

### 4.2.3 Odor Threat Assessment

In this study, the researchers were unable to develop a way to predict when an odor event will occur from individual meteorological parameters alone; however, certain key parameters have been noted in the literature and have demonstrated empirical relationships in this study, leading to the development of a proposed “Odor Threat Assessment Index”. Assessment of potential key weather conditions for occurrence of odor complaints could assist landfill site personnel in deciding whether or not to alter daily operations on a particular day. Meteorological parameters considered are:

- Wind speed/wind direction
- Temperature/Humidity
- Precipitation
- Atmospheric Stability Class (A-F; with A=being extremely unstable and F=moderately stable)
- Pressure drop over the previous 24 hours

The threat level is divided into five different categories, representing the level of possibility of an odor complaint. Those five categories are as follows (Figure 78):

1. Critical: Odor complaints are expected immediately (Red color)
2. Severe: Odor complaints are highly likely (Orange color)
3. Substantial: Odor complaints are a strong possibility (Yellow color)
4. Moderate: Odor complaints are possible, but not likely (Green color)
5. Low: Odor complaints are unlikely (Blue color)



**Figure 78. Odor Threat Assessment Levels based on the Possibility of an Odor Event**

No wind or weak wind speeds, lower than 3 miles per hour, are identified and ranked as critical for expecting a complaint. Low wind days also contribute to finding that stable weather conditions tend to have higher frequency of odor complaints. Lowest ranked are days with strong wind speeds of 18 miles per hour or greater (Figure 79).

Rank	Beaufort Number	Wind Speed, mph	Description
Critical	5+	<3	Light calm
Severe	4	4-7	Light breeze
Substantial	3	8-12	Gentle breeze
Moderate	2	13-18	Moderate breeze
Low	0-1	>18	Strong breeze

**Figure 79. Categories of Wind Speed Ranges Based on the Critical Level of Odor Complaint Occurrence**

Receptors located directly downwind from the source have highest possibility of becoming sensitive to dispersed odors. Key receptor locations are ranked as follows:

1. Critical: Directly downwind
2. Severe: Slightly downwind ( $\pm 45^\circ$ )
3. Substantial: Crosswind ( $\pm 90^\circ$ )
4. Moderate: Slightly upwind ( $\pm 135^\circ$ )
5. Low: Directly upwind ( $\pm 180^\circ$ )

Warm and humid conditions enhance the human sense of smell so that odors are perceived more intensely. Dew point temperature was selected as a parameter to reflect the relationship between humidity and temperature. By knowing the values for temperature and relative humidity, a value for dew point can be easily read from Table 45, which is adapted from the ASHRAE Psychrometric Chart.

**Table 45. Relationship between Relative Humidity, Temperature and the Dew Point**

Dew-Point Temperature (°F)															
Relative Humidity	Design Dry Bulb Temperature (°F)														
	32°F	35°F	40°F	45°F	50°F	55°F	60°F	65°F	70°F	75°F	80°F	85°F	90°F	95°F	100°F
100%	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
90%	30	33	37	42	47	52	57	62	67	72	77	82	87	92	97
80%	27	30	34	39	44	49	54	58	64	68	73	78	83	88	93
70%	24	27	31	36	40	45	50	55	60	64	69	74	79	84	88
60%	20	24	28	32	36	41	46	51	55	60	65	69	74	79	83
50%	16	20	24	28	33	36	41	46	50	55	60	64	69	73	78
40%	12	15	18	23	27	31	35	40	45	49	53	58	62	67	71
30%	8	10	14	16	21	25	29	33	37	42	46	50	54	59	62
20%	6	7	8	9	13	16	20	24	28	31	35	40	43	48	52
10%	4	4	5	5	6	8	9	10	13	17	20	24	27	30	34

As an example, if the temperature is 32°F with relative humidity 80%, a dew-point temperature is equal to 27°F. Temperature values higher than 75°F are ranked as critical, while temperature values below 50°F as low potential for an odor episode (Figure 80).

Rank	Dew Point (°F)
Critical	>75°F
Severe	65 - 75
Substantial	60 - 65
Moderate	50 - 60
Low	<50

**Figure 80. Categories of the Dew Point Temperatures Based on the Critical Level of Odor Complaint Occurrence**

Rainfall accumulation from 3 days prior to an odor complaint was identified as a possible indicator for higher frequency of odor complaints. Days with more than 15 mm/hr of rain accumulation in a 3-day period reflect the scenario of torrential rainy days (Figure 81). Those levels of rainfall are categorized as critical for odor complaint occurrence. Dry days with accumulated levels of rainfall less than 0.5 mm/hr over a 3-day period are categorized as a low-level threat for odor complaint (Figure 81).

Rank	Precipitation Previous 3 days (mm/hr)	Descriptor
Critical	>15	Intense/torrential
Severe	7.5-15	Heavy
Substantial	2.5-7.5	Moderate
Moderate	0.5-2.5	Light
Low	<0.5	Dry

**Figure 81. Categories of Precipitation Accumulated Previous 3 Days, Based on the Critical Level of Odor Complaint Occurrence**

Atmospheric stability class could be identified by measuring the local adiabatic lapse rate, which is the rate of temperature change occurring with a rising or descending air parcel. The vertical temperature gradient is a function of elevation and temperature. The instability of the atmosphere increases as the temperature decreases with elevation. When the temperature decreases slowly, or even momentarily increases, with elevation- the atmosphere is considered stable. This information is highly site-specific and is rarely reported at weather stations unless they are located at airports, which publish hodographs showing wind vectors at altitude. At landfills, for example, the vertical temperature gradient could be collected using multiple temperature sensors: one on the hill (landfill body) and one at the ground level (fence line). In addition, iSense has proposed to collect balloon

measurement devices or drone collected devices at landfill sites to collect this data. Since stable weather conditions (cloudy skies, low wind days) are related to more frequent odor complaints, those conditions were attributed with a higher level of threat for occurrence of odor complaints (Figure 82). An increase in temperature by more than 1.5°C/100m is identified as strongly stable atmospheric class F, while a decrease in temperature by less than 1.9°C/100m is considered as extremely unstable atmosphere class A (“Low” threat for odor complaints). Finally, the location of a temperature inversion layer must also be taken into consideration, since if an inversion layer is found aloft, then potential for fumigation of the ground level would increase the threat of odor complaints, while an inversion layer below the source would negate any threat to residents.

Rank	Pasquill-Gifford Scale	Vertical Temp Gradient $\Delta T/\Delta z$ (°C/100m)	Descriptor
Critical	F	> +1.5	Moderate/strongly stable
Severe	E	-0.5 to +1.5	Slightly stable
Substantial	D	-1.5 to -0.5	Neutral
Moderate	B-C	-1.9 to -1.5	Moderate/slightly unstable
Low	A	< -1.9	Extremely unstable

**Figure 82. Categories of Atmospheric Stability Classes Based on the Critical Level of Odor Complaint Occurrence**

Overnight pressure drop seems to be a useful indicator. However, more study is needed to develop useful scale. Low pressure days are considered as a “Critical” threat for occurrence of odor complaints (Figure 83).

Rank	Pressure drop	Descriptor
Critical	Low	
Severe	Falling	
Substantial	Neutral/normal	
Moderate	Rising	
Low	High	

**Figure 83. Categories for the Pressure Drop Based on the Critical Level of Odor Complaint Occurrence**

Odor threat levels can be calibrated locally by solid waste personnel to adapt to their site specific conditions by taking into consideration their past experiences with odor issues and by identifying weather patterns characteristic to their specific site. Based on that, landfill site managers can change the bins within each threat level to better represent situations relevant to their location. An example of how odor threat levels can be used is presented in Table 46 (without the pressure drop

category, which needs more development). Let's say the local conditions are as follows: wind speed is 1.5 mph, wind is blowing directly downwind from the odor source, temperature is 85°F, precipitation is greater than 15 mm/hour, and the atmospheric stability class "F" or "moderately stable" is identified, the threat for a possible odor complaint is severe (all fields in red color).

**Table 46. Example How to Use and Interpret "Odor Threat Levels"**

WS	WD	DP	P	ASC	dP
5 mph	crosswind	72°F	1.5 mm/hr	D	-20 mbar?
<3	Directly downwind	>75°F	>15	F	
4 – 7	Slightly downwind	65 – 75	7.5 – 15	E	
8 – 12	Crosswind	60 – 65	2.5 – 7.5	D	
13 – 18	Slightly upwind	50 – 60	0.5 – 2.5	B-C	
>18	Directly upwind	<50	<0.5	A	