NEW YORK STATE | Department of Environmental Conservation

Norlite Fugitive Dust Monitoring

INTERIM REPORT

FEBRUARY 2022

Contents

Introduction and Summary of Initial Results

Norlite LLC is a facility in Cohoes, NY that mines and processes shale to produce a light-weight aggregate product. The facility's name is derived from the name of the aggregate product. Shale is heat-treated resulting in a product that is useful for certain construction applications. The processes at the facility have the potential to directly emit or to allow for the re-entrainment of particulate matter that can leave the facility property.

The NYSDEC has received complaints over the years about dust impacting residences in Cohoes and most frequently in the vicinity of the Saratoga Sites apartment complex which is east of the Norlite facility. In response, in 2008, the NYSDEC operated a continuous (hourly) $PM_{2.5}$ (particulate matter 2.5 microns or less in size) sampler for eight months just to the south of Saratoga Sites. Those results did not show elevated levels of $PM_{2.5}$. In late 2020, the NYSDEC collected deposition samples at Saratoga Sites and at background locations further to the north and south. Deposition sampling uses a petri dish to collect particles over several days that fall (deposit) onto the collection dish. The results of the deposition sampling found particles in the community larger than 10 microns and these particles matched the characteristics of source particles collected onsite at Norlite. Figure 1 shows the locations of the 2008 $PM_{2.5}$ monitor and the 2020 deposition collection location at Saratoga Sites.

The NYSDEC initiated a more comprehensive study in spring 2021. The study was designed to characterize the larger particle sizes found in the Saratoga Sites community. The primary objective of the air monitoring was to provide direct evidence of whether fugitive dust from Norlite is impacting off-site communities. The monitoring sites were selected because they are in a public area, predominantly downwind and close to the fence line of the Norlite property. These locations are in areas where the public has observed visible dust blowing from Norlite across the railroad right of way and onto the Saratoga Sites property. This study included data on particulate levels at a background urban location for PM_{10} and $PM_{2.5}$ but not for other parameters measured.

This study included filter-based 24-Hr sampling at two locations for PM_{10} (particulate matter 10 microns or less in size), PM_{10} silica, and total suspended particles (TSP) (all suspended particles) microscopy and 1-Hr $PM_{2.5}$ monitoring. A continuous (1-Hr) PM_{10} analyzer was added in August to the south monitoring location at Saratoga Sites.

Each instrument was selected based on the usefulness of the data it can provide. The filter based PM_{10} and PM_{10} silica sampling were included because assessments of PM_{10} are generally based on 24-hr daily averages and because the NYSDEC annual guideline value for silica is also based on 24-hr measurement data. The TSP microscopy analysis was included because it can provide identifying information on all suspended particle sizes. The $PM_{2.5}$ sensors were included because most of the health effects associated with particle pollution are due to exposure to smaller particle sizes. The PM_{10} TEOM was included later in the study because the integrated filter PM_{10} data were not providing the time resolution needed to correlate visible plumes and public complaints with measurable data. Additional details about each type of monitoring are included in the Appendix. Figure 1 shows the 2021 and 2022 North and South monitoring locations at Saratoga Sites and the locations on Norlite's property where dust samples were collected.

The initial results from the more comprehensive study indicate that particles larger than $PM_{2.5}$ are leaving Norlite's property and are reaching the Saratoga Sites property. The hourly PM_{10} data show that these particle plume events usually occur in short, 1 to 3- or 4-hour intervals and levels are higher than PM_{10} observed in downtown Albany for the same hours. The 24-Hr PM_{10} data show occasional periods when the 24-hr average at the South site is 20 µg/m^3 higher than the 24-hr average at the North site. However, no PM_{10} 24-hour samples or monitoring results were above the level of the health-based, primary National Ambient Air Quality

Standard (NAAQS) of 150 micrograms per cubic meter. The TSP samples analyzed by microscopy show positive matches to Norlite source material for every filter analyzed to date. Consistent with work from 2008, the 2021 $PM_{2.5}$ results did not show an impact from Norlite emissions.

The $PM_{2.5}$ data collection concluded in September. The PM_{10}, silica and TSP 24-Hr filter-based sample collection concluded in late October 2021 after six months of samples had been collected. The NYSDEC has restarted PM_{10} and silica sampling and will continue to operate the 1-Hr PM_{10} analyzer at the South monitoring site at Saratoga Sites. Currently available interim results are presented below.

Current and Previous Sampling Locations

The majority of dust complaints have come from areas close to and including the Saratoga Sites apartment complex. Since this area was expected to have the highest concentrations of fugitive emissions from operations and uncovered material storage at Norlite, two monitoring sites (170 meters apart) were established along the western edge of the Saratoga Sites property as shown in Figure 1. The two sites were built on decks 1 m above ground level in order to elevate the sampling equipment and they both are in line of sight of Norlite. The monitoring sites which commenced operation in March 2021, are shown as purple circles in the map below. The green circles are locations where source material was collected from specific processes at Norlite. This source material (bulk dust) provided a comparison for the deposition and the filter samples.

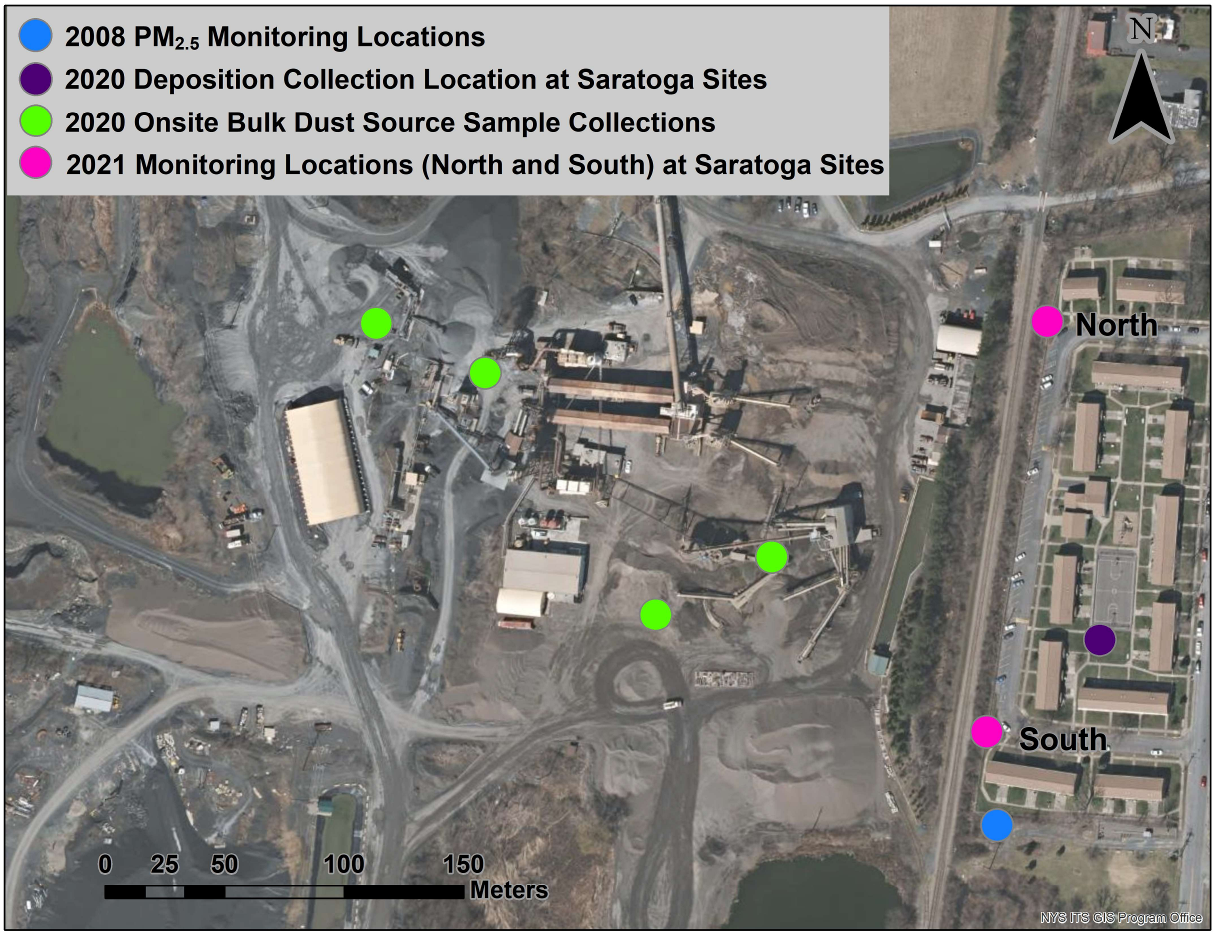

Figure 1. Onsite Bulk Dust Sampling Locations and Offsite Air Monitoring Locations and Deposition Sample Location

Study Parameters and Instrumentation

PM_{10} 24-Hr Silica and Mass Concentration Data

The samplers used to collect 24-Hr PM_{10} data are low volume Federal Reference Method TEI 2025i Partisol Sequential Air Samplers. The instruments collect a single filter sample over 24-Hrs on a 1-in-3 day schedule. Since there was only room on each platform for one 2025i sampler, the samplers alternated between mass based PM_{10} collection and filters used for PM_{10} silica analysis. The silica results in Figure 2, show 24-Hr averages from the North and the South locations at the Saratoga Sites apartment complex. The sample days that show large differences in the concentrations between the two sites indicate that there is a source of silica impacting one site more than the other. This would not be the case if the silica results were due to a distant or regional background source. This suggests that Norlite's silica emissions are periodically impacting the Saratoga Sites property.

The silica PM_{10} results at Saratoga Sites reported maximum values that ranged up to 6.04 µg/m^3 (South site) and 9.83 µg/m^3 (North site). Ambient background silica results for comparison are limited. The largest study of 22 cities in the US was performed in the early 1980s using samplers that provided results for particles in the size range from $PM_{2.5}$ to PM_{15}. This size range was known as coarse or super coarse. The silica concentrations in that study were 0.9 to 8 µg/m^3. The EPA, in 1996, took the percent silica as a fraction of mass from that study to estimate silica PM_{10} in ambient PM_{10} data from 1987 to 1993. That work provided an average for PM_{10} silica from 17 cities in the US of 1.9 µg/m^3 with a range from 0.8 to 5 µg/m^3.

The PM_{10} silica AGC set by DEC is 2 µg/m^3, which is a target to limit the amount coming from any one source. The AGC currently specifies PM_{10} as the particle size cut but sampling to collect only the respirable fraction of silica (PM_4) would provide additional information relative to silica exposures and potential health risks. Since PM_4 is more relevant for human health, the NYSDEC is making plans to change the ambient silica AGC and monitoring size fraction to PM_4 in the future.

All silica results are presented in Figure 2 and in Appendix A, Table 2.

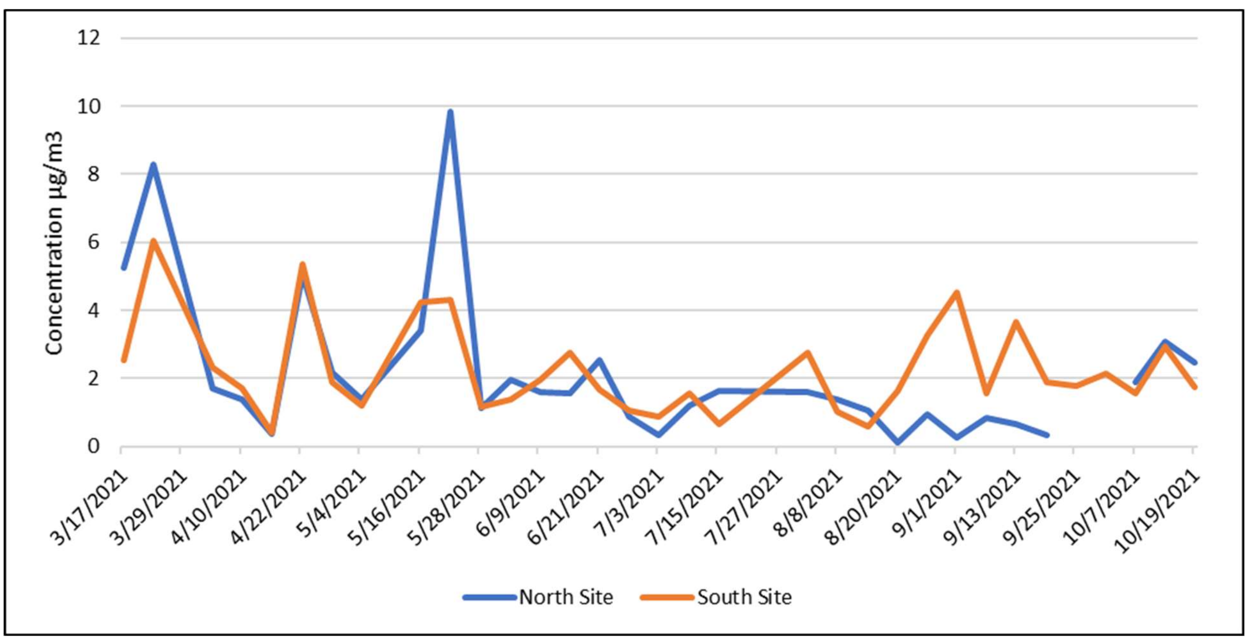

Figure 2. 24-hr Silica PM_{10}

As illustrated in Figure 3, there are days with large differences between the results from the North and South sites at Saratoga Sites for the filter-based PM_{10} mass concentration. This provides evidence that there is a large source of PM_{10} that is impacting one site more than the other. Again, this variability between sites that are very close to one another shows that the results on some days are not due to regional or background sources. This is confirmed by the comparison with the data from the PM_{10} sampler in Albany. The data from downtown Albany, agrees well with the Saratoga Sites data most often on days when the PM_{10} is low. These days with lower concentrations of PM_{10} typically have environmental conditions such as rainfall or low wind speeds that reduce PM_{10} levels in Albany as well as at Saratoga Sites. The Albany PM_{10} data are from a TAPI T640 continuous analyzer located 7 m above ground level and the data are averaged to 24-Hrs for comparison with the filter based PM_{10} data from Saratoga Sites.

The South site at Saratoga Sites had higher readings due to the contribution of fugitive dust from Norlite more frequently than the North site. This is consistent with observations from employees at the Saratoga Sites complex. They commented that dust from Norlite can frequently be seen reaching Route 32 on the eastern edge of the Saratoga Sites property. DEC monitoring staff observed these fugitive dust releases when the site locations were selected in February 2021.

All PM_{10} data are presented in Figure 3 and in Appendix B, Table 3.

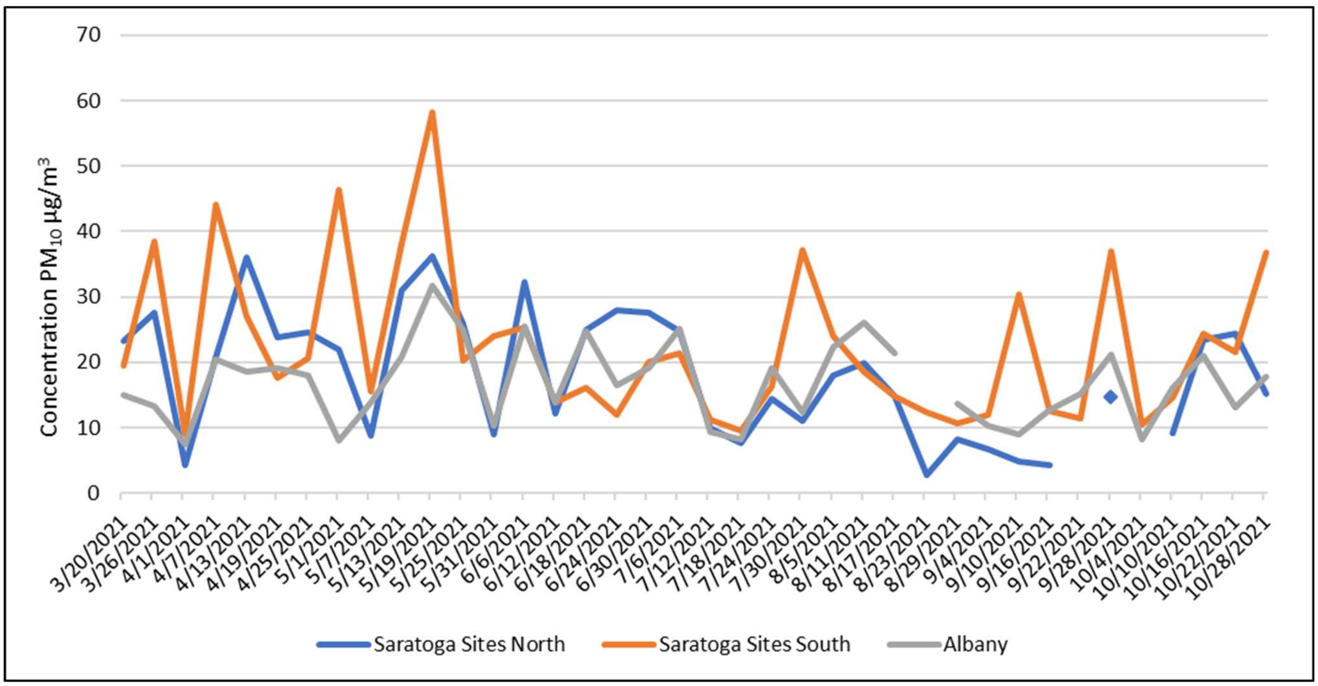

Figure 3. Saratoga Sites Filter Based and Albany PM_{10} 24-hr Data (Note: The National Ambient Air Quality Standard for PM_{10} 24-hr average is 150 ug/m3)

PM_{10} 1-Hr Data

A TEI TEOM 1400AB 1-Hr PM_{10} analyzer was installed at the South site on July 30, 2021. It was installed to determine the time of day when plumes of particles larger than $PM_{2.5}$ were reaching the Saratoga Sites property. The 1-Hr data confirmed that the higher concentrations detected at Saratoga Sites were intermittent, and typically lasted for 1 to several hours with a concentration range of 20 - 30 µg/m^3 or more. The highest concentrations of PM_{10} usually occurred in the early morning.

To illustrate the time of day with the highest concentrations of PM_{10} at Saratoga Sites, a diurnal plot was created. Diurnal plots provide an average by hour for the entire sampling interval.

As shown in Figure 4, the results from the Saratoga Sites South monitor show a large PM_{10} peak between 4:00 and 7:00 am local time. This peak is about 20 µg/m^3 higher than overnight concentrations. The Albany diurnal plot has a smaller, wider peak due to morning rush hour that extends from 6:00 to 11:00 am local time and is about 6.5 µg/m^3 higher than overnight hours. The plot also shows that PM_{10} is higher at Saratoga Sites than Albany throughout the afternoon and evening hours.

Figure 5 shows the hourly PM_{10} difference (Saratoga Sites – Albany) for all data. The hours above zero indicate when the concentration of PM_{10} is higher at Saratoga Sites than at the Albany monitor.

Additional PM_{10} data summaries are in Appendix C.

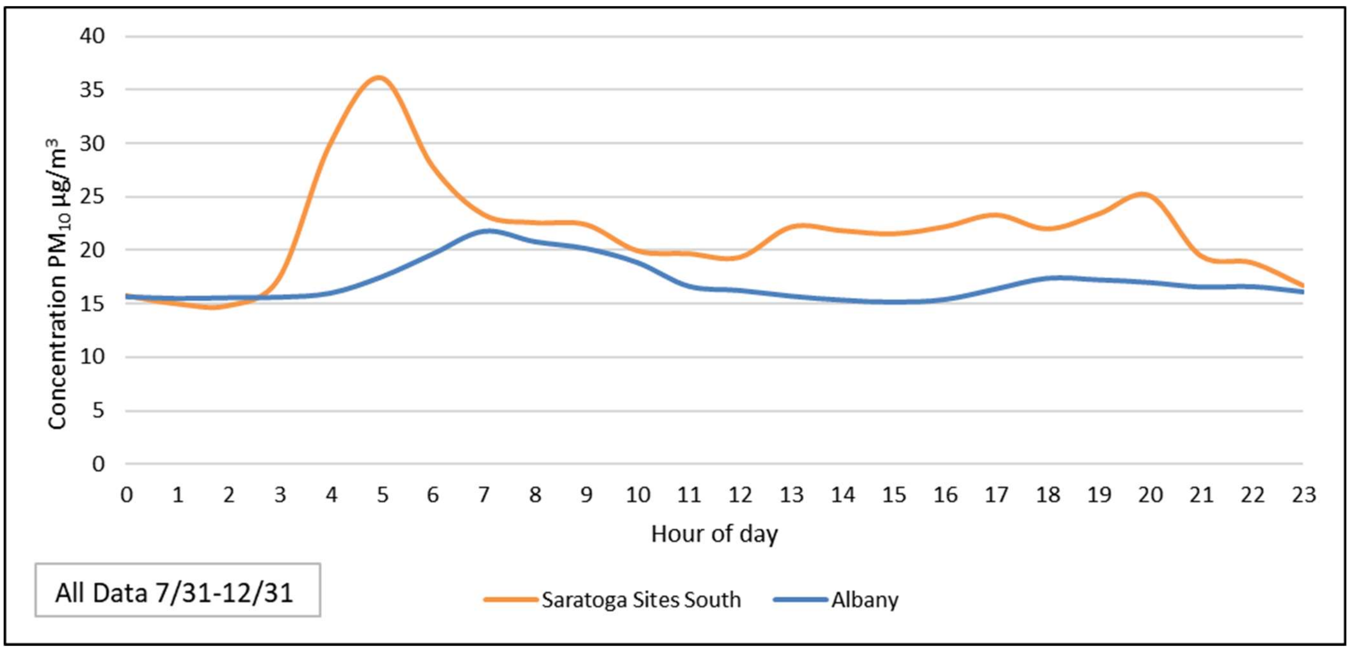

Figure 4. Diurnal Average PM_{10} July 31 – December 31 (Local Time)

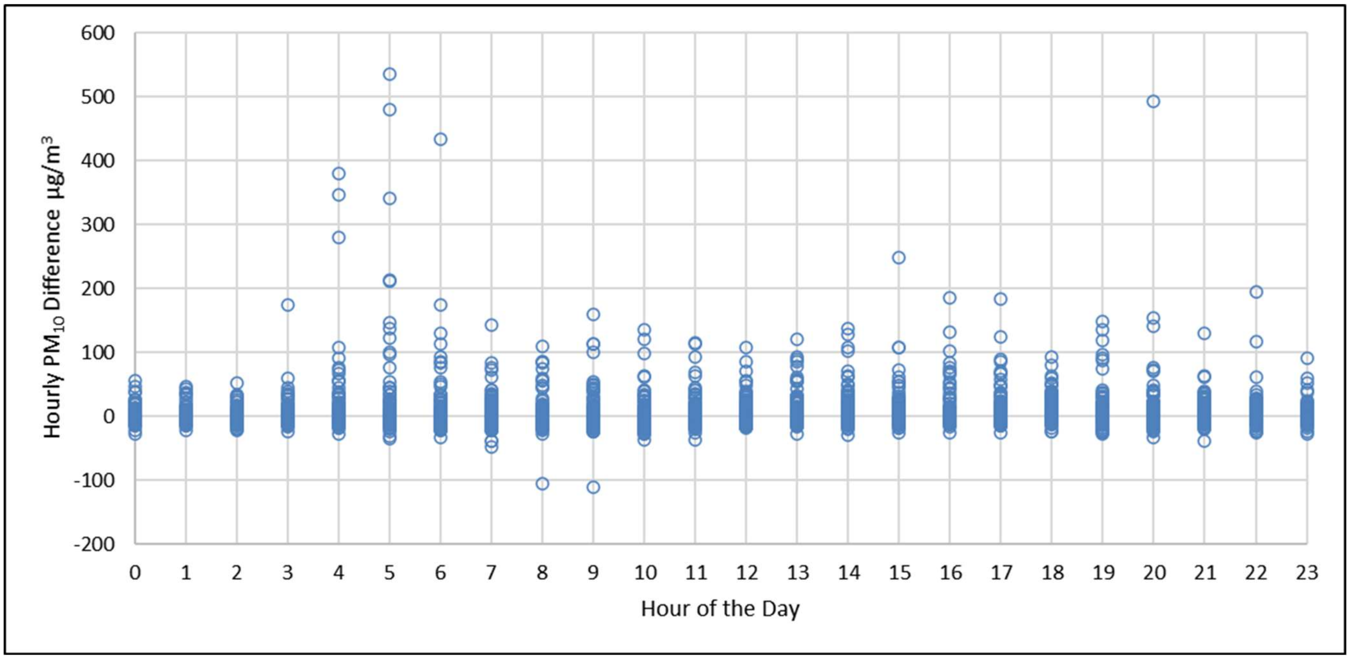

Figure 5. Diurnal Hourly Difference (Saratoga Sites – Albany) PM_{10} All Data July 31 - December 31 (Local Time)

Total Suspended Particulates - Microscopy

High volume samplers were installed at the North and South monitoring locations at Saratoga Sites. The samplers use 4" round filters suitable for microscopy and do not have a size selective inlet. The samplers are designed to collect all suspended particulate matter. These samplers were deployed to determine if particulate matter in the air at Saratoga Sites could be matched with material that originated at Norlite.

Bulk source material (dust) was collected from four different onsite locations, shown in Figure 6 in December 2020. The locations and material were selected to represent the primary processes at Norlite that could be releasing particulate matter into the environment.

Source Sample #1, called "Radial Stacker" is 12% heat-treated aggregate fines that have gone through the kiln and 88% baghouse dust. Baghouse dust is particulate that was captured in the stack emission controls and includes Lime. Lime is used in Norlite's emission control system to bind small particulate matter together to facilitate removal from the gas stream. The mix of heat-treated fines and baghouse dust are moved by conveyors to an outside storage pile.

Source Sample #2, called "Aggregate Fines to Silo" are the smallest particles left over after the heated aggregate (called clinker) has been processed and screened at the finishing plant. The sample was collected from a support structure under the conveyor belt that conveys the heat-treated aggregate fines to Silo #1, where they are stored prior to use in the block mix or dropped off the end of the radial stacker as its own aggregate fines product.

Source Sample #3, called "Baghouse Bottom of Kiln" is baghouse dust that was collected from the Kiln 1 baghouse hopper before being conveyed to the storage silos. These particles have been captured by the emissions control system. This is the only sample that was collected inside an enclosure.

Source Sample #4, called “Primary Shale Fines” is a bulk sample collected from the primary shale pile which is raw material from the on-site quarry. This material has not been heat treated.

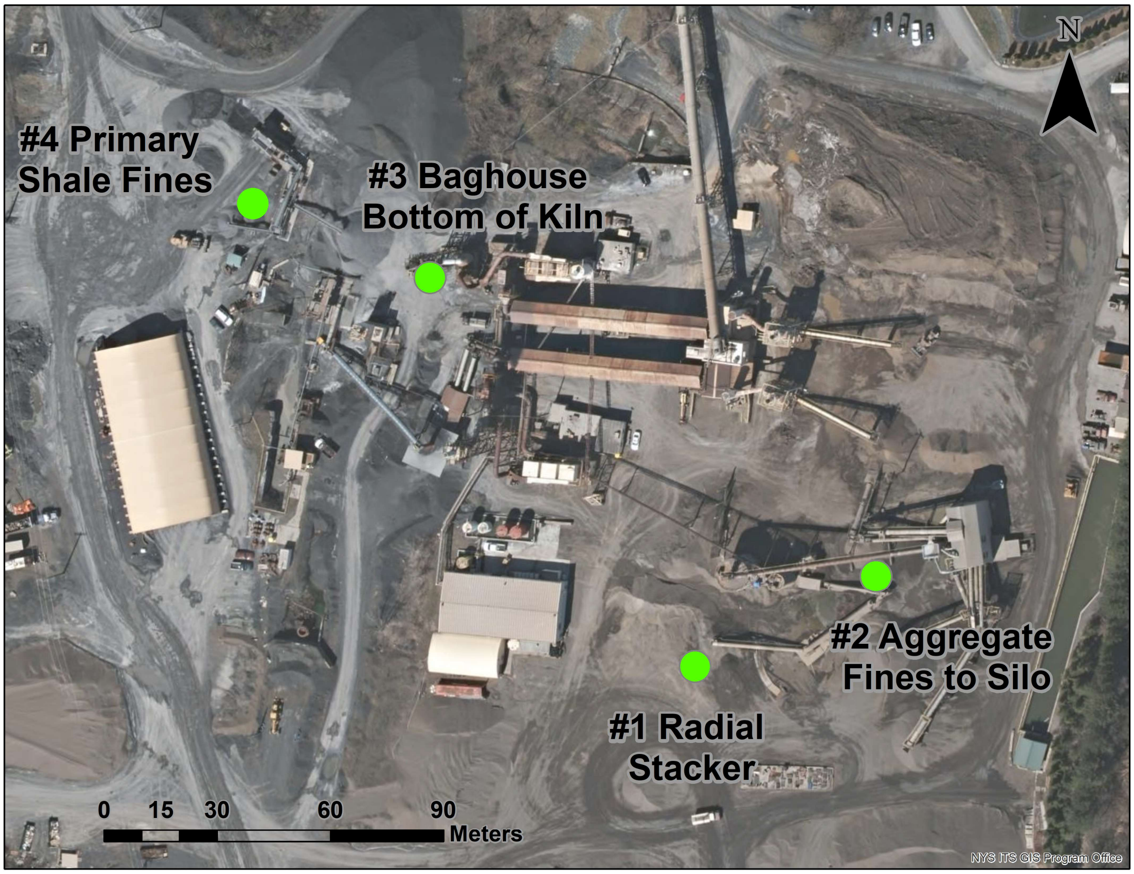

Figure 6. Onsite Bulk Dust Collection Locations

The microscopy analysis instrumentation consists of Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray Analysis (EDXA). The SEM identifies the morphology (shape and other characteristics of the particles collected. The EDXA provides an analysis of the elements that are on the surface of the particles. This analysis results in a plot of the relative concentration of the detected elements on both the Saratoga Sites particles and the onsite material. These plots known as spectra can be statistically compared to determine a relative match. The identification of particulate matter originating from Norlite, in samples collected at Saratoga Sites was achieved through a combination of matching morphology and spectra.

The microscopy analysis found that particles originating from Norlite were positively matched to particles on every sample collected at Saratoga Sites. The Norlite particles made up from 6% to 40% of the total number of particles on the sample filters. Figure 7 illustrates the percentage of Norlite particles matching each source sample by date.

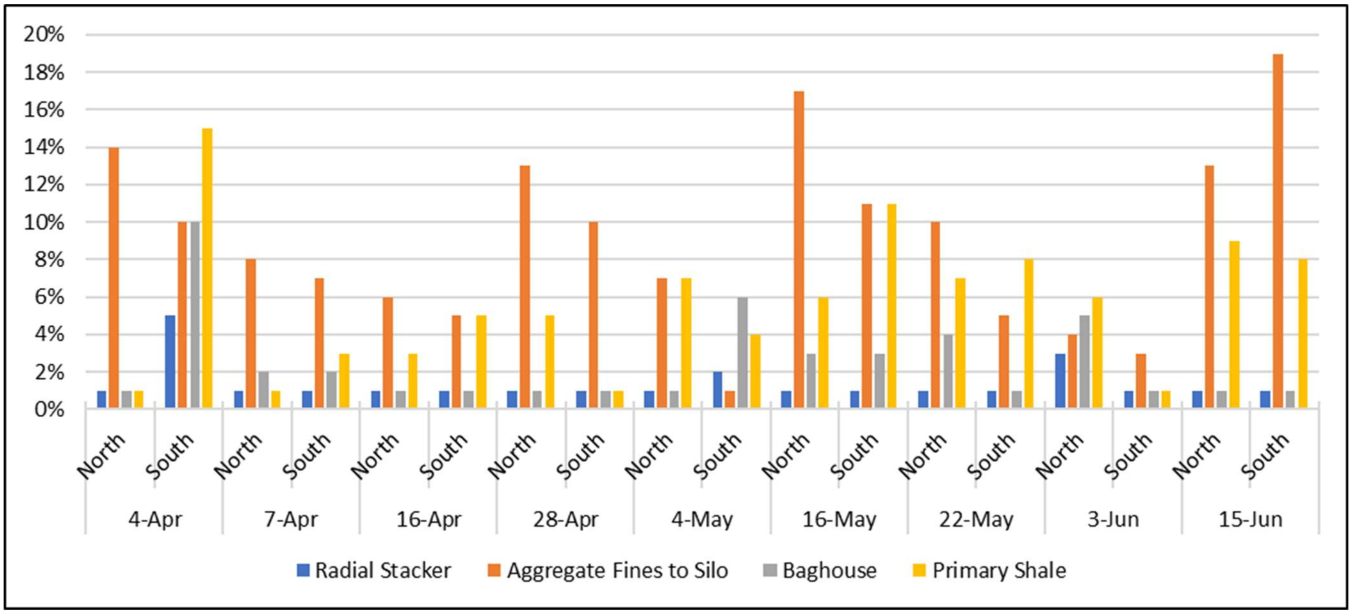

Figure 7. Particles Matched to Norlite Source Material

In December 2020 and in January 2021, the NYSDEC received letters from a researcher who had looked at deposited particles in residential attic spaces and wipe samples from vehicle windshields downwind of Norlite. The researcher had commented that the samples were devoid of smaller particulate and that the bulk of the material appeared to be pyroclastic and some of the particles were very angular with extremely sharp edges. The NYSDEC analysis of bulk dust collected from locations onsite at Norlite confirmed the researcher's observations. Norlite source samples 1 through 3 are particles that show the effect of high temperature processing in the kiln. Norlite source sample 4 is non-heat treated primary shale particles that often exhibit an angular shape and sometimes have very sharp edges. A particle collected on a filter at Saratoga Sites on April 7th, shown in Figure 8, which matched Norlite Primary Shale source material, exhibits very sharp edges.

Wipe and deposition samples are biased towards larger particles because larger particles have greater mass and fall/deposit closer to the source. The TSP microscopy analysis provides information on the composition of the particles and the physical size of particles but not the aerodynamic diameter relevant for comparison with health-based standards.

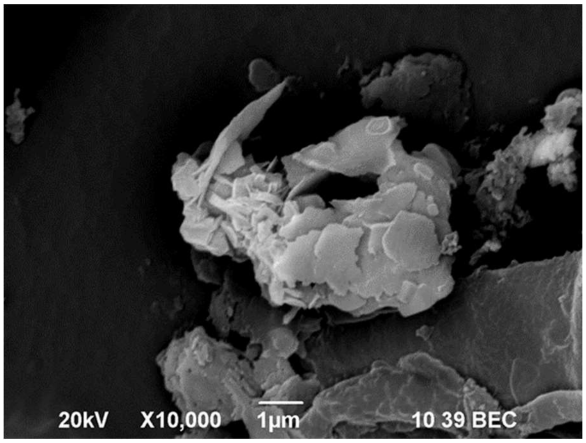

Figure 8. Scanning Electron Microscopy Image of a Particle Collected at Saratoga Sites

Images and spectra from the Norlite source material as well as some of the particles from the analysis are in Appendix D.

1-Hr $PM_{2.5}$ Data

Purple Air PA II SD Sensors were used to collect $PM_{2.5}$ hourly measurements at both North and South monitoring sites. These instruments are sensor based and have biases due to changes in humidity in comparison to FRM data. For this work, an EPA derived algorithm was used that included a humidity adjustment to make the data comparable to FRM data. The Purple Air results have more variability than FRM data and can sometimes result in negative values.

Based on the eight-month study conducted by NYSDEC in 2008, $PM_{2.5}$ impacts from the Norlite facility were expected to be low. The one change since then was that Norlite's emission control system had been updated and sometimes new systems can change the profile of the sizes of the particulate matter released into the atmosphere. The results from this six-month study did not find evidence of stack emissions or fugitive dust in the $PM_{2.5}$ size range impacting Saratoga Sites.

Table 1 provides average and the maximum 1-Hr $PM_{2.5}$ concentrations for six months of data collection at the two Saratoga sites compared to the downtown Albany site. The results show that concentrations were lower at both Saratoga Sites in comparison to the Albany site. There were very few short-term increases at either the North or South Saratoga sites. Additionally, the fugitive particle emissions events were not evident in the $PM_{2.5}$ dataset. The full set of 1-Hr data are plotted in Appendix E.

Table 1. Summary of $PM_{2.5}$ Results

Note: The National Ambient Air Quality Standard (NAAQS) for $PM_{2.5}$ as an Annual Average is 12 µg/m^3 and as a 24-Hr Average is 35 µg/m^3

March 8 to September 10, 2021	Saratoga Sites North	Saratoga Sites South	Downtown Albany
Average (µg/m^3)	6.23	6.24	8.06
Maximum 1-Hr (µg/m^3)	47.93	46.85	89.50
Maximum 24-Hr (µg/m^3)	26.45	25.53	42.39

Summary and Conclusions

This interim report describes a sampling effort designed to determine whether fugitive dust is leaving the Norlite property and entering the community as measured at two sampling locations at Saratoga Sites. The current results showing increases in large particles (PM_{10}) but not smaller particles ($PM_{2.5}$) on certain days and times of the day at Saratoga Sites indicates that windblown dust from Norlite is the predominant source of the increased particulate results. This finding is consistent with the microscopic and elemental analysis of the collected dust samples showing a match to Norlite source materials. Results also show that these larger particles contain silica and can create a sporadic increase in airborne silica concentrations. However, the elevations of PM_{10} and $PM_{2.5}$ are still well below federal health-based standards for these measurements. Additional monitoring of fugitive dust emissions from Norlite can help to further understand the possible health implications to nearby residents.

Appendix A: 24-Hr Silica Results

The silica samples were collected on PVC filters and were analyzed by a modified NIOSH Method 7500. The results were provided as mass concentration of alpha quartz. Alpha quartz was detected above the laboratory reporting limit for all samples analyzed. Analysis included two polymorphs of silica, cristobalite and tridymite but these analytes were not detected above the laboratory reporting limit for any of the sample filters.

NIOSH Method 7500 is typically used in a workplace setting where exposures are shorter and concentrations are higher. Method 7500 normally uses a PM_4 (particles 4 microns and less in size) cut point on a personal sampler with a flow rate typically 1-3 liters per minute. To use method 7500 for ambient concentrations, the cut point was changed to PM_{10} to match NYDEC's silica Annual Guideline Concentration of 2 μg/m^3, the flow rate was increased and the sampling interval was extended to 24-Hrs. These sampling modifications decreased the method detection limit from 5 μg/m^3 to 0.21 μg/m^3.

All results for both sites are shown in Table 2.

Table 2. 24-hr Average PM_{10} Silica Results

Sample Date	North Concentration (μg/m^3)	South Concentration (μg/m^3)		Sample Date	North Concentration (μg/m^3)	South Concentration (μg/m^3)
3/17/2021	5.25	2.54		7/9/2021	1.21	1.54
3/23/2021	8.29	6.04		7/15/2021	1.63	0.67
4/4/2021	1.71	2.33		8/2/2021	1.58	2.75
4/10/2021	1.38	1.71		8/8/2021	1.38	1.00
4/16/2021	0.38	0.42		8/14/2021	1.04	0.58
4/22/2021	5.08	5.38		8/20/2021	0.13	1.63
4/28/2021	2.17	1.88		8/26/2021	0.96	3.25
5/4/2021	1.38	1.21		9/1/2021	0.25	4.54
5/16/2021	3.42	4.25		9/7/2021	0.83	1.54
5/22/2021	9.83	4.29		9/13/2021	0.67	3.67
5/28/2021	1.13	1.17		9/19/2021	0.33	1.88
6/3/2021	1.96	1.38		9/25/2021	Eqpt malfunction	1.79
6/9/2021	1.58	1.96		10/1/2021	Eqpt malfunction	2.13
6/15/2021	1.54	2.75		10/7/2021	1.88	1.54
6/21/2021	2.54	1.67		10/13/2021	3.08	2.92
6/27/2021	0.88	1.04		10/19/2021	2.46	1.75
7/3/2021	0.33	0.88		10/25/2021	≤ 1.25 Lab error	≤ 1.25 Lab error

Note: Lab Error 10/25/2021 Samples – The analysis lab was not able to track which sample was from the North and which sample was from the South location. The silica concentration 1.25 μg/m^3 was the higher value of the two results. The lower result was 0.6 μg/m^3.

Appendix B: 24-Hr Federal Reference Method PM_{10} Results

The 24-Hr PM_{10} samples were collected on a TEI 2025i Partisol Sequential Air Sampler. The sampling filters are PTFE Teflon® membrane and are pre-weighed prior to sampling. After sampling, the filters are weighed again and the difference is the mass collected over the sampling interval.

The sampling and gravimetric analysis adhered to EPA guidance document:

> Quality Assurance Guidance Document 2.12 Monitoring $PM_{2.5}$ in Ambient Air Using Designated Reference or Class I Equivalent Methods, January 2016.

The Albany PM_{10} data were collected with a TAPI T640 analyzer. The 1-Hr data were averaged to match the 24-Hr filter samples from the Saratoga Sites North and South monitoring locations.

All results for both sites with a comparison to the downtown Albany site are shown in Table **3**.

Table 3. 24-hr Average PM_{10} Results

Sample Date	Saratoga Sites North µg/m³	Saratoga Sites South µg/m³	Albany µg/m³		Sample Date	Saratoga Sites North µg/m³	Saratoga Sites South µg/m³	Albany µg/m³
3/20/2021	23.21	19.53	14.98		7/12/2021	9.87	11.19	9.27
3/26/2021	27.67	38.45	13.25		7/18/2021	7.58	9.51	8.22
4/1/2021	4.25	8.91	7.53		7/24/2021	14.41	16.38	19.10
4/7/2021	20.88	44.13	20.45		7/30/2021	11.00	37.12	12.41
4/13/2021	36.00	26.96	18.59		8/5/2021	17.91	23.92	22.36
4/19/2021	23.88	17.62	19.15		8/11/2021	19.79	18.56	26.10
4/25/2021	24.63	20.55	18.03		8/17/2021	14.83	14.84	21.31
5/1/2021	22.00	46.37	8.06		8/23/2021	2.83	12.32	Invalid
5/7/2021	8.79	15.64	13.87		8/29/2021	8.12	10.68	13.71
5/13/2021	31.00	38.08	20.82		9/4/21	6.75	11.97	10.2
5/19/2021	36.17	58.14	31.62		9/10/21	4.75	30.47	9.05
5/25/2021	25.96	20.34	25.01		9/16/21	4.2	12.62	12.79
5/31/2021	8.88	24.04	10.27		9/22/21	Invalid	11.43	15.26
6/6/2021	32.33	25.28	25.55		9/28/21	14.66	36.95	21.14
6/12/2021	12.17	13.86	13.88		10/4/2021	Invalid	10.52	8.21
6/18/2021	24.96	16.03	24.77		10/10/2021	9.08	14.66	16.04
6/24/2021	27.88	11.94	16.53		10/16/2021	23.37	24.43	20.91
6/30/2021	27.63	19.97	19.14		10/22/2021	24.33	21.53	13.03
7/6/2021	24.70	21.40	25.23		10/28/2021	15.2	36.77	17.82

Appendix C: 1-Hr PM_{10} Data

The 1-Hr PM_{10} data were collected with a TEI TEOM 1400AB at Saratoga Sites and with a TAPI T640 at Albany. The TEOM is housed on the South Saratoga Sites sampling platform in an enclosure with full HVAC environmental control. The T640 is in a similar enclosure on the roof of the Albany County Health Department on South Pearl St in downtown Albany. The data from these continuous instruments are reported via cellular modem hourly to the NYSDEC data acquisition system in Albany.

The TEOM can only measure particles in one size category. For this study, the TEOM at Saratoga Sites utilized a PM_{10} inlet. The T640 in Albany can measure PM_{10} and $PM_{2.5}$ simultaneously. Data from both size fractions were used for comparisons with measurements taken at Saratoga Sites.

All of the 1-hour PM_{10} data from the TEOM at the South Saratoga Sites and the downtown Albany T640 are presented in Figure 9 through Figure **10**12.

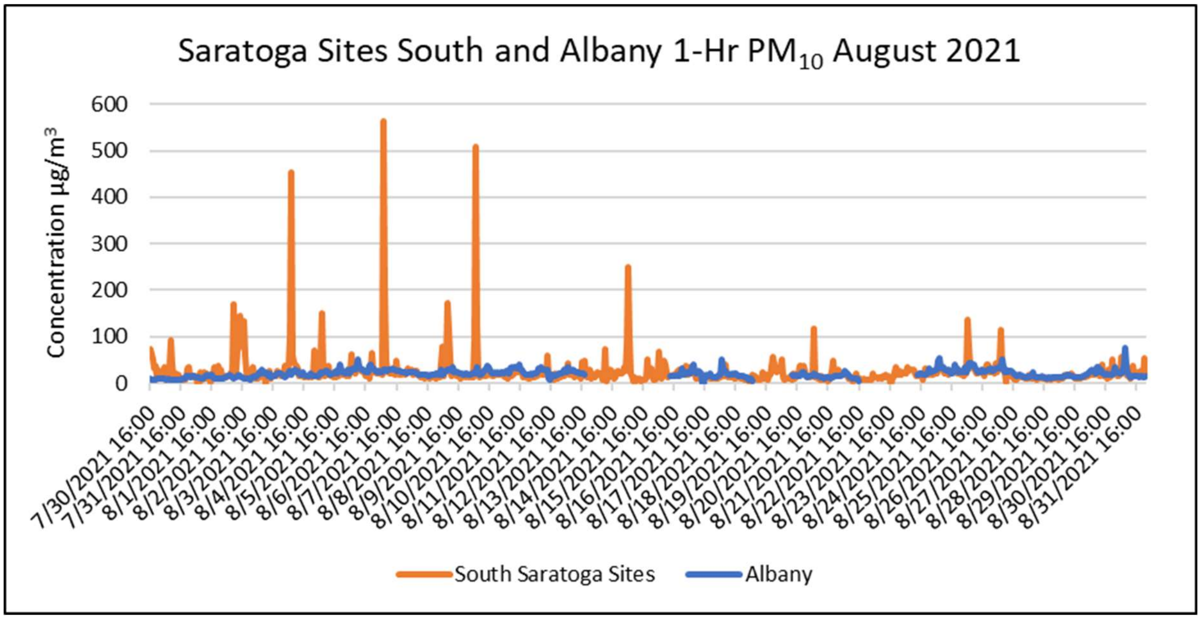

Figure 9. Saratoga Sites and Albany 1-hour PM_{10} August 2021

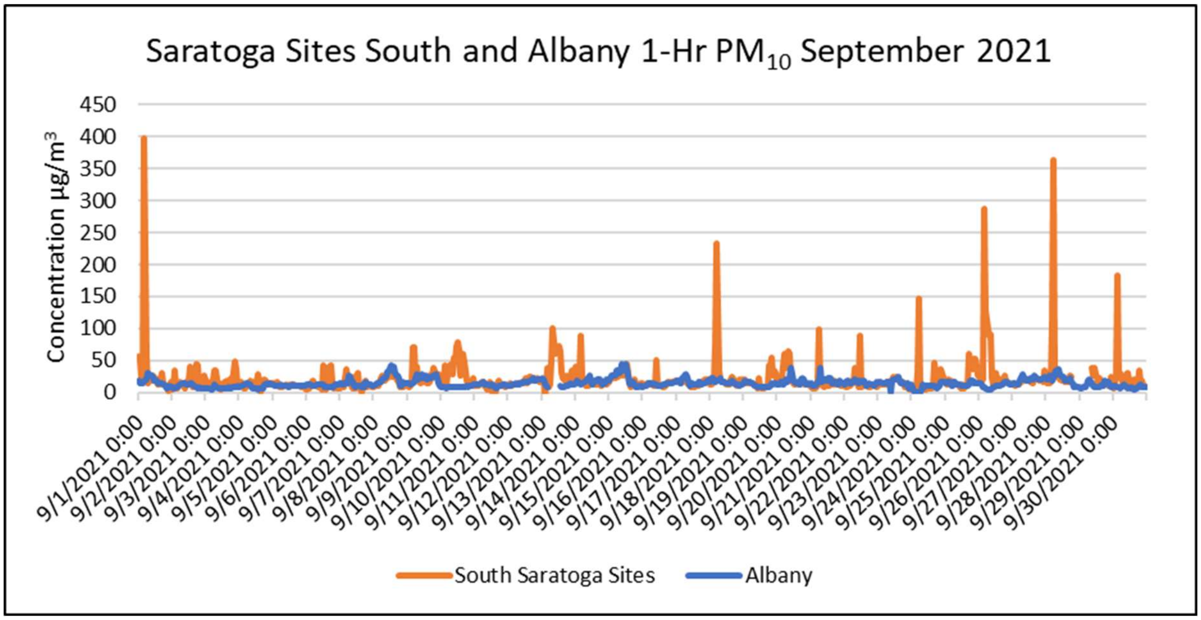

Figure 10. Saratoga Sites and Albany 1-hour PM_{10} September 2021

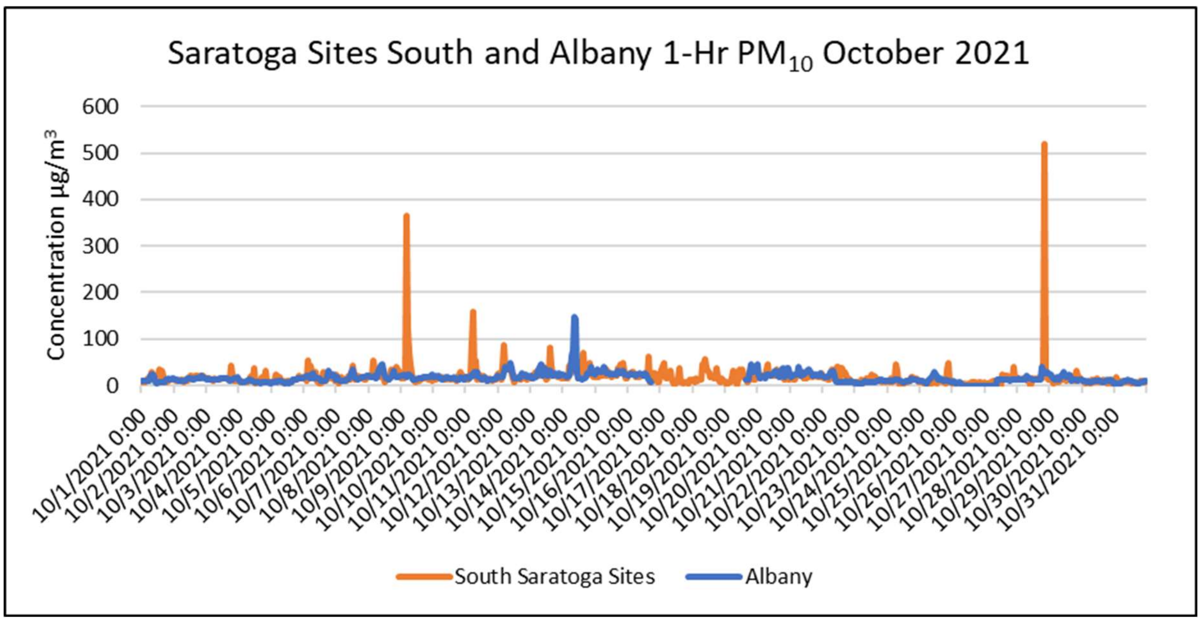

Figure 11. Saratoga Sites and Albany 1-hour PM_{10} October 2021

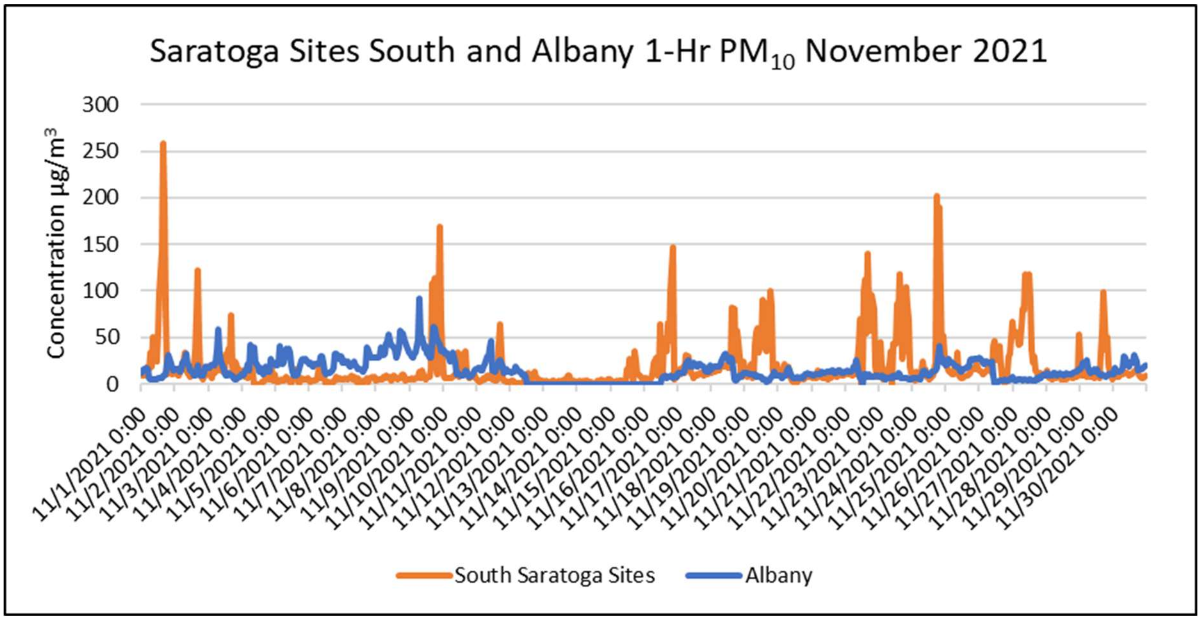

Figure 12. Saratoga Sites and Albany 1-hour PM_{10} November 2021

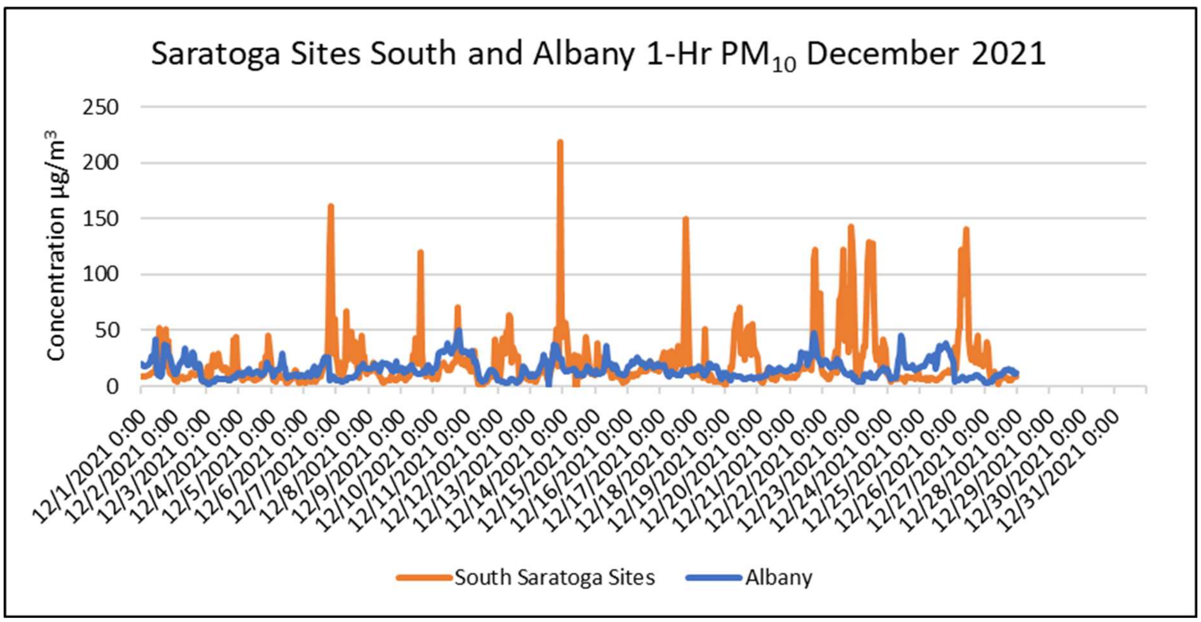

Figure 13. Saratoga Sites and Albany 1-hour PM_{10} December 2021

Appendix D: Total Suspended Particulate Microscopy

Electron microscopy coupled with energy dispersive X-Ray detection were used to make the morphology/spectroscopy determinations presented in this report. Electron microscopy impinges a voltage beam on the sample surface resulting in X-Rays that are captured to create an image. EDS or EDXA (Energy Dispersive X-Ray Analysis) identifies elements on the surface of the material being analyzed. Identification of compounds is not in the scope of the EDS detector and limits the results of the spectra to qualitative. A spectral library was created and used for comparison with the source material collected from Norlite. The EDXA software determines the match fit percent of spectra based on a Chi-Squared (test) of the elemental results. This is a statistical calculation that compares the known spectra (for example: baghouse, silo fines, primary shale, radial stacker) to unknown spectra (filters collected from Saratoga Sites). The percent match range of 89%-90% was assigned to determine definitively if the source sample material matched the particulate matter present on the sample filters. The threshold of 89%-90% was chosen because the elemental composition found in the Norlite aggregate is very much like that seen in earthen crustal particulate throughout New York State.

The summary of the first 10 sampling days for the Saratoga Sites North and South locations are shown in Table 4. The particles matched to Norlite source material comprised 6% to 40% of the total number of particles on the sampled filters. The category labeled Other includes the particles that did not match material from Norlite. The Other category includes biological particles, combustion particles and crustal material not related to Norlite.

Table 4. Particle Match Results for Ten Sampling Days

Date	Saratoga Sites	Radial Stacker	Aggregate Fines to Silo	Baghouse	Primary Shale	Other
4/4/21	North	<1%	14%	<1%	<1%	83%
4/4/21	South	5%	10%	10%	15%	60%
4/7/21	North	<1%	8%	2%	<1%	88%
4/7/21	South	<1%	7%	2%	3%	87%
4/16/21	North	<1%	6%	1%	3%	89%
4/16/21	South	<1%	5%	<1%	5%	87%
4/28/21	North	<1%	13%	<1%	5%	80%
4/28/21	South	<1%	10%	1%	1%	87%
5/4/21	North	<1%	7%	1%	7%	84%
5/4/21	South	2%	1%	6%	4%	87%
5/10/21	North	4%	1%	2%	13%	80%
5/10/21	South	1%	9%	2%	9%	79%
5/16/21	North	<1%	17%	3%	6%	73%
5/16/21	South	<1%	11%	3%	11%	74%

Date	Saratoga Sites	Radial Stacker	Aggregate Fines to Silo	Baghouse	Primary Shale	Other
5/22/21	North	<1%	10%	4%	7%	78%
5/22/21	South	<1%	5%	1%	8%	85%
6/3/21	North	3%	4%	5%	6%	82%
6/3/21	South	1%	3%	1%	1%	94%
6/15/21	North	1%	13%	1%	9%	76%
6/15/21	South	<1%	19%	1%	8%	71%

The elemental spectrum and images of each of the Norlite sources are presented below along with an example of a match from a particle collected at Saratoga Sites.

Source Sample #1 Radial Sacker:

This source material is 12% heat treated aggregate fines that have gone through the kiln and 88% baghouse dust. Baghouse dust is particulate that was captured in the stack emission controls and includes lime which is used to treat collected emissions and bind small particulate matter together so it can be removed from the gas stream. The elemental spectrum for these particles has a prominent calcium (Ca) or silicon (Si) peak as shown in Figure 14. This is due to the fact that the material is a mixture and lime contains Ca. The two spectra in Figure 14 and the image on the left in Figure 15 are representative of different portions from the onsite source material. in **Figure 14**Figure 15, the image on the right is a field sample from Saratoga Sites. As evident in **Figure 14**Figure 15, the intense heat removed the shale's sharp edges and created the cavities and holes. The particle in this image is what is called an agglomeration, different particles are attached making up a larger particle.

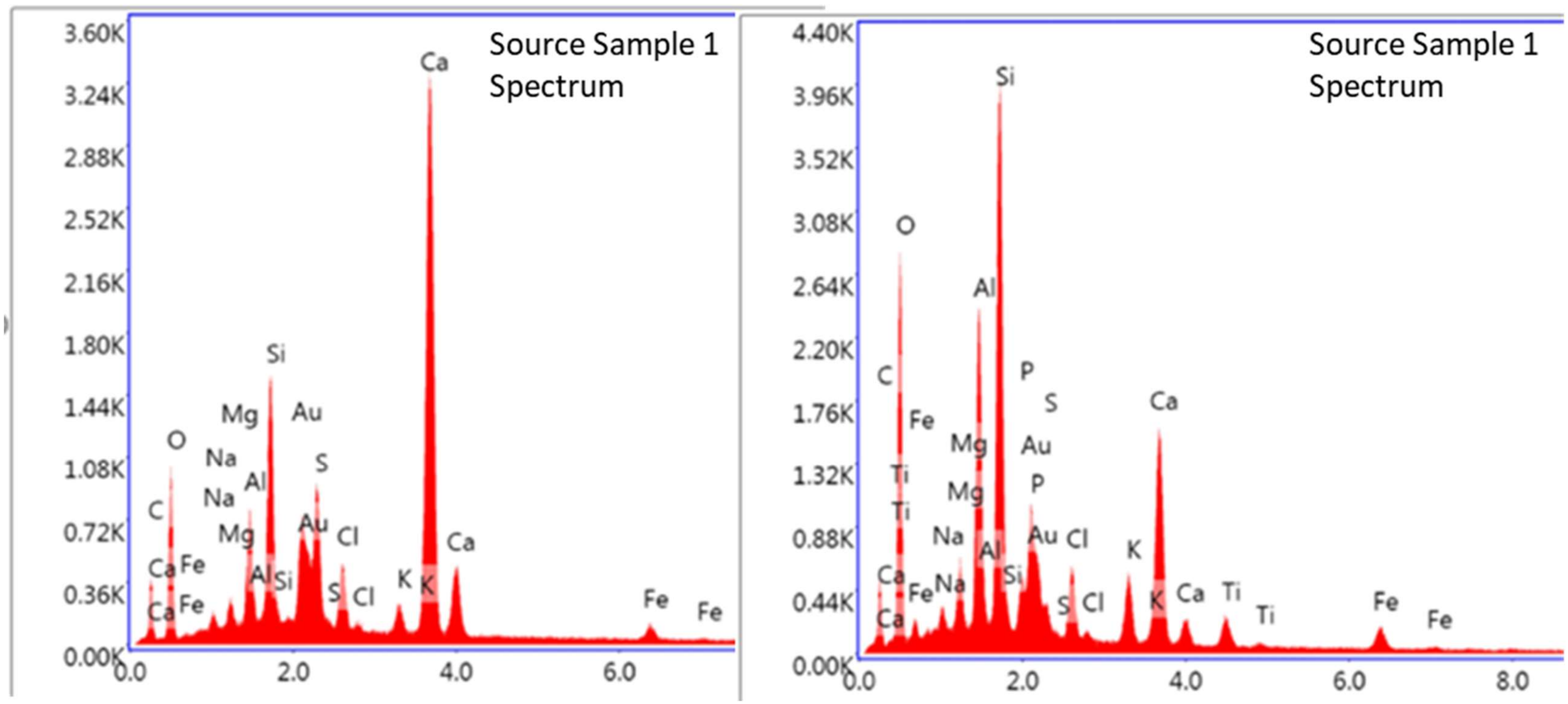

Figure 14. Source Sample Spectrums: Radial Stacker Bulk Sample Onsite showing Ca (Left) Si (Right)

Figure 15 illustrates a comparison between a sample collected from the Radial Stacker source material and a sample collected at Saratoga Sites on April 4th. The Radial Stacker source image included pollen (tulip shape) in the image on the left. The match for the Saratoga Site particle was just under 90%.

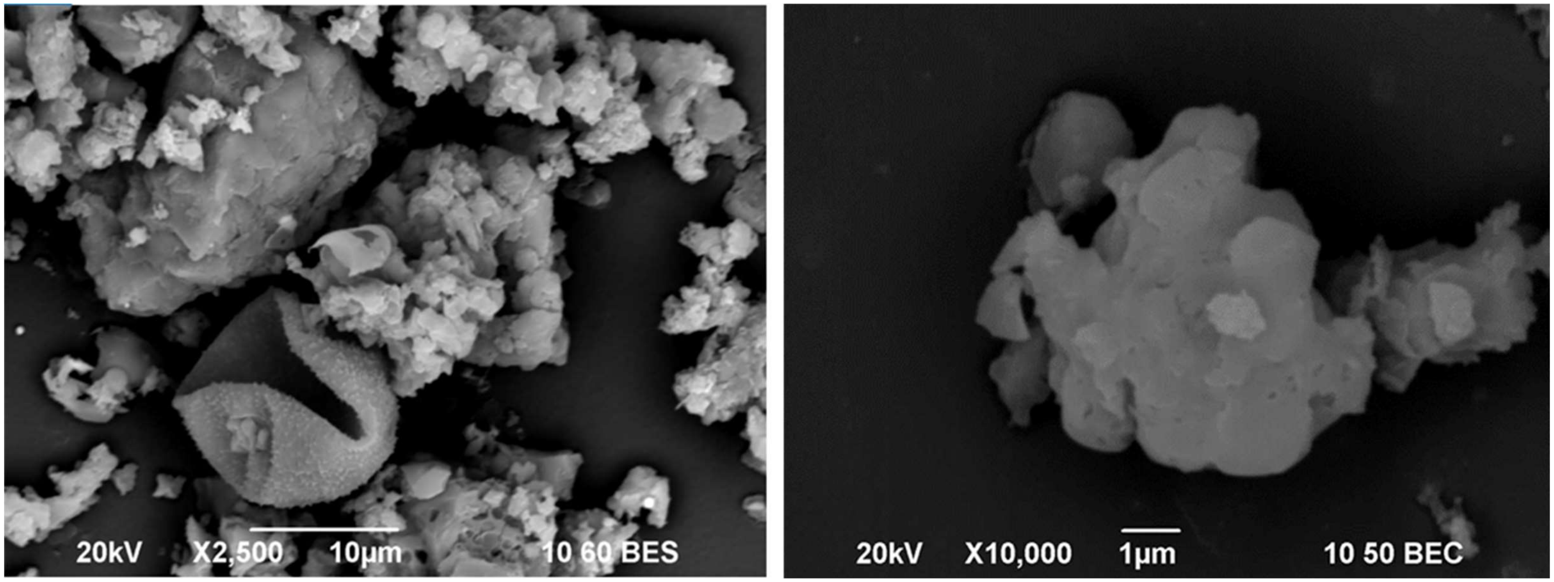

Figure 15. Scanning Electron Microscopy Images: Radial Stacker Bulk Sample Particle (Left) and Particle Collected at Saratoga Sites (Right)

Source Sample #2 Aggregate Fines to Silo:

This source material represents the smallest particles that have gone through the Norlite kiln. The intense heat removed the shale's sharp edges and created the cavities and holes evident in the images below. The particle in this image is what is called an agglomeration, different particles are attached making up a larger particle. The elemental spectrum for these particles has a prominent silicon (Si) peak as shown in Figure 16. The spectrum and images in Figure 16 are representative of both the source material as well as the field samples that match the source material.

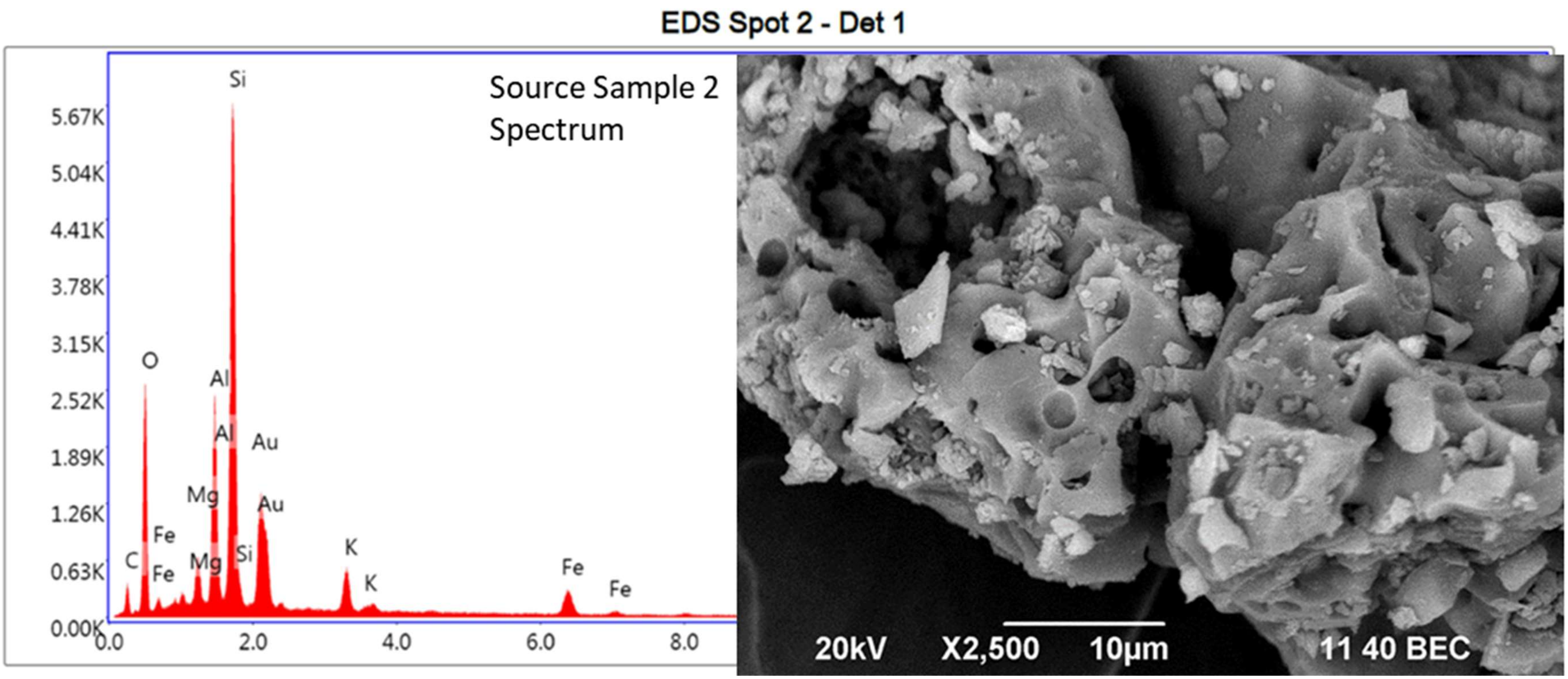

Figure 16. Aggregate Fines to Silo: Onsite Source Sample Spectrum (Left) and Scanning Electron Microscopy Image (Right)

Saratoga Sites April 4th Spectrum and Image: In Figure 17**,** the source spectrum is in blue and the Saratoga Sites Spectrum is in red. The Saratoga Sites elemental spectrum has a 91.87% match to the Aggregate Fines to Silo source spectrum.

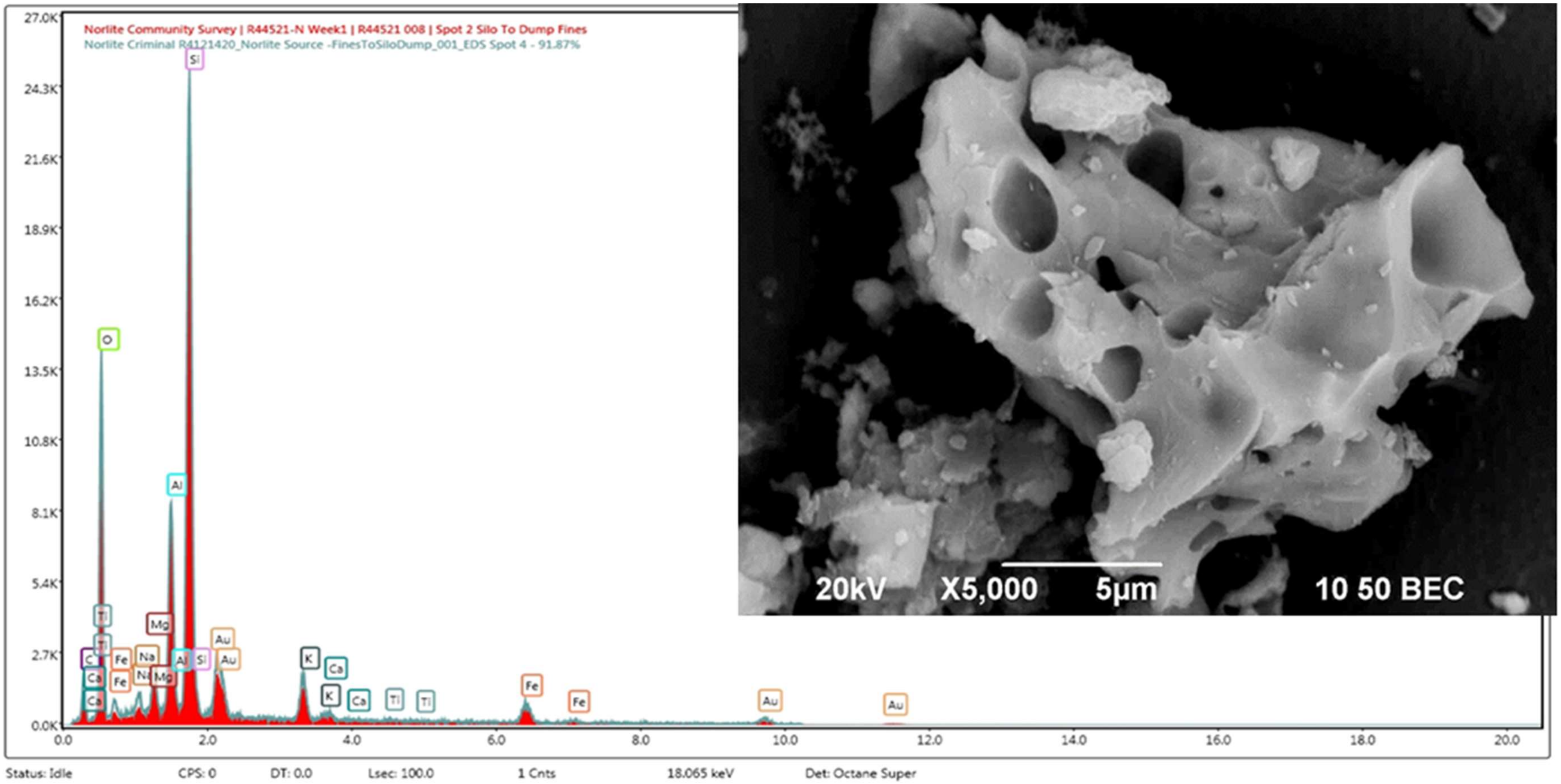

Figure 17. Overlay of Spectral Image from Onsite Sample (Blue) with Offsite Saratoga Sample (Red) (Left). Scanning Electron Microscopy Image from Onsite Sample (Right)

Source Sample #3 Baghouse Bottom of Kiln:

These particles have been captured by Norlite's emissions control system. The particles are similar in morphology to the radial stacker. The main elemental constituent is calcium (Ca) and the particles have undergone the incineration process. Ca in the form of Lime is used in the emissions control system (dry scrubber) to bind smaller particles together. The spectrum and images Figure **18**, are representative of both the source material as well as the field samples that match the source material.

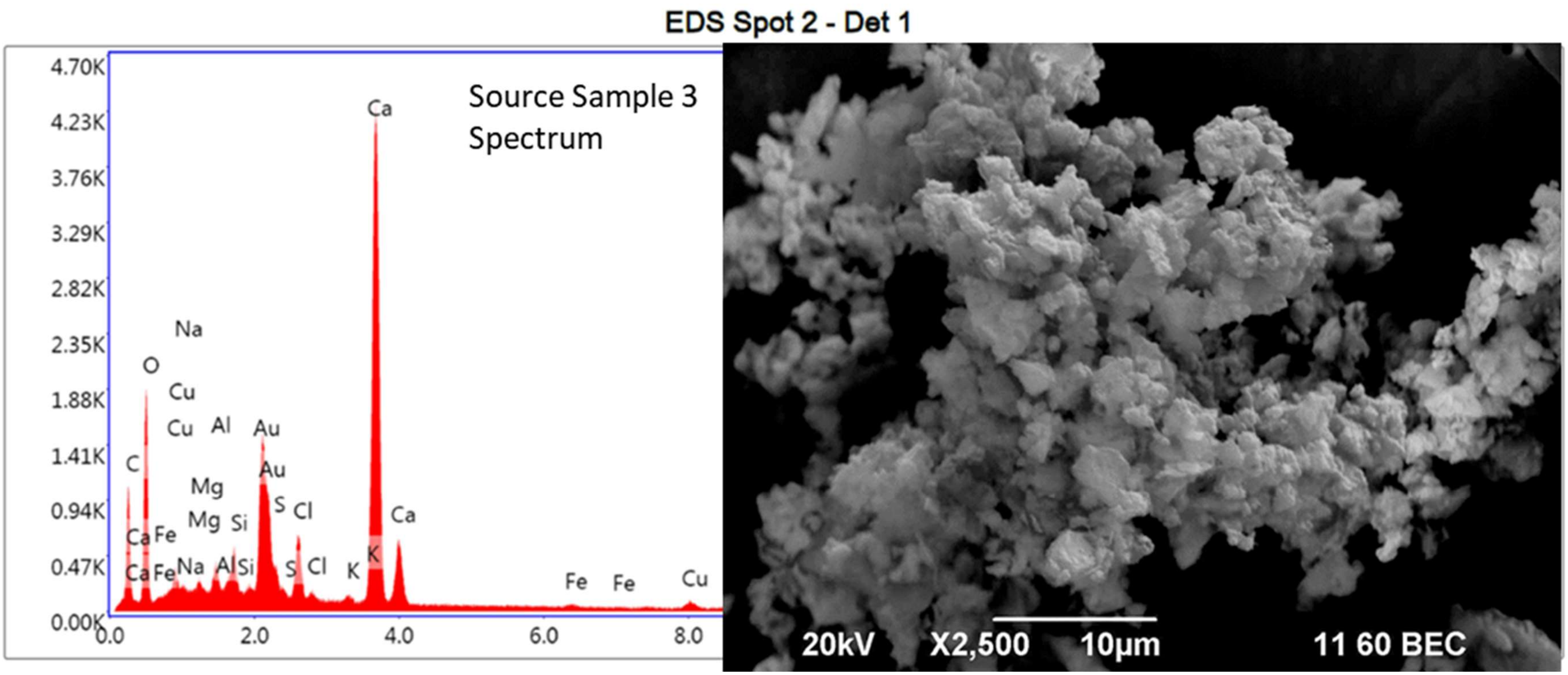

Figure 18. Baghouse Bottom of Kiln: Onsite Source Sample Spectrum (Left) and Scanning Electron Microscopy Image (Right)

Saratoga Sites April 4th Spectrum and Image: In Figure 19, the Norlite source spectrum is in blue and the Saratoga Sites April 4th sample spectrum is in red. The Saratoga Sites elemental spectrum was a 90% match to the baghouse bottom of kiln source spectrum.

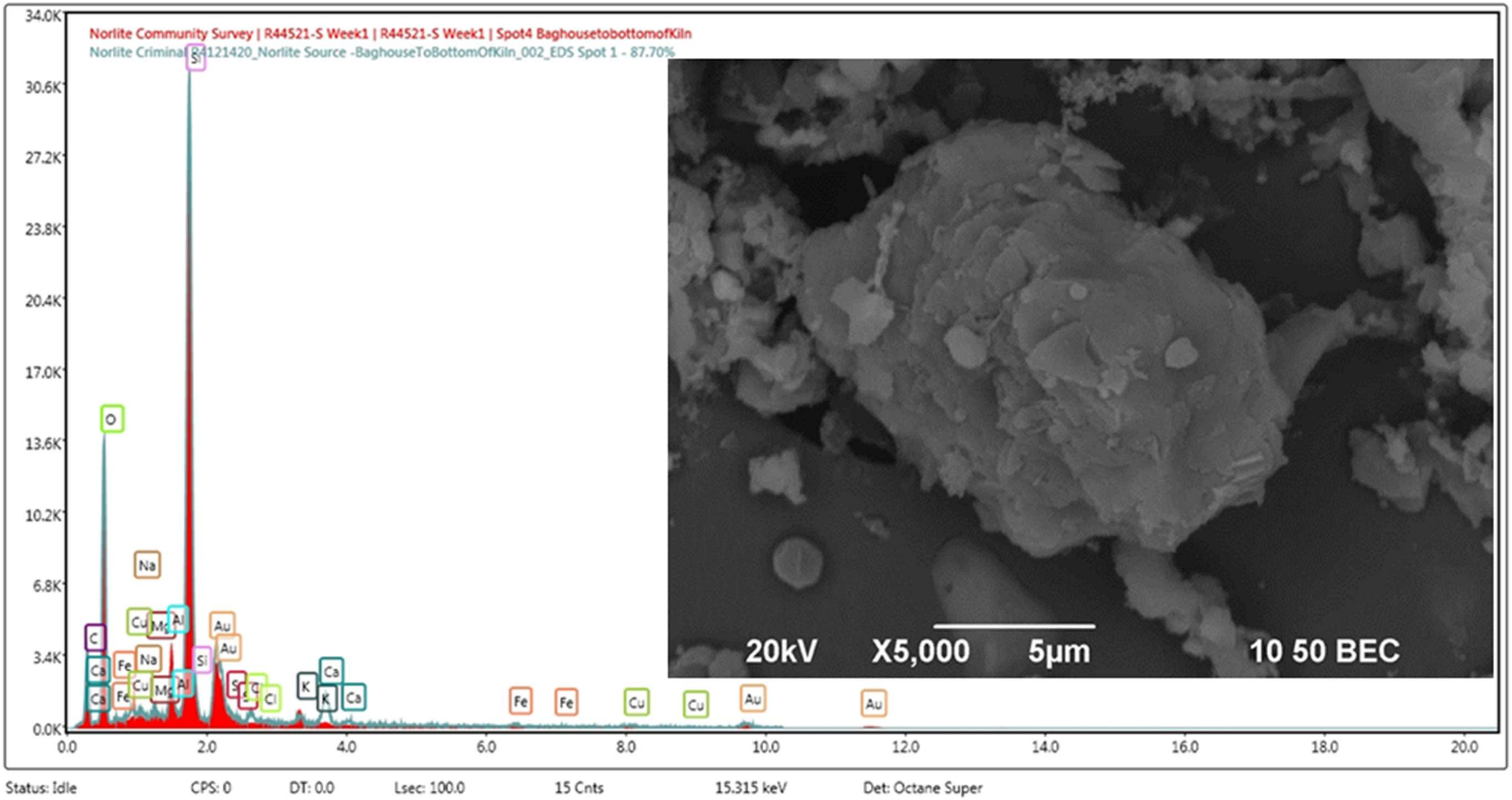

Figure 19. Overlay of Spectral Image from Onsite Sample (Blue) with Offsite Saratoga Sample (Red) (Left). Scanning Electron Microscopy Image from Onsite Sample (Right)

Source sample #4 Primary Shale Fines:

Primary shale fines are bulk particles collected from the primary shale pile which is raw material from the on-site quarry. This material has not been heat treated and is often angular with sharp edges. The elemental spectrum for these particles has a prominent silicon (Si) peak. The spectrum and images in Figure 20 are representative of both the source material as well as the field samples that match the source material.

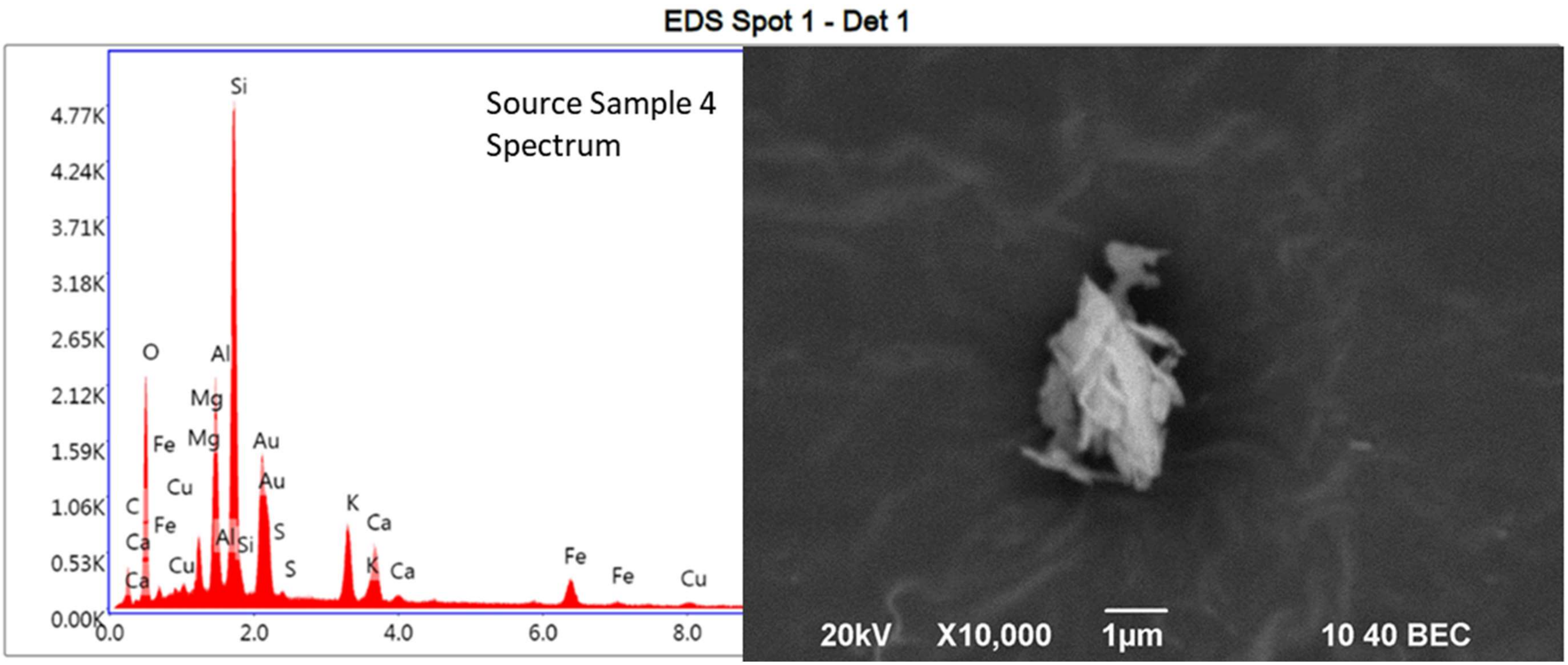

Figure 20. Primary Shale Fines: Onsite Source Sample Spectrum (Left) and Scanning Electron Microscopy Image (Right)

Saratoga Sites April 7th Spectrum and Image: In Figure 21, the primary shale fines source spectrum is in blue and the Saratoga Sites spectrum is in red. This elemental spectrum from a spot on this particle from Saratoga Sites is an 88.1% match to the primary shale fines source spectrum.

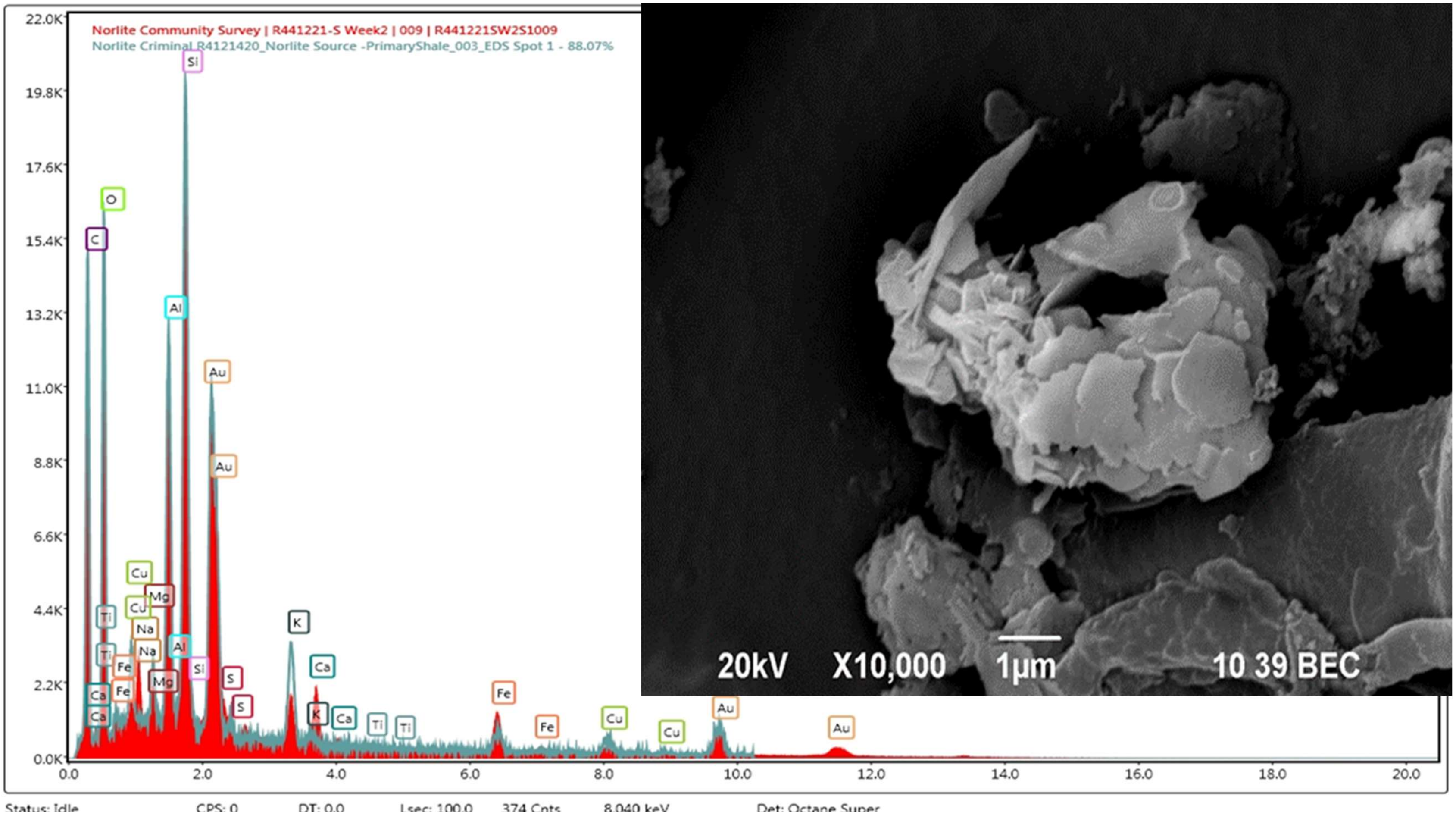

Figure 21. Overlay of Spectral Image from Onsite Sample (Blue) with Offsite Saratoga Sample (Red) (Left). Scanning Electron Microscopy Image from Onsite Sample (Right)

Appendix E: 1-Hr $PM_{2.5}$ Purple Air Sensor Data

The $PM_{2.5}$ data were collected with Purple Air model PA II SD monitors. These sensors store data on an SD card which was downloaded weekly. The data are reported every two minutes in Universal Coordinated Time format. An Excel macro was used to output data into hourly bins and in Eastern Standard Time (EST) format. EST was selected because it matches the data time standard for the other samplers used in the study.

Each Purple Air device contains two PM sensors that are compared to one another to determine if there are problems with its operation and a sensor for relative humidity (RH). The Purple Air PM sensor uses a laser light beam to scatter light off particles which are pulled through the sensor using a small fan. A proprietary internal algorithm is used to relate light scattering to mass concentration. There was no conditioning of the sampled air.

The response of the Purple Air sensor is affected by humidity. The $PM_{2.5}$ 1-hour data were adjusted to be similar to an EPA FEM data using an algorithm which corrects for humidity effects. The EPA utilizes this algorithm for data reported to the National Fire and Smoke map. For the equation below, relative humidity (RH) 1-hour data from the Purple Air sensor are used with the raw data to calculate adjusted values.

$$PA(adjusted) = 0.52 *PA(raw) -0.086*RH + 5.75$$

The North and South $PM_{2.5}$ Purple Air data tracked very well with an R^2 of 0.94. Data availability for the North site was 96.3% and for the South site was 99.95%. The mean $PM_{2.5}$ mass concentration for the North site was 6.23 $\mu g/m^3$ and the maximum was 47.9 $\mu g/m^3$. The mean $PM_{2.5}$ mass concentration for the South site was 6.24 $\mu g/m^3$ and the maximum was 46.9 $\mu g/m^3$.

The Purple Air PA II sensor also provides, in addition to $PM_{2.5}$, data labeled as PM_1 (one micron or less in size) and PM_{10}. These parameters were not used in this study. Purple Air PM_{10} data are biased low because the small fan in the sensor cannot capture larger and heavier particles in the environment.

Purple Air data have more variability than FEM data. This signal noise results in some of the data being negative at times. Negative values were not removed from the dataset and can be occasionally seen in the plots.

The 1-hour Purple Air data by month are presented in Figure 22 to Figure 27 along with a comparison to the Albany $PM_{2.5}$ data.

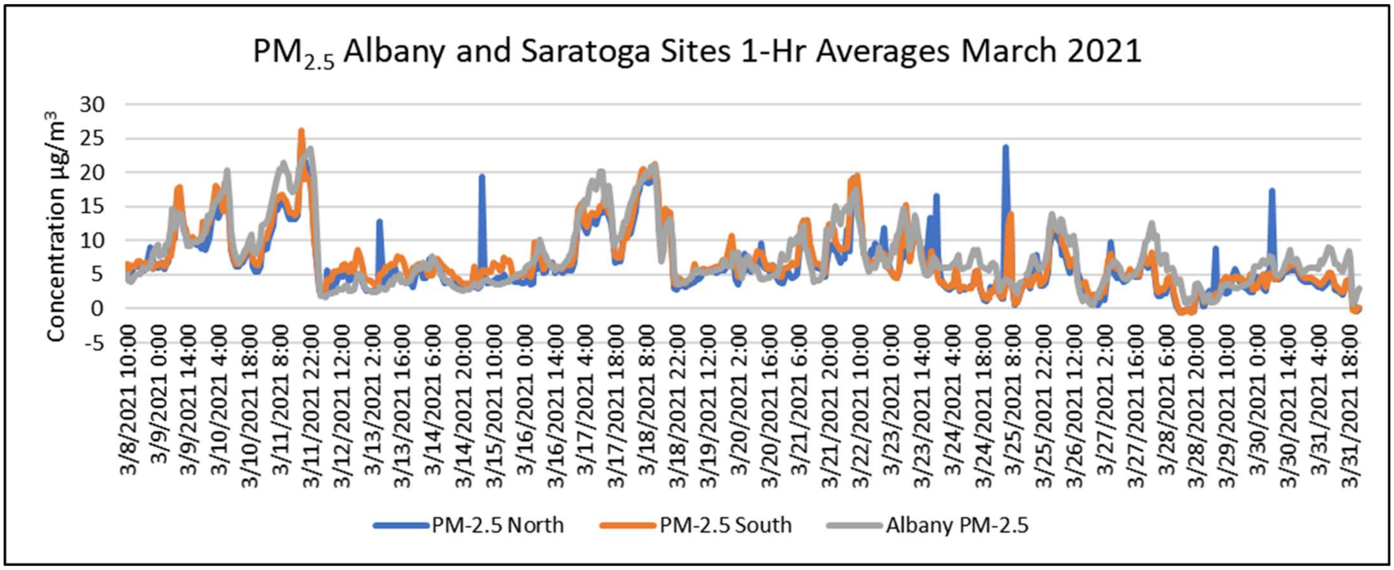

Figure 22. $PM_{2.5}$ March 2021, Saratoga North and South Sites compared to Albany

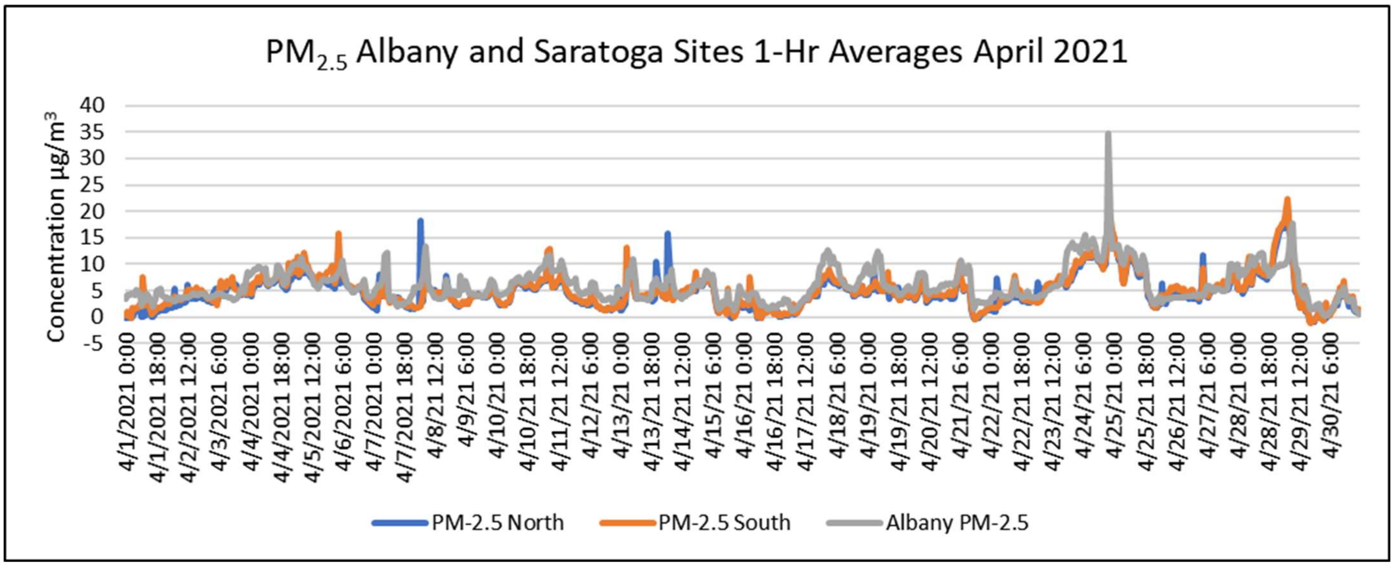

Figure 23. $PM_{2.5}$ April 2021, Saratoga North and South Sites compared to Albany

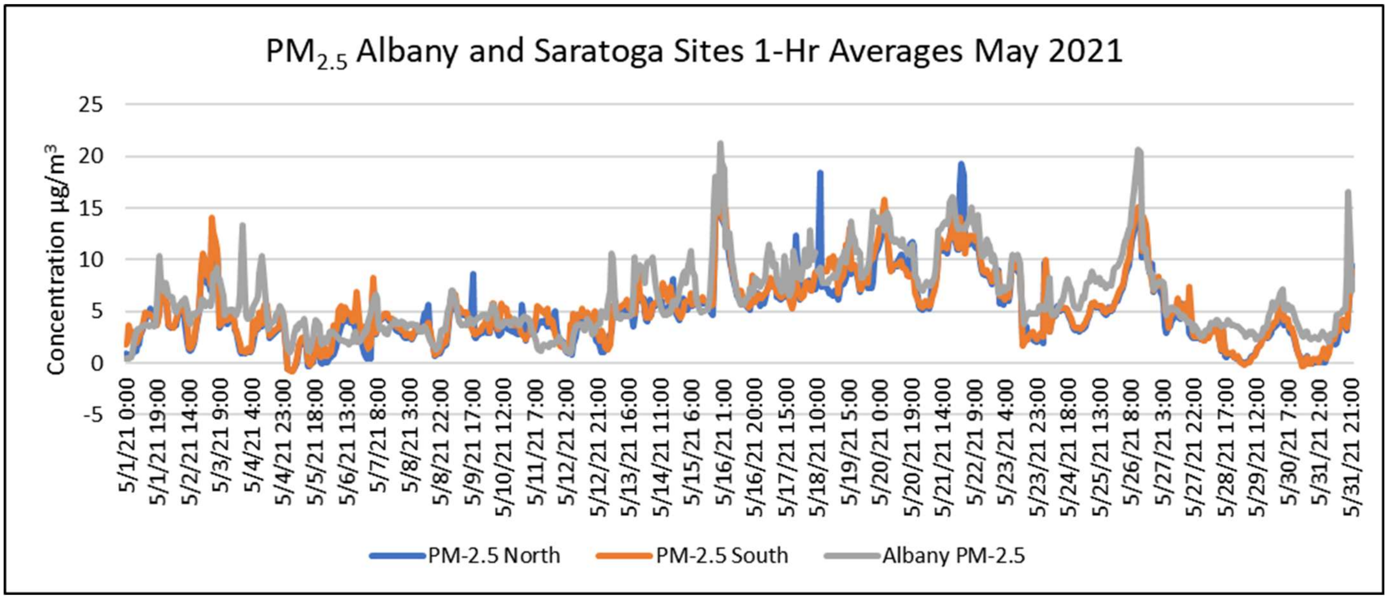

Figure 24. $PM_{2.5}$ May 2021, Saratoga North and South Sites compared to Albany

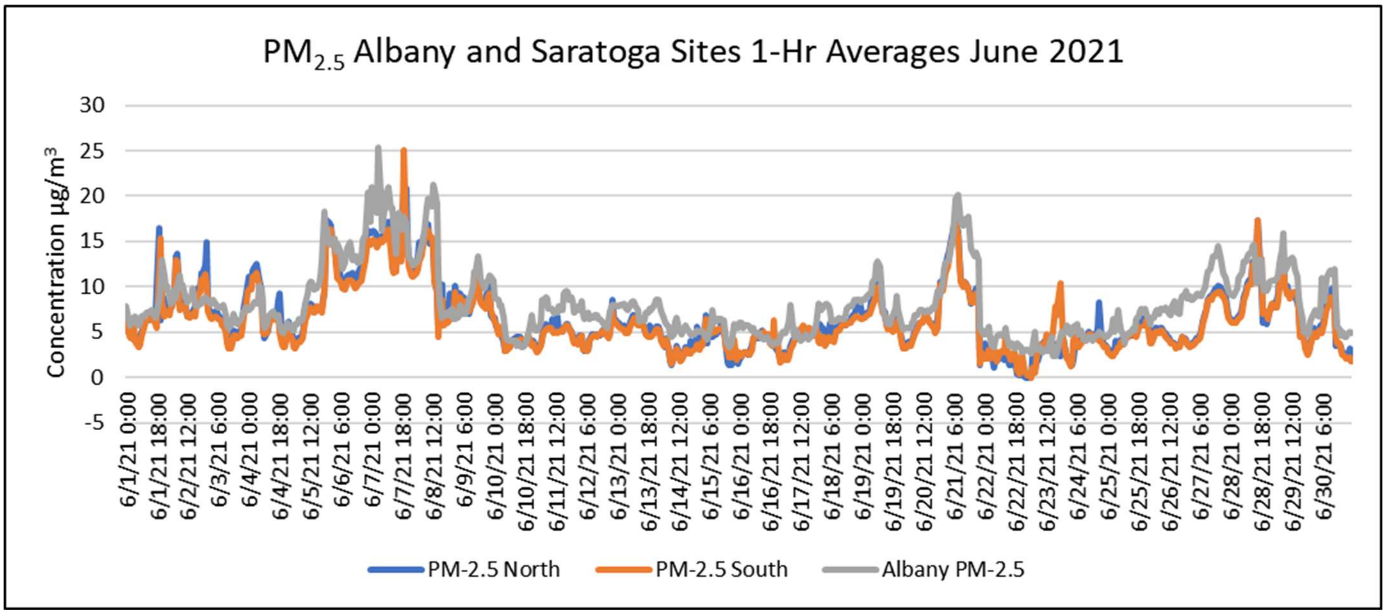

Figure 25. $PM_{2.5}$ June 2021, Saratoga North and South Sites compared to Albany

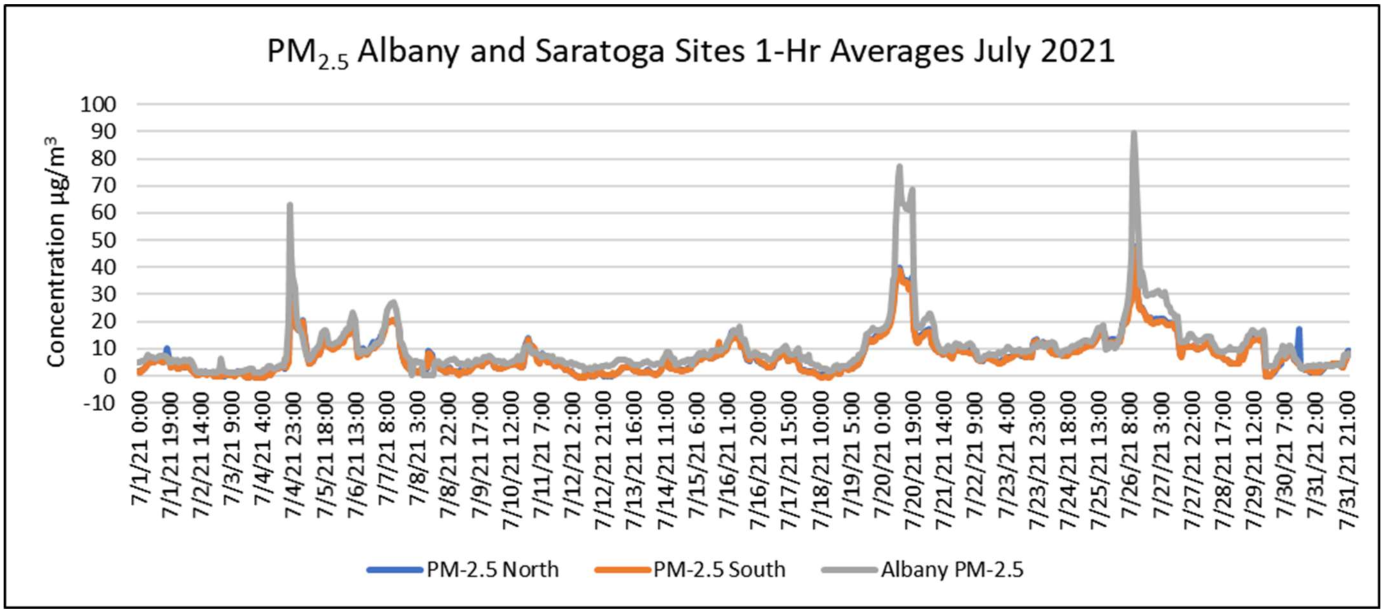

Figure 26. $PM_{2.5}$ July 2021, Saratoga North and South Sites compared to Albany

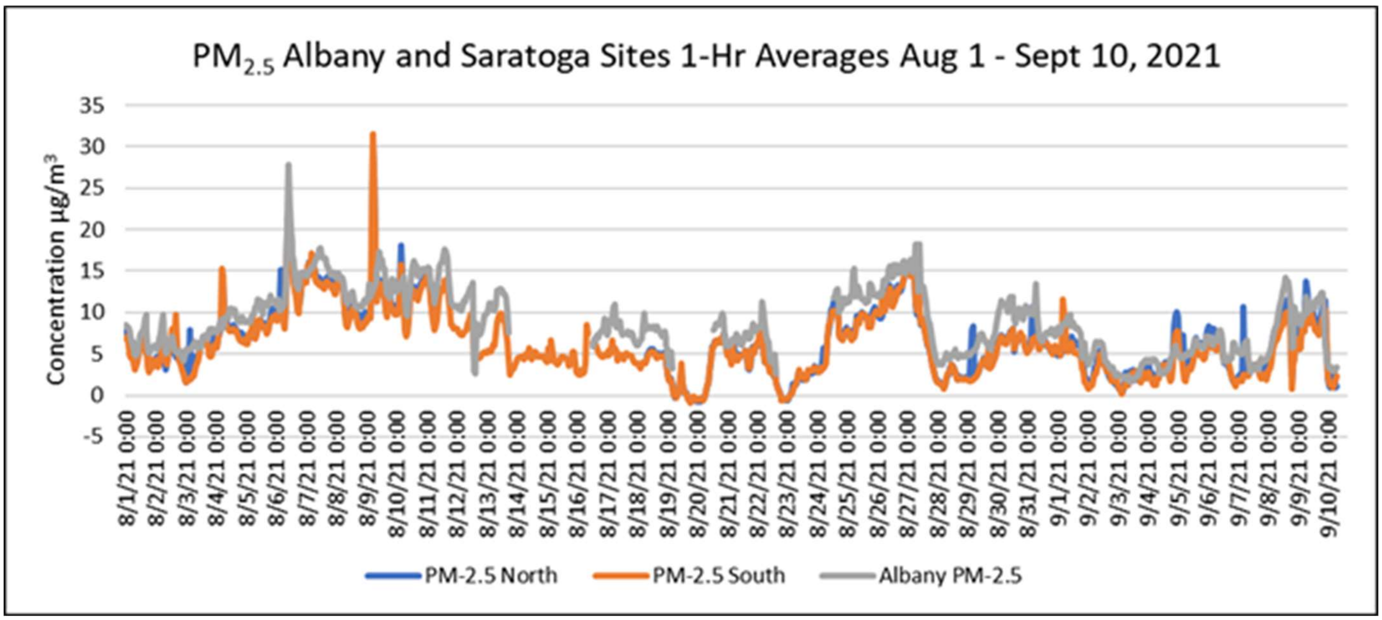

Figure 27. $PM_{2.5}$ August – September 10, 2021, Saratoga North and South Sites compared to Albany

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