

**Report of Findings for the Northern
Foredune Restoration Monitoring (NFRA)
Station – May to September 2025**

Report Prepared by the Desert Research Institute,
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for

California Department of Parks and
Recreation, Oceano Dunes State Vehicular
Recreation Area

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The San Luis Obispo County Hearing Board adopted a modification to the Stipulated Order of Abatement (SOA) in 2025 that requires reporting on data collected at the Northern Foredune Restoration (NFRA) station. This station, part of the meteorological and PM₁₀ monitoring network operated by California Department of Parks and Recreation, Oceano Dunes State Vehicular Recreation Area (ODSVRA), is closest to the ocean, separated from the water by a flat gently sloping beach approximately 100 m (328 feet) wide that was closed to Off Highway Vehicle (OHV) activity from March 1, 2025, to September 30, 2025, to protect potential Western Snowy Plover and California Least Tern nest sites (see Figure 1).

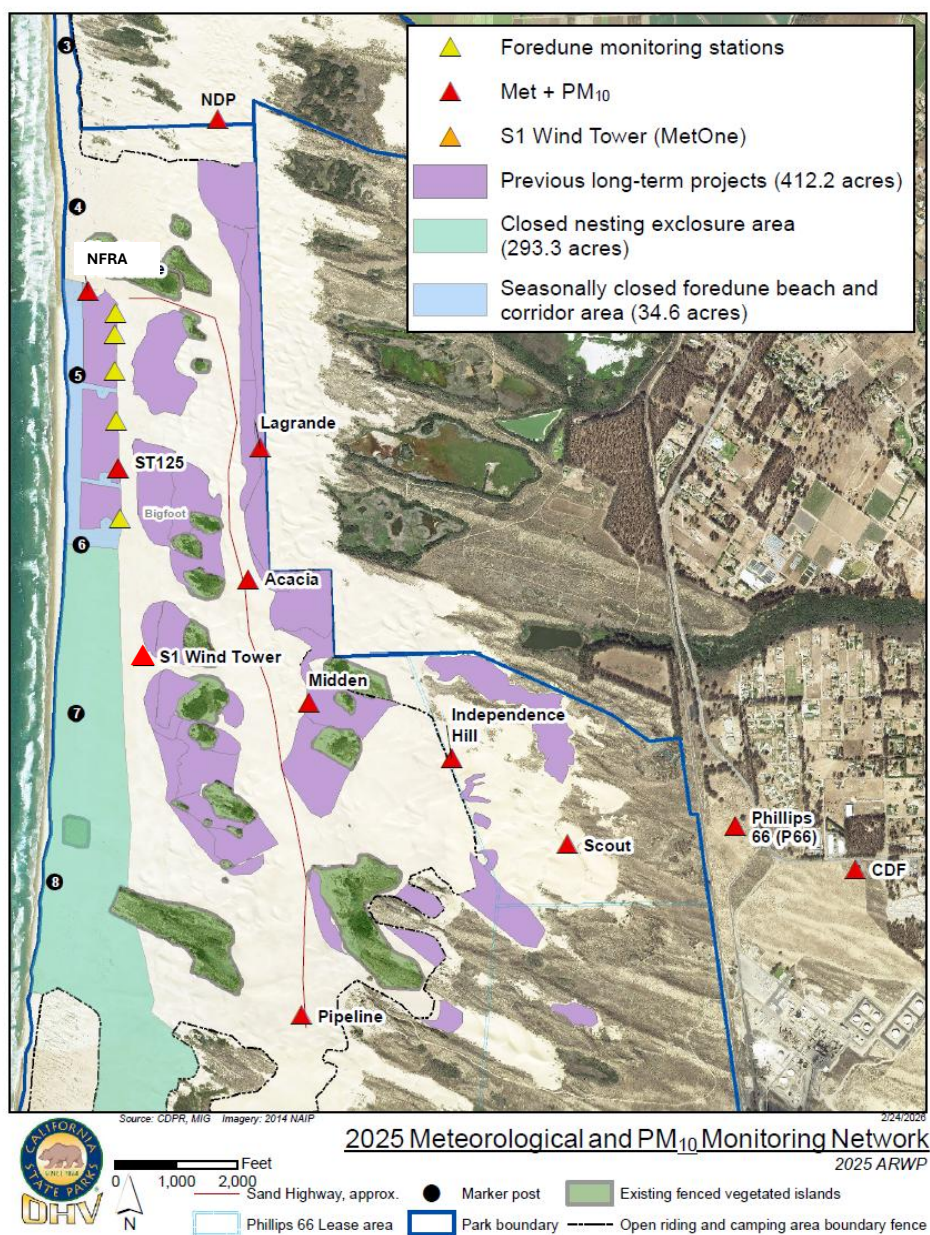


Figure 1. The positions of the meteorological and PM₁₀ monitoring stations in 2025.

The NFRA station was installed in May 2025. Installation of the met and PM₁₀ network is typically carried out in April, however in 2025, the instruments were not returned from factory servicing until May. The wind speed and wind direction data for the period from May through September 2025 are summarized in Figure 2. For the monitoring period, the wind speed range was between 0 and 12.5 m s⁻¹ (0 and 28 mph). The percentage of occurrence of winds reaching and exceeding the typical threshold wind speed for sand transport in the ODSVRA (i.e., 5.5 m s⁻¹ [12.3 mph] measured at 3.5 m [11.5 feet] above ground level (AGL) was 19%. Wind direction was bimodal with modes of 112.5° and 292.5°.

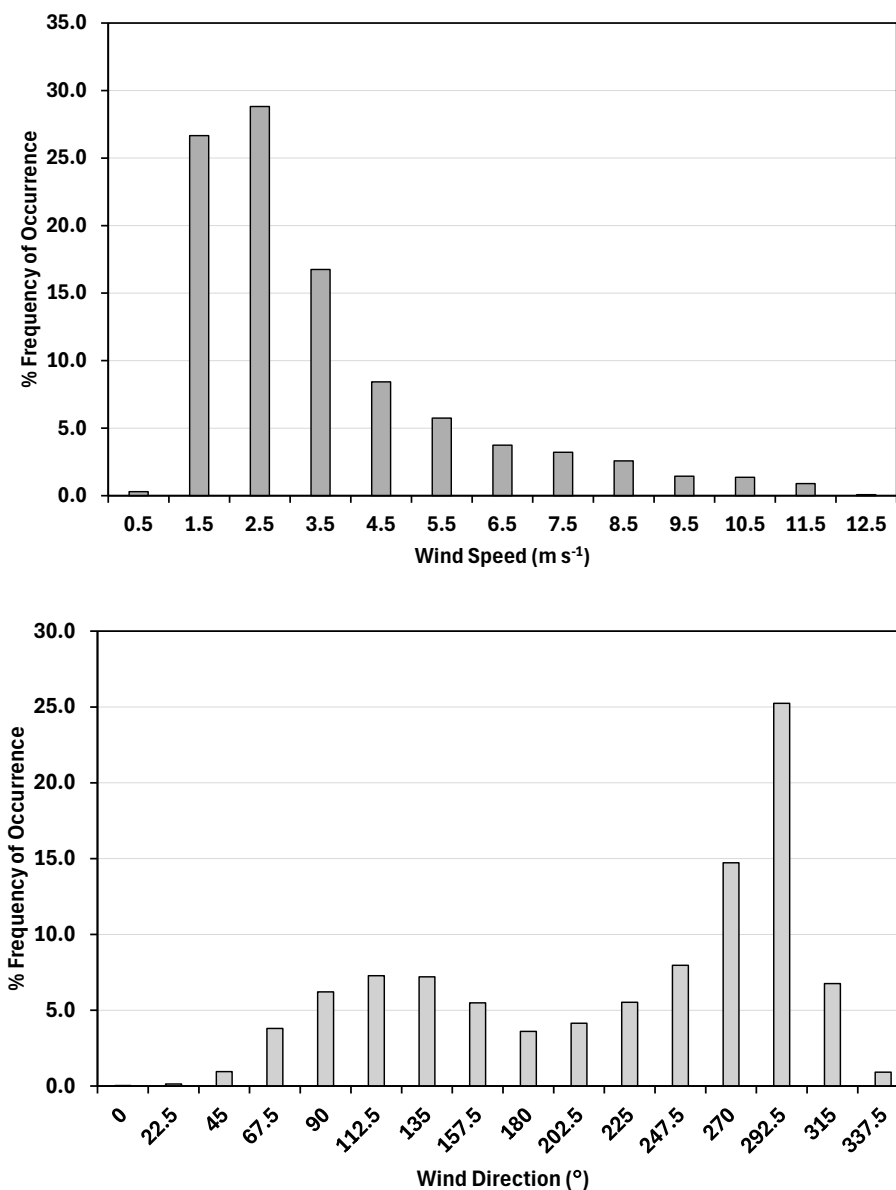


Figure 2. The frequency distributions for wind speed and wind direction measured at the NFRA station, May to September 2025.

The wind direction range 248° to 326° was used to define the wind direction condition that has the greatest potential to transport PM₁₀ to the San Luis Obispo County Air Pollution Control District's (SLOAPCD) CDF station (see Figure 1) when wind exceeds 5.5 m s⁻¹ [12.3 mph] at 3.5 m [11.5 feet] AGL. Under these wind speed and wind direction conditions, the other monitoring stations in the network show a correlation between wind speed and PM₁₀ (see Figure 3). At the NFRA station, the range of hourly mean PM₁₀ concentration was 36 µg m⁻³ to 45 µg m⁻³, which is considerably smaller than the stations farther inland. It was also observed for the 2025 NFRA data that the PM₁₀ data were not correlated with wind speed as shown in Figure 4. That the concentration of PM₁₀ was not correlated with wind speed suggests that, at this location, the PM₁₀ measured by the monitor was not, or was only weakly related to dust emissions from the beach upwind of the monitor. The PM₁₀ concentrations are also influenced by liquid sea-spray particles as the NFRA station was close to the shoreline and the surf zone. Salt (NaCl) and organic matter particles will also be present upon evaporation of the sea-spray particles. The production of sea spray typically increases with wind speed, but wave breaking can also be out of phase with current wind conditions reflecting more distant storm conditions from earlier times.

The relation between wind power density (WPD) (Skidmore, 1998) and PM₁₀ at the ODSVRA has been demonstrated by Gillies et al. (2022). Wind power density (WPD, W m⁻²) is an effective quantity for evaluating the relation between the energy in the wind and the response of the dust emission system to emit PM₁₀ from the surface. Wind power density is defined as (e.g., Kalmikov, 2017):

$$\text{WPD} = 0.5 \rho_a u^3 \quad (1)$$

where ρ_a is air density (kg m⁻³), and u (m s⁻¹) is wind speed (at a known height). The relation is demonstrated by plotting the Total PM₁₀ (TPM₁₀) against the Total Wind Power Density (TWP) values, which are summations of each hourly mean quantity for a set period of time (e.g., monthly) when the wind direction range at a station is 248° to 326° and the mean hourly WPD is $\geq 102 \text{ W m}^{-2}$ (equivalent to 5.5 m s⁻¹). The linear relationship between TPM₁₀ and TWP, for the defined wind direction range and for wind speeds $\geq 5.5 \text{ m s}^{-1}$ for the Acacia station in 2025 is shown in Figure 5 (other examples of this relation are shown in Gillies et al., 2022). The ratio of TPM₁₀:TWP provides a useful metric to compare the amount of PM₁₀ produced by equivalent amounts of WPD across the monitoring network. As shown in Figure 6, the near-shore stations in the network, NFRA, ST125, and S1 Tower have lower TPM₁₀:TWP ratio values than the stations farther inland. This indicates that high concentrations of PM₁₀ were not observed close to the shoreline in May through September 2025 for equivalent amounts of WPD.

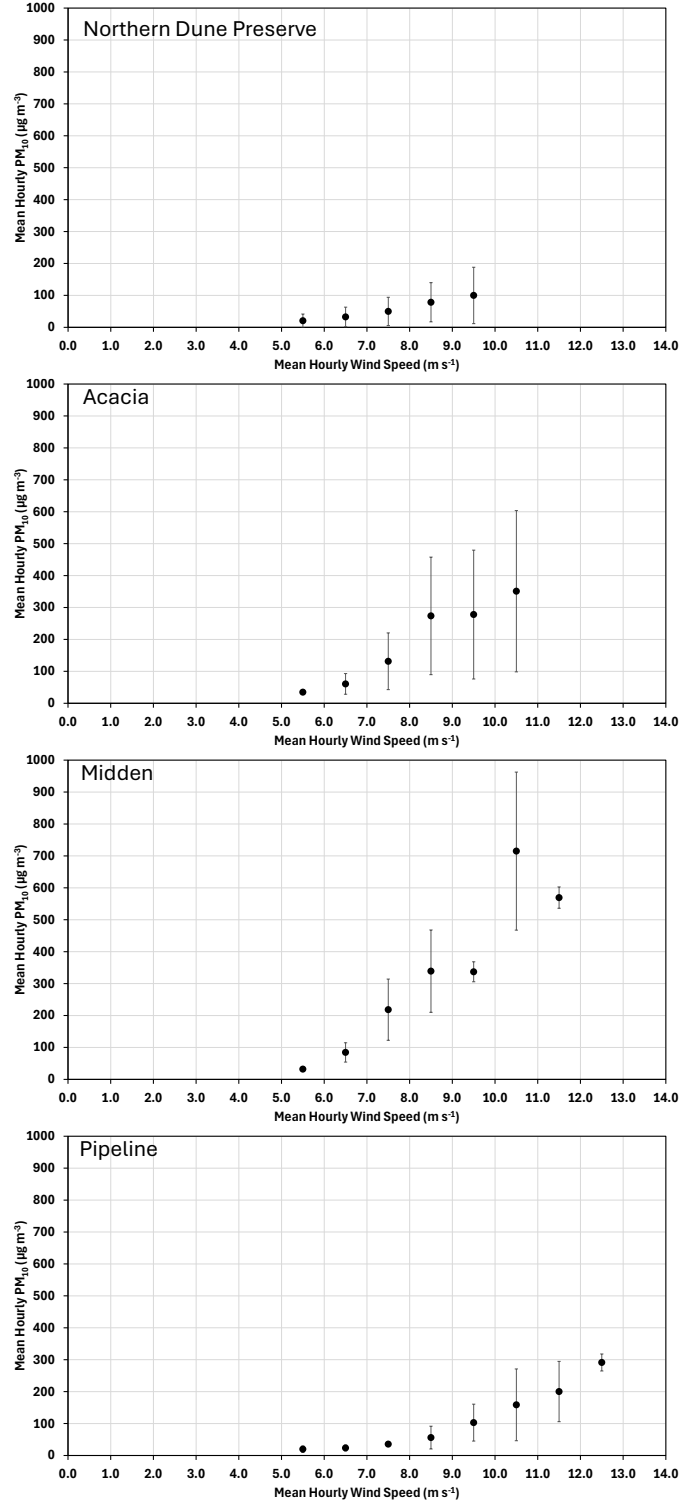


Figure 3. Relation between mean hourly PM₁₀ concentration (μg m⁻³) and mean hourly wind speed (m s⁻¹) for select stations on open sand areas of the ODSVRA (May-September 2025) spanning the network distance from north (NDP) to south (Pipeline). Error bars represent the standard deviation of the mean hourly PM₁₀ for each mean hourly wind speed class.

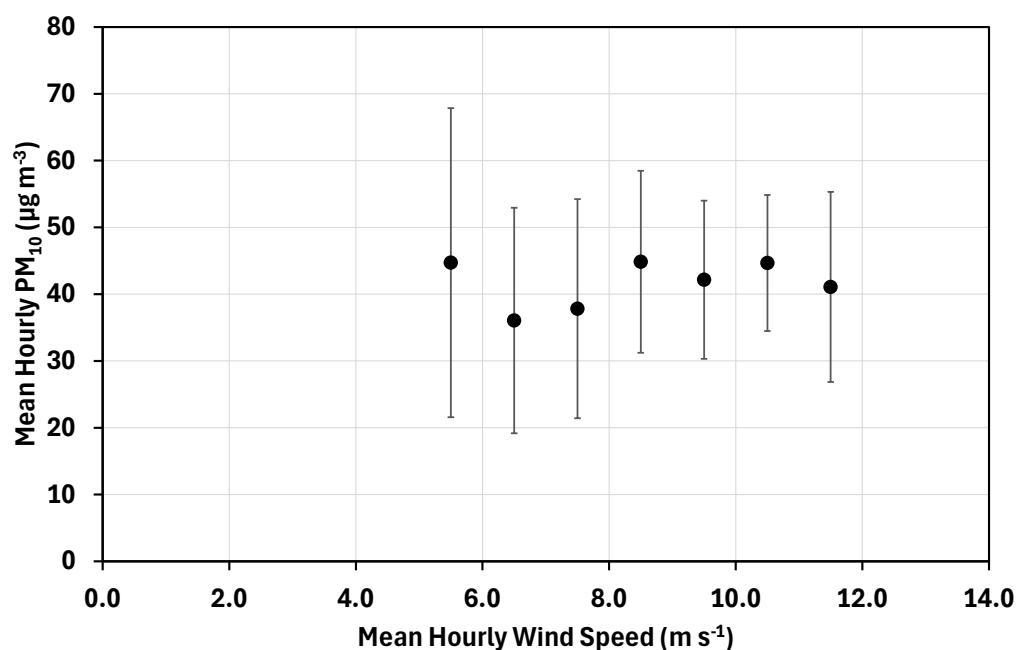


Figure 4. The mean hourly PM₁₀ (µg m⁻³) concentration compared with the mean hourly wind speed (m s⁻¹) at the NFRA station, May-September 2025. Error bars represent the standard deviation of the mean hourly PM₁₀ in each wind speed class.

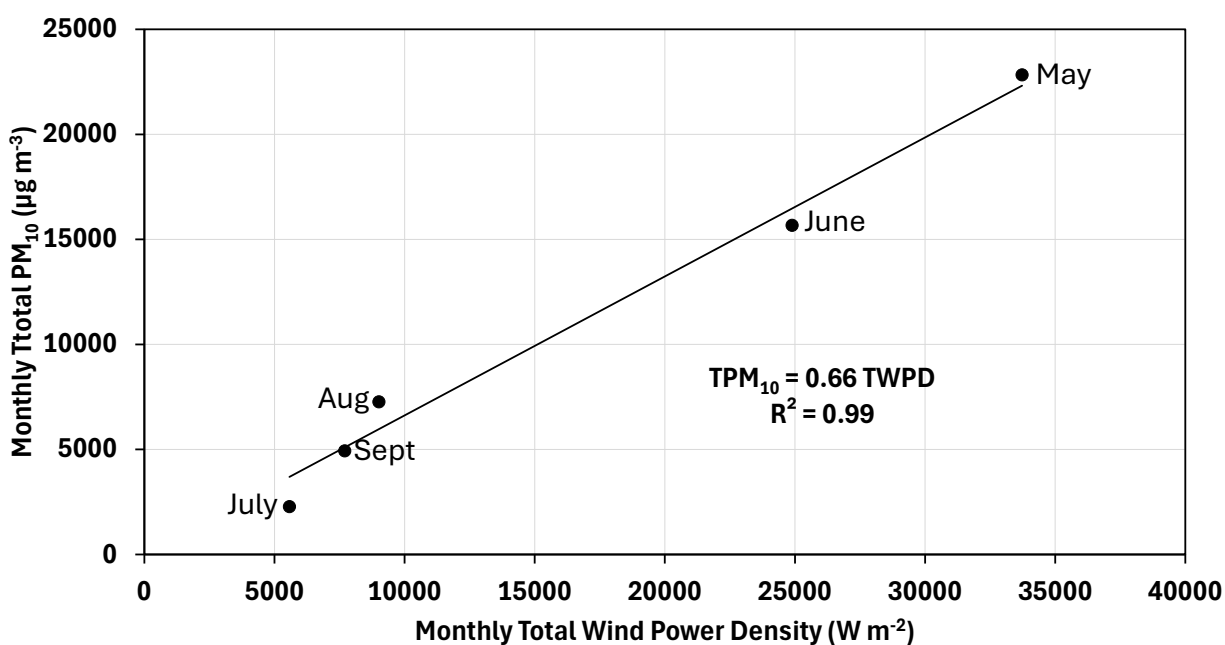


Figure 5. The relation between monthly TPM₁₀ (µg m⁻³) and monthly TWPD for the Acacia station in 2025.

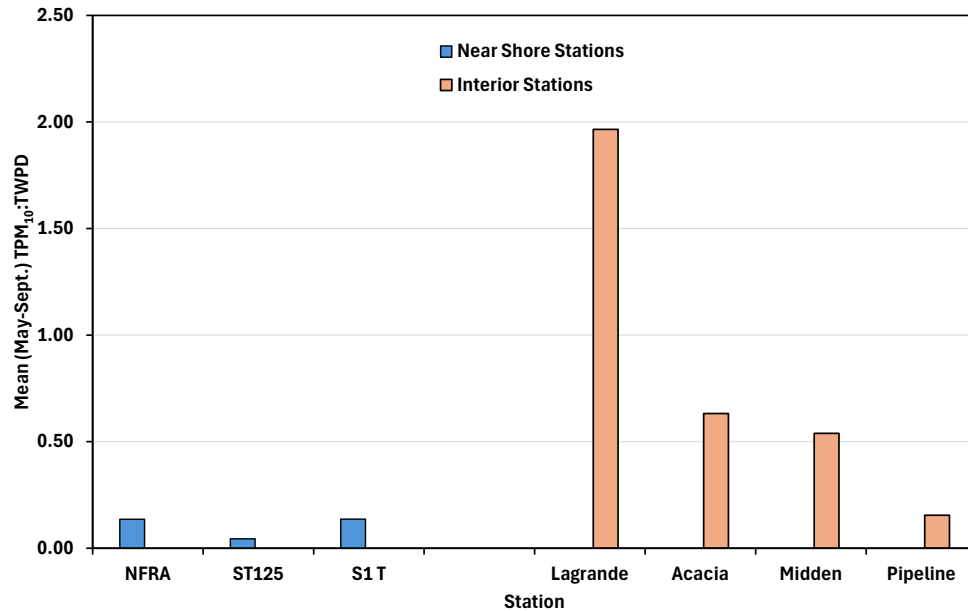


Figure 6. The TPM₁₀:TWPD ratio in 2025, (based on the summation of mean hourly data for May through September) for the near shore stations (NFRA, ST125, and S1T) compared to those farther inland that are located on sand-sheet areas of the ODSVRA (Lagrande, Acacia, Midden, and Pipeline). The values represent the ratio based on a 5-month period (May through September).

The increase in PM₁₀ produced per unit WPD with increasing distance from the shoreline indicates that the PM₁₀ concentrations at the inland network station locations cannot be a result of an initial input of high PM₁₀ concentrations from Oceanic sources.

The PM₁₀ measured at the NFRA location is likely composed of sea-spray particles and salt and organic particles following the evaporation of the liquid spray particles, as well as some mineral particles when the beach area is sufficiently dry and exposed to wind speeds that cause sand movement and PM₁₀ emissions. In 2025, however, concentrations of PM₁₀ exceeding 50 µg m⁻³ were not observed. As these near-shore PM₁₀ particles advect, disperse, and deposit downwind their contribution to the total PM₁₀ burden diminishes, and hence near shore concentrations of <50 µg m⁻³ could not contribute substantially to the PM₁₀ measured in 2025 at the inland monitoring stations CDF and Mesa2 operated by the SLOAPCD.

References

Gillies, J.A., E. Furtak-Cole, G. Nikolich, V. Etyemezian (2022). The role of off highway vehicle activity in augmenting dust emissions at the Oceano Dunes State Vehicular Recreation Area, Oceano CA. *Atmospheric Environment: X*, 13, 100146, doi: 10.1016/j.aeaoa.2021.100146.

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