Appendix D
2007 CRRNOS Study

PM_4 Crystalline Silica and PM_{10} Particulate Matter Emission Factors for Aggregate Producing Sources

2005 and 2006 Test Programs, Combined Report

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ACRONYMS

ACF	Actual Cubic Feet
ACFM	Actual Cubic Feet per Minute
AP42	U.S. EPA AP42 Emission Factor Database available at www.gov/epa/ttn
CAPCOA	California Air Pollution Control Officers Association
CARB	California Air Resources Board
CFR	Code of Federal Regulations
CRRNOS	Coalition for the Responsible Regulation of Naturally Occurring Substances
CS	Crystalline Silica
CTP	Conveyor Transfer Point
EPA	U.S. Environmental Protection Agency
C	Crusher
FRM	Federal Reference Method
MDAQMD	Mojave Desert Air Quality Management District
NSSGA	National Stone, Sand & Gravel Association
NIOSH	National Institute for Occupational Health and Safety
NIST	National Institute of Standards and Technology
OEEHA	Office of Environmental Health Hazard Assessment
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
R&P	Rupprecht & Patashnick, Inc.
REL	Reference Exposure Limit
RJL	R. J. Lee Group, Inc.
TEOM	Tapered Element Oscillating Microbalance
VMT	Vehicle Miles Traveled
VS	Vibrating Screen

Units of Measure

Micrometers	One millionth of a meter
mph	Miles per hour
Tons	Mass equal to 2,000 pounds
$\mu g/M^3$	Micrograms per cubic meter

1. SUMMARY

1.1 Purpose and Scope

This test program was sponsored by the Coalition for the Responsible Regulation of Naturally Occurring Substances ("CRRNOS") and was conducted by Air Control Techniques, P.C. in accordance with the test protocol dated July 20, 2005 provided in advance to the California Air Resources Board ("CARB") and the California Air Pollution Control Officers Association ("CAPCOA"). The primary purpose of this test program was to accurately measure PM_4 crystalline silica particulate matter emissions at representative sources at aggregate producing facilities. These data are needed by operators of crushed stone, sand & gravel plants, and other mineral extraction processes to confirm compliance with the Chronic Reference Exposure Level ("REL") for ambient crystalline silica exposure that was adopted February 10, 2005 by the California Office of Environmental Health Hazard Assessment ("OEHHA"). The REL applies to respirable particulate matter having an aerodynamic diameter of 4 micrometers as measured by NIOSH Method 0600 or methods having an equivalent particle size capture efficiency relationship.

Three test programs were conducted from October 2005 through September 2006. During October 17 - 28, 2005, tests were conducted at the Service Rock Products, Inc. Plant in Barstow, California. The sources tested at Barstow included (1) a 16 x 5-foot flat vibrating screening operation, (2) a short-head crusher, and (3) a conveyor transfer point. Emission factor tests were also conducted on a section of unpaved road between the quarry and the primary crusher. In September 2006, tests were conducted at the Carroll Canyon plant operated by Vulcan Materials, Inc. near San Diego, California. The equipment tested at Carroll Canyon included (1) a 16 x 8-foot flat vibrating screen, (2) a set of two cone crushers, and (3) a conveyor transfer point. Upwind and downwind ambient PM_4 crystalline silica monitoring was conducted at Carroll Canyon. In September 2006, tests were also conducted at the Vernalis Plant operated by Teichert Aggregates, Inc. near Tracy, California. The sources tested at Vernalis include (1) a 20 by 8-foot triple deck sloped vibrating screen, (2) a set of two cone crushers, and (3) a conveyor transfer point. Upwind and downwind ambient PM_4 crystalline silica monitoring was also conducted at Vernalis.

The scope of the programs at each of these three facilities included PM_{10} emission factor tests on the crushers, vibrating screens, and conveyor transfer points. The purpose of collecting PM_{10} data was to provide a comparison of measured PM_4 crystalline silica emissions with measured PM_{10} emissions.

The PM_4 crystalline silica emission factor tests were conducted using Rupprecht & Patashnick ("R&P") Model 2000 FRM $PM_{2.5}$ monitors meeting 40 CFR Part 50, Appendix L requirements and specially modified to adjust the particle size cut from 2.5 to 4.0 micrometers. The filter media were also modified from the Appendix L specifications to allow for crystalline silica quantification in accordance with NIOSH Method 7500. The performance capabilities of this measurement technique were summarized by Air Control Techniques, P.C. in a report dated July 13, 2005 and provided to CRRNOS, CARB, and CAPCOA in advance of this test program. The emissions from the process equipment were captured in sampling arrays designed in accordance with U.S. EPA Method 5D.

The PM_4 crystalline silica ambient concentrations were also measured using Rupprecht & Patashnick ("R&P") Model 2000 FRMs adjusted for PM_4 monitoring. These instruments were operated for 24 hours and obtained sample volumes of 16 cubic meters. The filter samples were weighed at R.J. Lee Group, Inc. ("RJL") using a microbalance and analyzed for crystalline silica using NIOSH Method 7500.

The PM_{10} emission concentrations were measured during the Barstow Study using a R&P Model 1400A tapered element oscillating microbalance ("TEOM") operated in accordance with EPA Reference Method IO-1.3. The PM_{10} emission concentrations in the Carroll Canyon and Vernalis Studies were measured with a R&P Model 2000 FRM modified for PM_{10} monitoring. Both the Model 1400A TEOM and the Model 2000 FRM were operated in accordance with EPA reference methods and provide equivalent PM_{10} concentrations. The PM_{10} emission concentrations were measured in the same sample gas stream as the PM_4 emission concentrations during all three of the studies.

This test report presents the emission factor test results, the aggregate characteristics, the process operating data, and the meteorological conditions during the test programs.

1.2. Emission Factor Test Results

The PM_{10} particulate matter, PM_4 particulate matter, and PM_4 crystalline silica emission factors for the equipment sources tested are presented in Tables 1-1a through 1-1c. The average values based on all three sets of data are provided in Table 1-1d.

Table 1-1a. PM_{10}, PM_4, and PM_4 Crystalline Silica Emission Factors, Barstow

Equipment Tested	Emission Factor	Emission Factor Values, Lbs/Ton of Stone Throughput		
		Measured Value	Ambient Upwind Equivalent[2]	Emission Factor
Vibrating Screen	PM_{10}	0.000167[1,3]	N/A	0.000167[1,3]
	PM_4	0.000079[3]	N/A	0.000079[3]
	PM_4 Crystalline Silica	0.000006[3]	N/A	0.000006[3]
Crusher	PM_{10}	0.002753	0.000172	0.002581
	PM_4	0.001442	0.000172	0.001270
	PM_4 Crystalline Silica	0.000111	0.000028	0.000083
Conveyor Transfer Point	PM_{10}	0.000625	0.000050	0.000575
	PM_4	0.000402	0.000050	0.000352
	PM_4 Crystalline Silica	0.000035	0.000006	0.000029

1. PM_{10} emission factors were calculated based on TEOM Data.
2 Ambient levels of PM_4 particulate matter and PM_4 crystalline silica upwind of the units tested were subtracted from the emission factors to account for material not emitted by the source.
3. Ambient levels of particulate matter and crystalline silica upwind of the vibrating screens were not subtracted due to the fact that the upwind monitors were below the elevation of the screens; therefore, the air quality at this elevation was not representative of air quality on the inlet side of the screen.

Table 1-1b. PM_{10}, PM_4, and PM_4 Crystalline Silica Emission Factors, Carroll Canyon				
Equipment Tested	Emission Factor	Emission Factor Values, Lbs/Ton of Stone Throughput		
		Measured Value	Ambient Upwind Equivalent	Emission Factor
Vibrating Screen	PM_{10}	0.000930	0.000100	0.000831
	PM_4	0.000386	0.000029	0.000356
	PM_4 Crystalline Silica	0.000048	0.000001	0.000046
Crusher	PM_{10}	0.001271	0.000039	0.001232
	PM_4	0.000611	0.000017	0.000593
	PM_4 Crystalline Silica	0.000099	0.000002	0.000098
Conveyor Transfer Point	PM_{10}	0.000552	0.000026	0.000525
	PM_4	0.000245	0.000009	0.000236
	PM_4 Crystalline Silica	0.000031	0.00000	0.000031

Table 1-1c. PM_{10}, PM_4, and PM_4 Crystalline Silica Emission Factors, Vernalis				
Equipment Tested	Emission Factor	Emission Factor Values, Lbs/Ton of Stone Throughput		
		Measured Value	Ambient Upwind Equivalent	Emission Factor
Vibrating Screen	PM_{10}	0.001754	0.000061	0.001693
	PM_4	0.000888	0.000006	0.000882
	PM_4 Crystalline Silica	0.000083	0.000002	0.000081
Crusher	PM_{10}	0.001767	0.000089	0.001677
	PM_4	0.000788	0.000021	0.000767
	PM_4 Crystalline Silica	0.000110	0.000001	0.000110
Conveyor Transfer Point	PM_{10}	0.001193	0.000103	0.001090
	PM_4	0.000476	0.000019	0.000457
	PM_4 Crystalline Silica	0.000088	0.000003	0.000085

The plant-to-plant differences in PM_4 crystalline silica emission factors are due primarily to the crystalline silica content of the material being handled. As indicated in Figure 1-1 and Figure 1-2, the bulk material crystalline silica content is responsible for most of the variance in the data. It is important to note, however, that due to the small number of test values (three), it is not possible to demonstrate that the relationship between PM_4 crystalline silica emission factors and bulk crystalline silica content is significant at the 90% confidence level.

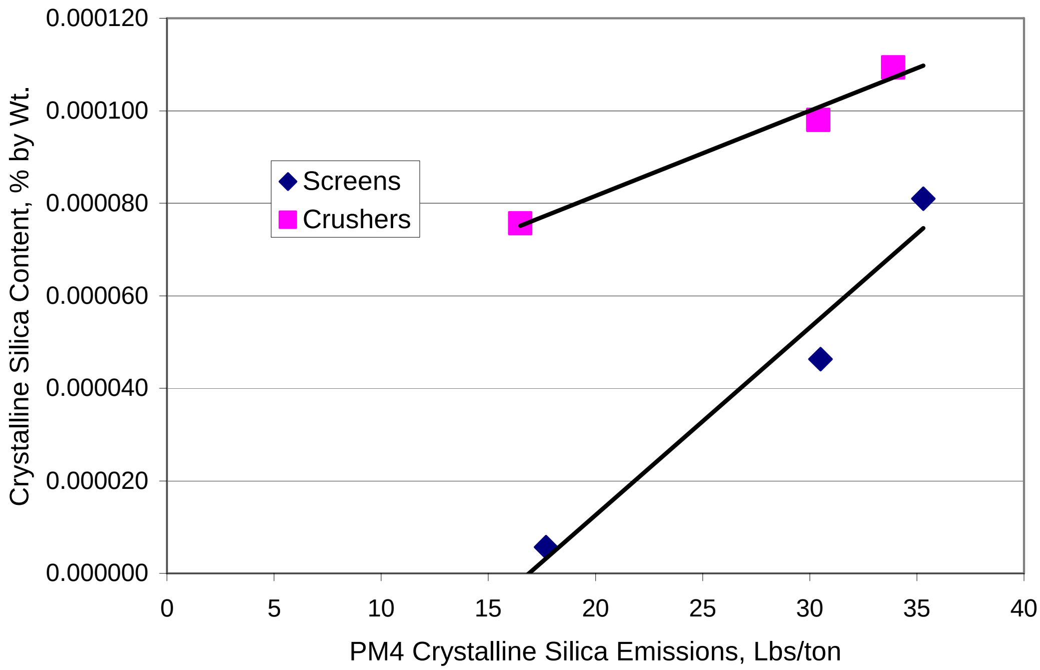

Figure 1-1. Relationship Between PM$_4$ Crystalline Silica Emission Factors and Bulk Material Crystalline Silica Concentrations, Crushers and Screens

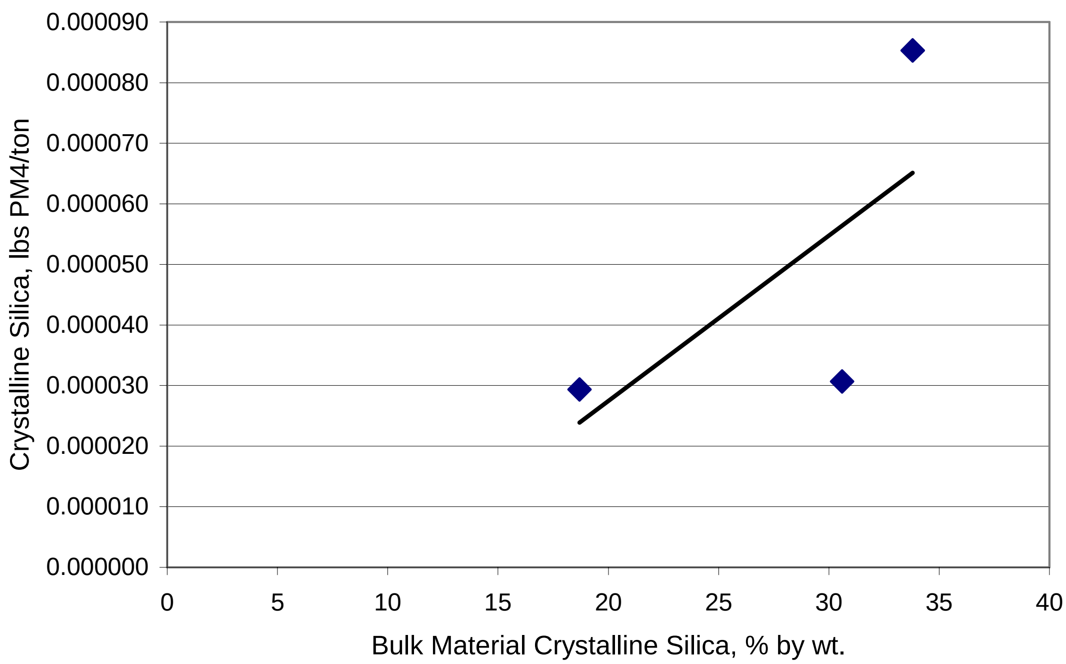

Figure 1-2. Relationship Between PM$_4$ Crystalline Silica Emission Factors and Bulk Material Crystalline Silica Concentrations, Conveyor Transfer Points

A less consistent relationship was observed for the conveyor transfer point tests. The emission factor value for the Carroll Canyon Plant (30.5% crystalline silica point in Figure 1-2) is believed to be reduced due to the high aggregate throughput of this unit. At very high throughputs, some of the stone in the flowing material stream is shielded from attrition and, therefore, does not contribute to emissions. Despite this one test value, there appears to be a relationship between PM_4 crystalline silica emission factors and the crystalline silica content of the bulk material.

The relationships observed between material crystalline silica content and the PM_4 crystalline silica emissions suggest that the emission factors could be expressed in an equation form that includes crystalline silica content as the main, and perhaps only, independent variable. Equations 1-1 through 1-3 provide a possible form for these emission factor expressions.

Screen PM_4 Crystalline Silica, Lbs/Ton = CS * (4 x 10^{-6}) - 7 x 10^{-5} Eqn. 1-1

Crusher PM_4 Crystalline Silica, Lbs/Ton = CS * (2 x 10^{-6}) + 4 x 10^{-5} Eqn. 1-2

Conveyor PM_4 Crystalline Silica, Lbs/Ton = CS * (3 x 10^{-6}) - 3 x 10^{-5} Eqn. 1-3

Where CS = Bulk Material Crystalline Silica Content, % by Weight

There equations adequately describe the results of the emission factor tests within the ranges of the bulk material crystalline silica concentrations at these plants.

An alternative approach for summarizing the PM_4 crystalline silica concentrations is to compile average values for the data sets for the crushers, screens, and conveyor transfer points tested. Average values are provided in Table 1-1d based on the data from the three plants provided in Tables 1-1a, b, and c.

Table 1-1d. Average Emission Factors
Barstow, Carroll Canyon, and Vernalis Combined Data Set

Source	Analyte	Emissions, Pounds/Ton
		Average
Vibrating Screen	PM_{10}	0.00090
	PM_4	0.00044
	PM_4 Crystalline Silica	0.000044
Crusher	PM_{10}	0.00183
	PM_4	0.00088
	PM_4 Crystalline Silica	0.000097
Conveyor Transfer Point	PM_{10}	0.00073
	PM_4	0.00035
	PM_4 Crystalline Silica	0.000048

The emission factors measured for the unpaved industrial haul road are presented in Table 1-2. Unpaved roads were tested only at the Barstow Plant.

Table 1-2. Haul Road PM_4 Crystalline Silica and PM_4 Emission Factors, Barstow		
Equipment Tested	Emission Factor Size Range	Pounds of Emission per VMT[1]
Haul Road	$\leq$ 4 Micrometers	0.624
Haul Road	$\leq$ 4 Micrometers Crystalline Silica	0.035

1. VMT - vehicle miles traveled

The crystalline silica fraction of the total PM_4 is summarized in Table 1-3. These data demonstrate that the crystalline silica content of the PM_4 material is considerably lower than the crystalline silica content measured in the bulk samples recovered from each unit tested. Based on an average of the tests at the three plants, the PM_4 crystalline silica content is 44% of the bulk material crystalline silica content. It is apparent that the crystalline silica content of the rock is not as prone to attrition size reduction as other constituents in the aggregate.

Table 1-3. Crystalline Silica Fraction of PM_4 Particulate Matter			
Plant	Source	Crystalline Silica Content, % wt of Total PM_4	Crystalline Silica Content, % wt of Material Samples
Barstow	Screen	7.5	17.5
	Crusher	6.5	16.5
	Conveyor Transfer Point	8.3	18.7
	Unpaved Industrial Road	5.4	16.5
	Average	6.9	17.3
Carroll Canyon	Screen	12.5	30.5
	Crusher	15.4	30.4
	Conveyor Transfer Point	12.8	30.6
	Average	13.6	30.5
Vernalis	Screen	9.6	35.3
	Crusher	21.9	33.9
	Conveyor Transfer Point	18.4	33.8
	Average	16.6	34.3

The process equipment and haul road PM_4 crystalline silica emission factors are intended for use as input data to dispersion models to evaluate annual average PM_4 concentrations at plant fence lines. For process equipment, the PM_4 crystalline silica emission factors compiled in this study are compared directly in Table 1-4 with the PM_{10} emission factors measured simultaneously. As indicated in this table, the crystalline silica PM_4 emission factors range from 3.21% to 7.95% of the PM_{10} emission factors. This is a useful ratio because it compares the PM_4 crystalline silica emissions with PM_{10} emissions for which data are often available.

Table 1-4. Comparison of Measured PM_{10} Emission Factors and PM_4 Crystalline Silica Emission Factors[2]

Source	Plant	PM_{10} Emission Factors lbs/ton[1]	Crystalline Silica PM_4 Factors Lbs/ton	Ratio, % PM_4 Crystalline Silica to PM_{10}	Bulk Material Crystalline Silica, % by wt.	Ratio, % PM_4 Crystalline Silica to PM_{10} Normalized to 25% Crystalline Silica
Screen	Barstow	0.000167	0.000006	3.59	17.5	5.13
	Carroll Canyon	0.000831	0.000046	5.54	30.5	4.54
	Vernalis	0.001693	0.000081	4.78	35.3	3.39
Crusher	Barstow	0.002581	0.000083	3.21	16.5	4.86
	Carroll Canyon	0.001232	0.000098	7.95	30.4	6.54
	Vernalis	0.001677	0.00011	6.56	33.9	4.84
Conveyor Transfer Point	Barstow	0.000575	0.000029	5.04	18.7	6.74
	Carroll Canyon	0.000525	0.000031	5.90	30.6	4.82
	Vernalis	0.00109	0.000085	7.80	33.8	5.77

1. Factors shown are for controlled conditions.
2. PM_{10} emission factors were not measured for the industrial unpaved road.

The ratio between the PM_4 crystalline silica emission factor and the PM_{10} emission factor have been normalized to a 25% crystalline silica level in the column shown on the far right in Table 1-4. The 25% crystalline silica level is the approximate mean of the entire data set for the three plants tested. This ratio ranges from 3.39% to 6.74%. The average normalized value for the screen tests was 4.4%. The normalized values for the crusher and conveyor transfer point tests were 5.4% and 5.8% respectively.

The ratio between the PM_4 crystalline silica emissions and the PM_{10} emissions appears to be strongly dependent on the crystalline silica content of the bulk material. This is illustrated in Figure 1-3 for screening operations, crushers, and conveyor transfer points respectively.

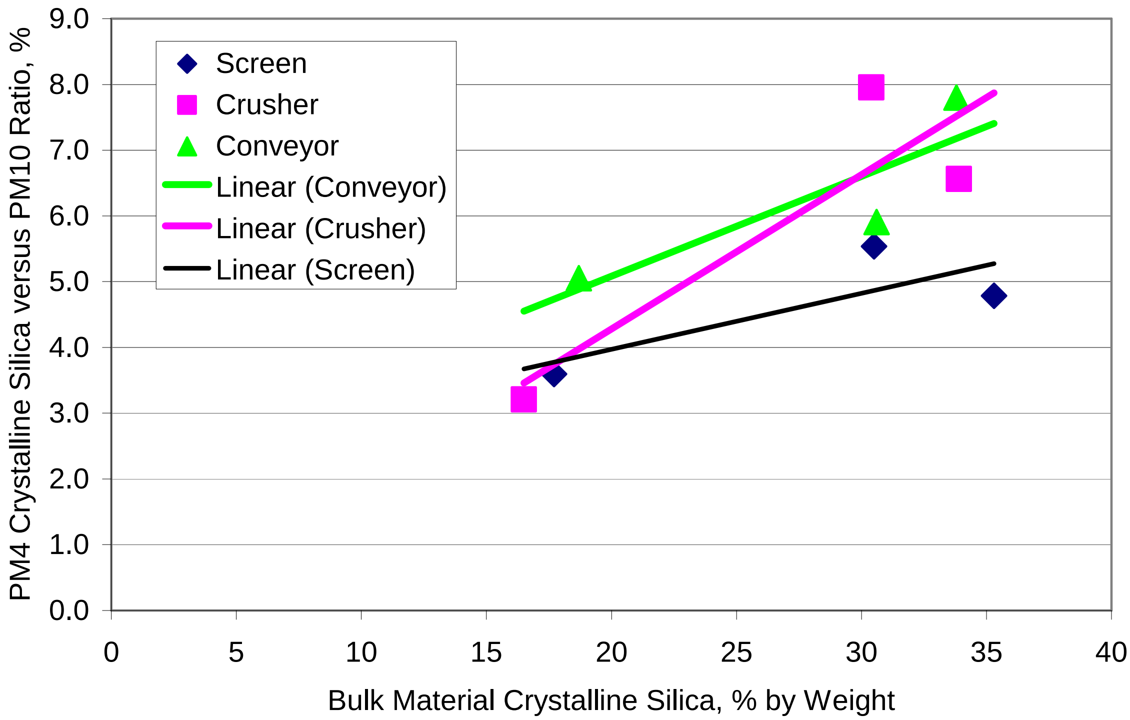

Figure 1-3. PM_4 Crystalline Silica Versus PM_{10} Ratio as a Function of the Bulk Crystalline Silica Concentration

The quality assurance requirements associated with the test methods used in these three studies were achieved. The fugitive dust capture system provided an effective means to sample fugitive dust emissions without influencing the emission rate, obstructing the operator's view of the process equipment, or creating safety issues.

The purpose of the crystalline silica testing was to evaluate the ratio of crystalline silica emissions to PM_{10} emissions during a limited series of short-term tests on a variety of equipment at "as found" operating and meteorological conditions. The measured PM_{10} emissions measurements in this report may or may not be representative of long-term operations under a variety of operating and meteorological conditions. However, the ratio of measured PM_4 crystalline silica emissions to measured PM_{10} emissions obtained from this test series, once found to be reproducible for the variety of conditions within this group of tests, can be applied to other operating and meteorological conditions as needed.

Ambient concentrations of PM_4 crystalline silica were measured during three consecutive 24-hour periods at the Carroll Canyon and Vernalis Plants. Two collocated R&P FRM monitors modified for PM_4 crystalline silica measurement were placed at a location downwind of the quarry and processing equipment. A single R&P FRM instrument for PM_4 crystalline silica monitoring was placed at a location upwind of the entire facility being tested. Meteorological monitoring stations were placed at both the upwind and downwind locations. The results of the ambient monitoring tests demonstrated that the plants operated at levels well below the 3 microgram per cubic meter REL value. These results are summarized in Tables 1-5a and 1-5b for the Carroll Canyon and Vernalis plants respectively.

Table 1-5a. Plant Upwind-Downwind Ambient Monitoring, Carroll Canyon			
Date	PM_4 Crystalline Silica, µg/M^3		
	Upwind	Downwind (Primary)	Downwind (Collocated)
September 17	1.3	1.1	1.0
September 18	1.4	0.7	0.8
September 19	0.6	0.5	0.4

Table 1-5b. Plant Upwind-Downwind Ambient Monitoring, Vernalis			
Date	PM_4 Crystalline Silica, µg/M^3		
	Upwind	Downwind (Primary)	Downwind (Collocated)
September 24	0.8	0.6	0.9
September 25	2.8	0.9	0.8
September 26	2.5	0.0	1.2

The differences between the upwind and downwind ambient PM_4 crystalline silica concentrations are small. The slightly higher upwind values observed during several of the test days are believed to be due to emissions from unpaved roads leading to or near the upwind monitoring sites. Based on the downwind concentration data, it is apparent that most of the localized ambient PM_4 crystalline silica on the upwind sides of the facilities settled to the ground during movement of ambient air over the facility.

2. TEST PROGRAM DESCRIPTION

2.1 Emission Factors Measurement Procedures

The PM_4 crystalline silica emission concentrations were measured using Rupprecht and Patashnick (R&P) Model 2000 FRMs[1] modified to have a 50% cut point of 4 micrometers rather than 2.5 micrometers. This monitoring method was developed in accordance with a protocol submitted to the California Air Resources Board in July 2005. The results of method confirmation tests are provided in a separate report. This method is considered an extension of the $PM_{2.5}$ ambient monitoring procedures specified in 40 CFR Part 50, Appendix L procedures.

Fugitive PM_{10} particulate matter concentrations from the process equipment sources tested in Barstow were measured using an R&P tapered element oscillating microbalance (TEOM) in accordance with EPA Reference Method IO-3. For the tests at Carroll Canyon and Vernalis the fugitive PM_{10} particulate matter concentrations were measured using Rupprecht and Patashnick (R&P) Model 2000 FRMs modified for PM_{10}.

Fugitive dust capture arrays designed based on U.S. EPA Method 5D (40 CFR Part 60, Appendix A) were mounted around the process equipment being tested. The mass fluxes of PM_4 and PM_{10} fugitive particulate matter through the arrays were determined by multiplying the ambient wind speed by the measured PM_4 and PM_{10} concentrations.

2.2 Test Site Selection

Prior to the 2005 tests, CRRNOS and CARB jointly selected the jurisdiction of the Mojave Desert Air Quality Management District ("MDAQMD") for the test program. After visits to a number of facilities in the MDAQMD area, Air Control Techniques, P.C. recommended that these tests be conducted at the Service Rock Products, Inc. Plant in Barstow, California.

During the 2006 test program, CRRNOS determined that the plants to be sampled should be in Southern California and in the Central Valley area. Air Control Techniques, P.C. visited a number of facilities in these areas and selected the Carroll Canyon Plant of Vulcan Materials, inc. and the Vernalis Plant of Teichert Aggregates, Inc.

The following selection criteria were applied by CRRNOS and Air Control Techniques, P.C. in selecting all three facilities tested.

Process Equipment

- The plant must have a vibrating screen, crusher, and conveyor transfer point that are configured to allow for the positioning of large sampling arrays immediately downwind of each unit.
- The process equipment must handle aggregate materials having crystalline silica contents and material size distributions that are representative of a large number of facilities in California.

[1] The term "FRM" is part of the registered name of the instrument. The term means "Federal Reference Method."

- The process equipment must be representative of crushers, screens, and conveyor transfer points at a large number of facilities in California.
- The annual material throughput of the process equipment being tested must be greater than 300,000 tons per year.
- There must be safe access to the sampling areas for Air Control Techniques, P.C. test personnel, CRRNOS representatives, and MDAQMD observers.
- It must be possible to quantify the material throughput through the specific process units being tested with an accuracy of plus or minus 10%.
- The process equipment must be controlled with wet suppression techniques that are reasonably representative of other facilities in California.

Industrial Unpaved Haul Road

- There must be a straight section of the unpaved road that is oriented properly with respect to the prevailing winds.
- The road segment must be relatively free of flow disturbances.
- The road surface must have crystalline silica contents and silt levels that are representative of a large number of facilities in California.
- The road section must be located in an area within the facility that is not subject to unusual upwind fugitive dust concentrations that would complicate the accurate measurement of emission factors.
- The road section must be controlled with fugitive dust control techniques that are reasonably representative of other facilities in California.
- The road section must have a traffic volume of a minimum of twenty vehicles per hour for a minimum of eight hours during work-week days.

All three plants tested as part of this test program satisfied these selection criteria. Table 2-1 outlines the crystalline silica levels at the tested facilities.

Table 2-1. Crystalline Silica Levels		
Plant	Source	Average Crystalline Silica Content of Material Samples % by weight[1]
Barstow	Screen < 200 mesh	17.7
	Crusher < 200 mesh	16.5
	Transfer Point < 200 mesh	18.7
	Haul Road < 200 mesh[1]	16.5
Carroll Canyon	Screen < 200 mesh	30.5
	Crusher < 200 mesh	30.4
	Transfer Point < 200 mesh	30.6
Vernalis	Screen < 200 mesh	35.3
	Crusher < 200 mesh	33.9
	Transfer Point < 200 mesh	33.8

[1]. R.J. Lee analysis of minus 200 mesh samples.

2.3 Process Equipment Emission Factor Testing Procedures

Air Control Techniques, P.C. measured process equipment PM_4 crystalline silica emissions using sampling arrays designed based on EPA Method 5D (40 CFR Part 60, Appendix A). The following criteria were used in designing the arrays.

- The capture system must not create higher-than-actual PM_4 and PM_{10} emission rates due to high gas velocity conditions near the point of PM_4 and PM_{10} particle entrainment.
- The capture system must not result in the deposition of PM_4 and PM_{10} particulate matter in the sampling array ducts leading to the particulate matter monitors.
- The capture system must isolate the process equipment unit being tested from other adjacent sources of PM_4 and PM_{10} emissions to the maximum extent possible.
- The capture system must not create safety hazards for the emission test crew or for plant personnel. It must not create risks to the plant process equipment.
- The capture system and overall test procedures must be economical, practical, and readily adaptable to other plants so that these tests can be repeated by organizations wishing to verify the emission factor data developed in this project.

These arrays were closely coupled to the process equipment source being tested. Due to the open structure of the arrays, they did not block wind flow through the process equipment where fugitive emissions originate. Accordingly, the arrays did not influence the rate of fugitive dust emission. The open structure of the array also allowed the plant operator to visually monitor process operating conditions. Air Control Techniques, P.C. believes that this fugitive dust capture technique provides the most accurate means possible to quantify fugitive dust emissions without affecting the rate of fugitive dust emission and without interfering with safe plant operations.

The ambient airflow rate through each array was calculated based on the ambient wind speed and direction. The adequacy of fugitive dust capture by the array was documented on a continuous basis using (1) visible wind direction indicators and (2) a nephelometer continuous particulate matter concentration analyzer used on an intermittent basis in areas both inside and outside of the array. A schematic of these arrays is provided in Figure 2-1.

Fugitive PM_{10} particulate matter concentrations from the process equipment sources tested in Barstow were measured using an R&P tapered element oscillating microbalance (TEOM) in accordance with EPA Reference Method IO-3. For the tests at Carroll Canyon and Vernalis the fugitive PM_{10} particulate matter concentrations were measured using Rupprecht and Patashnick (R&P) Model 2000 FRMs modified for PM_{10}. The PM_{10} emission factors were calculated based on (1) the mass concentration of PM_{10} particulate matter in the sample gas stream, (2) the ambient air flow rate through the sampling arrays being used to capture the sample gas stream, and (3) the aggregate throughput rate of the process equipment being tested.

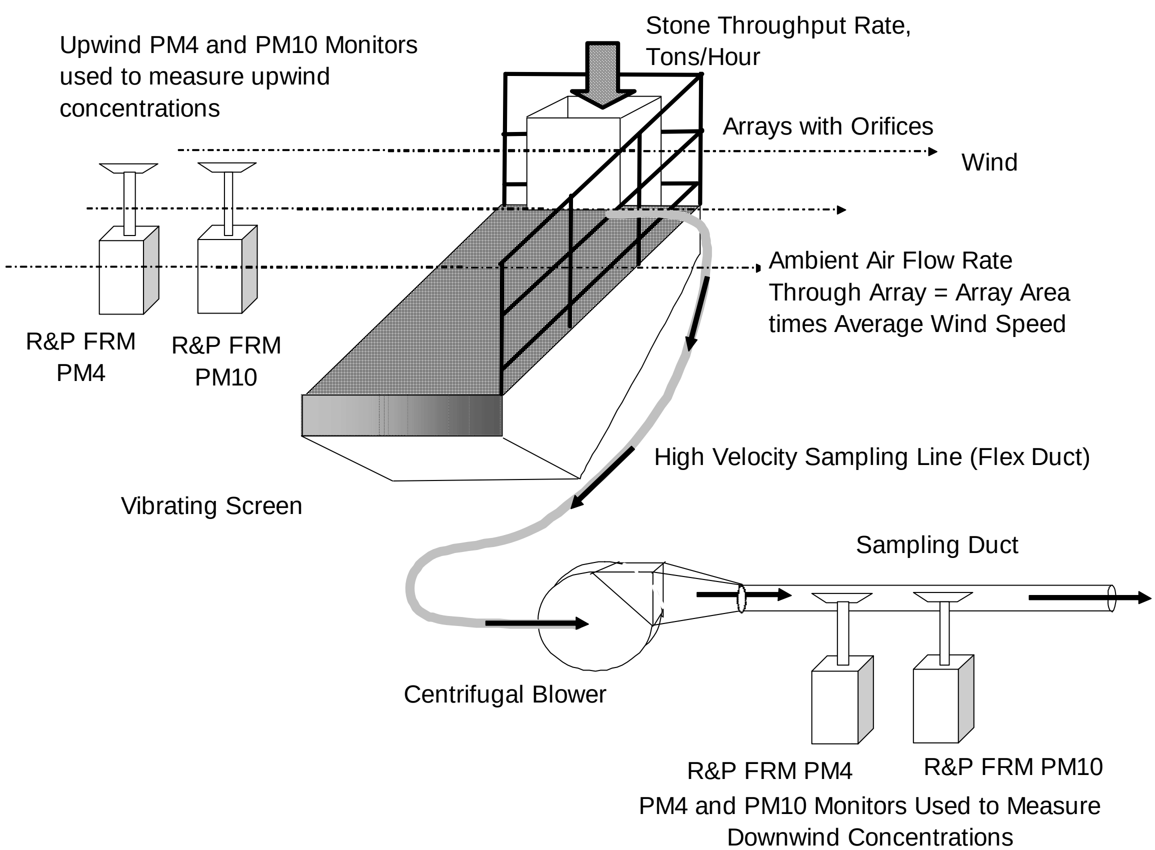

Figure 2-1. Sampling System Schematic

An R&P FRM 2000 modified to collect PM_4 was used to sample the gas stream from the arrays, which were closely coupled to the fugitive dust source being tested. After gravimetric analysis, the PVC filter samples from the R&P instruments were analyzed in accordance with

NIOSH Method 7500 to quantify the crystalline silica content. The PM_4 crystalline silica emission factors were calculated based on (1) the concentration of crystalline silica in the PM_4 particulate matter catch, (2) the mass concentration of PM_4 particulate matter in the sample gas stream, (3) the ambient or upwind concentration of crystalline silica in the ambient PM_4 particulate matter catch, (4) the mass concentration of ambient or upwind PM_4 particulate matter, (5) the ambient air flow rate through the sampling arrays, and (6) the aggregate throughput rate of the process equipment during each test run.

Air Control Techniques, P.C. had calculated that a sampling time of 1 to 3 hours would be required in order to meet the minimum detection limits of NIOSH 7500 for crystalline silica during tests on the process equipment. These sampling time estimates were based on (1) PM_{10} TEOM particulate matter concentration data, (2) the NIOSH Method 7500 detection limit of 5 micrograms, (3) the R&P FRM 2000 sample gas flow rate of 11.1 liters per minute that was used to collect PM_4, and (4) the estimated crystalline silica content of the stone material being processed. Crystalline silica was detected in all but one filter sample, which confirmed the adequacy of the 1 to 3 hour sampling periods used in the study.

2.4 Fugitive Emission Sampling Arrays

Air Control Techniques, P.C. used a set of sampling arrays mounted vertically along the downwind sides of the vibrating screen, crusher, and conveyor transfer point being tested. The arrays for the vibrating screens, tertiary crushers and conveyor transfer points were mounted within five feet of the locations of particulate matter entrainment by ambient air. Due to this close spacing of the arrays to the source, the "plume" did not have time to disperse substantially in either the horizontal or vertical direction. Accordingly, the dispersing particulate matter from the sources was fully sampled even as the ambient winds shifted direction within an angle of approximately 90 degrees.

There were more than one hundred sampling points in each array set. This substantially exceeds the thirty sampling points specified in U.S. EPA Method 5D for the testing of open top sources. The area monitored by the sampling array exceeded the area subject to dispersion of the uncaptured particulate matter mounted on the downwind side of the process unit being tested. Each array consisted of manifolds having equally spaced nozzles for air sampling. The gas transport velocities through all sampling tubes and ductwork were maintained at a minimum of 3,200 feet per minute to prevent any gravitational settling of dust. Air Control Techniques, P.C. believes that this transport velocity was prudent even though the terminal settling velocities for PM_4 particulate matter are extremely slow. The sampling manifolds and ductwork were visually inspected after each test run. Method 22 visual observations and intermittent nephelometer particulate matter concentration tests were conducted during the test runs to confirm that fugitive emissions from the process equipment being tested were passing through the sampling arrays. Table 2-2 outlines the array specifications for each piece of equipment tested.

Each of the array sampling manifolds was ducted together to yield a single sample gas stream. This gas stream was directed into a round duct 12 inches in diameter with sampling ports for an R&P FRM 2000 (modified for PM_4) sampling head and an R&P PM_{10} TEOM sampling head. This duct size is the minimum necessary to accommodate the relatively large inlet heads for the R&P FRM 2000 and the TEOM. The gas velocity through the portion of the duct with the sampling ports for the monitoring instruments was maintained at less than 10 mph to be consistent with typical ambient wind velocities.

Table 2-2a. Process Equipment Array Specifications, Barstow

Enclosure	Area of Array, Square Feet	Number of Sample Nozzles in Array	Air Flow Rate in Array Duct, ACFM	Diameter of Array Duct, Inches	Gas Velocity in Array Duct, FPM
Vibrating Screen	64	195	96	1	4,018
Crusher	56	243	99	1	5,180
Conveyor Transfer Point	56	300	84	1	4,395

Table 2-2b. Process Equipment Array Specifications, Carroll Canyon

Enclosure	Area of Array, Square Feet	Number of Sample Nozzles in Array	Air Flow Rate in Array Duct, ACFM	Diameter of Array Duct, Inches	Gas Velocity in Array Duct, FPM
Vibrating Screen	150	650	165	1	7,151
Crusher	148	650	168	1	4,854
Conveyor Transfer Point	96	650	159	1	6,884

Table 2-2c. Process Equipment Array Specifications, Vernalis

Enclosure	Area of Array, Square Feet	Number of Sample Nozzles in Array	Air Flow Rate in Array Duct, ACFM	Diameter of Array Duct, Inches	Gas Velocity in Array Duct, FPM
Vibrating Screen	120	650	154	1	6,662
Crusher	285	585	171	1	3,290
Conveyor Transfer Point	48	650	159	1	6,884

A centrifugal blower used at Barstow maintained gas flow through the sampling arrays to the instrument sampling locations. This blower was capable of delivering a sample gas flow rate of approximately 100 actual cubic feet per minute at static pressures of up to 20 inches water column. The blower was also capable of handling moderate-to-high dust loadings. A larger centrifugal blower was used in the tests at Carroll Canyon and Vernalis. This fan had an air flow capacity of approximately twice the fan used at Barstow.

The actual sample gas flow rates through the sampling arrays were set to provide near-isokinetic sampling velocities in the nozzles of the sampling arrays. The nozzles were sized to provide isokinetic sampling velocities equal to or lower than 110% at an average ambient wind speed of 5 mph. At isokinetic sampling rates below 100%, there is a slight bias to higher-than-true PM_4 concentrations due to the excessive inertia of the PM_4 particles; however, the isokinetic effect is small for PM_4 particles due to the extremely low mass per particle. Figures 2-2 and 2-3 show the combined sampling duct arrangement at Carroll Canyon. Similar sampling duct arrangements were used at Barstow and Vernalis. The position of the sampling head in the duct is shown in Figure 2-4.

Figure 2-2. Side View of Combined Sampling Duct, Carroll Canyon
(FRM 2000 PM_4 Monitor Left, PM_{10} TEOM Monitor Right)

Figure 2-3. View of Centrifugal Blower and Combined Sampling Duct, Carroll Canyon
(FRM 2000 PM_4 Monitor Center-Left, PM_{10} TEOM Left)

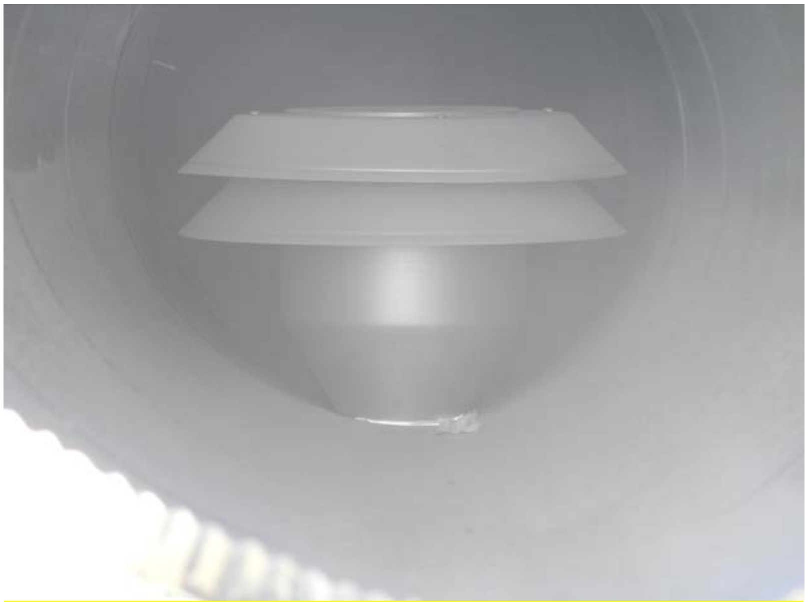

Figure 2-4. View of R&P PM_{10} TEOM Sampling Head in Combined Sampling Duct, Barstow

Barstow Plant

Vibrating Sizing Screens

The unit tested at the Service Rock Products, Inc. Barstow Plant is a 5-foot by 16-foot vibrating sizing screen. The screen serves a 4 ¼ foot short-head crusher. The stone material is fed into the vibrating sizing screen by a conveyor. Figures 2-5 and 2-6 show the vibrating sizing screen sampling array and the vibrating screen inlet.

Figure 2-5. Side View of Vibrating Sizing Screen Array, Barstow

Figure 2-6. View of Vibrating Sizing Screen Material Inlet, Barstow

Crusher

The crusher tested at the Service Rock Products, Inc. Barstow Plant is a 4 ¼ foot short-head tertiary crusher. The feed stream to the crusher is the oversized material discharged from the 5 foot by 16 foot vibrating sizing screen, which was also tested as part of this study. The crusher discharges the crushed stone material onto a conveyor. The stone is transferred from one conveyor to another conveyor and is then sent back to the vibrating sizing screen. The stone flow through this part of the Barstow plant is termed "closed circuit" because oversized material recirculates through the vibrating sizing screen and crusher until the stone is crushed small enough to fall through the vibrating sizing screen. Figures 2-7 and 2-8 show different views of the crusher sampling arrays.

Figure 2-7. Side View of Upper Crusher Array, Barstow

Figure 2-8. Close-up Side View of Crusher Lower Array, Barstow

Transfer Point

The transfer point tested at the Service Rock Products, Inc. Barstow Plant handles the material that has been sent through the crusher and vibrating screen closed loop. This material is then conveyed to a second and final sizing screen prior to shipment. The conveyor transfer point tested handles the material that is discharged from the first sizing screen. This conveyor transfer point sampling arrays are shown in Figures 2-9 and 2-10.

Figure 2-9 South Side View of Transfer Point, Barstow

Figure 2-10. View of Transfer Point and Upwind PM_4 Monitors, Barstow

Industrial Unpaved Roads

Air Control Techniques, P.C. used a conventional upwind downwind profiling technique to measure PM_4 crystalline silica emissions from the haul road section. Towers were set-up on both sides of the road to avoid the variable wind directional problem common due to the local meteorology in many parts of California. Each side could serve as the downwind side, depending on the wind direction. Each tower had an Appendix L-based PM_4 filter sampler to measure the PM_4 crystalline silica concentration. A mast with four sampling nozzles and lines arranged vertically was used to obtain an integrated sample of the upwind and downwind air steams at four discrete elevations above the road surface. The heights of the sample with nozzle intakes ranged from approximately 4 feet to 24 feet above the ground.

The differences between the upwind and downwind PM_4 crystalline silica concentrations have been used as a measure of the emissions from the vehicles. The emissions for the entire road section have been divided by the vehicle traffic measured in units of vehicle miles per test hour.

The tests were scheduled for a period of between 2 to 4-hours. A TEOM modified to serve as a continuous PM_4 monitor was also used on the upwind and downwind side of the road test section to provide an indication of the total PM_4 concentrations. These real time data were used to determine the actual runs times. The overall sampling array is illustrated in Figures 2-11 and 2-12.

Figure 2-11. View of Upwind Array with Downwind Array Behind the Haul Truck, Barstow

Figure 2-12. View of Upwind Array, Barstow

Carroll Canyon Plant

Vibrating Sizing Screens

The unit tested at the Carroll Canyon Plant is a 16-foot by 8-foot flat vibrating sizing screen. Oversized material from this screen is conveyed to the cone crusher included in this test program. The stone material is fed into the vibrating sizing screen by a conveyor. Figures 2-13 and 2-14 show different views of the vibrating sizing screen sampling arrays.

Figure 2-13. Side View of Vibrating Sizing Screen Array, Carroll Canyon

Figure 2-14. View of Vibrating Sizing Screen Material Inlet, Carroll Canyon

Crusher

A set of two cone crushers were tested at the Vulcan Materials Co. Carroll Canyon Plant. The crushers discharge the crushed stone material onto a conveyor. The discharge point onto this conveyor is controlled by a hood and a pulse jet fabric filter.

The stone is transferred from one conveyor to another conveyor and is then sent back to the vibrating sizing screen. The stone flow through this part of the Carroll Canyon Plant is termed “closed circuit” because oversized material recirculates through the vibrating sizing screen and crusher until the stone is crushed small enough to fall through the vibrating sizing screen. Figures 2-15 through 2-17 show different views of the crusher sampling arrays.

Figure 2-15. Side View of Crusher Inlet Sampling Array, Carroll Canyon

Figure 2-16. View of Crusher Inlet Sampling Array, Carroll Canyon

Figure 2-17. Side View of Crusher Discharge Array, Carroll Canyon

Transfer Point

The transfer point tested at the Vulcan Materials, Inc. Plant handles the material that has been sent through the crusher and is being returned to the vibrating screen. This conveyor transfer point sampling arrays are shown in Figures 2-18 and 2-19.

Figure 2-18. Side View of Conveyor Transfer Point Upper and Lower Arrays, Carroll Canyon

Figure 2-19. Close Up View of the Conveyor Transfer Point Upper Array, Carroll Canyon

The upwind monitors used for tests of the vibrating screen, crushers, and conveyor transfer point are shown in Figures 2-20 and 2-21. These monitors were located on a platform located approximately ninety feet from the conveyor transfer point and approximately 110 feet from the vibrating screen and crushers. These monitors were in a area that was immediately upwind of the equipment being tested.

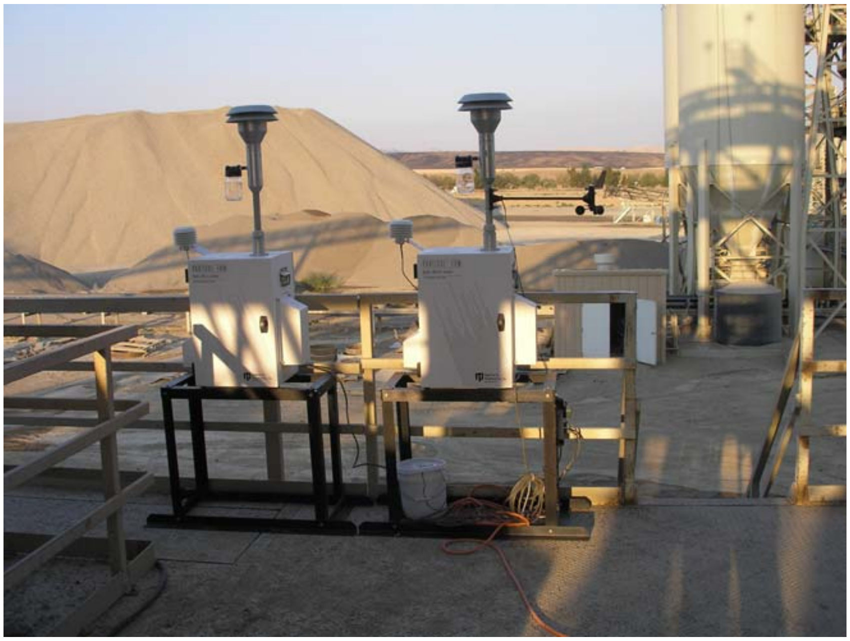

Figure 2-20. Process Equipment Upwind Monitors, Carroll Canyon

Figure 2-21. Process Equipment Upwind Monitors Looking Toward Conveyor Transfer Point, Vibrating Screen and Crusher, Carroll Canyon

Upwind Downwind Ambient Monitoring Locations

Air Control Techniques, P.C. mounted a set of two collocated ambient PM_4 crystalline silica monitors on the west side of the plant at a location adjacent the plant entry road. At this location, ambient air coming from the southwest, west, and northwest passed over the entire Carroll Canyon facility, including the unpaved roads, processing equipment, storage piles, and quarry. These monitors were within two hundred feet of the western property line of facility. This monitoring location is shown in Figure 2-22.

Figure 2-22. Plant Downwind Monitors, Carroll Canyon

A single ambient PM_4 crystalline silica monitor was placed on a berm on the west side of the plant quarry. This location is upwind of the unpaved roads in the plant, the processing equipment, the storage piles, and the quarry. This monitoring location was near to Camino

Ruiz road. The main Vulcan quarry and the Hanson, Inc. aggregates plant is located to the west of the Carroll Canyon Plant. The upwind monitor is shown in Figure 2-23.

Figure 2-23. Upwind Monitor, Carroll Canyon

Vernalis Plant

Vibrating Sizing Screens

The unit tested at the Teichert Aggregates, Inc. Vernalis Plant is a 24 foot by 8 foot triple deck sloped vibrating sizing screen. The stone material is fed into the vibrating sizing screen by a conveyor. Figures 2-24 and 2-25 show different views of the vibrating sizing screen sampling arrays.

Figure 2-24. Side View of Vibrating Sizing Screen Array, Vernalis

Figure 2-25. Side View of Vibrating Screen, Vernalis

Crushers

Secondary and tertiary crushers were tested at the Teichert Aggregates, Inc. Vernalis Plant. The crushers discharge onto a conveyor that was also tested as part of this study. The stone is transferred by conveyor to the vibrating sizing screen. The stone flow through this part of the Vernalis Plant is termed "closed circuit" because oversized material recirculates through the vibrating sizing screen and crusher until the stone is crushed small enough to fall through the vibrating sizing screen. Figures 2-26 through 2-27 show different views of the crusher sampling arrays.

Figure 2-26. Side View of Upper Crusher Array, Vernalis

Figure 2-27. Side View of Crusher Material Outlet, Vernalis

Transfer Point

The transfer point tested at the Teichert Aggregates, Inc. Vernalis Plant handles the material from the sloped vibrating screen also tested as part of this study. The conveyor transfer point sampling arrays are shown in Figures 2-28 and 2-29. A set of upwind monitors for PM4 and PM10 were located approximately fifteen feet from the vibrating screen and the screening operation. These upwind monitors are shown in Figure 2-30 from the corner of the conveyor transfer point.

Figure 2-28. Conveyor Transfer Point Array, Vernalis

Figure 2-29. View of Conveyor Transfer Point Array, Vernalis

Figure 2-30. Process Equipment Upwind Monitors for Screen and Transfer Point Tests, Vernalis

Upwind Downwind Ambient Monitoring Locations

Air Control Techniques, P.C. mounted a set of two collocated ambient PM_4 crystalline silica monitors on the east side of the plant at a location adjacent the plant quarry. At this location, ambient air coming from the southwest, west, and northwest passed over the entire Vernalis facility, including the unpaved roads, processing equipment, storage piles, and quarry. These monitors were within twenty feet of the eastern property line of facility.

A single ambient PM_4 crystalline silica monitor was placed on the scale house/office building roof near the northwest corner of the facility. This location is upwind of the unpaved roads in the plant, the processing equipment, the storage piles, and the quarry.

2.5 Wet Suppression Fugitive Dust Control

Wet suppression is used for fugitive dust control at all of the crushers, screens, and transfer points included in the scope of this test program. Not all water spray nozzles in the overall plant systems are required to control fugitive dust emissions. The amount of wet suppression required to control fugitive dust emissions is dependent on the ambient temperature, relative humidity, and composition of the material being handled. Over-wetting the stone does not have any environmental benefits, and it can cause blinding of the screens or blockage of the fines discharge chute underneath the vibrating sizing screens.

The unpaved haul road at the Barstow Plant was watered on an as needed basis. The amount of wet suppression required to control fugitive dust emissions on the haul road is dependent on the ambient temperature, relative humidity, amount of truck traffic, and composition of the road material.

2.6 Meteorological Data

As part of this testing program, Air Control Techniques, P.C. installed meteorological monitoring stations to measure the following parameters during both the process equipment and the industrial unpaved road test programs.

- Average and peak wind speeds
- Wind direction
- Ambient temperature

Air Control Techniques, P.C. installed fabric strips in the area of the sample arrays for ease in visually confirming the correct wind directions.

During the industrial unpaved road tests, meteorological data were monitored on a continuous basis on the downwind side of the unpaved road at two levels. The monitoring stations were located at elevations of 2 meters and 8 meters. These instrument systems monitored wind speed, wind direction, and temperature at the 2-meter location only. The meteorological data were recorded continuously and reduced to 5-minute average values in a data acquisition system. Air Control Techniques, P.C. retrieved these data on a daily basis.

2.7 Process Data

During each of the test runs, Air Control Techniques, P.C. compiled data concerning the process operating conditions and the characteristics of the materials being handled. The data included the following for the process equipment.

- Crystalline silica content of aggregate being processed through the units being tested
- Material moisture content (% weight)
- Material particle size distribution (sieve analyses)
- Material throughput (tons/hour)

During the unpaved industrial road test runs, Air Control Techniques, P.C. compiled data concerning the traffic and road conditions. The data for the industrial unpaved road included the following.

- Crystalline silica content of the road silt (<200 mesh sample)
- Road surface moisture level
- Road particle size distribution and silt content (sieve analyses)
- Number of truck passes along the haul road
- Average vehicle speed
- Truck weight (loaded and unloaded)

Stone Size Distribution and Silt Content
Barstow Plant
The stone samples for the vibrating screen, crusher, and conveyor transfer points were obtained at the discharge of each unit. The samples for the vibrating screen were taken as the stone left the top deck of the screen and moved toward the crusher. The sample for the crusher was obtained from the conveyor at the discharge of the crusher. The sample for the conveyor transfer point was taken on the conveyor transporting material from the transfer point. The crusher discharge and conveyor transfer point discharge conveyors were stopped for approximately five minutes to allow for sampling and the measurement of conveyor materials loadings per linear foot of belt.

Carroll Canyon Plant
The stone samples for the Carroll Canyon plant were taken from the conveyor on the inlet of the screen.

Vernalis Plant
The stone samples for the vibrating screen and the crusher station were taken from the discharge of the crusher station. The sample for the conveyor transfer point were taken from the discharge of the conveyor.

Stone Sample Processing, All Plants
A sample was selected for analysis by placing the stone in a pile and dividing it into four quadrants. The quadrant randomly selected for analysis was further subdivided in quadrants until the sample quantity was less than approximately 2 pounds. Following the procedures outlined in Appendices C.1 and C.2 of the Fifth Edition of AP-42, the sample was weighed,

dried, and reweighed. The weight loss during the drying cycle was used to calculate the moisture content.

The silt content has been defined as the minus 200 mesh material. The initial sample quadrants used for moisture analysis were also used for analysis by ASTM sizing screens. The sample of approximately 2 pounds (following moisture analysis) was allowed to cool and then loaded into the ASTM sizing screens.

The following specific sizing screens were used.

- 19 millimeters
- 850 micrometers
- 150 micrometers
- 75 micrometers (200 mesh)
- Pan (less than 200 mesh / silt

The loaded ASTM screens were placed in a RO-TAP® shaker and processed for 15 minutes. The weights of stone remaining on each of the screens were then determined by subtracting the screen tare weights from the loaded weights.

Following the size distribution and silt content analyses, samples were analyzed for crystalline silica content. The aggregate sample was sent to the R.J. Lee Group for analysis using NIOSH Method 7500.

Stone Throughput Rates, All Plants

The stone processing rate for the crusher was defined as the total quantity of stone per hour exiting the crusher and discharging on the conveyor belt. The stone processing rates for the transfer point and vibrating screens were defined as the total quantity of stone per hour entering the transfer point and vibrating screen.

The stone throughput rates at the Barstow and Carroll Canyon Plants were determined by stopping the feed conveyor to the unit being tested, removing a two foot linear sample, and weighing the sample. The stone throughput rates were calculated by multiplying the conveyor speed in feet per minute and then divided by 2 (length of conveyor sample) to produce a pounds per minute stone throughput. This number was then multiplied by 60 minutes and divided by 2,000 pounds per ton to yield a stone throughput rate in tons per hour.

The stone throughput rates at the Vernalis plant were determined using conveyor weigh belt monitors. These use load cells to determine the weight on the belt. The feed rate is then determined by multiplying the conveyor speed times the weight of stone per linear foot of belt.

2.8 PM_4 Crystalline Silica Monitoring

The R&P FRM 2000 modified for PM_4 sampling operated in full accordance with 40 CFR Part 50 Appendix L procedures except for (1) a sample flow rate of 11.1 liters per minute and (2) the use of a PVC filter as specified by NIOSH Method 0600. The PVC filter had a pore size of 5 micrometers as specified by NIOSH Method 0600.

The fugitive PM_4 emissions were measured by multiplying the measured ambient PM_4 concentration by the ambient airflow rate through the sampling array. A Davis Instruments Inc. Weather Wizard III meteorological station was located within 5 feet of each of the sampling arrays and at the same elevation as the sampling arrays to measure the wind directions and wind speeds through the arrays.

Collocated R&P FRM 2000 monitors modified for PM_4 were used to capture the upwind ambient air approaching the process units being tested. The filter samples from these monitors were also tested for PM_4 crystalline silica using NIOSH Method 7500. The total mass flux of PM_4 crystalline silica in the upwind air was subtracted where applicable from the downwind mass flux to determine the total PM_4 crystalline silica emission factor for the unit.

The extensive quality assurance protocol built into the R&P FRM monitors would alarm and flag any suspect data if any operations parameters were out of the specified range. The PM_4 monitor data logger was scanned for any problems that could potentially affect the adequacy of the observed PM_4 concentrations.

$PM_{2.5}$ ambient monitors operated in accordance with 40 CFR Part 50, Appendix L appear to be especially well-suited for the measurement of PM_4 crystalline silica. Using this approach, already established quality assurance requirements apply to control of sample flow rate variability and to filter weighing precision. Furthermore, the particle cut size curve of Appendix L instruments is similar to that of NIOSH Method 0600. The main adjustment necessary to an Appendix L qualifying instrument is a change in the 50% cut size of instrument to adjust from $PM_{2.5}$ to PM_4. This was achieved by adjusting the flow rate into the R&P sharp cut cyclone to a flow of 11.1 liters per minute instead of the 16.67 liters per minute used for $PM_{2.5}$ monitoring. This adjustment was based on microsphere-oriented particle cut size tests conducted by Air Control Techniques, P.C. and guidance provided by the instrument manufacturer. Figure 2-31 shows a photograph of the R&P sharp cut cyclone.

Figure 2-31. R&P Sharp Cut Cyclone

The sharp cut cyclone's catch cup was checked and cleaned after every test and run in order to determine if there was any overloading of the filter during the run. This never occurred. Air Control Techniques, P.C. visually inspected filters after each test run to verify that there had been no apparent overloading of the sharp cut cyclone. The test sample times would have been shortened, and the tests would have been repeated if the cyclone catch cup or the filter media had any signs of overloading.

2.9 PM_{10} Monitoring

The PM_{10} TEOM had a PM_{10} sampling head and operated at a flow rate of 16.67 liters per minute. The TEOM was operated in accordance with Method IO-1.3. The TEOM was calibrated in accordance with Section 12.1 of Method IO-1.3.

The fugitive PM_{10} emissions were measured by multiplying the measured ambient PM_{10} concentration by the ambient airflow rates through the sampling arrays. Davis Instruments, Inc. meteorological monitoring stations were located within 5 feet of the sampling arrays and at the same elevation as the sampling array to measure the wind directions and wind speeds through the arrays.

Leak checks were performed at the test sites according to the R&P performance audit procedures. The leak checks were conducted prior to sampling and immediately following the final day of sampling. Single point verifications of the sample flow rate were conducted by Air Control Techniques, P.C. using an NIST traceable orifice. This test was conducted prior to testing and following the field tests. The temperature and pressure calibration checks were also conducted prior to testing and following the field tests.

The extensive quality assurance protocol built into the TEOM instrument alarms and stops sampling if any required operations parameters are out of the Method IO-1.3 specified range.

The PM_{10} monitor operating data were scanned for any problems that could potentially affect the adequacy of the observed PM_{10} concentrations.

During the haul road tests, the PM_{10} TEOM used for the process equipment tests was recalibrated for 11.1 liters per minute and outfitted with a sharp cut cyclone to convert it to a PM_4 monitor in order to determine the required sample times of the haul road tests.

2.10 Gas Stream Testing

The flue gas velocities and volumetric flow rates during the PM_4 and PM_{10} tests were determined according to the procedures outlined in U.S. EPA Reference Method 2. Velocity measurements were made using S-type Pitot tubes conforming to the geometric specifications outlined in Method 2. Accordingly, each Pitot tube was assigned a coefficient of 0.84. Velocity pressures were measured with a digital micromanometer. Effluent gas temperatures were measured with chromel-alumel thermocouples equipped with hand-held digital readouts. Cyclonic flow check were performed prior to the tests at each sampling location.

Flue gas analyses and calculation of flue gas dry molecular weight was performed in accordance with EPA Method 3 (40 CFR Part 60 Appendix A, Method 3, Section 3.0 Single-Point Grab Sampling). Following these guidelines, a single point was used to obtain a flue gas sample prior to testing. A stainless steel probe was used for this purpose. Moisture was removed from the sample gas by means of a knockout jar located prior to the aspirator. Oxygen and carbon dioxide were determined using a Fyrite® apparatus. Due to the fact that all of the air sampled in the arrays was ambient air, the oxygen and carbon dioxide were verified to be 20.9 % oxygen and 0% carbon dioxide. These concentration values were entered into calculations used to determine the average molecular weight of the gas stream.

EPA Method 4 is the most common procedure for determining the moisture content of stationary source emissions; however, these emission factor tests involved fugitive dusts suspended in ambient air having low absolute humidity. For this reason, Method 4 was not an ideal method for quantifying the moisture concentration of the sample gas stream. The moisture content was determined using the dry bulb temperature, ambient relative humidity, and standard psychrometric calculations.

3. EMISSION FACTOR TEST RESULTS

3.1 Process Equipment Test Conditions

3.1.1 Process Equipment Throughput Rates, Moisture Levels, Silt Levels, and Size Distributions

The stone throughput rates, moisture, and silt levels for the PM_4 and PM_{10} equipment emission factor tests at the three plants are presented in Tables 3-1a through 3-1c. These data are compared in a series of graphs provided as Figures 3-1 through 3-3.

Table 3-1a. Stone Throughput Rates, Moisture Levels, and Silt Levels, Barstow

Date	Run Number	Sample Conveyor	Stone Throughput, Tons/Hour	Stone Silt Content, %	Stone Moisture Level, %
October 20, 2005	VS - 1	Discharging to Screen	121.2	1.86	2.10
October 20, 2005	VS - 2		241.8	1.54	1.10
October 21, 2005	VS - 3		159.6	1.55	1.41
October 22, 2005	C - 1	Discharging from Crusher	40.6	5.17	4.67
October 22, 2005	C - 2		83.4	2.32	1.27
October 22, 2005	C - 3		48.9	2.35	0.99
October 25, 2005	CTP - 1	Discharging from Conveyor to Conveyor	91.2	2.29	1.93
October 25, 2005	CTP - 2		78.6	2.25	2.00
October 25, 2005	CTP - 3		104.9	2.20	1.64

Table 3-1b. Stone Throughput Rates, Moisture Levels, and Silt Levels, Carroll Canyon

Date	Run Number	Sample Conveyor	Stone Throughput, Tons/Hour	Stone Silt Content, %	Stone Moisture Level, %
September 19, 2006	SCR – 1	Discharging to Screen	532.5	2.04	1.83
September 19, 2006	SCR – 2		511.4	2.02	1.86
September 19, 2006	SCR – 3		539.5	1.56	2.12
September 20, 2006	TC -1	Discharging from Crusher	523.4	1.74	2.14
September 20, 2006	TC – 2		526.5	1.82	2.04
September 20, 2006	TC -3		509.1	1.38	2.12
September 18, 2006	CTP – 1	Discharging from Conveyor to Conveyor	512.5	1.19	1.07
September 18, 2006	CTP – 2		497.4	0.95	1.66
September 18, 2006	CTP – 3		548.6	1.30	1.95

Table 3-1c. Stone Throughput Rates, Moisture Levels, and Silt Levels, Vernalis					
Date	Run Number	Sample Conveyor	Stone Throughput, Tons/Hour	Stone Silt Content, %	Stone Moisture Level, %
September 24, 2006	SCR – 1	Discharging to Screen	580	2.08	3.35
September 25, 2006	SCR – 2		715	2.09	2.65
September 25, 2006	SCR – 3		1150	1.68	1.70
September 26, 2006	TC -1	Discharging from Crusher	1090	1.48	1.84
September 26, 2006	TC – 2		1165	1.61	2.19
September 26, 2006	TC -3		1160	0.64	1.26
September 25, 2006	CTP – 1	Discharging from Conveyor to Conveyor	100	0.38	0.92
September 25, 2006	CTP – 2		110	0.42	0.37
September 25, 2006	CTP – 3		98	1.03	1.21

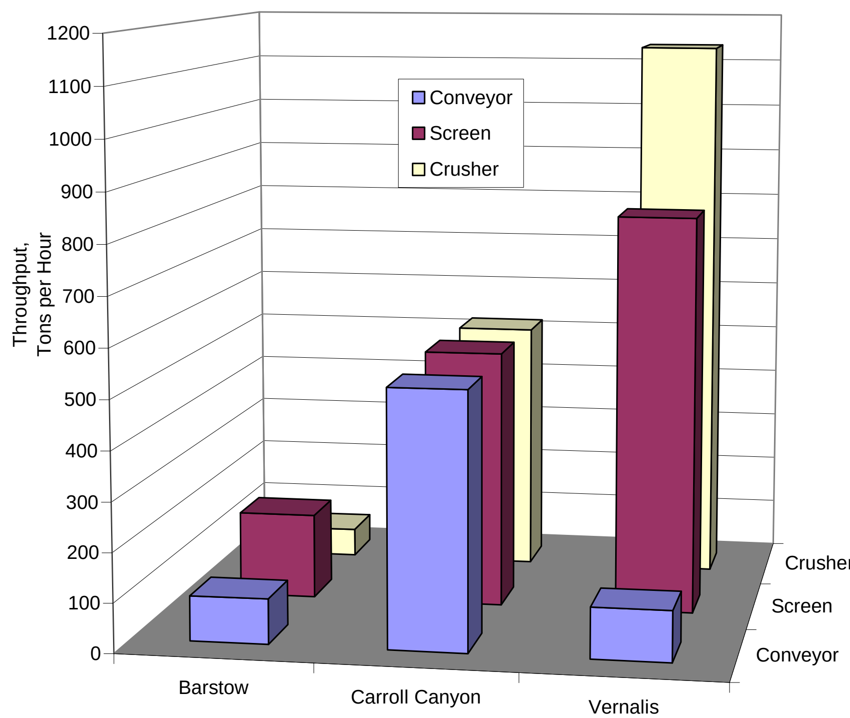

Figure 3-1. Comparison of Throughput Rates During Emission Factor Tests

It is apparent that the throughput rates at the Carroll Canyon and Vernalis plants were substantially above those at the Barstow Plant. The Carroll Canyon and Vernalis plants were selected for the 2006 test program to ensure that the throughput rates for the units tested represent a large portion of the facilities in California.

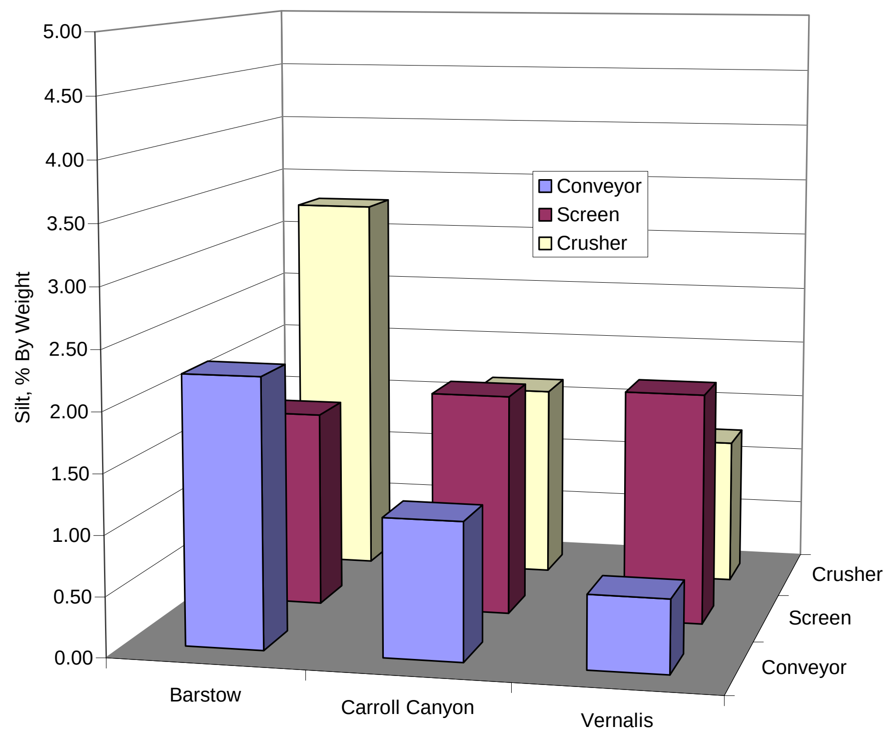

Figure 3-2. Comparison of Silt Levels During Emission Factor Tests

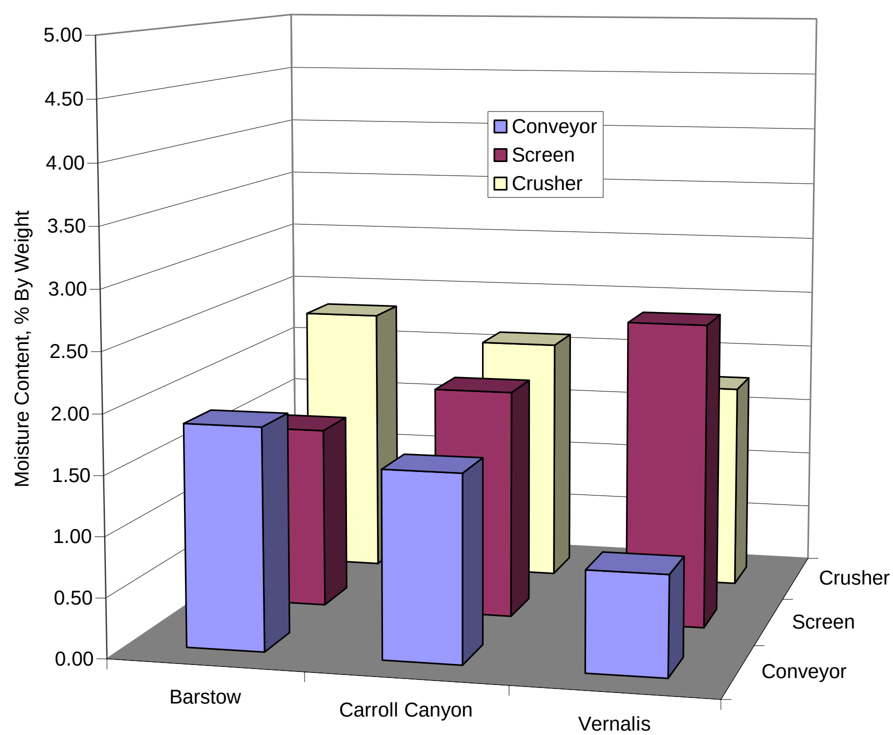

Figure 3-3. Comparison of Material Moisture Levels During the Emission Factor Tests

The silt levels of the material being processed (Figure 3-2) during the emission factor tests were in the range from 0.5 to 3.0 percent by weight. Most of the tests involved materials with silt levels between 1.0 and 2.0 percent by weight. These silt levels are typical of the aggregate processing industry.

The moisture levels of the material being processed (Figure 3-3) during the emission factor tests were primarily in the range of 1 to 2.5 percent by weight. The lowest moisture level measured was 0.83 percent by weight during the conveyor transfer point tests at Vernalis. The highest moisture level was 2.57 percent by weight during the screening operation tests at Vernalis. These moisture levels are typical of the aggregates processing industry.

The material size distribution data for the emission factor tests at the three plants are summarized in Tables 3-2a, b, and c. The silt data provided in these tables are identical to the silt content levels summarized in Tables 3-1a, b, and c, and identical to the silt levels illustrated in Figure 3-2. The data provided in Tables 3-2a, b, and c. are useful in confirming that the size distributions of the materials being processed during the emission factor tests are representative of the aggregates processing industry.

Table 3-2a. Process Equipment Particle Size Distributions, Percentages Greater than Sieve Size, Barstow

Sieve Size	VS-1	VS-2	VS-3	C-1	C-2	C-3	CTP-1	CTP-2	CTP-3
Sample Date, 2005	10/20	10/20	10/21	10/22	10/22	10/22	10/25	10/25	10/25
% 19 Millimeters	21.21	3.82	4.07	0.00	1.97	7.36	0.00	0.00	0.00
% 850 Micrometer	71.68	89.91	89.74	82.76	88.19	84.38	88.09	91.01	85.77
% 150 Micrometer	3.51	3.72	3.65	10.35	6.77	4.58	8.17	5.52	10.20
% 75 Micrometer	1.06	1.01	0.99	1.72	0.74	1.33	1.45	1.22	1.83
% Silt, (< 200 Mesh)	1.86	1.54	1.55	5.17	2.32	2.35	2.29	2.25	2.20

Table 3-2b. Process Equipment Particle Size Distributions, Percentages Greater than Sieve Size, Carroll Canyon

Sieve Size	VS-1	VS-2	VS-3	C-1	C-2	C-3	CTP-1	CTP-2	CTP-3
Sample Date, 2006	9/19	9/19	9/19	9/20	9/20	9/20	9/18	9/18	9/18
% 19 Millimeters	9.62	2.59	8.56	7.31	5.20	11.07	18.10	12.57	8.50
% 850 Micrometer	76.80	85.61	80.45	80.17	81.34	75.30	76.77	80.82	83.28
% 150 Micrometer	9.55	7.98	8.03	8.93	9.78	10.52	3.04	4.63	5.85
% 75 Micrometer	1.99	1.80	1.40	1.85	1.86	1.74	0.9	1.03	1.12
% Silt, (< 200 Mesh)	2.04	2.02	1.56	1.74	1.82	1.38	1.19	0.95	1.30

Table 3-2c. Process Equipment Particle Size Distributions, Percentages Greater than Sieve Size, Vernalis									
Sieve Size	VS-1	VS-2	VS-3	C-1	C-2	C-3	CTP-1	CTP-2	CTP-3
Sample Date, 2006	9/24	9/25	9/25	9/26	9/26	9/26	9/25	9/25	9/25
% 19 Millimeters	5.10	4.57	24.84	44.14	8.08	64.79	95.09	96.51	91.25
% 850 Micrometer	79.14	80.86	62.37	46.97	81.24	31.96	2.91	1.80	3.34
% 150 Micrometer	11.18	10.26	9.46	6.14	7.87	2.03	1.09	0.88	3.46
% 75 Micrometer	2.50	2.22	1.65	1.28	1.20	0.59	0.54	0.40	0.93
% Silt, (< 200 Mesh)	2.08	2.09	1.68	1.48	1.61	0.64	0.38	0.42	1.03

3.1.2 Process Equipment Test Run Wind Directions and Speeds

The wind directional data for the studies at the three plants tested are summarized in Tables 3-3a, b, and c. The wind directional data were consistent with project requirements for the array monitoring of the process equipment. As indicated in Tables 3-3a, b, and c and in Figures 3-4 and 3-5, the average and maximum wind speeds were higher during the tests at the Carroll Canyon and Vernalis plants.

Table 3-3a. Process Equipment Wind Direction and Wind Speed Data, Barstow				
Plant	Test Date	Dominant Wind Direction	Average Wind Speed, mph	Maximum Wind Speed, mph
Vibrating Screen	10/20/05	N	0.78[1]	1[1]
	10/20/05	N	1.11	2
	10/21/05	N	0.92	1
Crusher	10/22/05	NW	0.70	2
	10/22/05	NW	1.10	3
	10/22/05	NNW	2.94	6
Conveyor Transfer Point	10/25/05	W	0.64	1
	10/25/05	W	0.44	1
	10/25/05	W	0.80	2

[1]Where average wind speed was less than 1 mile per hour, an average of 1 mile per hour was used for emission factor calculations.

Table 3-3b. Process Equipment Wind Direction and Wind Speed Data, Carroll Canyon				
Plant	Test Date	Dominant Wind Direction	Average Wind Speed, mph	Maximum Wind Speed, mph
Vibrating Screen	9/19/06	S	2.63	5.19
	9/19/06	NW	7.00	11.76
	9/19/06	WSW	7.04	11.12
Crusher	9/20/06	SSW	1.24	3.12
	9/20/06	WNW	3.08	6.68
	9/20/06	WNW	3.41	7.11
Conveyor Transfer Point	9/18/06	SW	1.24	3.08
	9/18/06	W	3.40	7.72
	9/18/06	WNW	3.40	9.20

Table 3-3c. Process Equipment Wind Direction and Wind Speed Data, Vernalis				
Plant	Test Date	Dominant Wind Direction	Average Wind Speed, mph	Maximum Wind Speed, Mph
Vibrating Screen	9/24/06	W	5.52	10.00
	9/25/06	W	4.12	7.64
	9/25/06	NW	2.80	4.60
Crusher	9/26/06	WNW	2.40	4.88
	9/26/06	NW	2.32	4.56
	9/26/06	N	7.00	10.92
Conveyor Transfer Point	9/25/06	NW	2.40	4.20
	9/25/06	N	3.32	5.68
	9/25/06	WNW	1.70	3.96

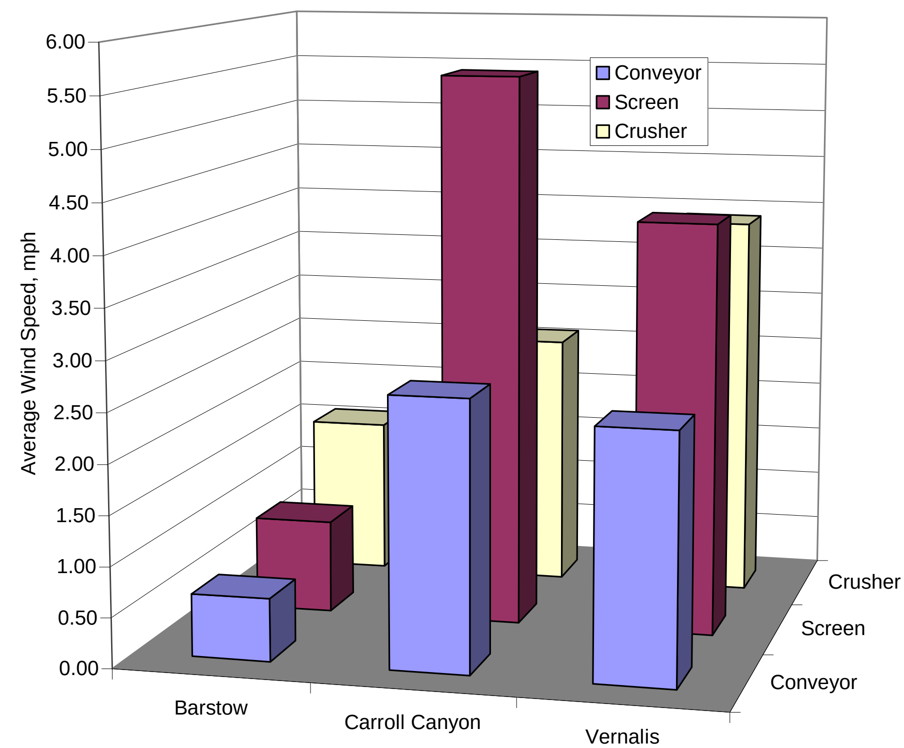

Figure 3-4. Comparison of Average Wind Speeds During the Emission Factor Tests

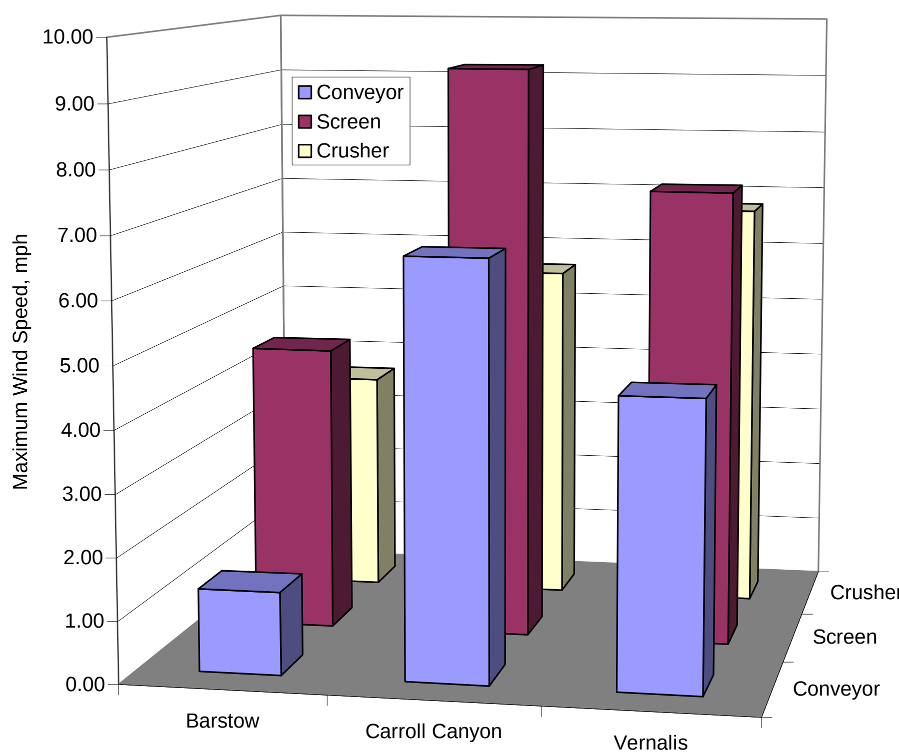

Figure 3-5. Comparison of Maximum Wind Speeds During the Emission Factor Tests

3.2 Process Equipment PM_4 Crystalline Silica and PM_{10} Emission Factors

The PM_4 and PM_{10} and crystalline silica emission factors were calculated in accordance with the procedures illustrated in the example calculation in the Appendix. The PM_{10} emission factors for the Barstow Plant were derived from the TEOM data. The PM_{10} emission factors for the Carroll Canyon and Vernalis Plants were derived from the PM_{10} FRM monitor data. The particulate matter captured on the filters in the R&P FRM 2000 monitors was weighed to yield a PM_4 capture weight. X-ray diffraction analyses of the PM_4 filter samples were provided by R. J. Lee Group, Inc. ("RJL"). As indicated in the RJL report reproduced in the Appendix, all of the filters had non-detectable levels of the cristobalite and tridymite forms of crystalline silica. Quartz was the only form of crystalline silica detected on all of the filters analyzed during the test program.

The emission factors are presented in Tables 3-4a, b, and c. The average emission factors for the set of three plants are presented in Table 3-4d. The data are expressed in pounds of PM_{10} and pounds of PM_4 silica per ton of stone throughput. A comparison of the emission factor values measured at each of the plants is provided in Figure 3-6.

Table 3-4a. PM_{10}, PM_4 and PM_4 Crystalline Silica (CS) Emission Factors, Barstow

Test Runs and Averages	Vibrating Screen			Crusher			Conveyor Transfer Point		
	PM_{10} lb/ton	$PM_{4.0}$ lb /ton	$PM_{4.0}$ lb CS/ton	PM_{10} lb/ton	$PM_{4.0}$ lb /ton	$PM_{4.0}$ lb CS/ton	PM_{10} lb/ton	$PM_{4.0}$ Lb /ton	$PM_{4.0}$ lb CS/ton
Measured Emissions									
Run #1	0.000060	0.000038	0.000002	0.001762	0.000625	0.000094	0.000570	0.000329	0.000020
Run #2	0.000108	0.000039	0.000005	0.000956	0.000504	0.000034	0.000726	0.000471	0.000052
Run #3	0.000333	0.000161	0.000010	0.005540	0.003197	0.000203	0.000579	0.000406	0.000034
Measured Average	0.000167	0.000079	0.000006	0.002753	0.001442	0.000094	0.000625	0.000402	0.000035
Ambient Upwind Equivalent Concentrations									
Run #1	N/A	N/A	N/A	0.000205	0.000205	0.000051	0.000030	0.000030	0.000003
Run #2	N/A	N/A	N/A	0.000107	0.000107	0.000015	0.000064	0.000064	0.000009
Run #3	N/A	N/A	N/A	0.000204	0.000204	0.000019	0.000057	0.000057	0.000007
Ambient Average	N/A	N/A	N/A	0.000172	0.000172	0.000019	0.000050	0.000050	0.000006
Emission Factors Corrected for Upwind Equivalent Concentrations									
Run #1	0.000060	0.000038	0.000002	0.001557	0.000420	0.000043	0.000539	0.000299	0.000017
Run #2	0.000108	0.000039	0.000005	0.000849	0.000397	0.000019	0.000663	0.000407	0.000043
Run #3	0.000333	0.000161	0.000010	0.005336	0.002993	0.000184	0.000522	0.000349	0.000028
Emission Factor Average	0.000167	0.000079	0.000006	0.002581	0.001270	0.000083	0.000575	0.000352	0.000029

Table 3-4b. PM_{10}, PM_4 and PM_4 Crystalline Silica (CS) Emission Factors, Carroll Canyon

Test Runs and Averages	Vibrating Screen			Crusher			Conveyor Transfer Point		
	PM_{10} lb/ton	$PM_{4.0}$ lb /ton	$PM_{4.0}$ lb CS/ton	PM_{10} lb/ton	$PM_{4.0}$ lb /ton	$PM_{4.0}$ lb CS/ton	PM_{10} lb/ton	$PM_{4.0}$ lb /ton	$PM_{4.0}$ lb CS/ton
Downwind Emissions									
Run #1	0.000402	0.000168	0.000022	0.000407	0.000211	0.000025	0.000064	0.000081	0.000011
Run #2	0.001110	0.000476	0.000055	0.001808	0.000898	0.000135	0.000664	0.000296	0.000042
Run #3	0.001280	0.000514	0.000067	0.001599	0.000723	0.000138	0.000926	0.000357	0.000040
Downwind Average	0.000930	0.000386	0.000048	0.001271	0.000611	0.000099	0.000552	0.000245	0.000031
Ambient Upwind Equivalent Concentrations									
Run #1	0.000056	0.000017	0.000002	0.000020	0.000008	0.000001	0.000020	0.000006	0.000001
Run #2	0.000120	0.000039	0.000000	0.000048	0.000027	0.000002	0.000026	0.000011	0.000000
Run #3	0.000123	0.000033	0.000002	0.000051	0.000018	0.000002	0.000034	0.000010	0.000000
Ambient Average	0.000100	0.000030	0.000001	0.000039	0.000018	0.000002	0.000026	0.000009	0.000000
Emission Factors Corrected for Upwind Equivalent Concentrations									
Run #1	0.000346	0.000152	0.000020	0.000387	0.000203	0.000025	0.000044	0.000074	0.000010
Run #2	0.000990	0.000437	0.000055	0.001760	0.000872	0.000133	0.000639	0.000285	0.000042
Run #3	0.001157	0.000480	0.000064	0.001548	0.000705	0.000136	0.000892	0.000347	0.000040
Emission Factor Average	0.000831	0.000356	0.000046	0.001232	0.000593	0.000098	0.000525	0.000236	0.000031

Table 3-4c. PM_{10}, PM_4 and PM_4 Crystalline Silica (CS) Emission Factors, Vernalis

Test Runs and Averages	Vibrating Screen			Crusher			Conveyor Transfer Point		
	PM_{10} lb/ton	$PM_{4.0}$ lb /ton	$PM_{4.0}$ lb CS/ton	PM_{10} lb/ton	$PM_{4.0}$ lb /ton	$PM_{4.0}$ lb CS/ton	PM_{10} lb/ton	$PM_{4.0}$ lb /ton	$PM_{4.0}$ lb CS/ton
Downwind Emissions									
Run #1	0.002577	0.001131	0.000087	0.000300	0.000111	0.000030	0.000876	0.000293	0.000053
Run #2	0.001457	0.000480	0.000049	0.000353	0.000140	0.000037	0.001675	0.000608	0.000113
Run #3	0.001229	0.001052	0.000114	0.004647	0.002111	0.000263	0.001027	0.000528	0.000096
Measured Average	0.001754	0.000888	0.000083	0.001767	0.000788	0.000110	0.001193	0.000476	0.000088
Ambient Upwind Equivalent Concentrations									
Run #1	0.000084	0.000000	0.000003	0.000060	0.000010	0.000001	0.000100	0.000018	0.000002
Run #2	0.000071	0.000012	0.000003	0.000054	0.000012	0.000001	0.000137	0.000022	0.000002
Run #3	0.000030	0.000006	0.000001	0.000154	0.000041	0.000000	0.000073	0.000016	0.000005
Ambient Average	0.000061	0.000006	0.000002	0.000089	0.000021	0.000001	0.000103	0.000019	0.000003
Emission Factors Corrected for Upwind Equivalent Concentrations									
Run #1	0.002494	0.001131	0.000084	0.000240	0.000101	0.000029	0.000776	0.000275	0.000052
Run #2	0.001386	0.000468	0.000046	0.000299	0.000129	0.000036	0.001538	0.000586	0.000112
Run #3	0.001200	0.001045	0.000113	0.004492	0.002070	0.000263	0.000955	0.000512	0.000092
Emission Factor Average	0.001693	0.000882	0.000081	0.001677	0.000767	0.000110	0.001090	0.000457	0.000085

Table 3-4d. Average Emission Factors, Combined Data Set		
Source	Analyte	Emissions, Pounds/Ton
		Average
Vibrating Screen	PM_{10}	0.00090
	PM_4	0.00044
	PM_4 Crystalline Silica	0.000044
Crusher	PM_{10}	0.00183
	PM_4	0.00088
	PM_4 Crystalline Silica	0.000097
Conveyor Transfer Point	PM_{10}	0.00073
	PM_4	0.00035
	PM_4 Crystalline Silica	0.000048

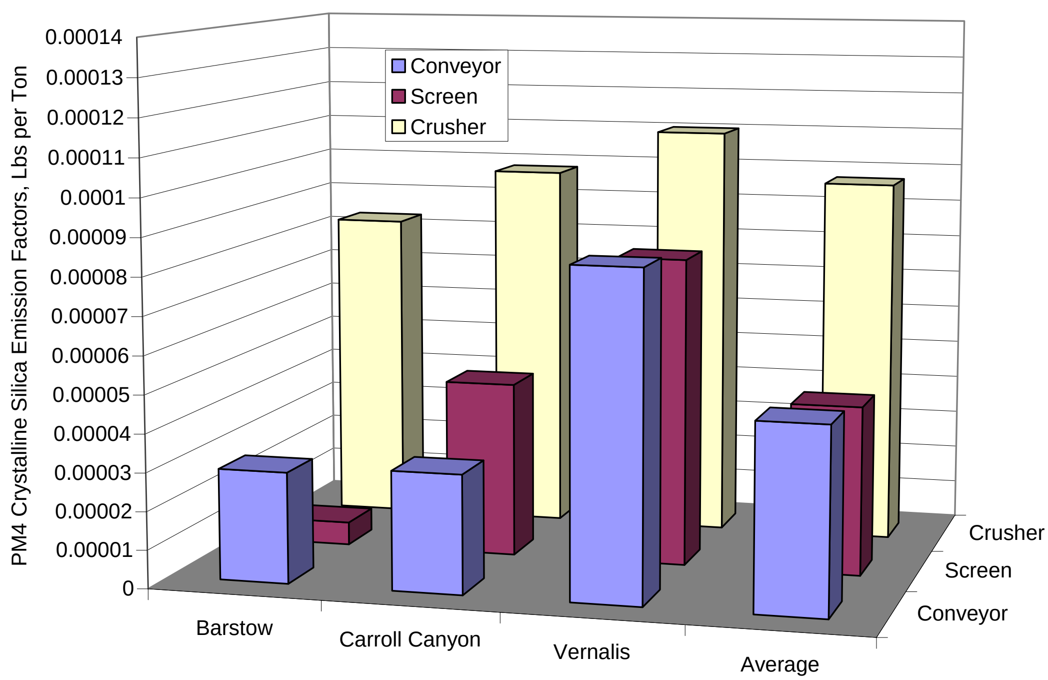

Figure 3-6. Comparison of PM_4 Crystalline Silica Emission Factors

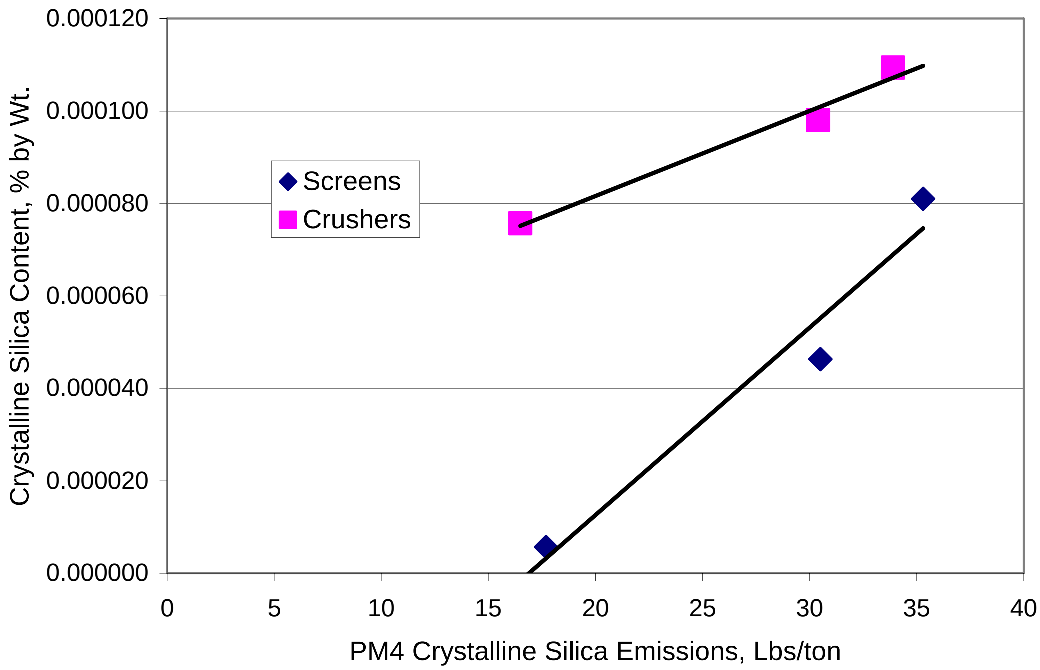

Figure 3-7. Relationship Between PM_4 Crystalline Silica Emission Factors and Bulk Material Crystalline Silica Concentrations, Crushers and Screens

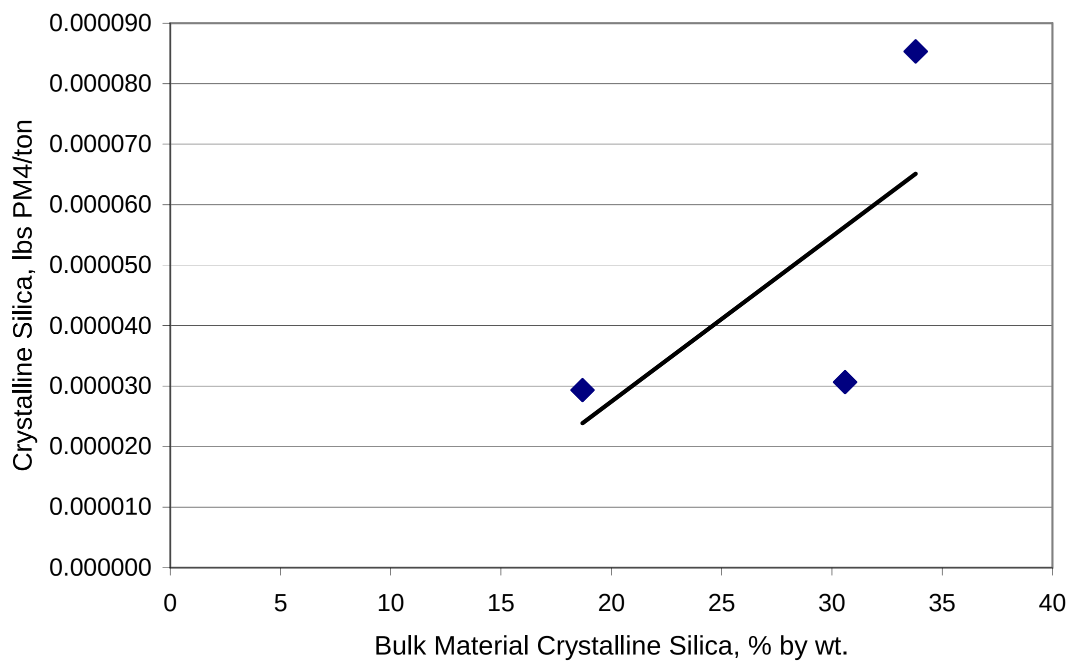

Figure 3-8. Relationship Between PM_4 Crystalline Silica Emission Factors and Bulk Material Crystalline Silica Concentrations, Transfer Points

The plant-to-plant differences in PM_4 crystalline silica emission factors are due primarily to the crystalline silica content of the material being handled. As indicated in Figures 3-7 and 3-8, the bulk material crystalline silica content appears to be responsible for most of the variance in the data. It is important to note; however, that due to the small number of test values (three), it is not possible to demonstrate that the relationship between PM_4 crystalline silica emission factors and bulk crystalline silica content is significant at the 90% confidence level.

The PM_4 crystalline silica emission factors for all sources tested are low because very high energy levels are needed to cause attrition of the crystalline silica fraction of the bulk material to the less than 4 micrometer range.

The data for the conveyor transfer points has more variability than the data sets for crushers and screens. The low emission factor value (30.5% crystalline silica value in Figure 3-8) measured at the Carroll Canyon Plant is due to the very high throughput for this unit. This large material stream passing through the conveyor transfer points shields a portion of material from attrition points that could result in the formation of PM_4 particles.

The PM_4 crystalline silica emission factors compiled in this study are compared directly in Table 3-5 with the PM_{10} emission factors measured simultaneously. As indicated in this table, the crystalline silica PM_4 emission factors range from 3.21% to 7.95% of the PM_{10} emission factors. This is a useful ratio because it compares the PM_4 crystalline silica emissions with PM_{10} emissions for which data are often available.

Table 3-5. Comparison of Measured PM_{10} Emission Factors and PM_4 Crystalline Silica Emission Factors[2]

Source	Plant	PM_{10} Emission Factors lbs/ton[1]	Crystalline Silica PM_4 Factors lbs/ton	Ratio, % PM_4 Crystalline Silica to PM_{10}	Bulk Material Crystalline Silica, % by wt.	Ratio, % PM_4 Crystalline Silica to PM_{10} Normalized to 25% Crystalline Silica
Screen	Barstow	0.000167	0.000006	3.59	17.5	3.95
	Carroll Canyon	0.000831	0.000046	5.54	30.5	5.13
	Vernalis	0.001693	0.000081	4.78	35.3	4.13
Crusher	Barstow	0.002581	0.000083	3.21	16.5	3.58
	Carroll Canyon	0.001232	0.000098	7.95	30.4	7.38
	Vernalis	0.001677	0.00011	6.56	33.9	5.78
Conveyor Transfer Point	Barstow	0.000575	0.000029	5.04	18.7	5.47
	Carroll Canyon	0.000525	0.000031	5.90	33.9	5.20
	Vernalis	0.00109	0.000085	7.80	33.8	6.88

1. Factors shown are for controlled conditions.
2. PM_{10} emission factors were not measured for the industrial unpaved road.

The ratio between the PM_4 crystalline silica emission factor and the PM_{10} emission factor have been normalized to a 25% crystalline silica level in the column shown on the right in Table 3-5. The 25% crystalline silica level is the approximate mean of the entire data set for the three plants tested. This ratio ranges from 3.58% to 7.38%. The average normalized value for the screen tests was 4.40%. The normalized values for the crusher and conveyor transfer point tests were 5.58% and 5.85% respectively.

The ratio between the PM_4 crystalline silica emissions and the PM_{10} emissions appears to be strongly dependent on the crystalline silica content of the bulk material. This is illustrated in Figures 3-9 through 3-11 for screening operations, crushers, and conveyor transfer points respectively.

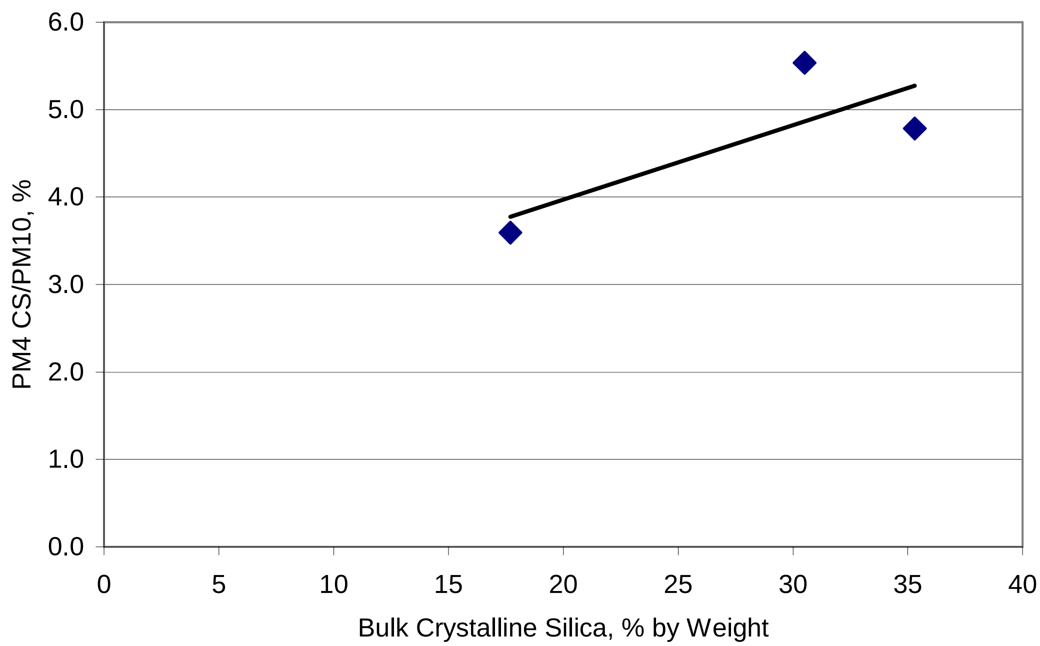

Figure 3-9. PM_4 Crystalline Silica Versus PM_{10} Ratio as a Function of the Bulk Crystalline Silica Concentration, Screening Operation Tests

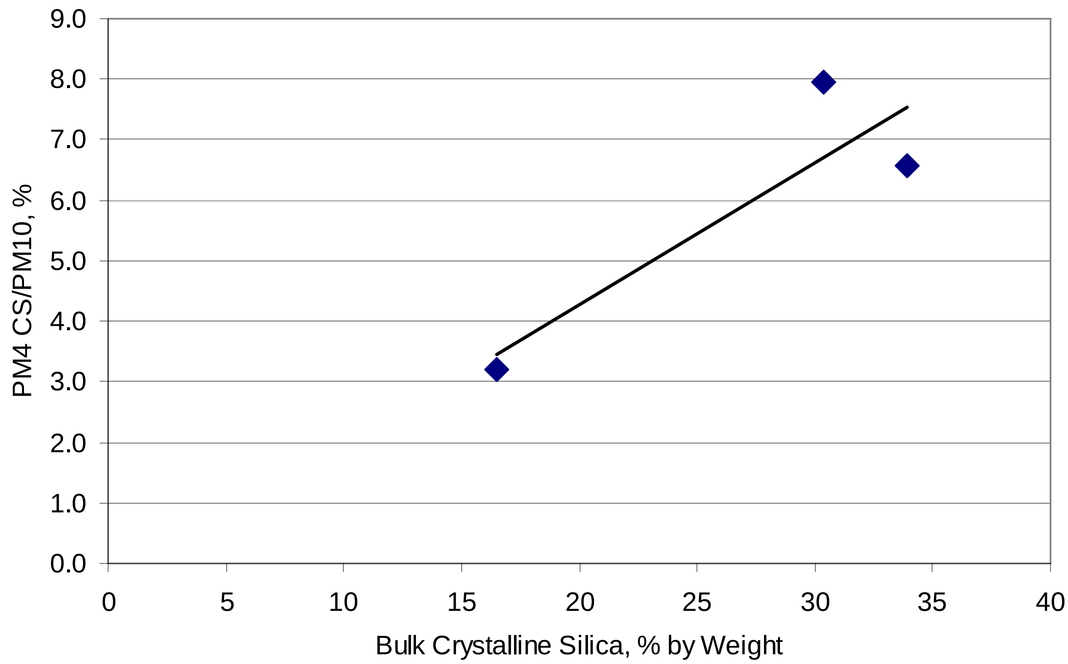

Figure 3-10. PM$_4$ Crystalline Silica Versus PM$_{10}$ Ratio as a Function of the Bulk Crystalline Silica Concentration, Crusher Tests

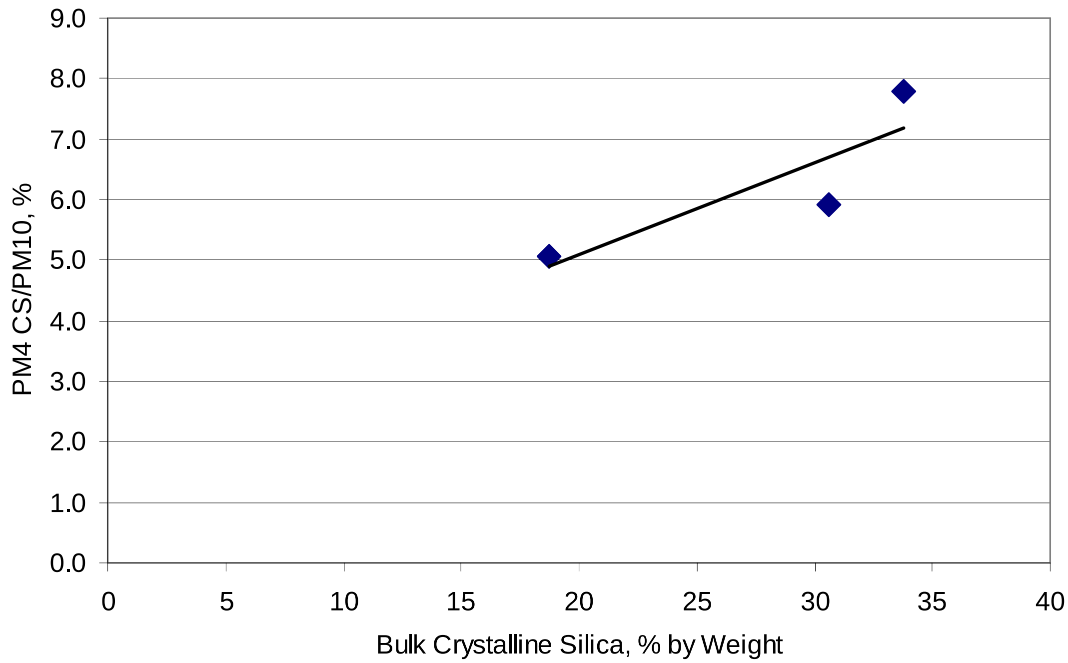

Figure 3-11. PM$_4$ Crystalline Silica Versus PM$_{10}$ Emission Ratio as a Function of the Bulk Crystalline Silica Concentration, Conveyor Transfer Point Tests

The results of the PM_4 crystalline silica concentration tests at the three plants are highly consistent. The PM_4 crystalline silica concentrations were measured at plants with capacities, materials, and operating practices typical of aggregate facilities throughout California.

3.3 Haul Road Test Conditions

3.3.1 Haul Road Moisture Levels, Silt Levels, and Particle Size Data

The size distribution and silt content data for the haul road emissions tests are presented in Table 3-6. The stone analyses show low levels of dust in the minus 200 mesh (75 micrometers) or silt size range. The haul road particle size data are summarized in Table 3-7.

Table 3-6. Haul Road Stone Moisture and Silt Levels, Barstow

Date	Run Number	Stone Silt Content, %	Stone Moisture Level, %
October 26, 2005	1	2.55	1.37
October 26, 2005	2	2.53	0.97
October 27, 2005	3	1.84	1.55
October 27, 2005	4	3.47	1.15
October 27, 2005	5	3.76	0.89
	Average	2.83	1.19

Table 3-7. Haul Road Particle Size Distributions, Percentages Greater than Sieve Size, Barstow

Sieve Size	1	2	3	4	5
Sample Date	10/26	10/26	10/27	10/27	10/27
Sample Time	11:15	13:15	06:20	09:05	12:50
% 19 Millimeters	0.00	0.05	7.16	2.10	4.25
% 850 Micrometers	71.63	66.86	72.14	72.18	60.11
% 150 Micrometers	23.57	27.98	16.63	19.91	28.24
% 75 Micrometers (200 Mesh)	2.26	2.58	2.24	2.34	3.64
% Silt, (Less than 200 Mesh)	2.55	2.53	1.84	3.47	3.76

3.3.2 Haul Road Wind Directions and Speeds

The wind directional data for the haul road studies are summarized in Tables 3-8 and 3-9. The wind directional data were consistent with project requirements for upwind-downwind monitoring of the haul road.

Table 3-8. Haul Road Downwind Location Wind Direction and Wind Speed Data, Barstow					
Plant	Test Date	Test Time	Dominant Wind Direction	Average Wind Speed, Mph	Maximum Wind Speed, mph
Barstow	10/26/05	10:45 – 12:45	W	6.5	10
	10/26/05	12:50 – 15:20	WNW	5.8	9
	10/27/05	05:30 – 08:30	WNW	2.5	6
	10/27/05	08:35 – 12:35	W	8.2	11
	10/27/05	12:40 – 14:40	WNW	8.7	12

Table 3-9. Wind Speed Averages at the 2- and 8-Meter Elevations, Barstow			
Test Site	2 Meter Elevation Average Wind Speed, MPH	8 Meter Elevation Average Wind Speed, MPH	Average Wind Speed, MPH
Barstow	8.6	8.8	8.7

3.3.3 Haul Road Activity Rates

The total vehicle miles traveled by the haul road trucks during the emission test runs were counted and recorded. These data were used directly in the calculation of the emission factors. An average truck load of 83.6 tons (truck dependent) was used to calculate the production rates. The number of truck passes and the estimated production rate are summarized in Table 3-10.

Table 3-10. Barstow Haul Road Activity Rates, Barstow			
Test Date	Run Number	Haul Truck Passes During Test Time	Tons of Production Transported on Haul Road
10/26/05	1	39	2463
10/26/05	2	34	2100
10/27/05	3	51	3000
10/27/05	4	48	3013
10/27/05	5	45	2375
Average for 5 Test Runs		43.4	2590

3.3.4 Haul Road Truck Speeds

An average truck speed was obtained for the haul trucks passing the sampling system. All haul trucks eere timed over a one hundred foot distance in front of the sampling system. The averages presented in Table 3-11 summarize the haul truck speeds for both loaded and unloaded conditions. Each recorded truck speed can be found in the Appendix of this report.

Table 3-11 Haul Truck Speed Averages, Barstow				
Test Site	Number of Passes (Loaded and Unloaded)	Highest Truck Speed, MPH	Lowest Truck Speed, MPH	Average Truck Speed, MPH
Barstow	553	22.9	4.6	14.0

3.4 Haul Road PM_4 and PM_4 Crystalline Silica Emission Factors

The PM_4 crystalline silica emission factors were calculated in accordance with the procedures illustrated in the example calculations shown in the Appendix. The particulate matter captured on the filters in the R&P FRM 2000 monitors was weighed to yield a PM_4 capture weight. X-ray diffraction analyses of the PM_4 filter samples were provided by RJL. As indicated in the RJL report reproduced in the Appendix, all of the filters had non-detectable crystalline silica levels of cristobalite and tridymite. Quartz was the only form of crystalline silica detected on all of the filters but one analyzed during the haul road test program.

The emission factors are presented in Table 3-12. The data are expressed in pounds of PM_4 crystalline silica and PM_4 per vehicle mile traveled.

Table 3-12. Haul Road Emission Factors, Barstow						
Test Date	Run Number	PM_4 Emission Rate, Pounds/ Hour	PM_4 Silica Emission Rate, Pounds/Hour	Vehicle Miles Traveled Through 100 foot long test area per Hour	PM_4 Emission Factor, Pounds / Vehicle Mile Traveled	PM_4 Silica Emission Factor, Pounds Silica / Vehicle Mile Traveled
10/26/05	1	0.555	0.0363	0.9470	0.586	0.038
10/26/05	2	0.365	0.0199	0.6818	0.536	0.029
10/27/05	3	0.070	0.0073	0.7071	0.099	0.010
10/27/05	4	0.597	0.0331	0.6676	0.895	0.050
10/27/05	5	1.048	0.0488	1.0417	1.006	0.047
Average for 5 Test Runs		0.527	0.0290	0.8090	0.624	0.035

The PM_4 emissions should be relatively low because very high energy levels are needed to cause stone attrition to the less than 10 micrometer range. Therefore, it is unlikely that the haul trucks are creating substantial quantities of PM_4 particulate. This is indicated in the upwind and downwind PM_4 concentration data. The PM_4 concentration data are presented in Table 3-13. This is also indicated in the size distribution and silt analysis conducted by Air Control Techniques, P.C. using dried stone. These size distribution and silt content data are presented in Table 3-7. The stone analyses show near negligible levels of dust in the minus 200 mesh (75 micrometer) or silt size range.

Table 3-13. Upwind and Downwind Haul Road PM_4 Concentration Data, Barstow[1]				
Run #	Test Date	Upwind Location PM_4, μg/M^3	Downwind Location PM_4, μg/M^3	Difference Downwind minus UpwindPM_4, μg/M^3
1	10/26/05	129.2	246.9	117.7
2	10/26/05	111.8	198.2	86.5
3	10/27/05	52.0	90.5	38.5
4	10/27/05	80.0	180.4	100.4
5	10/27/05	134.6	300.0	165.4

[1]Data from R&P FRM 2000 Monitors

4. QUALITY ASSURANCE AND QUALITY CONTROL

4.1 QA/QC Procedures for PM_4 and PM_{10} Sampling

All of the tests were conducted using QA/QC procedures established by the U.S. EPA and Air Control Techniques, P.C. for IO-1.3 (TEOMs) and 40 CFR Part 50, Appendix L (R&P FRM 2000s). Complete records concerning the QA/QC procedures have been prepared and are documented in the Appendices of this report.

The QA/QC data are summarized in Tables 4-1 through 4-8. As indicated in these tables, the R&P PM_4 monitors, the R&P PM_{10} monitors and the TEOM used for both PM_4 and PM_{10} monitoring performed extremely well throughout the three test programs.

Table 4-1a. Pre-Post Test R&P FRM PM_4 Quality Assurance Results, Barstow

Monitor #	Pre or Post Test Check	Filter Temperature	Ambient Temperature	Ambient Pressure	Flow Audit	Leak Rate
Requirement		±2°C	±2°C	±10mm Hg	<0.55 LPM	<80 ml/min
20685	Pre	0.5	0.6	5.2	0.0	41
20161	Pre	0.2	0.3	5.2	0.0	34
20512	Pre	0.8	0.9	5.2	0.0	29
20685	Post	1.0	1.4	4.0	0.1	31
20161	Post	0.0	0.4	4.0	0.0	29
20512	Post	0.2	0.1	4.0	0.0	31

As indicated in Tables 4-1a through 4-1c, all of the PM_4 concentration monitors used for emission factor testing and ambient air monitoring met all of the pre- and post-test requirements concerning filter temperature, ambient temperature, barometric pressure, sample flow, and sample gas stream leak rates.

The monitors listed in Table 4-1a were used at Barstow for PM_4 crystalline silica emission factor tests. Two of these monitors were located immediately upwind of the process unit being tested. One of these PM_4 monitors was used to sample the combined gas stream from the arrays mounted immediately downwind of the process unit being tested.

Four of the PM_4 monitors listed in Tables 4-1b and 4-1c for the Carroll Canyon and Vernalis Plants were used for emission factor testing at locations identical to those described with respect to the Barstow Plant. In addition, a set of three PM_4 monitors was used to conduct upwind and downwind monitoring. Two of the PM_4 ambient monitors were collocated at the downwind monitoring location, and one of the ambient PM_4 monitors was at the upwind monitoring location.

The data listed in Tables 4-1b and 4-1c also indicate that the R&P FRM monitors used for PM_{10} monitoring during emission factor tests also met all pre- and post-test requirements. A R&P FRM was not used for PM_{10} monitoring at Barstow. Instead a TEOM was used.

Table 4-1b. Pre-Post Test R&P FRM PM$_4$ and PM$_{10}$ Quality Assurance Results, Carroll Canyon

Monitor #	Pre or Post Test Check	Filter Temperature	Ambient Temperature	Ambient Pressure	Flow Audit	Leak Rate
Requirement	N/A	±2°C	±2°C	±10mm Hg	<0.55 LPM	<80 ml/min
204778	Pre	0.9	0.7	5.7	0.2	51
204283	Pre	0.5	0.8	5.7	0.2	40
204781	Pre	0.8	1.0	8.7	0.0	24
204359	Pre	1.4	0.4	5.7	0.3	31
204358	Pre	0.2	0.4	5.7	0.3	34
204360	Pre	0.4	0.1	6.7	0.2	35
204389	Pre	0.5	1.2	6.7	0.1	30
204778	Post	0.5	0.2	2.0	0.0	17
204283	Post	1.4	0.9	5.0	0.2	16
204781	Post	0.3	0.1	7.0	0.2	13
204359	Post	0.0	0.2	6.0	0.2	55
204358	Post	0.0	0.2	6.0	0.1	20
204360	Post	0.4	0.5	6.0	0.1	34
204389	Post	1.5	0.0	7.0	0.1	34

Table 4-1c. Pre-Post Test R&P FRM PM$_4$ and PM$_{10}$ Quality Assurance Results, Vernalis

Monitor #	Pre or Post Test Check	Filter Temperature	Ambient Temperature	Ambient Pressure	Flow Audit	Leak Rate
Requirement	N/A	±2°C	±2°C	±10mm Hg	<0.55 LPM	<80 ml/min
204778	Pre	0.5	0.2	2.0	0.0	17
204283	Pre	1.4	0.9	5.0	0.2	16
204781	Pre	0.3	0.1	7.0	0.2	13
204359	Pre	0.0	0.2	6.0	0.2	55
204358	Pre	0.0	0.2	6.0	0.1	20
204360	Pre	0.4	0.5	6.0	0.1	34
204389	Pre	1.5	0.0	7.0	0.1	34
204778	Post	1.0	0.8	5.0	0.0	54
204283	Post	0.8	0.3	7.0	0.1	43
204781	Post	1.1	0.8	4.0	0.2	35
204359	Post	1.3	0.5	5.0	0.1	79
204358	Post	0.6	1.2	6.0	0.1	51
204360	Post	0.3	1.1	7.0	0.0	56
204389	Post	0.6	0.8	6.0	0.0	50

Two TEOMs were used during the tests at Barstow. Instrument 21831 was used during the emission factor tests of the tertiary crusher, the vibrating screen, and the conveyor transfer point. This same instrument was fitted with a PM_4 sharp cut cyclone to change the unit from a PM_{10} monitor to a PM_4 monitor. TEOM 22161 was used exclusively for the haul road emission factor tests and this unit was also equipped with a PM_4 sharp cut cyclone. As indicated in Table 4-2a, both instruments satisfied the pre- and post-test quality assurance checks.

Table 4-2. R&P TEOM Pre-Audit Quality Assurance Results, Barstow

Monitor #	Main Flow Leak Rate	Auxiliary Flow Leak Rate	Ambient Temperature	Ambient Pressure	Total Flow Audit	Main Flow Audit
PM_{10} Requirement	<0.15 LPM Pre/Post	<0.60 LPM Pre/Post	±2°C	±10mm Hg	16.67 ± 1 LPM	3 ± 0.2 LPM
21831 PM_{10}	0.12/0.22	0.13/0.25	0.4	2.1	16.22	2.94
PM_4 Requirement	<0.15 LPM Pre/Post	<0.60 LPM Pre/Post	±2°C	±10mm Hg	11.1 ± 1 LPM	3 ± 0.2 LPM
21831 PM_4	0.13 / 0.13	0.27 / 0.26	1.5	1.6	10.5	2.98
22161 PM_4	0.06 / 0.08	0.00 / 0.00	0.3	2.6	10.9	3.06

During each of the test runs, the R&P PM_4 instruments continuously monitored the sample flow rate, the variations in the sample flow rate, and the differences between the filter temperature and the ambient air temperature adjacent to the instrument. These operating parameters must remain with limits specified in 40 CFR Part 50, Appendix L.

The instrument operating parameter monitoring during each test run is summarized in Tables 4-3 through 4-8. As indicated in these tables, the R&P PM_4 monitors and R&P PM_{10} monitors met all of the Appendix L quality assurance requirements for the large majority of the runs. A few exceptions are noted in these tables. Air Control Techniques, P.C. does not believe that these few exceptions had a significant impact on the test results.

The TEOMS used in the Barstow Study also monitored sampling conditions on a continuous basis. The data provided in Tables 4-4 through 4-6.

Table 4-3a. Run by Run Equipment R&P FRM PM_4 Quality Assurance Results, Barstow					
Run #	Monitor #	Monitor Location	Average Flow Rate	Max Filter Temperature Differential	Coefficient of Variance
Requirement			11.1 ± 0.55 LPM	<5°C	<4%
VS – 1	20512	Equipment Duct	11.1	1.8	0.1
	20685	Primary Upwind	11.1	2.3	0.1
	20161	Collocated Upwind	11.1	1.2	6.4[1]
VS – 2	20512	Equipment Duct	11.1	1.8	0.1
	20685	Primary Upwind	11.1	2.1	0.1
	20161	Collocated Upwind	11.1	N/D[1]	0.0
VS – 3	20512	Equipment Duct	11.1	1.3	0.2
	20685	Primary Upwind	11.1	2.0	0.3
	20161	Collocated Upwind	11.1	1.3	0.0
C – 1	20512	Equipment Duct	11.1	1.3	0.2
	20685	Primary Upwind	11.1	1.6	0.1
	20161	Collocated Upwind	11.1	1.3	0.2
C – 2	20512	Equipment Duct	11.1	1.5	0.2
	20685	Primary Upwind	11.1	2.2	0.2
	20161	Collocated Upwind	11.1	1.9	0.3
C – 3	20512	Equipment Duct	11.1	1.8	0.1
	20685	Primary Upwind	11.1	1.6	0.1
	20161	Collocated Upwind	11.1	1.4	0.1
CTP – 1	20512	Equipment Duct	11.1	1.3	0.1
	20685	Primary Upwind	11.1	1.1	0.1
	20161	Collocated Upwind	11.1	0.9	0.2
CTP – 2	20512	Equipment Duct	11.1	1.3	0.1
	20685	Primary Upwind	11.1	1.5	0.1
	20161	Collocated Upwind	11.1	1.0	0.2
CTP – 3	20512	Equipment Duct	11.1	1.8	0.2
	20685	Primary Upwind	11.1	2.1	0.2
	20161	Collocated Upwind	11.1	1.5	0.1

[1]It was found that the memory battery on the printed circuit board was failing, it was replaced prior to the third vibrating screen test run.

Table 4-3b. Run by Run Equipment R&P FRM PM_4 and PM_{10} Quality Assurance Results, Carroll Canyon					
Run #	Monitor #	PM_4 / PM_{10} Monitor Location	Average Flow Rate	Max. Filter Temp. Diff.	Coefficient of Variance
Requirement		PM_{10}	16.7 + 0.80 LPM	<5°C	<4%
		PM_4	11.1 ± 0.55 LPM		
SCR - 1	204358	Upwind PM_{10}	16.7	3.5	0.2
	204360	Upwind PM_4	11.1	5.3	4.1[1]
	204359	Equipment Duct PM_{10}	16.7	4.8	0.1
	204389	Equipment Duct PM_4	11.1	3.4	4.0
SCR - 2	204358	Upwind PM_{10}	16.7	3.1	0.2
	204360	Upwind PM_4	11.1	2.7	0.2
	204359	Equipment Duct PM_{10}	16.7	4.7	0.1
	204389	Equipment Duct PM_4	11.1	3.1	0.1
SCR - 3	204358	Upwind PM_{10}	16.7	2.2	0.2
	204360	Upwind PM_4	11.1	1.2	0.2
	204359	Equipment Duct PM_{10}	16.7	3.8	0.0
	204389	Equipment Duct PM_4	11.1	1.8	0.1
TC - 1	204358	Upwind PM_{10}	16.7	3.1	0.2
	204360	Upwind PM_4	11.1	2.0	0.2
	204359	Equipment Duct PM_{10}	16.7	5.0	0.1
	204389	Equipment Duct PM_4	11.1	1.2	0.3
TC - 2	204358	Upwind PM_{10}	16.7	2.2	0.1
	204360	Upwind PM_4	11.1	1.3	0.2
	204359	Equipment Duct PM_{10}	16.7	4.6	0.1
	204389	Equipment Duct PM_4	11.1	1.9	0.1
TC - 3	204358	Upwind PM_{10}	16.7	2.2	0.2
	204360	Upwind PM_4	11.1	1.5	0.1
	204359	Equipment Duct PM_{10}	16.7	4.0	0.1
	204389	Equipment Duct PM_4	11.1	2.5	0.8
CTP - 1	204358	Upwind PM_{10}	16.7	2.6	0.1
	204360	Upwind PM_4	11.1	4.0	0.1
	204359	Equipment Duct PM_{10}	16.7	4.1	0.2
	204389	Equipment Duct PM_4	11.1	1.7	0.0
CTP - 2	204358	Upwind PM_{10}	16.7	2.2	0.1
	204360	Upwind PM_4	11.1	1.4	0.2
	204359	Equipment Duct PM_{10}	16.7	4.0	0.1
	204389	Equipment Duct PM_4	11.1	1.9	0.2
CTP - 3	204358	Upwind PM_{10}	16.7	2.5	0.1
	204360	Upwind PM_4	11.1	1.8	0.1
	204359	Equipment Duct PM_{10}	16.7	4.0	0.1
	204389	Equipment Duct PM_4	11.1	2.0	0.2

[1] Monitor was stopped incorrectly, causing a erroneous % CV.

Table 4-3c. Run by Run Equipment R&P FRM PM_4 and PM_{10} Quality Assurance Results, Vernalis					
Run #	Monitor #	PM_4 / PM_{10} Monitor Location	Average Flow Rate	Max. Filter Temp. Diff.	Coefficient of Variance
Requirement		PM10	16.7 +0.80 LPM	<5°C	<4%
		PM_4	11.1 ± 0.55 LPM		
SCR - 1	204358	Upwind PM_{10}	16.7	0.7	0.2
	204360	Upwind PM_4	11.1	0.5	0.2
	204359	Equipment Duct PM_{10}	16.7	4.0	0.1
	204389	Equipment Duct PM_4	11.1	1.0	0.3
SCR - 2	204358	Upwind PM_{10}	16.7	1.2	0.1
	204360	Upwind PM_4	11.1	1.2	0.2
	204359	Equipment Duct PM_{10}	16.7	5.1	0.2
	204389	Equipment Duct PM_4	11.1	1.6	0.1
SCR - 3	204358	Upwind PM_{10}	16.7	2.3	0.2
	204360	Upwind PM_4	11.1	2.7	0.2
	204359	Equipment Duct PM_{10}	16.7	5.4	0.1
	204389	Equipment Duct PM_4	11.1	3.2	0.1
TC - 1	204358	Upwind PM_{10}	16.7	2.8	0.1
	204360	Upwind PM_4	11.1	1.4	0.2
	204359	Equipment Duct PM_{10}	16.7	2.8	0.2
	204389	Equipment Duct PM_4	11.1	1.5	0.1
TC - 2	204358	Upwind PM_{10}	16.7	1.3	0.1
	204360	Upwind PM_4	11.1	0.9	0.1
	204359	Equipment Duct PM_{10}	16.7	3.2	0.1
	204389	Equipment Duct PM_4	11.1	1.1	0.2
TC - 3	204358	Upwind PM_{10}	16.7	1.6	0.2
	204360	Upwind PM_4	11.1	1.1	0.1
	204359	Equipment Duct PM_{10}	16.7	3.7	0.1
	204389	Equipment Duct PM_4	11.1	1.5	0.1
CTP - 1	204358	Upwind PM_{10}	16.7	1.2	0.1
	204360	Upwind PM_4	11.1	1.3	0.2
	204359	Equipment Duct PM_{10}	16.7	4.4	0.0
	204389	Equipment Duct PM_4	11.1	2.0	0.1
CTP - 2	204358	Upwind PM_{10}	16.7	0.7	0.1
	204360	Upwind PM_4	11.1	0.5	0.3
	204359	Equipment Duct PM_{10}	16.7	3.9	2.0
	204389	Equipment Duct PM_4	11.1	1.7	0.3
CTP - 3	204358	Upwind PM_{10}	16.7	0.6	0.2
	204360	Upwind PM_4	11.1	0.6	0.2
	204359	Equipment Duct PM_{10}	16.7	3.9	0.2
	204389	Equipment Duct PM_4	11.1	1.0	0.3

Table 4-4. Run by Run Equipment R&P TEOM PM_{10} Quality Assurance Results, Barstow					
Run #	Monitor #	Monitor Location	Average Main Flow Rate	Average Auxiliary Flow Rate	Total Flow Rate
Requirement			3 ± 0.2 LPM	13.67± 0.7 LPM	16.67 ± 0.8 LPM
VS – 1	21831	Equipment Duct	3.00	13.64	16.64
VS – 2	21831	Equipment Duct	2.99	13.64	16.63
VS – 3	21831	Equipment Duct	3.00	13.64	16.64
C – 1	21831	Equipment Duct	3.00	13.64	16.64
C – 2	21831	Equipment Duct	3.00	13.64	16.64
C – 3	21831	Equipment Duct	3.00	13.64	16.64
CTP – 1	21831	Equipment Duct	3.00	13.64	16.64
CTP – 2	21831	Equipment Duct	2.99	13.64	16.63
CTP – 3	21831	Equipment Duct	2.99	13.64	16.63

Table 4-5. Run by Run Haul Road R&P FRM PM_4 Quality Assurance Results, Barstow					
Run #	Monitor #	Monitor Location	Average Flow Rate	Max Filter Temperature Differential	Coefficient of Variance
Requirement			11.1 ± 0.55 LPM	<5°C	<4%
HR-1	20512	Upwind	11.1	0.2	2.3
	20685	Downwind	11.1	0.2	1.6
HR – 2	20512	Upwind	11.1	0.2	2.6
	20685	Downwind	11.1	0.2	2.3
HR – 3	20512	Upwind	11.1	0.2	1.9
	20685	Downwind	11.1	0.1	2.0
HR – 4	20512	Upwind	11.1	0.1	2.3
	20685	Downwind	11.1	0.2	1.8
HR – 5	20512	Upwind	11.1	0.1	2.6
	20685	Downwind	11.1	0.1	2.4

Table 4-6. Run by Run Equipment R&P TEOM PM_4 Quality Assurance Results, Barstow					
Run #	Monitor #	Monitor Location	Average Main Flow Rate	Average Auxiliary Flow Rate	Total Flow Rate
Requirement			3 ± 0.2 LPM	8.1± 0.4 LPM	11.1 ± 0.55 LPM
HR-1	21831	Upwind	2.99	8.07	11.06
	22161	Downwind	2.95	7.91	10.86
HR – 2	21831	Upwind	2.99	8.07	11.06
	22161	Downwind	2.95	7.91	10.86
HR – 3	21831	Upwind	3.00	8.08	11.08
	22161	Downwind	2.95	7.93	10.88
HR – 4	21831	Upwind	2.99	8.07	11.06
	22161	Downwind	2.95	7.93	10.88
HR – 5	21831	Upwind	2.99	8.07	11.06
	22161	Downwind	2.94	7.88	10.82

Table 4-7. Plant Upwind and Downwind R&P FRM PM_4 Quality Assurance Results, Carroll Canyon					
Run #	Monitor #	PM_4 Monitor Location	Average Flow Rate	Max Filter Temperature Differential	Coefficient of Variance
Requirement			11.1 ± 0.55 LPM	<5°C	<4%
1	204778	Plant Upwind PM_4	11.1	1.6	0.3
	204283	Primary Plant Downwind PM_4	11.1	2.2	0.0
	204781	Collocated Plant Downwind PM_4	11.1	4.1	0.3
2	204778	Plant Upwind PM_4	11.1	2.6	0.2
	204283	Primary Plant Downwind PM_4	11.1	2.7	0.2
	204781	Collocated Plant Downwind PM_4	11.1	2.8	0.0
3	204778	Plant Upwind PM_4	11.1	1.8	0.3
	204283	Primary Plant Downwind PM_4	11.1	2.2	0.2
	204781	Collocated Plant Downwind PM_4	11.1	1.0	0.5

Table 4-8. Plant Upwind and Downwind R&P FRM PM_4 Quality Assurance Results, Vernalis					
Run #	Monitor #	PM_4 Monitor Location	Average Flow Rate	Max Filter Temperature Differential	Coefficient of Variance
Requirement			11.1 ± 0.55 LPM	<5°C	<4%
1	204778	Plant Upwind PM_4	11.1	2.6	0.3
	204283	Primary Plant Downwind PM_4	11.1	3.1	0.3
	204781	Collocated Plant Downwind PM_4	11.1	2.2	0.0
2	204778	Plant Upwind PM_4	11.1	1.7	0.2
	204283	Primary Plant Downwind PM_4	11.1	1.6	0.0
	204781	Collocated Plant Downwind PM_4	11.1	1.4	0.3
3	204778	Plant Upwind PM_4	11.1	2.1	0.3
	204283	Primary Plant Downwind PM_4	11.1	4.0	0.2
	204781	Collocated Plant Downwind PM_4	11.1	3.0	0.0

Air Control Techniques, P.C. believes that the R&P FRM and R&P TEOM operating data confirms that the sample flow rates were maintained at the 11.1 liter per minute flow rate necessary to maintain the instrument cut size at 4 ±0.5 micrometers. The instrument temperatures and sample gas pressures also remained within all Appendix L requirements.

The sharp cut cyclones were inspected after each set of emission factor tests. No significant accumulation of particulate matter was found following these relatively short test periods.

4.2 General Sampling Equipment

4.2.1 Leak Checks. Pretest and posttest leak checks were conducted according to the manufacturer's specifications on each monitor. The observed leak rates were less than 80 milliliters per minute which made them acceptable.

4.2.2 S-Type Pitot Tube Calibration. All S-type Pitot tubes used in this project conformed to EPA guidelines concerning construction and geometry. Pitot tubes were inspected prior to use. When the specified guidelines were met, a Pitot tube coefficient of 0.84 was used. Information pertaining to S-type Pitot tubes is presented in detail in Section 3.1.1 of EPA Publication No. 600/4-77-027b. Only S-type Pitot tubes meeting the required EPA specifications were used in this project. Standard Pitots where used when S-type Pitots were not practical.

4.2.3 Temperature Monitor Calibration. The thermocouples used in this project to verify and calibrate the monitors were calibrated using the procedures described in Section 3.4.2 of EPA Publication No. 600/4-77-027b. Each sensor was calibrated at a minimum of 3 points over the anticipated range of use against an NIST-traceable mercury in glass thermometer.

4.2.4 Scale Calibration. The scales used at the test location to determine stone moisture and particle size distribution were calibrated using a standard set of weights.

4.2.5 Wind Speed Monitors - The wind speed data were routinely checked by observing the movement of the light-weight tapes attached at numerous points of the sampling arrays. The wind speed monitors were not highly accurate for wind speeds less than approximately 1 mile per hour. The wind speed cup assembly failed to start moving promptly when the tape indicators demonstrated that the wind speed had increased to approximately 1 mile per hour.

4.2.6 Array Elements - Following each set of emission tests, the sampling array piping and flex ducts were disassembled and checked for solids deposits. No deposits were found in any sections of the sampling system.

4.3 QA/QC Checks for Data Reduction, Validation and Reporting

Daily quality audits were conducted using data quality indicators that require the review of the recording and transfer of raw data, calculations, and documentation of testing procedures. All data and calculations for air flow rates and sampling rates were recorded manually or automatically where applicable and then transferred to a portable computer. The calculations were verified by independent, manual checks.

Any suspect data or outliers were noted and identified with respect to the nature of the problem and potential effect on data quality.

All filter samples were recovered using standard EPA procedures. Sample recovery was performed in the Air Control Techniques, P.C. mobile laboratory. All sampling equipment was sealed to prevent contamination during transport to the laboratory.

All of the samples were labeled immediately after recovery. The samples were packed in numbered boxes and sealed. A chain of custody record and sample log was maintained during the emissions study. The samples were delivered to R.J. Lee for analyses along with the appropriate chain of custody record forms.

4.4 Weather Conditions

This test program at Barstow was initiated two days after a heavy rain storm passed over the Barstow area. Some localized flooding occurred in the plant area. However, the flooding did not affect the active quarry located in a relatively high elevation area of the plant. Aggregate moisture levels during the test program also appeared to be unaffected by the rain.

Some forest/grass land fires were present in the Tracy area prior to and during the test program at the Vernalis Plant. The plumes from these fires were not passing over the Vernalis Plant. Air Control Techniques does not believe that these fires significantly affected the upwind and downwind ambient PM_4 crystalline silica concentration measurements.

5. TEST PARTICIPANTS AND OBSERVERS

The CRRNOS Project Manager for this testing project was Mr. Charles Rea. The Air Control Techniques, P.C. project manager was Mr. John Richards, Ph.D., P.E. The Service Rock Products, Inc. company contact was Mr. Robert Burmeister. The Vulcan Materials Company contact was Mr. Brian Anderson. The Teichert Aggregates, Inc. company contact was Ms. Becky Wood. Addresses and phone numbers of these individuals are provided below.

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Dr. Richards was responsible for project management and coordination with CRRNOS and Service Rock Products, Inc. Mr. Todd Brozell, P.E. assisted Dr. Richards in project management and test program coordination.

R.J. Lee Group, Inc. performed the crystalline silica analyses. The project manager for these analyses is listed below.

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Mr. Richard Wales of the Mojave Desert Air Quality Management District observed the screening and industrial unpaved haul road emission factor tests at the Barstow Plant.