Ambient Monitoring of Particulates, Including Crystalline Silica, Near APO Facilities
Final Report

Toxicology, Risk Assessment, and Research Division
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Background

Aggregate production operations (APOs) refer to sites from which aggregates are being or have been removed or extracted from the earth. Aggregates are any commonly recognized construction material originating from an APO, including materials such as dimension stone, crushed and broken limestone, sand, etc. Aggregates do not include clay or shale mined for use in the manufacturing of structural clay products. APO facilities may include operations such as rock crushing. Rock crushers break larger rocks down into cobblestones, gravel, or other smaller pieces, which are sorted by size to be used for pavement, construction, and other uses. APO facilities are located where material can be extracted from the earth and, in some cases, may be close to communities. Due to their occasional proximity to developed areas, APOs have come under scrutiny over the past few years. Specifically, citizens have become concerned about the impact of APOs in their communities due to the potential for increased emissions of particulate matter (PM), which may contain crystalline silica. Texas has approximately 1,000 registered APO facilities.

Silica, in both amorphous and crystalline forms, is the most abundant mineral in the earth's crust and is present in soil, sand, and rock formations. Aggregates may contain silica, making APOs a potential source of crystalline silica. Crystalline silica is significantly more hazardous than amorphous silica and is recognized as an occupational inhalation hazard. In the United States, approximately 2.3 million workers in 676,000 workplaces are exposed to crystalline silica; this includes approximately 2 million workers in the construction industry. Workers exposed daily for several years, up to a lifetime, to high occupational levels of fine particles of crystalline silica may develop silicosis, a rare lung disease that is irreversible, progressive, and often fatal. The effects of inhaled crystalline silica are strictly associated with occupational exposure to particles of respirable size, that is, small enough to be inhaled deep into the lungs (i.e., PM_4, particulate matter with an aerodynamic diameter less than or equal to 4 micrometers [µm], which can only be seen using a light microscope). Because of the natural hardness of silica, high energy is required to fracture this mineral into respirable size. Activities such as grinding, cutting, sawing, drilling, crushing, and abrasive blasting of stone, rock, concrete, mortar, or brick may generate respirable crystalline silica.

The size of the particles that cause silicosis is at least 100 times smaller than ordinary sand found on beaches and playgrounds. The risk from community exposure to crystalline silica is different from the risk associated with occupational exposure. The general public is not at risk from developing silicosis; however, some members of the general public could potentially be exposed to high levels of silica through hobbies, such as pottery making. Airborne silica is a universal mineral that is not unique to areas near APOs and is not unique to Texas. Both amorphous and crystalline forms may be found in airborne particles from various sources, including paved and unpaved roads, wind-blown soil and agricultural activities, as well as industrial sources such as construction, foundries, glass manufacturing, abrasive blasting or any industrial or commercial use of sand and quartz, and mining and rock crushing operations. Not all airborne crystalline silica is small enough to be inhaled deep into the lungs.

Crystalline silica is not one of the six criteria pollutants regulated under the Federal Clean Air Act (FCAA), which requires the US Environmental Protection Agency (EPA) to establish the National Ambient Air

Quality Standards (NAAQS), and it is not included on EPA's list of 188 hazardous air pollutants. Although crystalline silica is not specifically regulated in ambient air, the federal NAAQS do regulate total $PM_{2.5}$ and PM_{10} (particulate matter with an aerodynamic diameter less than or equal to 2.5 and 10 µm, respectively), which may contain crystalline silica. In Texas, certain facilities located at an APO site, like rock crushers, require an air permit prior to start of operation and must meet federal standards for $PM_{2.5}$ and PM_{10}. The Texas Commission on Environmental Quality (TCEQ) has also developed health-based effects screening levels (ESLs) for air permitting, as well as air monitoring comparison values (AMCVs) specifically for crystalline silica. ESLs and AMCVs are not standards; they are guidelines that are protective of human health and welfare. Health-based ESLs and AMCVs are safe levels at which exposure is unlikely to result in adverse health effects.

Since crystalline silica is widely considered to be an occupational hazard and not an ambient air quality concern, the EPA does not monitor for crystalline silica, nor does EPA have an approved method for monitoring for crystalline silica in ambient air. There is no federal regulation or EPA standard for ambient crystalline silica concentrations, and there is no EPA requirement for TCEQ to monitor for crystalline silica. Crystalline silica ambient air monitoring is very difficult; however, monitoring has been conducted periodically throughout the nation in urban areas and near APOs, industrial sand mines, and sand processing plants, typically as special monitoring projects. To better assess the crystalline silica concentrations near APO facilities in Texas, TCEQ conducted an air monitoring project in 2022-2023 near APO facilities.

The aim of this monitoring project was to measure concentrations of crystalline silica PM_4 and total $PM_{2.5}$ at monitoring sites that are publicly accessible and downwind of APO facilities, as well as at a monitoring site that is publicly accessible but is not located near an APO facility (i.e., a background site). The goal was to monitor these chemicals at existing TCEQ stationary ambient air monitoring sites to determine what contribution, if any, the APO facilities have to ambient air concentrations of crystalline silica PM_4 and total $PM_{2.5}$ relative to that of background in the Central Texas area. Three of the sampling sites were located within one mile of an APO and were predominantly downwind of the facility. A fourth sampling site, located in the city of Austin, did not have any APOs nearby and was used as a background site. Figure 1 provides a map of all sites.

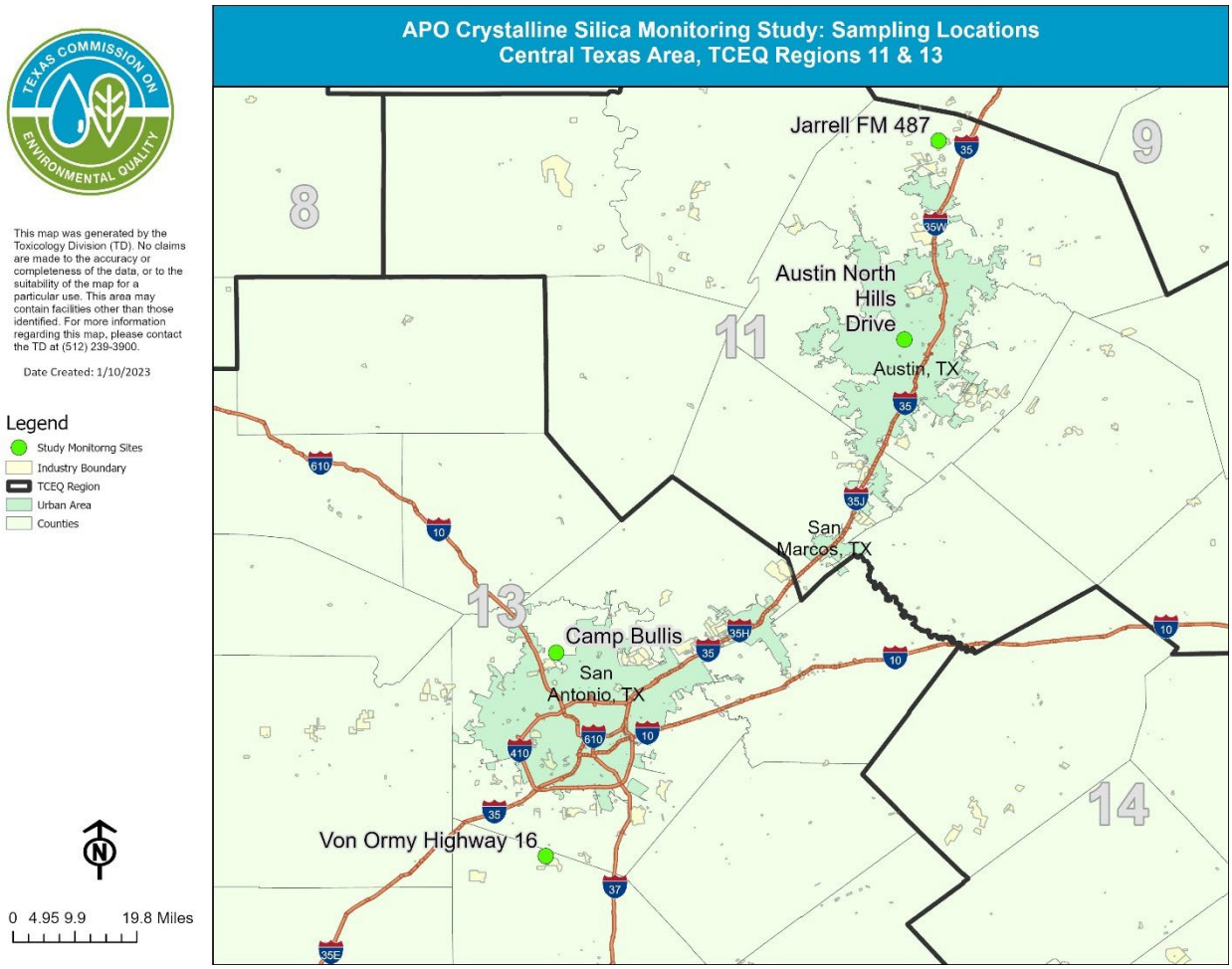
Stationary site locations that were chosen include:

- Camp Bullis[1] (F Range [1000 yd marker off Wilderness Trail], near Wilderness Rd, San Antonio, 78257)

[1]www17.tceq.texas.gov/tamis/index.cfm?fuseaction=report.view_site&formSub=1&showActiveOnly=1&showActMonOnly=1&siteID=231

- Jarrell FM 487[2] (4831 Farm to Market 487, Jarrell, 76537)
- Von Ormy Highway 16[3] (17534 North State Highway 16, Von Ormy, 78073)
- Austin North Hills Drive[4] (3824 North Hills Drive, Austin, 78731) – background site

Figure 1. Map showing the location of all study sampling sites in TCEQ Region 11 (Austin) and Region 13 (San Antonio).



[2]www17.tceq.texas.gov/tamis/index.cfm?fuseaction=report.view_site&siteID=1255&siteOrderBy=name&showActiveOnly=0&showActMonOnly=1&formSub=1&tab=info. This site was deactivated on June 26, 2024.

[3]www17.tceq.texas.gov/tamis/index.cfm?fuseaction=report.view_site&formSub=1&showActiveOnly=1&showActMonOnly=1&siteID=1251

[4]www17.tceq.texas.gov/tamis/index.cfm?fuseaction=report.view_site&formSub=1&showActiveOnly=1&showActMonOnly=1&siteID=29

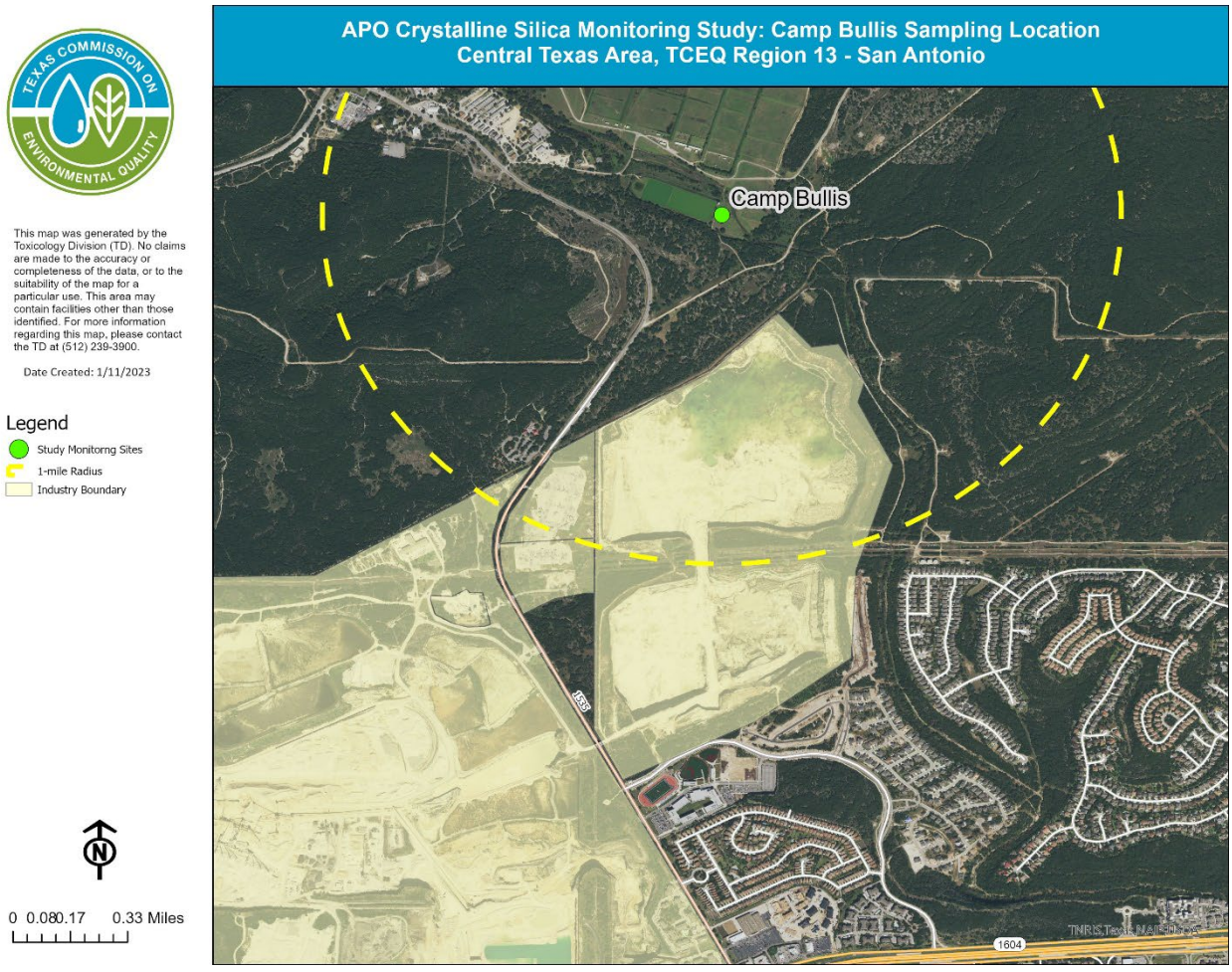
Sampling Information

Sampling Sites

Camp Bullis

The Camp Bullis site is located in TCEQ Region 13 – San Antonio (Figure 2). It is approximately one mile outside the city of San Antonio's outer loop, to the north of city center. This site was chosen based on its close proximity to a large APO facility that has several different APO operations present, such as a limestone quarry, rock crushing, cement mixing, and asphalt mixing.

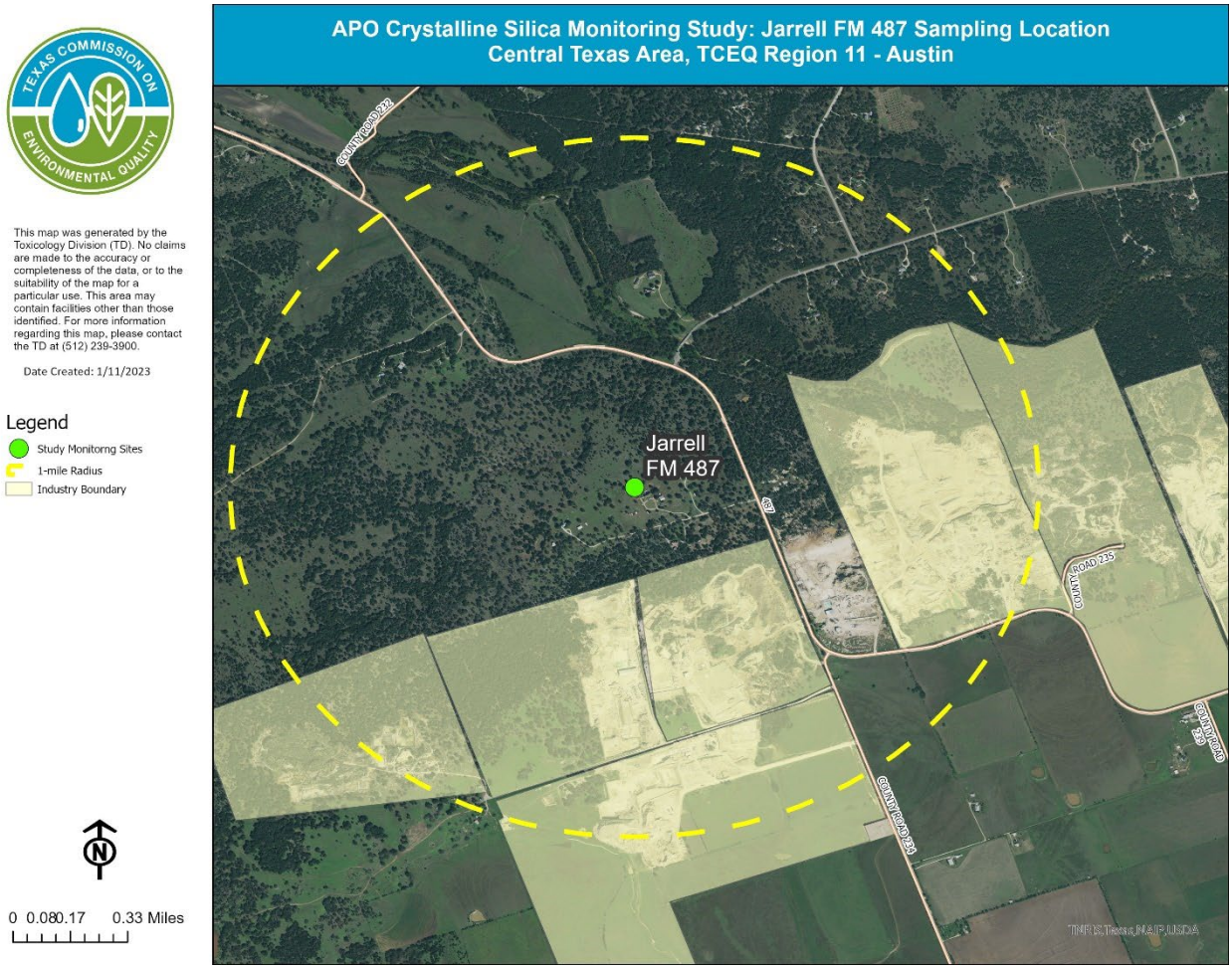
Figure 2. Map showing the location of the Camp Bullis monitoring site and the surrounding area. The APO facility areas are shaded in yellow.



Jarrell FM 487

The Jarrell FM 487 site was a temporary study site that is no longer operational. It was located in TCEQ Region 11 – Austin, to the west of Jarrell (Figure 3). Jarrell is located to the north of Austin. This site was chosen based on its close proximity to a quarry that includes several rock crusher and stone cutter facilities.

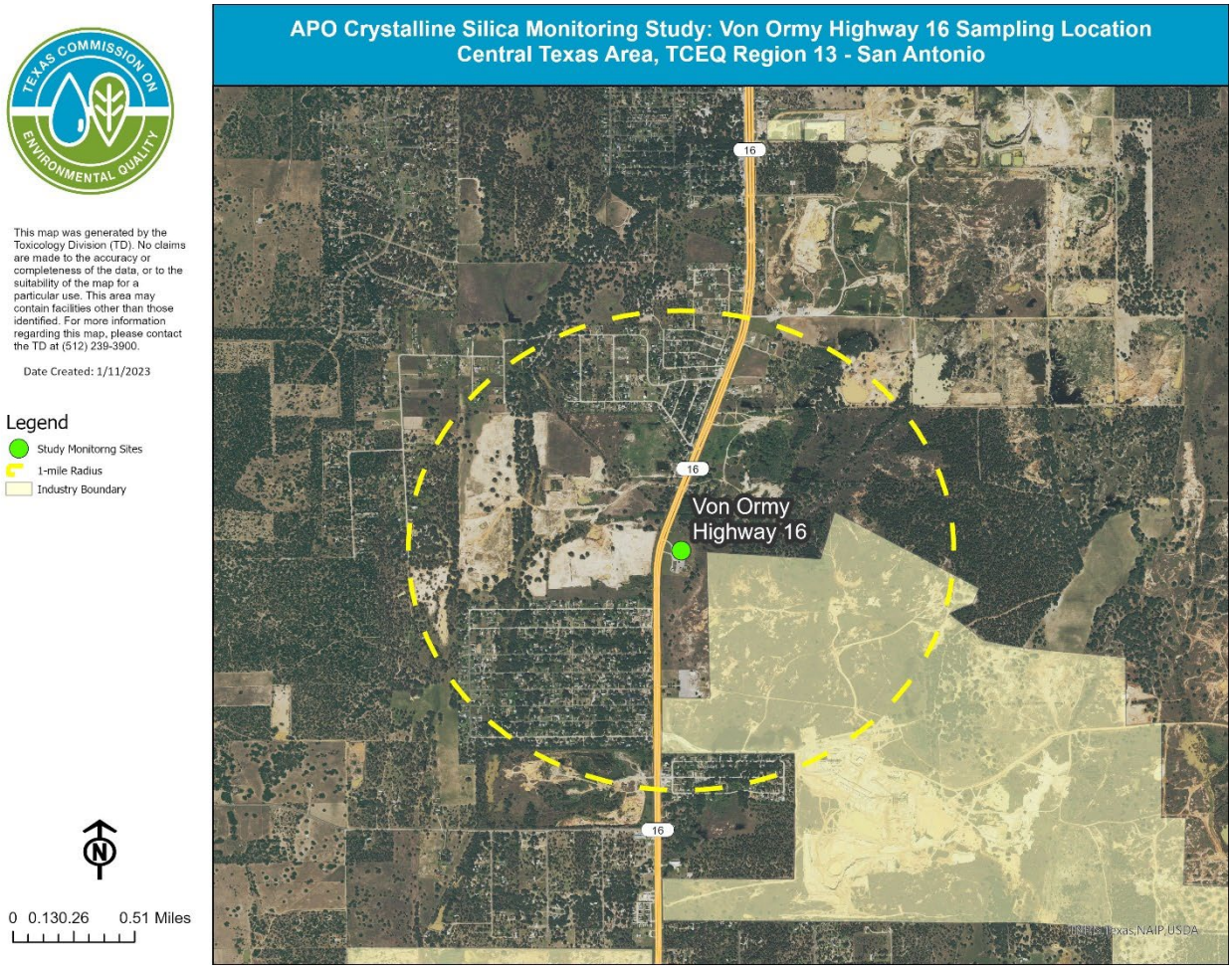
Figure 3. Map showing the location of the Jarrell FM 487 monitoring site and the surrounding area. The APO facility areas are shaded in yellow.



Von Ormy Highway 16

The Von Ormy Highway 16 site is located in TCEQ Region 13 – San Antonio (Figure 4). It is approximately five miles outside the city of San Antonio's outer loop, to the south of city center. This site was chosen due to its close proximity to several sand mining pits.

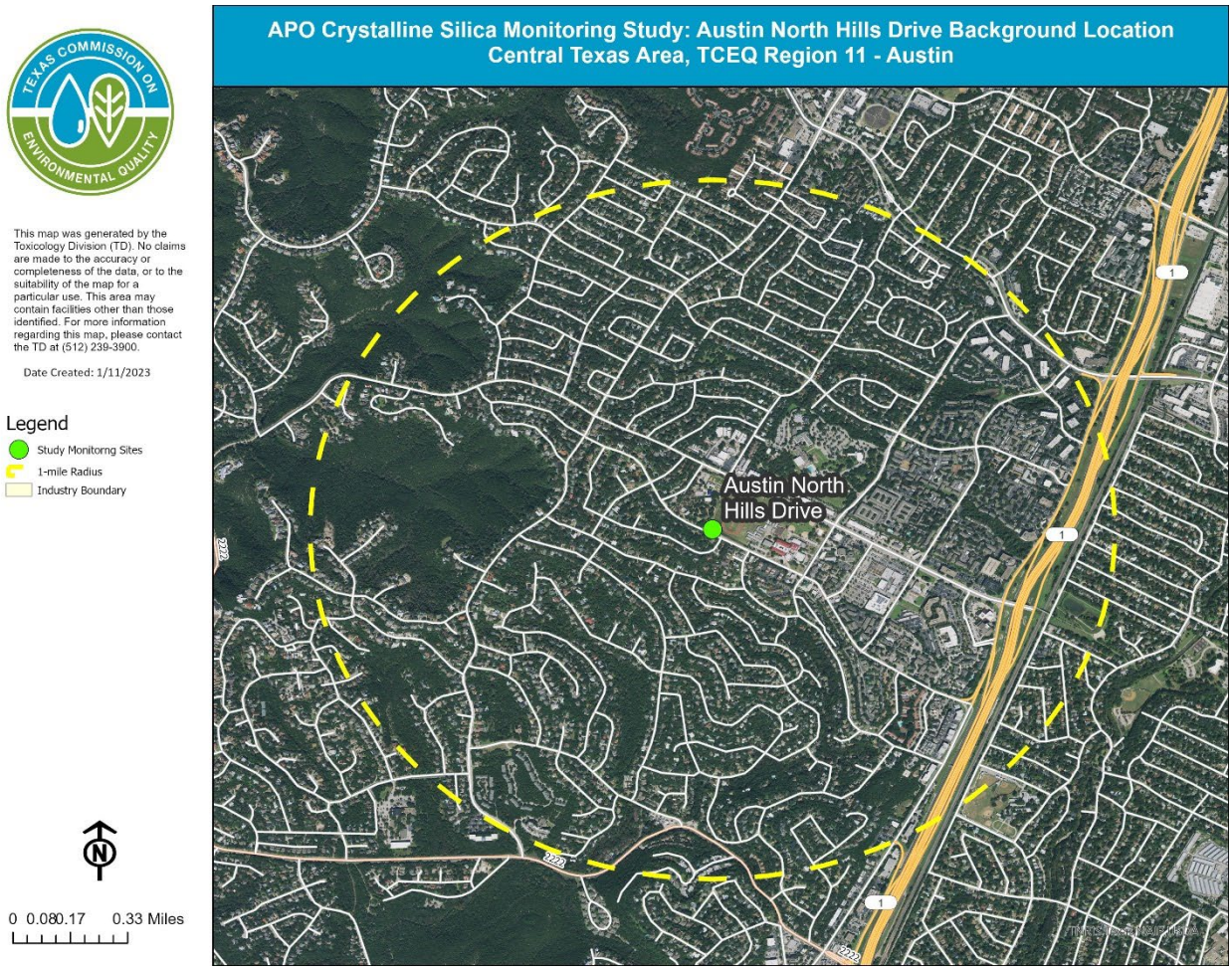
Figure 4. Map showing the location of the Von Ormy Highway 16 monitoring site and the surrounding area. The APO facility areas are shaded in yellow.



Austin North Hills Drive (Background Site)

The Austin North Hills Drive site is located in TCEQ Region 11 – Austin (Figure 5). It is in the Northwest Hills area of the city of Austin, to the northwest of city center. This site was chosen as the background sampling site. It does not have any active APO facilities within a one-mile radius.

Figure 5. Map showing the location of the Austin North Hills Drive monitoring site and the surrounding area.



Sampling Details

Four PM_4 crystalline silica samplers were deployed for this project; three at sites near APO facilities and one at a background site. Because there are no specific PM_4 samplers required by regulation, the samplers used were Federal Reference Method (FRM) $PM_{2.5}$ samplers that had a modified flow rate to capture the PM_4 fraction. The modified flow rate of 11.11 liters per minute (lpm) was determined by a study conducted outside of TCEQ. The FRM flow rate was 16.67 lpm for collection of $PM_{2.5}$. Modification of FRM $PM_{2.5}$ samplers for use as PM_4 samplers has been used for determination of crystalline silica PM_4

by others in published studies[5] of ambient air monitoring near facilities that potentially emit crystalline silica PM_4 (e.g., sand mining, fracking-sand, and sand and gravel facilities in various states). Each stationary site contained a PM_4 crystalline silica sampler (that provided data for both total PM_4 and PM_4 crystalline silica) and a total $PM_{2.5}$ sampler. Meteorological data were also collected at each sampling site.

All four PM_4 crystalline silica samplers had a sample collection duration of 24-hours. Samples were collected at the three samplers that were located near APO sites once every three days and at the background sampler once every sixth day. The duration of the project was one year (June 2022 to July 2023), and specifically included sample collection during the summer when the Central Texas area is dry.

Sampling frequencies of one-in-six days and one-in-three days are common practice in ambient air data collection. These sampling frequencies are designed to provide a representative average for the area sampled. The days chosen for sampling were aligned with the EPA's published annual sampling schedule for ambient air monitoring, which includes one-in-three, one-in-six, and one-in-12 day sampling for consistency in national sampling schedules.

Analytical instruments can reliably measure down to a specific chemical concentration when samples are analyzed; below that level, the instrument is no longer able to "see," or detect, a concentration. This level is called the detection limit and can vary based on analytical method and chemical. When data are not detected, zero may be provided in the dataset for that sample. For the purposes of this evaluation, when a sample was not detected, rather than indicating a concentration of zero for the sample, the concentration was assigned the value of one-half the detection limit. This is a common practice in human health evaluation of ambient air monitoring data. While the concentration is unknown when it is below the detection limit, by giving it a value of ½ the detection limit, the measurement is included in the assessment. Table 1 provides the detection limits and ½ detection limits for these data.

Table 1. Detection limits and one-half detection limits for the chemicals measured in this study.

Chemical	*Detection Limit ($\mu g/m^3$)*	*½ Detection Limit ($\mu g/m^3$)*
Crystalline Silica PM_4	0.3	0.15
Total PM_4	3.1	1.55
Total $PM_{2.5}$	5.0	2.5

[5] Richards J and T Brozell. 2021. Compilation and evaluation of ambient respirable crystalline silica air quality data near sand quarries and processing facilities. Atmosphere. 12:903. www.mdpi.com/2073-4433/12/7/903

Data Evaluation

Sample collection started at the beginning of June 2022 and ended mid-July 2023. Twelve months of sampling yielded approximately 60 – 120 samples per site, depending on the site and sampling schedule. Some data collection issues caused several lost data days.

Several sampling days in June, July, and August of 2022, and July of 2023, coincided with the seasonal arrival of Saharan dust in Central Texas. Overlapping Saharan dust event/sample collection dates in 2022 and 2023 were as follows:

- June 13, 16, 19, and 22, 2022
- July 16, 19, 22, and 31, 2022
- Aug. 3 and 6, 2022
- July 11, 2023

Saharan dust days are indicated in all the figures with areas of tan shading.

Shown below in Figure 6, Figure 7, Figure 8, and Figure 9 are the measurements of crystalline silica PM_4, total PM_4, and total $PM_{2.5}$ for each sampling site. Also shown are the TCEQ 24-hr AMCV for crystalline silica, and the level of the EPA's 24-hour $PM_{2.5}$ NAAQS (for context only)[6]. These figures also provide monthly wind roses to show the predominant wind directions associated with the data. The predominant wind directions are typically from the south and southeast, which puts the monitors predominantly downwind of the nearby facilities.

[6] The levels of the $PM_{2.5}$ NAAQS are noted in this evaluation only to provide when viewing the total $PM_{2.5}$ concentration data. This data cannot be used for determining attainment with the NAAQS.

Figure 6. Crystalline silica PM_4, total PM_4, and total $PM_{2.5}$ 24-hr average concentrations measured at the background site (Austin North Hills Drive) with Saharan dust event days noted. Monthly wind roses are provided along with a map of the site.

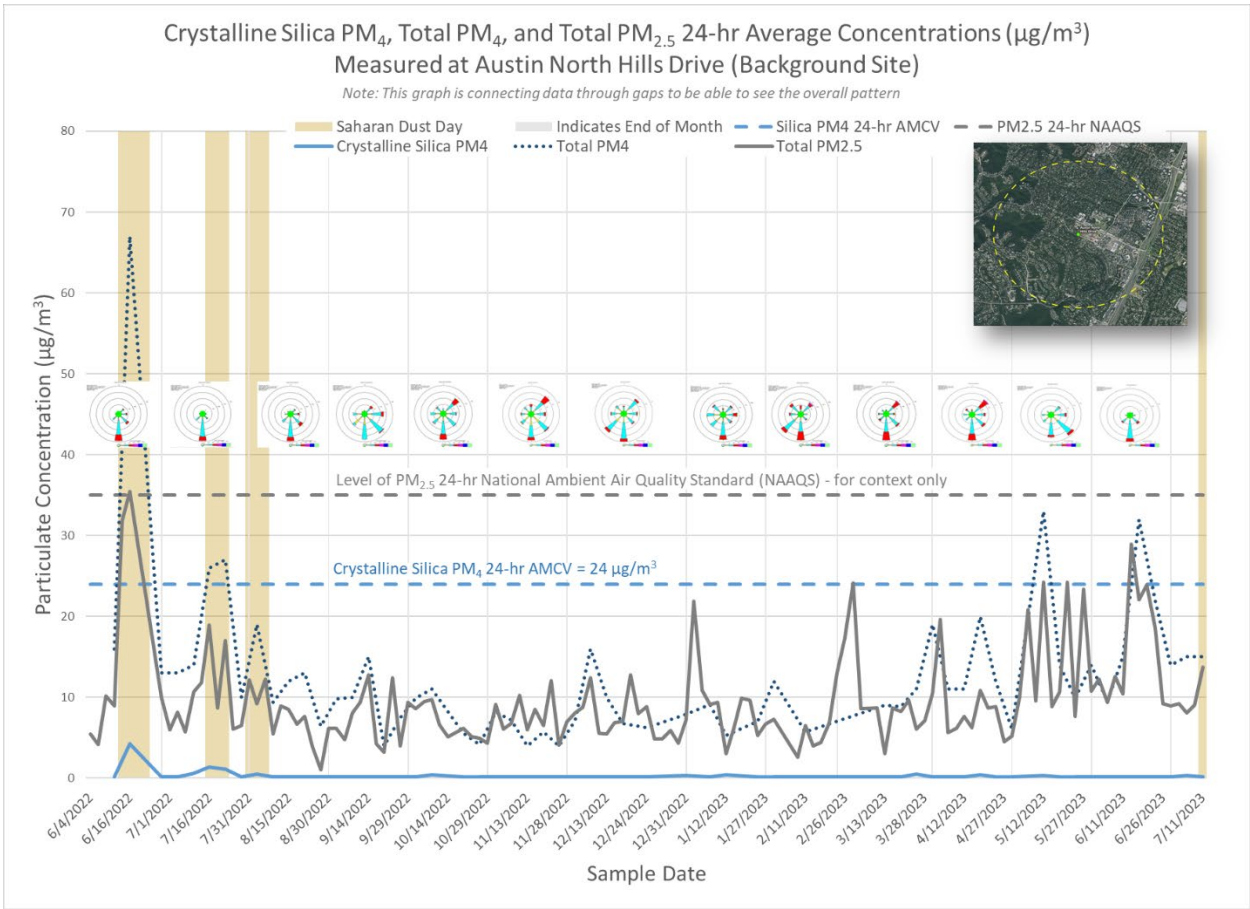


Figure 7. Crystalline silica PM_4, total PM_4, and total $PM_{2.5}$ 24-hr average concentrations measured at Camp Bullis (located near a large APO facility that has a quarry and rock crushers) with Saharan dust event days noted. Monthly wind roses are provided along with a map of the site.

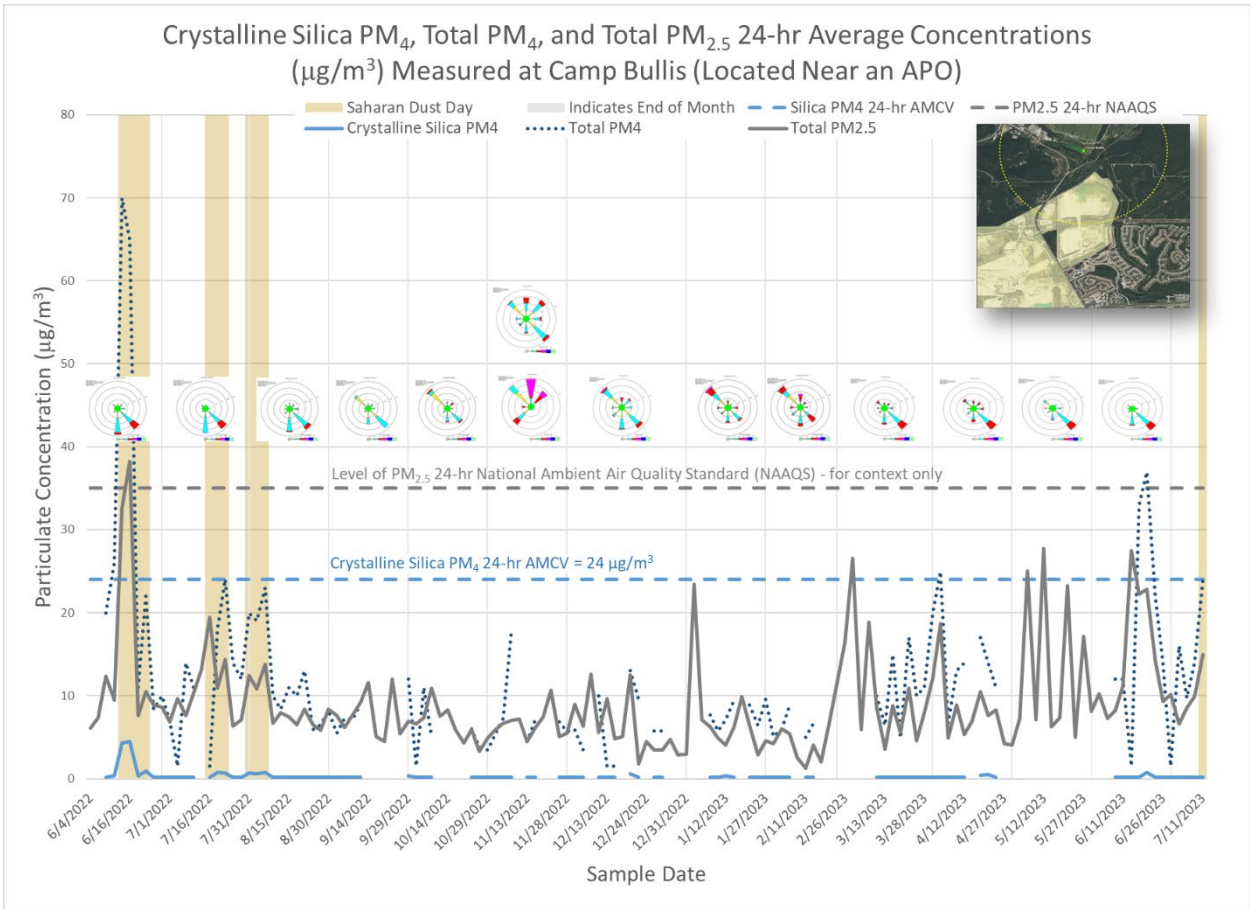


Figure 8. Crystalline silica PM_4, total PM_4, and total $PM_{2.5}$ 24-hr average concentrations measured at Jarrell FM 487 (located near a quarry that has rock crushers and stone cutters) with Saharan dust event days noted. Monthly wind roses are provided along with a map of the site.

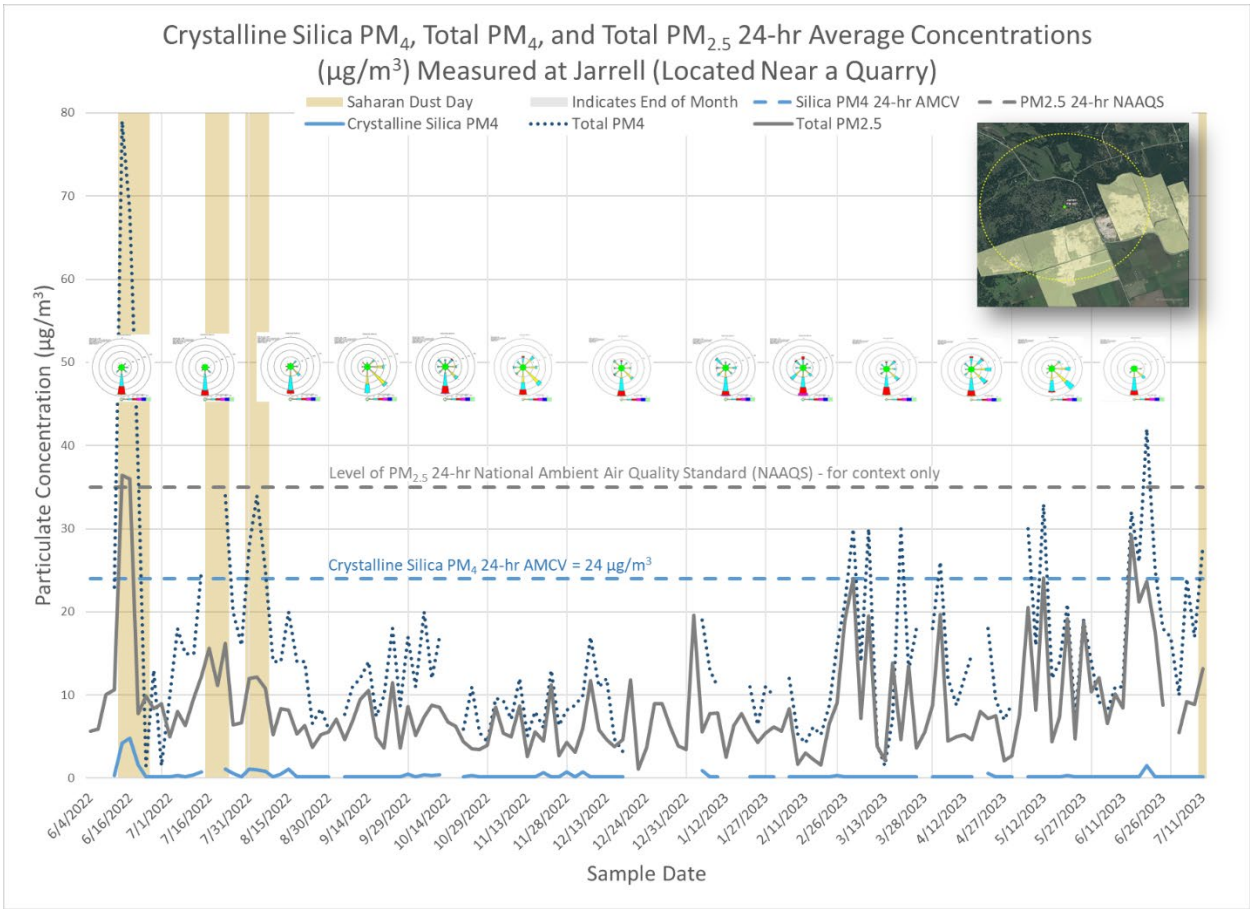
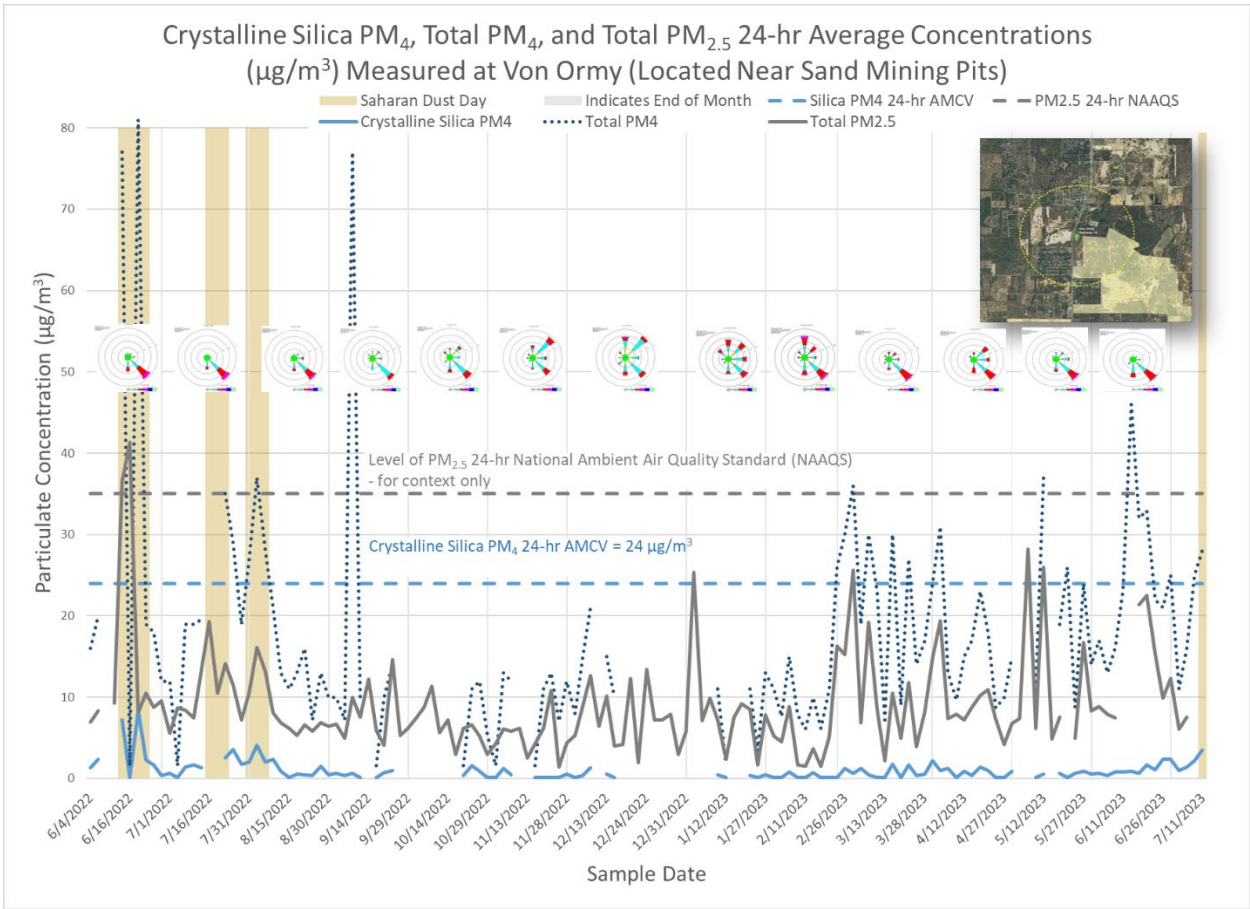


Figure 9. Crystalline silica PM_4, total PM_4, and total $PM_{2.5}$ 24-hr average concentrations measured at Von Ormy Highway 16 (located near sand mining pits) with Saharan dust event days noted. Monthly wind roses are provided along with a map of the site.



Saharan Dust Impacts and Short-Term Evaluation

Those sampling days that coincided with Saharan dust events showed a marked increase in particulate matter and crystalline silica concentrations at all sampling locations, including the background site (Figure 10, Figure 11). In fact, the highest PM and crystalline silica concentrations were measured on days where air quality across the region was impacted by Saharan dust. Crystalline silica, PM_4, and $PM_{2.5}$ contributions from Saharan dust events cannot be differentiated from potential APO site contributions.

Figure 10. Crystalline silica PM_4 concentrations measured at all project sites with Saharan dust event days noted.

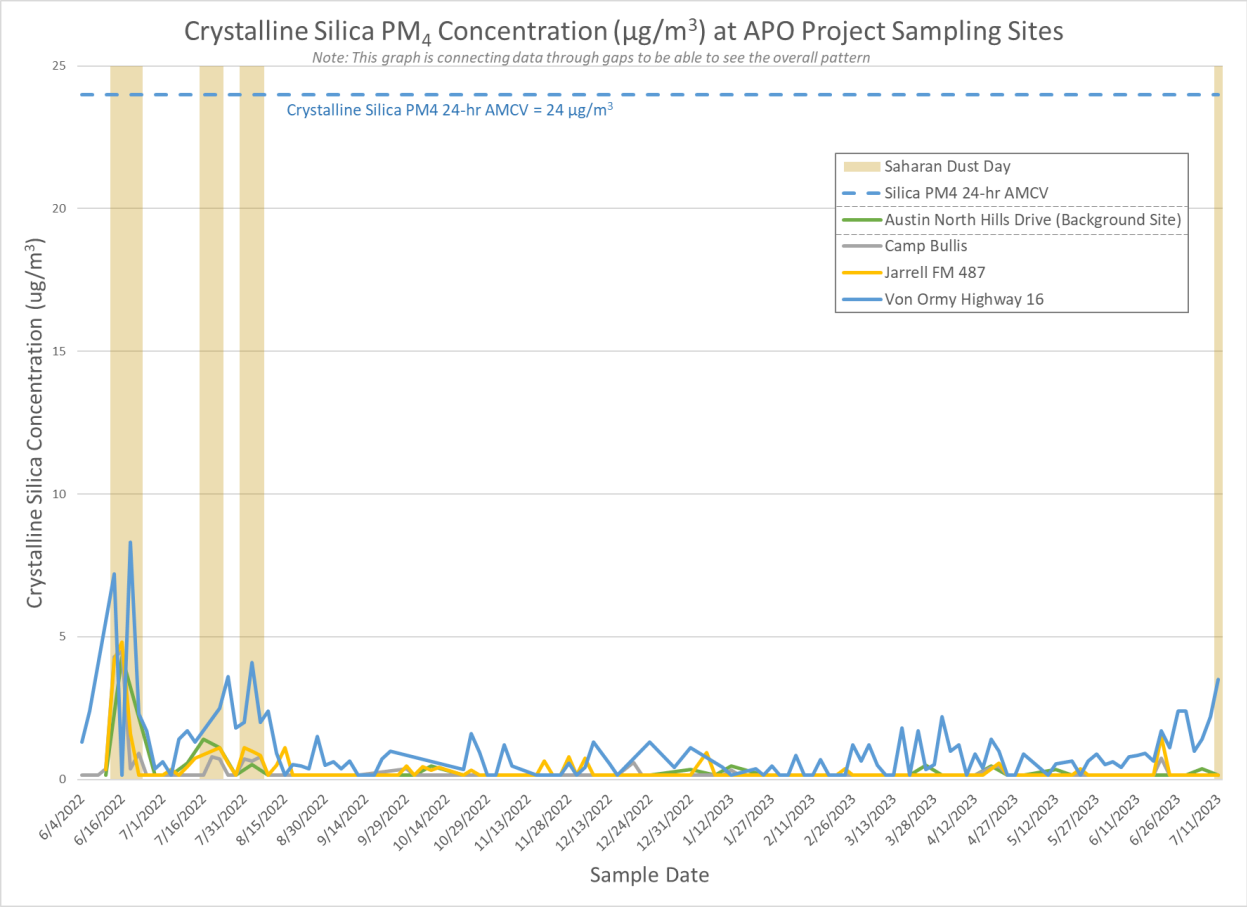
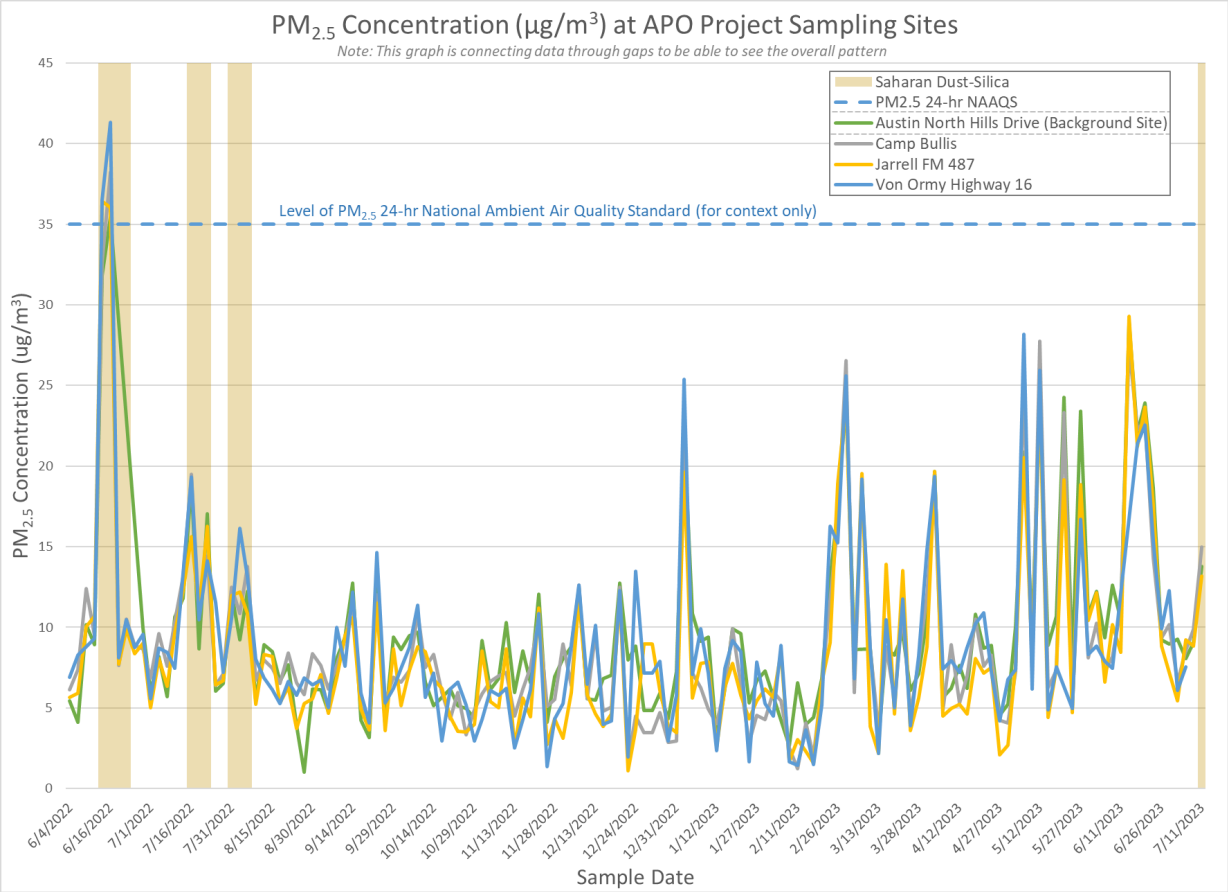


Figure 11. Total $PM_{2.5}$ concentrations measured at all project sites with Saharan dust event days noted.



Based on the concentration data collected, there were measurable levels of crystalline silica present at all sampling sites, including the background site. This result was anticipated, because silica is the most abundant mineral in the earth's crust and therefore some amount of silica would be expected to be present in ambient air. All crystalline silica measurements were well below the TCEQ's health-based 24-hr crystalline silica AMCV (24 µg/m^3).

The 24-hr $PM_{2.5}$ measurements were all below the level of the 24-hr $PM_{2.5}$ standard (35 µg/m^3), except on a single day that was impacted by Saharan dust (Figure 11). Note that comparison of $PM_{2.5}$ levels to federal standards is for context purposes only. The pattern of $PM_{2.5}$ concentrations was very similar among all the sites, regardless of whether the monitors were sited downwind of APOs.

Long-term Evaluation

Crystalline Silica

Because at least one year's worth of data were collected, the long-term (annual) average was calculated for each monitored chemical at each site. These annual averages were then compared to appropriate long-term comparison values. For crystalline silica, these values are designed to protect against

crystalline silica-induced lung cancer and silicosis. There are two long-term AMCVs available for this purpose. The first is a value that assumes any exposure to crystalline silica causes an increased lung cancer risk. However, this assumption is unlikely to apply to the way that crystalline silica realistically contributes to lung cancer, and so the value based on the assumption serves as a health-protective screening tool when evaluating crystalline silica concentrations. The second AMCV is based on preventing silicosis. Workers who get lung cancer from long-term exposure to high levels of crystalline silica develop silicosis before they get cancer. Therefore, this value can also be applied to prevention of lung cancer because protecting against silicosis protects against subsequent development of lung cancer. The long-term cancer-based non-threshold AMCV (screening level) is 0.27 µg/m^3 and the long-term silicosis- (and threshold cancer-) based AMCV is 2 µg/m^3.

The long-term averages of PM_4 crystalline silica concentrations at the four sampling sites ranged from 0.3 – 1 µg/m^3. It is important to note that the detection limit for the measurement method was 0.3 µg/m^3. The detection limit is the point at which the instrument cannot reliably measure the chemical concentration, and concentrations below the detection limit are reported as less than 0.3 µg/m^3. For calculation purposes, the detection limit was replaced with one half the detection limit (0.15 µg/m^3 in this case) rather than using a value of zero. The detection limit from this measurement method is the lowest technically feasible detection limit available for measuring crystalline silica, and it is the same detection limit that was used in several studies conducted in other states[5].

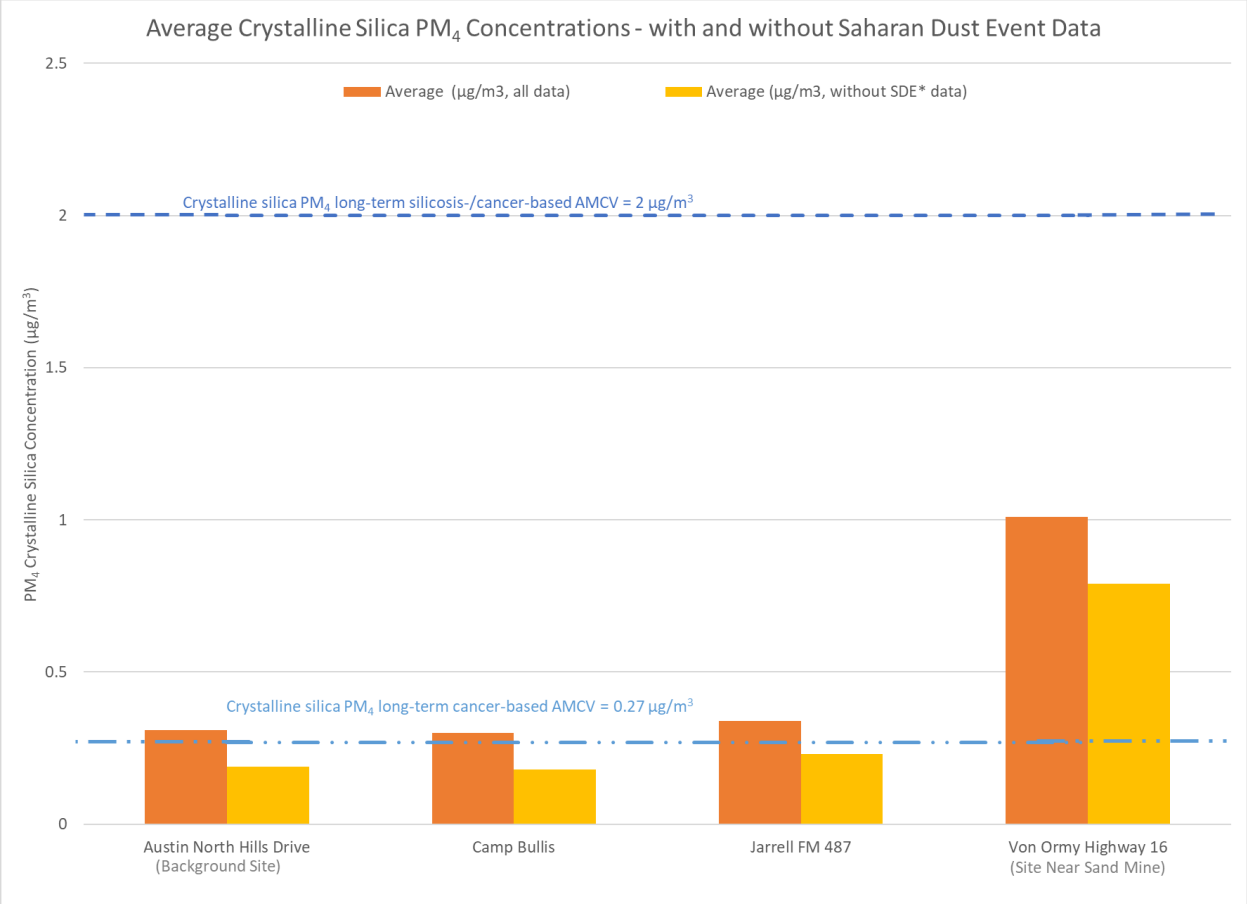
The long-term cancer-based AMCV (non-threshold screening level) is slightly lower than the detection limit for the measurement method (0.27 µg/m^3 versus 0.3 µg/m^3). Because non-detects, which are values lower than the detection limit, are assigned a value of one half the detection limit for the evaluation, the resulting average is likely artificially inflated. This is particularly the case for datasets with many non-detects. Three of the sites, including the background site, had approximately 80% non-detects in their datasets, and so the annual averages of crystalline silica at these sites were likely influenced by the detection limit of the measurement method. The annual averages at those sites were in fact marginally above the lowest comparison value (0.27 µg/m^3), but were below this comparison value when the Saharan dust days were excluded from the calculations (Figure 11 and Table 2).

Table 2. Long-term averages of crystalline silica calculated by site, with and without Saharan dust event days, and their respective percent non-detects.

Site	*LT-AMCV (cancer) (µg/m^3)*	*LT-ReV (silicosis*) (µg/m^3)*	***Average Silica PM$_4$ (µg/m^3)***	***Average Silica PM$_4$ (µg/m^3) without SDE***	*%ND*	*#ND/Total Samples Collected*
Austin North Hills Drive	*0.27*	*2*	***0.31***	***0.19***	*79%*	*46/58*
Camp Bullis	*0.27*	*2*	***0.30***	***0.18***	*83%*	*81/97*
Jarrell FM 487	*0.27*	*2*	***0.34***	***0.23***	*77%*	*93/120*
Von Ormy Highway 16	*0.27*	*2*	***1.01***	***0.79***	*27%*	*30/111*

*LT – long-term; AMCV – air monitoring comparison value; ReV – reference value; SDE – Saharan dust event; ND – non-detect; *the long-term silicosis-based ReV is also considered a threshold cancer-based value that is protective of crystalline silica-induced lung cancer.*

Figure 12. Average crystalline silica PM_4 concentrations – with and without Saharan dust event data.



**SDE – Saharan dust event*

The Von Ormy site had only 27% non-detects in its dataset and therefore the average crystalline silica concentration was likely to be less influenced by the detection limit. The average crystalline silica concentration of 1 µg/m^3 at this site exceeded the long-term non-threshold cancer-based AMCV of 0.27 µg/m^3. In addition to the conservatism inherent in assuming that crystalline silica has no threshold in its mechanism for causing cancer (as discussed above, this assumption is unlikely to be true), the long-term non-threshold cancer-based AMCV uses an excess cancer risk level of 1 in 100,000. An excess cancer risk level is the amount of additional cancer risk (on top of the background lifetime cancer risk in the US of about 1 in 3) from a lifetime exposure to a carcinogen. The risk level of 1 in 100,000 used by the TCEQ is ten-times lower than the EPA's maximum acceptable excess cancer risk of 1 in 10,000. The risk associated with the silica concentrations at the Von Ormy site would equate to 0.37 in 10,000, which is within the acceptable cancer risk range. The safe air concentration that would be associated with EPA's maximum acceptable excess cancer risk of 1 in 10,000 would be 2.7 µg/m^3.

On the other hand, the annual average crystalline silica concentration of 1 µg/m^3 at the Von Ormy site was lower than the long-term threshold silicosis (threshold cancer-based) value of 2 µg/m^3. As discussed above, it is likely that crystalline silica acts through a threshold mechanism for cancer, with silicosis development as a precursor event for silica-induced lung cancer. This makes the silicosis (threshold cancer-based) comparison value of 2 µg/m^3 a more reasonable comparison value. The annual average concentrations of crystalline silica at all four sites, including the Von Ormy site, were lower than this long-term threshold comparison value of 2 µg/m^3.

The long-term average concentrations of crystalline silica for three of the sites, including the background site, was approximately 0.3 µg/m^3. Von Ormy was the only site with an average concentration elevated above the background site, which is consistent with its placement downwind of a sand mining and processing facility.

Across all four sites, the highest concentrations of PM_4 crystalline silica were measured on days that were impacted by Saharan dust. The long-term average concentrations of crystalline silica, when excluding the Saharan dust days (up to 11 days in total over the time period), ranged from 0.18 – 0.79 µg/m^3. See Table 3 for average and maximum concentrations for each site.

Table 3. One-year average and 24-hour maximum concentrations of crystalline silica, with all data included or excluding the Saharan dust event days, at all four sites.

Site	*Average (µg/m^3, all data)*	*Average (µg/m^3, without SDE* data)*	*Max (µg/m^3, all data)*	*Max (µg/m^3, without SDE* data)*
Austin North Hills Drive	0.31	*0.19*	4.30	*0.57*
Camp Bullis	0.30	*0.18*	4.50	*0.73*
Jarrell FM 487	0.34	*0.23*	4.80	*1.50*
Von Ormy Highway 16	1.01	*0.79*	8.30	*3.60*

**SDE – Saharan dust event*

For the Austin North Hills Drive (background site) and Camp Bullis and Jarrell FM 487 sites (downwind of quarries/rock crushers), crystalline silica made up approximately 3-4% of the measured total PM_4. At the Von Ormy site, which is close to a sand mining and processing facility, crystalline silica accounted for approximately 6% of total PM_4 (see Table 4). The average ratio of PM_4 crystalline silica to total $PM_{2.5}$ ranged from 0.07 – 0.14, with the highest average ratio observed at the Von Ormy site. See Table 4 for average and median percent crystalline silica in total PM_4 for each site.

Table 4. Average and median % crystalline silica in total PM_4; and average and median ratio of PM_4 silica to total $PM_{2.5}$.

Site	*Average % (95% CI) Silica in Total PM_4*	*Median % Silica in Total PM_4*	*Average Ratio (95% CI) PM_4 Silica: Total $PM_{2.5}$*	*Median Ratio PM_4 Silica: Total $PM_{2.5}$*
Austin North Hills Drive	4.2% (2.9 – 5.5%)	4.2%	0.07 (0.04 – 0.09)	0.06
Camp Bullis	3.8% (3.0 – 4.5%)	3.4%	0.07 (0.05 – 0.08)	0.06
Jarrell FM 487	4.0% (3.1 – 4.9%)	3.2%	0.09 (0.07 – 0.11)	0.08
Von Ormy Highway 16	6.5% (5.7 – 7.3%)	6.1%	0.14 (0.11 – 0.17)	0.10

**CI – confidence interval; The values above represent the entire dataset for each site and include data collected on days of Saharan dust events.*

Total $PM_{2.5}$

Annual average $PM_{2.5}$ concentrations from this study were compared to the level of the EPA's annual $PM_{2.5}$ NAAQS. *This comparison was used only to provide context when evaluating the total $PM_{2.5}$ concentration data. These data should not be used for determining attainment with the NAAQS.* When including Saharan dust event days, $PM_{2.5}$ annual average values at all four sites were below the level of the 2012 annual $PM_{2.5}$ NAAQS (12 µg/m^3) (Table 5). However, the average $PM_{2.5}$ values for three of the four sites (Austin North Hills, Camp Bullis, and Von Ormy) were marginally higher than the level of the revised annual $PM_{2.5}$ NAAQS of 9 µg/m^3, which EPA promulgated in February 2024. The highest annual average (9.71 µg/m^3) occurred at the background site (Austin North Hills). When the Saharan dust event days were excluded, the annual average $PM_{2.5}$ concentrations for the three sites near the APOs were below the revised level of the annual $PM_{2.5}$ NAAQS. However, the background site was slightly above the revised level of the annual $PM_{2.5}$ NAAQS (9.13 µg/m^3). Regional $PM_{2.5}$ levels are known to be impacted by a variety of sources including automobile exhaust, which likely contributed to the observation that, of the four sites, the highest $PM_{2.5}$ average was found at the background site that is located in a suburban area (with greater contributions from vehicle traffic than the other three sites). Overall, APOs did not measurably contribute to total $PM_{2.5}$ levels, with the annual averages of total $PM_{2.5}$ at each site downwind of the APOs being similar to or slightly lower than that of the background site.

Table 5. One-year average concentrations of total $PM_{2.5}$, with all data included or excluding the Saharan dust event days, at all four sites.

Site	*EPA 2012 Annual NAAQS (µg/m^3) ‡*	*EPA 2024 Annual NAAQS (µg/m^3) ‡*	Average (µg/m^3, all data)	Average (µg/m^3, without SDE* data)
Austin North Hills Drive	*12*	*9*	9.71	9.13
Camp Bullis	*12*	*9*	9.12	8.46
Jarrell FM 487	*12*	*9*	8.61	7.94
Von Ormy Highway 16	*12*	*9*	9.09	8.38

SDE – Saharan dust event; ‡ In 2012, the EPA $PM_{2.5}$ NAAQS annual value was 12 µg/m^3. In 2024, the EPA revised the annual $PM_{2.5}$ NAAQS to 9 µg/m^3. While the 2024 value does not apply to these data, it is provided here for reference.* ***All NAAQS values provided here are for comparison purposes only, these data should not be used to determine compliance with the NAAQS.*

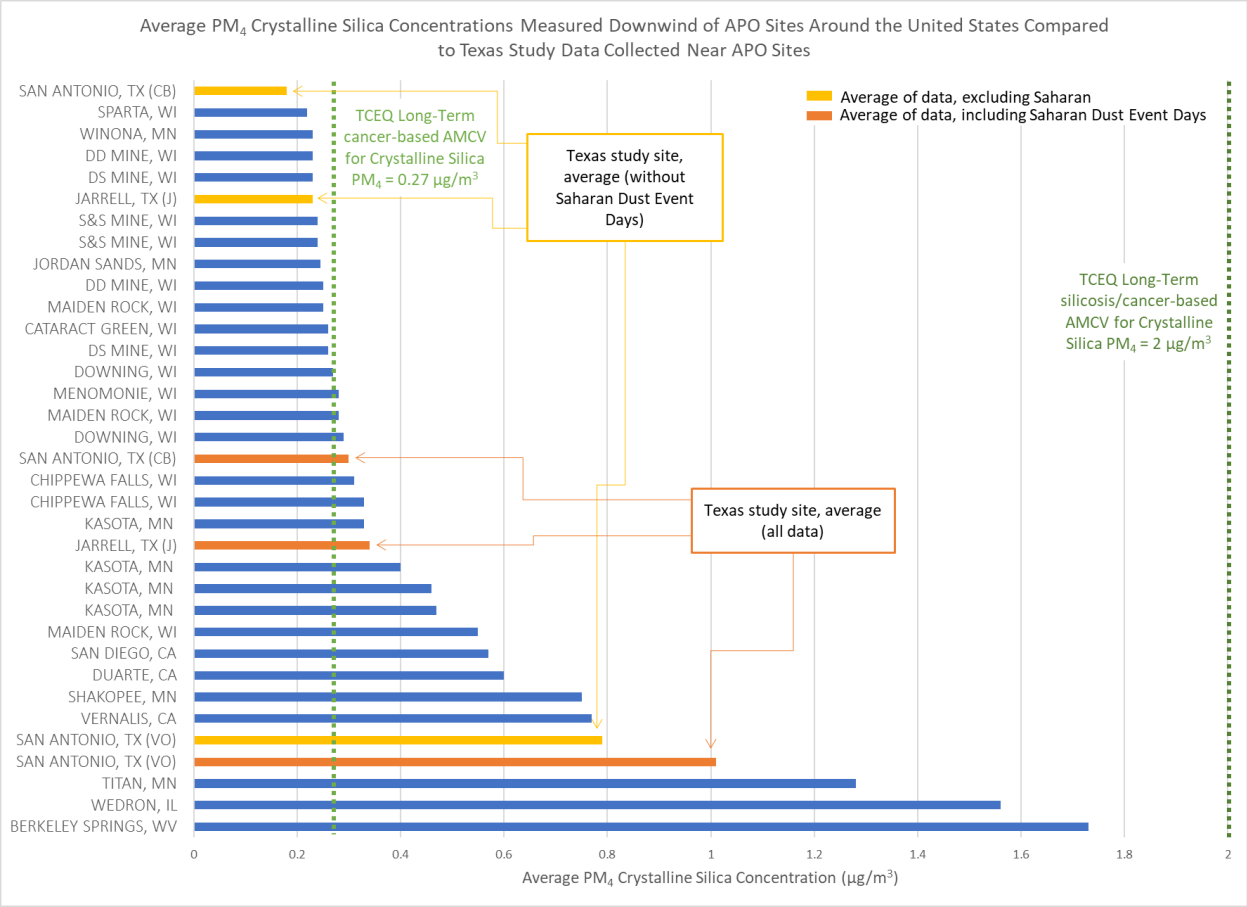
Comparison with Other APO-Crystalline Silica Monitoring Studies

PM_4 crystalline silica concentrations measured in this study were within the range of average concentrations measured in APO monitoring studies conducted in other US states[5]. In these other studies, PM_4 crystalline silica concentrations ranged from 0.18 – 1.73 µg/m^3 downwind of APO sites[7] compared to 0.3 – 1.01 µg/m^3 (including Saharan dust days) measured in this study. The other states where such studies were conducted are not typically impacted by Saharan dust events.

The average measurements from these other studies were similar whether they were collected downwind or upwind of APO sites, or from a background site. For measurements upwind of APO sites or at background sites, PM_4 crystalline silica concentrations ranged from 0.19 – 2.0 µg/m^3, which was very similar to measurements downwind of APOs. Figure 14 provides the average PM_4 crystalline silica concentrations that were measured downwind of APO sites in various US states and Figure 15 provides the average PM_4 crystalline silica concentrations that were measured upwind of APO sites or at background sites in various US states. The Texas averages are also included in both graphs for comparison, both with and without the Saharan dust event days.

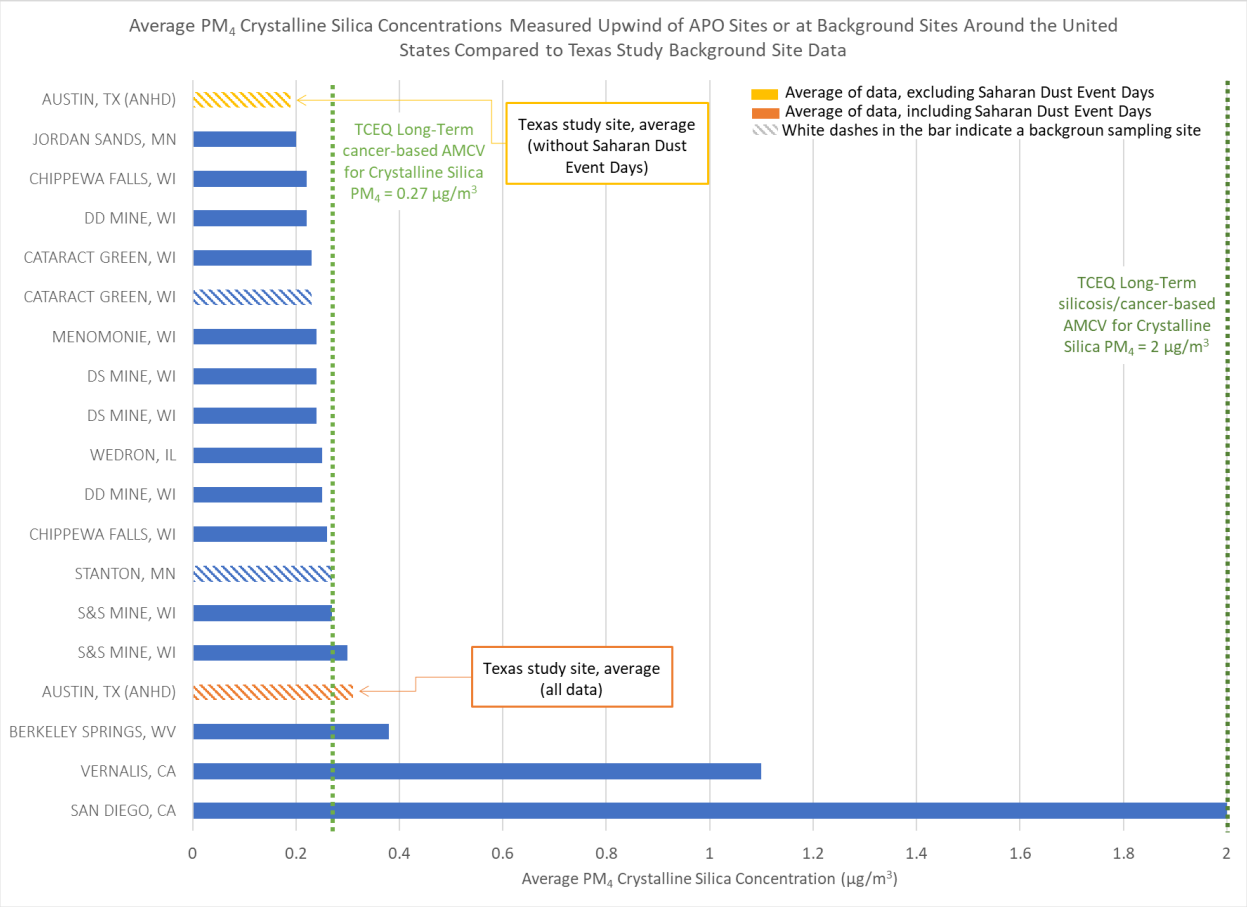
[7] Data from Richards and Brozell 2021 were split between graphs depending on the designations provided in the paper. If a site was designated as upwind or background, they were included in a graph specific to the upwind and background data for comparison with the TCEQ background site (Figure 16). Not all averages provided in the paper are representative of a full year's worth of data; see paper for details.

Figure 13. PM_4 crystalline silica concentrations measured downwind of APO sites around the United States compared to this study.



Study data are identified by city or facility name and state abbreviation. Texas study sites are noted with an abbreviation in parenthesis at the end of the name: (CB) – Camp Bullis; (J) – Jarrell FM 487; (VO) – Von Ormy Highway 16.

Figure 14. PM_4 crystalline silica concentrations measured upwind of APO sites or at background sites around the United States compared to this study.



Study data are identified by city or facility name and state abbreviation. Texas study sites are noted with an abbreviation in parenthesis at the end of the name: (ANHD) – Austin North Hills Drive (Background Site).

Conclusions

All 24-hr PM_4 crystalline silica measurements are well below the health-based 24-hr AMCV of 24 µg/m^3. Therefore, exposure to these monitored concentrations would not be expected to cause short-term adverse health effects. In addition, the measured crystalline silica levels at the background site are very similar to the levels measured downwind of two of the three APO facilities, with only the measurements near a sand mine being consistently higher than the background site concentrations (although still below levels of short-term health concern).

Annual average crystalline silica concentrations at all four sites, including the background site, exceeded the conservative cancer-based AMCV of 0.27 µg/m^3 but were below the more realistic silicosis- (and threshold cancer-) based AMCV of 2 µg/m^3. Average crystalline silica concentrations at three of the four sites were impacted by a high percentage (approximately 80%) of non-detects, which were assigned a concentration of ½ the detection limit (0.15 µg/m^3) for annual average calculations. This caused the

annual average to exceed the cancer-based AMCV, even though crystalline silica levels were so low at those sites that they could rarely be detected. Samples collected at the Von Ormy site were mostly detected, and that site had the highest PM_4 crystalline silica average (for all data points) at 1 µg/m^3. However, the average PM_4 crystalline silica concentration at the Von Ormy site was still below the more realistic silicosis- and (threshold cancer-) based AMCV of 2 µg/m^3. Therefore, exposure to these monitored concentrations would not be expected to cause long-term adverse health effects.

$PM_{2.5}$ concentrations (both magnitude and daily variation) were very similar among all four monitoring sites. The 24-hr $PM_{2.5}$ measurements were all below the level of the 24-hr $PM_{2.5}$ standard, except on a single day that was impacted by Saharan dust. Annual average $PM_{2.5}$ concentrations were similar among all four sites, with the highest average concentration measured at the background site. The averages were below the level of the EPA's 2012 annual $PM_{2.5}$ NAAQs. In addition, the highest PM and crystalline silica concentrations were measured on days where air quality across the region was impacted by Saharan dust.