**Increments of Progress Towards Air Quality Objectives - ODSVRA Dust Controls 2022 Update**

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Dust controls including temporary wind fences and vegetation projects have been used within the ODSVRA to reduce the emissions of $PM_{10}$ originating from the ODSVRA and lower the regional $PM_{10}$ burden on the Nipomo mesa. Beginning in 2014 and continuing through 2022, when 90 additional acres of dust controls were put into place, a total of 412.5 acres of controls have been established in the ODSVRA (ARWP, 2022, Attachment 1).

Here we demonstrate that the $PM_{10}$ (hourly BAM) data measured at CDF and Mesa2 and the wind data measured 10 m above ground level (AGL) at the S1 tower show that $PM_{10}$ measured at CDF and Mesa2 are lower now than prior to the emplacement of dust controls and that this reduction in $PM_{10}$ scales with the increase in acres of dust control. In this report we update the relation between the ratio Total $PM_{10}$ ($TPM_{10}$):Total Wind Power Density (TWPD) for CDF and Mesa2 and acres of dust control from Gillies et al. (2021) with data from April to September, 2022.

**Methods**

The metric used to evaluate the production of $PM_{10}$ from the ODSVRA is the ratio of total hourly $PM_{10}$ ($TPM_{10}$, µg $m^{-3}$ [measured with a Beta Attenuation Monitor or BAM]) operated by the San Luis Obispo County Air Pollution Control District, SLOAPCD and total hourly wind power density (W $m^{-2}$) as measured at the S1 tower within the ODSVRA, for winds that are expected to cause saltation and dust emissions during a set period of time. Here we set the period of time to be the spring-summer period from April through September, which is typically considered the windy season in the region.

The following constraints were applied for the available environmental data.

1) A wind speed filter was applied based on screening for the conditions where it was most likely that the $PM_{10}$ reaching CDF and Mesa2 was due to the generation of dust by saltation within the ODSVRA. Winds from 248° to 326° were used to ensure, conservatively, that the air flow that reached CDF and Mesa2 had most likely travelled from the ODSVRA.
2) Wind speed that indicated the initiation of a relation with increasing PM10 at the CDF and Mesa2 sites were determined from data that relates $PM_{10}$ to wind speed measured at each of the sites.
3) Based on searches for precipitation data for monitoring sites near the ODSVRA the number of days where precipitation was identified to occur prior to the hour of observation were identified. Hours of observation were removed from analysis if precipitation was observed less than 3 days prior.

To standardize the calculation of TWPD a lower limit of wind speed is chosen that corresponds with the lowest speed where the relation between increasing wind speed and simultaneous increase in $PM_{10}$ is observed at a monitoring station (Fig. 1). Similar to previous years a wind speed of 3.5 m $s^{-1}$ at 10 m above ground level (WPD= 26 W $m^{-2}$) for CDF and Mesa2 defines the lowest value for the range over which $PM_{10}$ is summed at these stations to calculate $TPM_{10}$. TWPD is the summation of the hourly mean wind speed measured at the S1 tower for the hours identified at CDF or Mesa2 that correspond to hourly mean wind speed ≥3.5 m $s^{-1}$ (after screening for the wind direction and precipitation criteria).

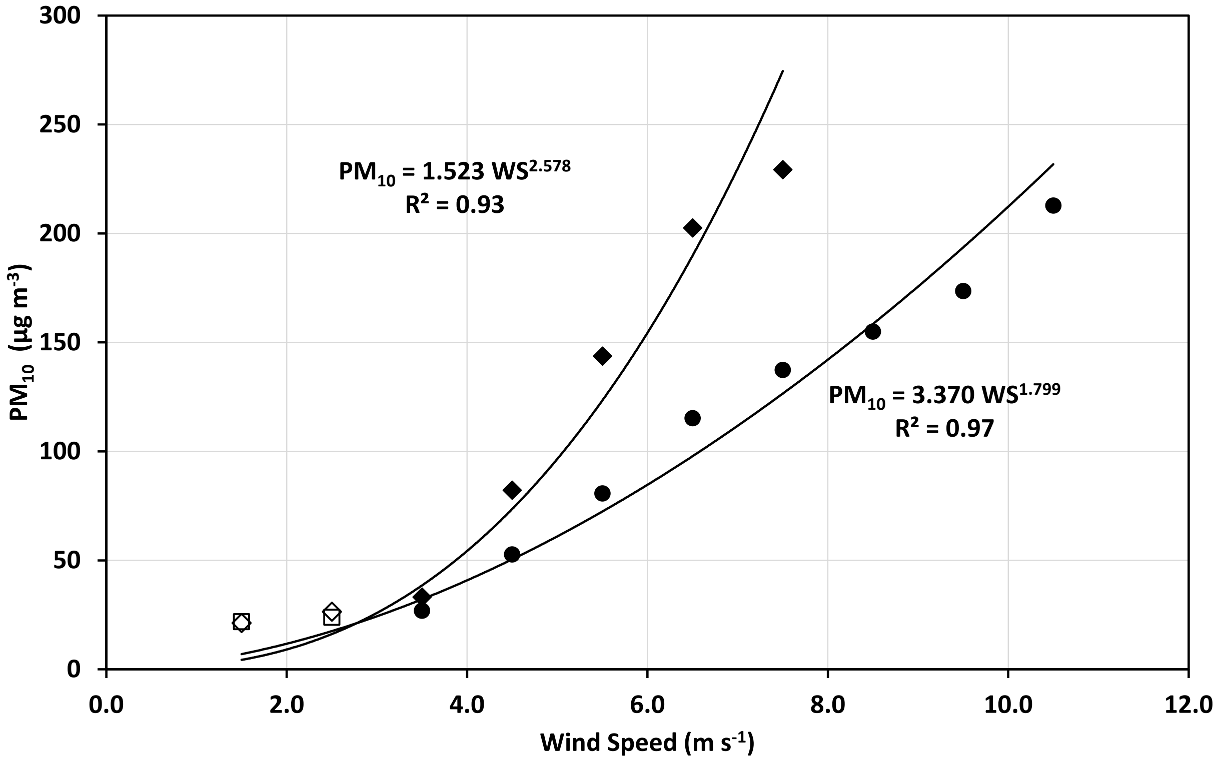


**Figure 1**. The relation between hourly mean $PM_{10}$ and hourly mean wind speed for winds from 248°-326° observed at CDF (diamonds) and Mesa2 (circles), April-September 2022. $PM_{10}$ increases as a function of wind speed for wind speeds ≥3.5 m $s^{-1}$. White symbols indicate below threshold wind speed conditions and these data were not used to define the regression-derived best fit equations.

Wind power density (WPD, W $m^{-2}$) is defined as (e.g., Kalmikov, 2017):

$$WPD=0.5\ \rho_a\ u^3 \qquad (1)$$

where $\rho_a$ is air density (kg $m^{-3}$), and u (m $s^{-1}$) is wind speed at the measurement height above ground level (10 m AGL), a unit area of 1 $m^2$ is assumed in this application. For comparison among different locations, the height of measurement of wind speed must be the same.

**Results 2022**

**Total Wind Power Density April-September 2011-2022**

The wind speed record at the S1 tower for the period April-September 2022 had values that were higher than observed in 2021. To place the wind conditions into context across the available S1 tower data record, 2011-2022, TWPD for the period April-September in each year was calculated (Fig. 2). As Fig. 2 shows the TWPD in 2022 as measured at the S1 tower is the highest observed for the data record. This suggests that the potential for wind-driven sand transport and dust emissions within the ODSVRA was also at its highest level over the 11 years of record.

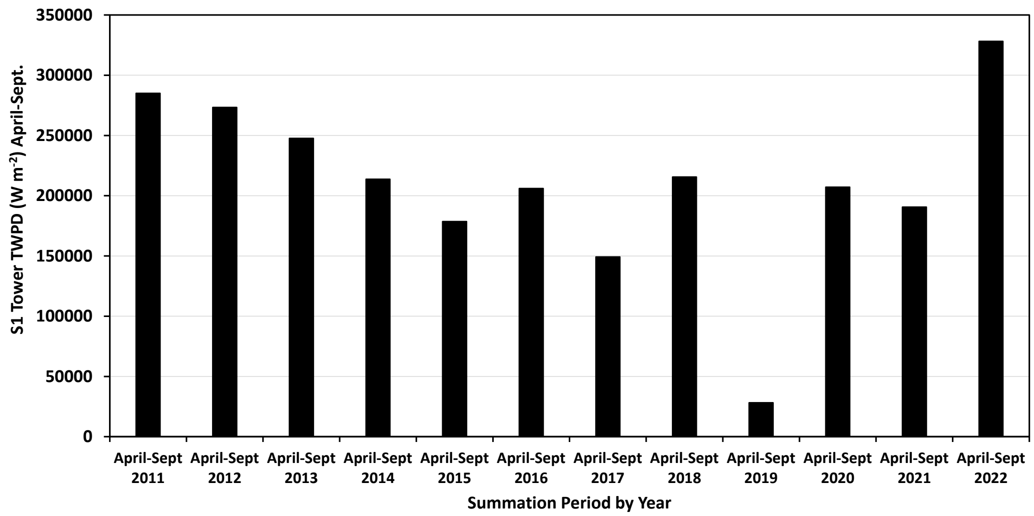


**Figure 2**. Total Wind Power Density (W $m^{-2}$) at the S1 tower for the period April-September, 2011-2022.

**Total $PM_{10}$ and Total WPD April-September 2022, CDF**

As shown previously (Gillies et al., 2021) total WPD (TWPD), i.e., the summation of hourly mean wind speed for a defined period of time, measured at S1 was correlated with total $PM_{10}$ at CDF (Gillies et al., 2020). Figure 3 shows that this relation holds in 2022 for CDF and S1 and Mesa2 and S1.

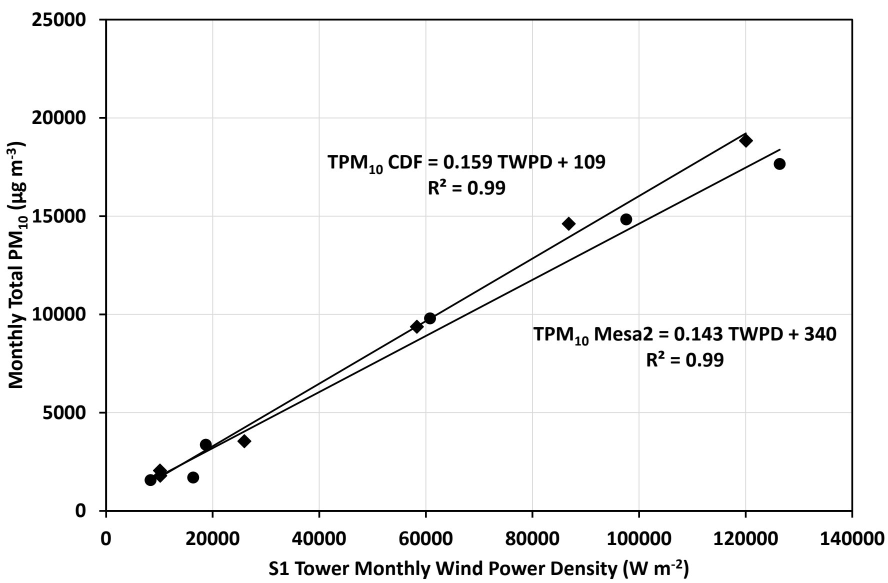


**Figure 3**. The relation between monthly Total $PM_{10}$ and monthly Total Wind Power Density for all hours when the wind direction was from 248°-326° observed at CDF (diamonds) and Mesa2 (circles), wind speeds were ≥3.5 m $s^{-1}$ (at CDF and Mesa2), and hours wherein there were <3 days since the last record of precipitation were removed.

Based on the number of acres of dust control that have been established from 2013 through 2022, Fig. 4 shows that at CDF for the period April through September there was a downward trend in the $TPM_{10}$:TWPD ratio with increasing amounts of dust control acreage, with the caveat that the data from 2019 were removed because there were few hours where the winds exceeded the threshold wind speed (i.e., an unstable ratio condition). The $TPM_{10}$:TWPD ratio for 2020 was not included in the least squares regression as during April-September of that year since the Park restricted OHV activity due to COVID19.

Figure 4 indicates that the 2022 $TPM_{10}$:TWPD value supports the established downward trend in this dust emission metric as acres of dust control continued to increase in 2022. That the downward trend continued even as the TWPD reached a level greater than in the years 2011-2021, suggests that the dust control management strategies are working as intended and were not overwhelmed by 2022's high wind conditions.

**Total $PM_{10}$ and Total WPD May-September 2022, Mesa2**

The ratio of $TPM_{10}$:TWPD for Mesa2 and S1 data for the period April through September for the years 2013-2022 as a function of acres of dust control is shown in Fig. 5. This figure shows that a downward trend in the $TPM_{10}$:TWPD ratio is observed with increasing acres of dust control for the period 2018-2022 (2019 data removed, 2020 data not included in the regression). Prior to 2018, there was no clear trend in the $TPM_{10}$:TWPD ratio data as there were few acres of dust control upwind of the Mesa2 monitoring station.

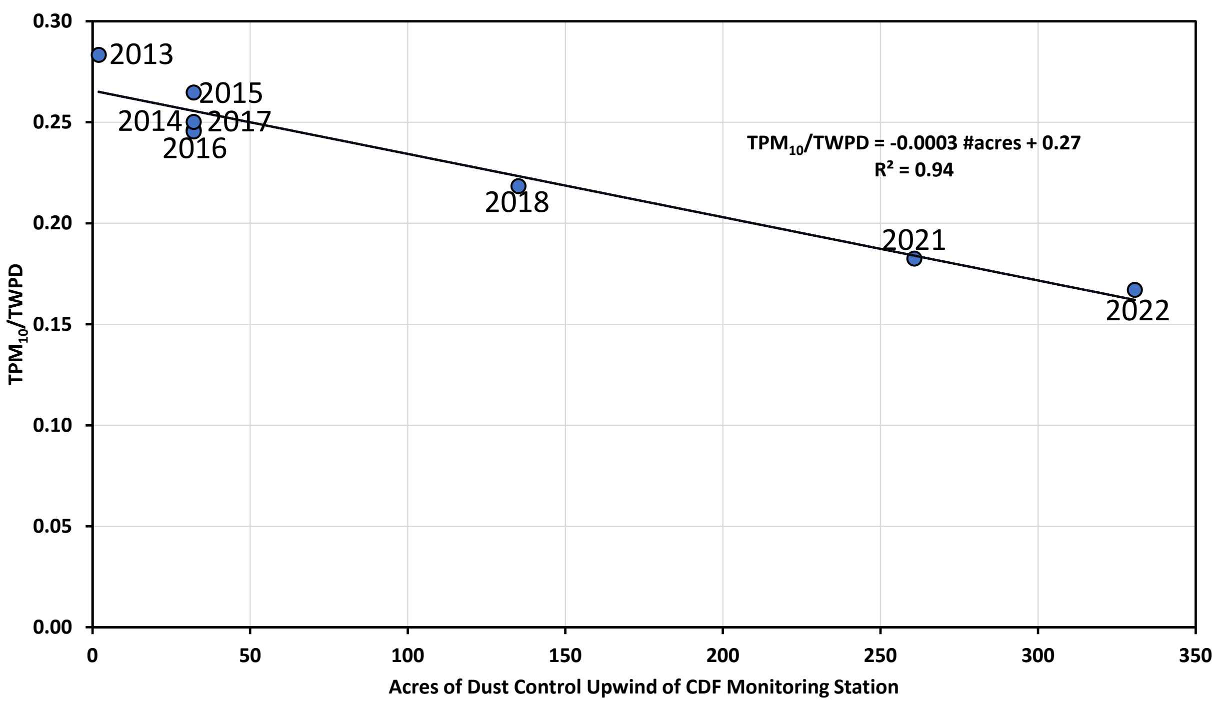


**Figure 4**. The relation between TPM10:TWPD ratio value measured at CDF and the acres of dust control from 2013 through to 2022 placed upwind of CDF in the directional range 270° to 325°. Data from 2019 and 2020 were excluded as discussed elsewhere. Note 2014 and 2017 data align on top of each other.

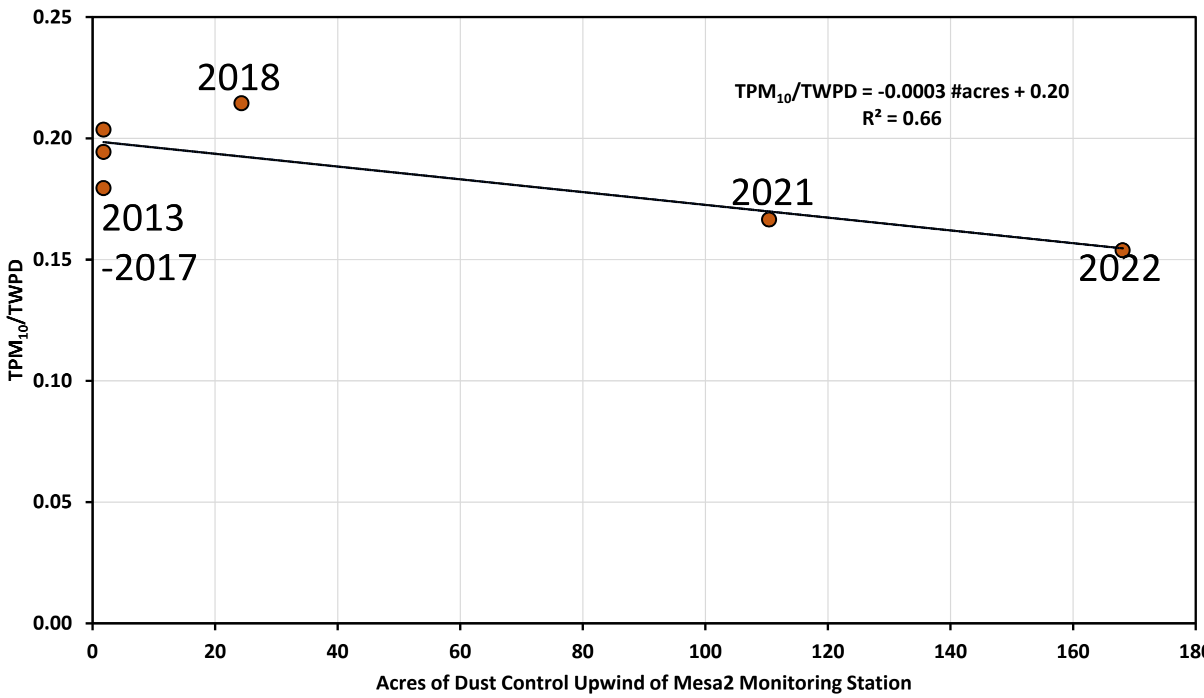


**Figure 5**. The relation between TPM10:TWPD ratio value measured at Mesa2 and the acres of dust control from 2013 through to 2022 placed upwind of Mesa2 in the directional range 270° to 305°. Data from 2019 and 2020 were excluded as discussed elsewhere. Note for the 2013-2017 data points some years are aligned on top of one another.

Figure 5 indicates that a downward trend in the $TPM_{10}$:TWPD ratio is observed for Mesa2 with the inclusion of the 2022 data. It must be noted that 2020 was the year OHV was restricted during the critical monitoring period and as reported by Gillies et al. (2022) the ratio of Total $PM_{10}$ and Total WPD changed significantly compared with other years and is not included in the figure. The data for 2019 were removed as described above for the CDF analysis.

**Discussions and Conclusions**

This analysis has demonstrated that TWPD is a powerful metric for explaining the relationship between wind-driven saltation and the accompanying emission of $PM_{10}$ from the ODSVRA as measured at two key receptor sites, CDF and Mesa2. The TWPD and $TPM_{10}$ measurement-based metric indicates that the $PM_{10}$ originating from the ODSVRA has been reduced by the dust controls by approximately 41% at CDF in 2022 for equivalent WPD conditions compared with the baseline year of 2011. For Mesa2, the TWPD and $TPM_{10}$ measurement-based metric indicates that the $PM_{10}$ originating from the ODSVRA has been reduced by the dust controls by approximately 32% for equivalent WPD conditions compared with the value for 2018 when there were few acres of dust control upwind of the Mesa2 station.

Figures 4 and 5 demonstrate that the $TPM_{10}$:TWPD ratio can be used to track the progress of the effect of dust controls on the dust emission system within the ODSVRA. It allows for quantification of the increments of progress as management efforts to limit the dust emissions are further developed to meet the SOA. It needs to be noted that the $TPM_{10}$:TWPD ratio indicates the production potential of $PM_{10}$ as a function of WPD. An increase in WPD can result in more exceedances of the State or Federal standard even in the presence of increased amounts of dust controls because the $PM_{10}$ is produced from the uncontrolled areas and it increases as a power function of wind speed, while the efficiency of the dust control does not. Under the higher WPD conditions of April-September, 2022, however, the established dust controls, including the additional 90 acres of controls established in 2022, appear to be functioning with sufficient efficiency to modulate the dust emission processes to reduce the production of $PM_{10}$ as a function of wind power density compared with all previous years.

**References**

Gillies, J.A., Furtak-Cole, E., Etyemezian, V. (2021). Increments of Progress Towards Air Quality Objectives - ODSVRA Dust Controls. Report prepared for California State Parks by the Desert Research Institute, December 2021.

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