it is important to characterize the reported visibility at the Brookings Airport. The Brookings Airport is located near the coast in a marine environment and would be representative of an observer on land looking offshore toward the potential wind farm.

Table 1 summarizes the percent of time that the reported visibility was less than 10 miles and the percent of time that the reported visibility was 10 miles or greater (the furthest distance bin category reported). Table 1 presents the analysis by annual metrics, 10-year period, seasonal periods over the 10-year period, and daylight and nighttime hours over the 10-year period. When the visibility is reported to be less than 10 miles, aa wind farm would not be visible from the shore. When the reported visibility is 10 miles (representing ≥ 10 miles), it indicates that some of the time there is the potential for aa wind farm to be visible to an observer on shore. Table 1 also presents a summary of the data capture for the visibility parameter for the study period. Percentages of both available and missing visibility observations are summarized. Data capture for the 10-year period average is 93%, with most of the annual periods exceeding 90% data capture, except for 2012 and 2015 that had 88% and 81% available visibility parameter, respectively. The amount of time the reported visibility is less than 10 miles varied from year to year, ranging from 25% of the time in 2019 to 65% of the time in 2014. On average (10-year) at least 38% of the time, a wind farm will not be visible from land. The spring and summer have more hours when a wind farm would not be visible, 40% and 42% of the time, respectively, than the fall and winter, 35% and 34%, respectively. During 36% of daylight hours and 40% of nighttime hours, a wind farm would not be visible. Table 1 also summarizes the weather conditions associated with the visibility categories < 10 miles and ≥ 10 miles. This shows that if it is foggy or hazy, then shorter visibility distances are always reported (100%). During precipitation events, 86% of the time shorter visibility distances (wind farm not visible) are reported. It also shows that visibility can be less than 10 miles while the skies are clear (15% of the time) or cloudy (20% of the time).

The distribution of weather conditions observed at the Brookings Airport was also analyzed over the full 10-year period. Table 2 presents the frequency of occurrence and distribution of clear, cloudy, precipitation, foggy, and hazy conditions by annual metrics, 10-year period, seasonal periods over the 10-year period, and daylight and nighttime hours over the 10-year period. As described in Section 2.3, weather conditions were prioritized to assign a single weather condition for each hour to avoid double counting of conditions and allow the percentages to be summed to equal 100%. The rightmost column summarizes the percent of time that the weather condition parameters are missing. Weather condition data capture over the 10-year period is quite good, with 9 out of the 10 years with greater than 90% available data. The exception is 2015, which has 81% available data.

On average over the 10 years, clear conditions are twice as likely to occur than cloudy hours or hours with precipitation. Foggy and hazy conditions occur least frequently, only 9% and 2% of the time, respectively. Clear conditions occur more frequently in summer and fall, with clouds and precipitation more likely in winter and spring. Clear conditions were reported more frequently during the daytime than nighttime, while cloudy conditions were almost equally distributed during daytime and nighttime. Precipitation and fog were more prevalent at night than during the day, and hazy conditions were only reported during daylight hours.

Figure 6 presents the relationship between reported visibility ≤ 10 miles and the distribution of reported weather conditions for each visibility at Brookings Airport. Fog is associated with reported visibility of 0.5 miles or less. Haze is associated with reported visibility of 6 miles or less. Visibilities of 7-10 miles can be associated with either clear or cloudy conditions, while precipitation can be associated with visibilities ranging from 0.8 miles to 10 miles.

The largest visibility distance reported at the airport stations is10 miles. To estimate the visibilities greater than 10 miles, visibility was computed for the hours at Brookings Airport that had visibility reported in the DS-3505 as ≥ 10 miles. The polynomial relationship determined based on the light extinction measurements at the Crescent City ASOS site was applied as discussed in Section 2.3. Table 3 presents the frequency of calculated visibilities that are between 10-13.8 miles, as well as greater than 13.8 miles, for each season and annually. This estimation corresponds to the percent of time that a potential wind farm located in the Brookings Call Area may be visible or not visible from onshore. Over the 10-year study period, it is estimated that on average a wind farm will not be visible two-thirds (66%) of the time. There is not much variation from season to season, each having approximately the same number of hours when a wind farm is expected to not be visible. A wind farm is expected to not be visible for 76% of the nighttime hours and 57% of the daytime hours. Just under half of the non-visible hours (47%) occur when the skies are clear, 80% when it is cloudy and 99% during precipitation events. It is expected that a wind farm located within the Brookings Call Area will not be visible during fog or haze conditions.

Table 1. Frequency of Reported and Truncated Visibility Ranges at Brookings Airport AWOS

Parameter		Available Data (%)	KBOK Visibility (%)		
			Less Than 10 Miles	Greater Than or Equal To 10 Miles	Missing
YEAR	2012	88%	53%	35%	12%
	2013	94%	42%	52%	6%
	2014	96%	65%	31%	4%
	2015	81%	47%	34%	19%
	2016	92%	27%	65%	8%
	2017	95%	30%	66%	5%
	2018	96%	28%	69%	4%
	2019	92%	25%	67%	8%
	2020	98%	30%	67%	2%
	2021	97%	32%	65%	3%
	10-YEAR	**93%**	**38%**	**55%**	**7%**
SEASON	Winter	90%	34%	56%	10%
	Spring	94%	40%	55%	6%
	Summer	95%	42%	54%	5%
	Fall	92%	35%	56%	8%
DAYLIGHT	Day	93%	36%	57%	7%
	Night	93%	40%	53%	7%
WEATHER	Clear	-	15%	85%	-
	Cloudy	-	20%	78%	-
	Precipitation	-	86%	14%	-
	Foggy	-	100%	0%	-
	Hazy	-	100%	0%	-

Table 2. Frequency of Weather Conditions Reported at Brookings Airport AWOS

Parameter		KBOK Weather Condition (%)					
		Clear	Cloudy	Precipitation	Foggy	Hazy	Missing
YEAR	2012	36%	18%	23%	12%	3%	8%
	2013	52%	12%	15%	12%	2%	7%
	2014	42%	12%	23%	13%	5%	4%
	2015	44%	11%	17%	8%	2%	19%
	2016	44%	22%	20%	6%	0%	8%
	2017	43%	22%	22%	6%	2%	5%
	2018	48%	22%	18%	7%	1%	4%
	2019	47%	19%	20%	6%	0%	8%
	2020	50%	19%	20%	8%	1%	2%
	2021	48%	18%	21%	9%	0%	3%
	10-YEAR	**45%**	**18%**	**20%**	**9%**	**2%**	**7%**
SEASON	Winter	41%	17%	25%	6%	1%	10%
	Spring	43%	20%	22%	7%	2%	6%
	Summer	50%	18%	14%	14%	2%	3%
	Fall	47%	16%	18%	9%	2%	8%
DAYLIGHT	Day	48%	18%	17%	7%	3%	7%
	Night	41%	17%	24%	11%	0%	7%

Figure 6. Relationship between Weather Conditions and Reported Visibility at Brookings Airport AWOS

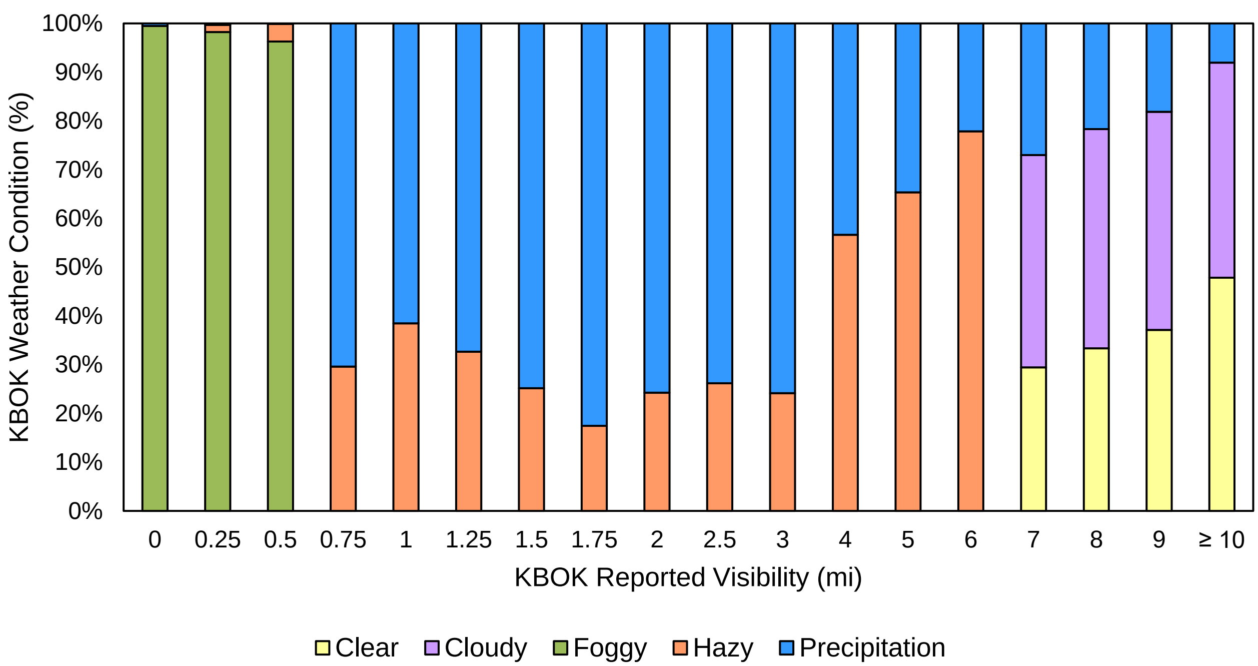


Table 3. Frequency of Calculated Visibility Ranges at Brookings Airport AWOS

Parameter		KBOK Predicted Visibility (%)			
		Wind Farm Not Visible		Wind Farm Visible	Missing
		Less Than 10 Miles	Greater Than or Equal to 10 and Less Than 13.8 Miles	Greater Than or Equal to 13.8 and Less Than 25 Miles	
YEAR	2012	53%	22%	18%	7%
	2013	42%	23%	28%	6%
	2014	65%	13%	18%	4%
	2015	47%	19%	16%	19%
	2016	27%	34%	31%	8%
	2017	30%	34%	32%	5%
	2018	28%	32%	37%	4%
	2019	25%	34%	33%	8%
	2020	30%	33%	35%	2%
	2021	32%	35%	30%	3%
	Total	**38%**	**28%**	**28%**	**7%**
SEASON	Winter	34%	31%	26%	10%
	Spring	40%	26%	28%	6%
	Summer	42%	27%	28%	3%
	Fall	35%	28%	29%	8%
DAYLIGHT	Day	36%	21%	36%	7%
	Night	40%	36%	17%	7%
WEATHER	Clear	15%	32%	53%	-
	Cloudy	20%	60%	20%	-
	Precipitation	86%	13%	2%	-
	Foggy	100%	0%	0%	-
	Hazy	100%	0%	0%	-

3.2 COOS BAY CALL AREA

For the Coos Bay Call Area analysis, ten years (2012-2021) of DS-3505 surface observation data at North Bend Municipal Airport were analyzed. Wind roses of the annual frequency distribution of wind speed and direction, as well as the seasonal frequency distributions of the winds were developed. Figure 7 presents the annual distribution of the wind measurements at North Bend Municipal Airport for the 10-year period. Figure 7 shows that winds from the north are dominant, followed by winds from the southeast and south-southeast. The winds from the north and northwest tend to be stronger than those from the southeast sectors. Seasonal wind roses are presented in Figure 8 and show that southeasterly winds are dominant through the winter months, and that spring brings a northernly component and a reduction in southeasterly winds that continues through the summer. By summer, strong northerly winds are dominant, and the southeast component is further diminished. During the fall, the northerly winds decrease, and the occurrence of southeast winds increase again.

Like the Brookings Call Area, the closet distance to land of the Coos Bay Call Area is 13.8 miles. The North Bend Municipal Airport is located near the coast along a stretch of land that is surrounded by water on three sides. Visibility reported there is representative of an observer on land looking offshore toward the potential wind farm.

Table 4 summarizes the percent of time that the reported visibility was less than 10 miles and the percent of time that the reported visibility was 10 miles or greater (the furthest distance bin category reported). Table 4 presents the analysis by annual metrics, 10-year period, seasonal periods over the 10-year period, and daylight and nighttime hours over the 10-year period. When the visibility is reported to be less than 10 miles, a wind farm would not be visible from shore. When the reported visibility is 10 miles (representing ≥ 10 miles), it indicates that some of the time there is the potential for a wind farm to be visible to an observer on shore. Data capture for the visibility parameter for the study period is very good (available 99% of the time), with all the annual periods exceeding 95% data capture. The amount of time the reported visibility is less than 10 miles, ranging only from 20% to 26% of the time, varied less than at the Brookings site. On average (10-year) at least 23% of the time, a wind farm will not be visible from land. The fall and winter have more hours when a wind farm would not be visible, 28% and 24% of the time, respectively, than the spring and summer, 18% and 22%, respectively. A wind farm would not be visible during 18% of daylight hours and 29% of nighttime hours. Table 4 also summarizes the weather condition associated with the visibility categories < 10 miles and ≥ 10 miles. This shows that during precipitation events 44% of the time shorter visibility distances (wind farm not visible) are reported. It also shows that visibility can be less than 10 miles while the skies are clear (5% of the time) or cloudy (7% of the time).

The distribution of the weather conditions observed at the North Bend Airport was also analyzed over the full 10-year period. Table 5 presents the frequency of occurrence and distribution of clear, cloudy, precipitation, foggy/hazy conditions by annual metrics, 10-year period, seasonal periods over the 10-year period, and daylight and nighttime hours over the 10-year period. As described in Section 2.3, weather conditions were prioritized to assign a single weather condition for each hour to avoid double counting of conditions and allow the percentages to be summed to equal 100%. The rightmost column summarizes the percent of time that the weather condition parameters are missing. Weather condition data capture over the 10-year period is quite good, with 94% to 100% available data on an annual basis. Fog and Haze were grouped together because these weather codes were missing for several years (2012-2016, and part of 2017) and an estimation of their occurrence was made based on the combination of reported visibility and weather condition observed at the KBOK station, as seen in Figure 6. These relationships were used to assign foggy and hazy conditions at North Bend Airport for the early years of the study period. If visibility

Figure 7. Ten-year (2012-2021) Wind Rose of Measurements at North Bend Municipal Airport

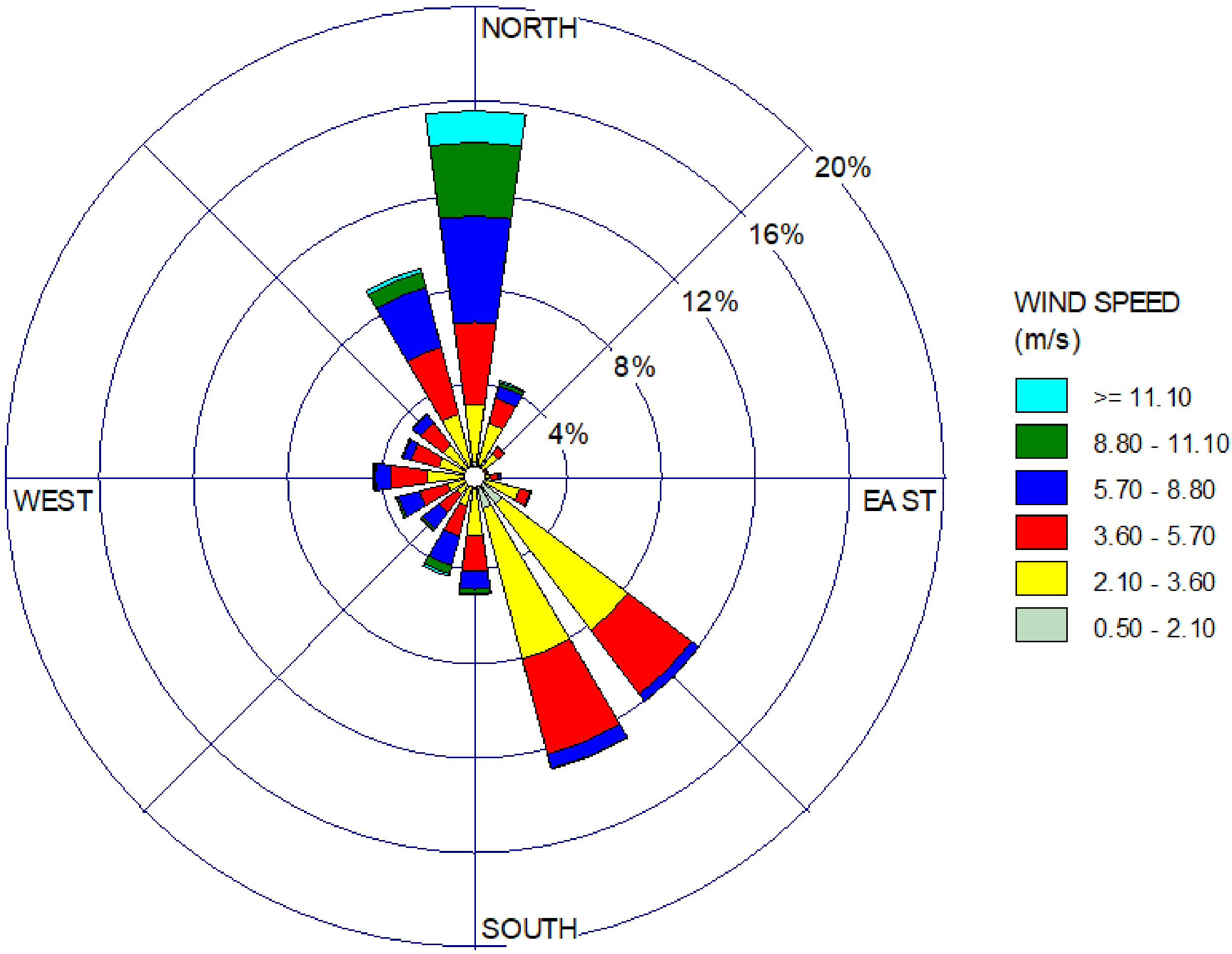
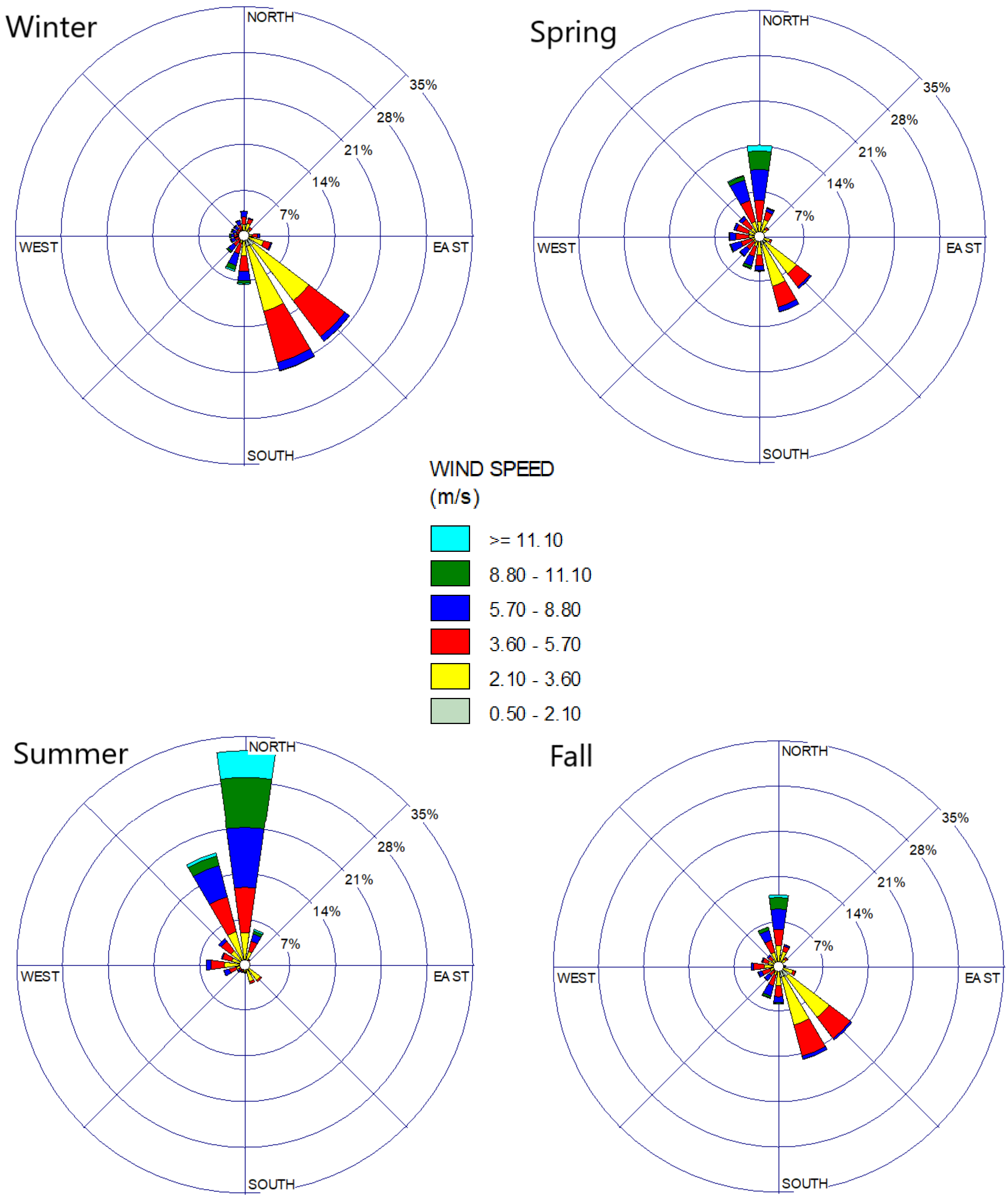


Figure 8. Seasonal 10-year (2012-2021) Wind Roses of Measurements at North Bend Municipal Airport



was less than 0.5 miles, fog was reported, if visibility was between 0.3 and 6 miles, then haze conditions could be reported. In the case when either fog or haze is reported, visibility would be less than 6 miles, therefore a wind farm would not be visible from shore.

On average over the 10-years, clear conditions (36%) occur slightly more often than cloudy hours (33%) and are twice as likely to occur than hours with precipitation (17%). Foggy and hazy conditions occur least frequently, 12% of the time. Clear conditions occur more frequently in summer and fall, with cloudy conditions more likely in spring and summer. Precipitation is most likely to occur in winter. Clear conditions were reported more frequently during the daytime than nighttime, while cloudy conditions were equally distributed during daytime and nighttime. Precipitation and fog were more prevalent at night than during the day.

Visibility in miles was computed for the hours at North Bend Municipal Airport that had visibility reported as ≥ 10 miles in the DS-3505 meteorological data set. The polynomial relationship determined based on the light extinction measurements at the Crescent City ASOS site were applied as discussed in Section 2.3. Table 6 presents the frequency of calculated visibilities that are at less than 13.8 miles (wind farm is not visible), and greater than 13.8 miles (wind farm may be visible), for each season and on an annual basis. Over the 10-year study period, it is estimated that on average a wind farm in the Coos Bay Call Area will not be visible 72% of the time. It is more likely to be not visible during the fall and winter. AA wind farm is expected to not be visible for 90% of the nighttime hours and 57% of the daytime hours. Non-visible hours are associated with clear skies 53% of the time, cloudy conditions 75% and during precipitation events 93% of the time. It is anticipated that a wind farm located within the Coos Bay Call Area will not be visible during foggy conditions.

Table 4. Frequency of Reported and Truncated Visibility Ranges at North Bend AWOS

Parameter		Available Data (%)	KOTH Visibility (%)		
			Less Than 10 Miles	Greater Than or Equal To 10 Miles	Missing
YEAR	2012	96%	25%	71%	4%
	2013	99%	25%	75%	1%
	2014	100%	22%	77%	0%
	2015	99%	20%	80%	1%
	2016	100%	21%	79%	0%
	2017	99%	24%	75%	1%
	2018	99%	22%	76%	1%
	2019	98%	21%	77%	2%
	2020	100%	26%	74%	0%
	2021	98%	25%	74%	2%
	10-YEAR	**99%**	**23%**	**76%**	**1%**
SEASON	Winter	98%	24%	74%	2%
	Spring	99%	18%	80%	1%
	Summer	99%	22%	77%	1%
	Fall	99%	28%	71%	1%
DAYLIGHT	Day	99%	18%	81%	1%
	Night	98%	29%	69%	2%
WEATHER	Clear	-	5%	95%	-
	Cloudy	-	7%	93%	-
	Precipitation	-	44%	56%	-
	Foggy	-	100%	0%	-
	Hazy	-	98%	2%	-

Table 5. Frequency of Weather Conditions Reported at North Bend AWOS

Parameter		KOTH Weather Condition (%)				
		Clear	Cloudy	Precipitation	Foggy / Hazy	Missing
YEAR	2012	30%	39%	12%	15%	4%
	2013	36%	38%	7%	17%	1%
	2014	36%	39%	11%	14%	0%
	2015	41%	38%	9%	12%	1%
	2016	33%	36%	13%	11%	6%
	2017	34%	32%	21%	11%	1%
	2018	36%	29%	24%	9%	2%
	2019	41%	27%	23%	7%	2%
	2020	39%	26%	24%	11%	0%
	2021	36%	29%	24%	10%	2%
	Total	**36%**	**33%**	**17%**	**12%**	**2%**
SEASON	Winter	31%	30%	28%	10%	2%
	Spring	34%	40%	18%	8%	1%
	Summer	42%	37%	6%	13%	1%
	Fall	38%	27%	17%	16%	3%
DAYLIGHT	Day	44%	33%	14%	8%	1%
	Night	28%	33%	20%	16%	3%

Table 6. Frequency of Calculated Visibility Ranges at North Bend Airport AWOS

Parameter		KOTH Predicted Visibility (%)			
		Wind Farm Not Visible		Wind Farm Visible	
		Less Than 10 Miles	Greater Than or Equal to 10 and Less Than 13.8 Miles	Greater Than or Equal to 13.8 and Less Than 25 Miles	Missing
YEAR	2012	25%	32%	39%	4%
	2013	25%	50%	25%	1%
	2014	22%	54%	24%	0%
	2015	20%	57%	22%	1%
	2016	21%	51%	28%	0%
	2017	24%	48%	27%	1%
	2018	22%	48%	28%	1%
	2019	21%	52%	25%	2%
	2020	26%	49%	25%	0%
	2021	25%	47%	26%	2%
	10-YEAR	**23%**	**49%**	**27%**	**1%**
SEASON	Winter	24%	53%	21%	2%
	Spring	18%	48%	32%	1%
	Summer	22%	45%	32%	1%
	Fall	28%	49%	22%	1%
DAYLIGHT	Day	18%	39%	43%	1%
	Night	29%	61%	8%	2%
WEATHER	Clear	5%	48%	48%	-
	Cloudy	7%	68%	25%	-
	Precipitation	44%	49%	7%	-
	Foggy	100%	0%	0%	-
	Hazy	98%	1%	1%	-

3.3 CONCLUSIONS

An assessment of the meteorological conditions associated with each of the Brookings and Coos Bay Call Areas was conducted. Visibility was analyzed for the different seasons, daylight versus nighttime hours, and various weather conditions.

Based on the analysis of 10 years of meteorological data and the estimation of visibilities greater than 10 miles the assessment estimated that a wind farm located in the Brookings Call Area would not be visible from shore on average 66% of the time, and at a minimum 60% of the time and at most 78% of the time (based on 2018 and 2014 data, respectively).

Likewise, based on 10 years of data, a wind farm located in the Coos Bay Call Area is likely to not be visible from shore on average 72% of the time, and at a minimum 57% of the time and at most 77% of the time (based on 2012 and 2015 data, respectively).

4.0 REFERENCES

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