Note: This is a reference cited in *AP 42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

AP42 Section:	11.19.2
Background Chapter	4
Reference:	13
Title:	*Investigation of Particulate Emissions from Construction Aggregate Crushing Operations and Related New Source Performance Standards* *National Crushed Stone Association, Washington DC* December 1979

AN INVESTIGATION OF PARTICULATE EMISSIONS FROM CONSTRUCTION AGGREGATE CRUSHING OPERATIONS AND RELATED NEW SOURCE PERFORMANCE STANDARDS

December, 1979

Prepared by:

National Crushed Stone Association
National Industrial Sand Association
Associated General Contractors of America
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FORWARD

The Clean Air Act has placed significant responsibilites upon the crushed stone, sand and gravel, industrial sand, and related construction industries.

This document is intended to provide a better understanding of the above industries' effect on ambient air quality and to promote appropriate standards of operation.

The following individuals, sitting as the New Source Performance Standards Steering Committee, conceived, authored, and edited this publication.

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Joseph P. Ashooh, Associated General Contractors of America
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INTRODUCTION

The Environmental Protection Agency must prepare new source performance standards which employ the best technological system of continuous emission reduction which has been adequately demonstrated. In order to develop such standards, ambient air quality contributions from aggregate crushing operations must be understood. Several new studies have been commissioned by industry to increase the data in this area.

The attached materials represent the findings of investigations into the nature of particulate emissions from construction aggregate crushing operations. They consist of:

1) A report on "Particulate Emissions from Stone Crushing Operations" prepared by Monsanto Research Corporation.
2) A report on "Source Measurements Crushed Stone - Sand and Gravel Plants" prepared by The Research Corporation of New England.
3) An analysis of air quality impact of emissions from a sand and gravel operation prepared by TRC - Denver.

The development of new source performance standards for the processing of construction aggregates must take into consideration the nature of the particulate emissions being generated. An understanding of the sizes of the particles generated and their settling velocities helps to quantify the contributions of aggregate crushing operations to ambient air quality. For example, AP-42 contains emission factors for stone processing

(defined as TSP) which recognize that an uncontrolled emission factor must be lowered according to the amount of particulate which settles out within the plant boundaries. Because the nature of particulate emissions was not completely understood at the time AP-42 was compiled, the amount of uncontrolled emissions (by weight) was exaggerated while the percentage of particulate which settled out (by weight) in the plant was significantly underestimated.

From the March, 1979, NSPS support document:

> The property boundaries of the six plants are assumed to be a minimum distance of 300 meters from any stack. For the purposes of this study, only ground-level particulate concentrations that occur at and beyond the plant property boundaries were used in assessing the air quality impact of plant emissions.
>
> From a consideration of the results of the preliminary analysis and the fact that only off-property ground-level particualte concentrations are of concern....(See page 7-14.)

The information herein was gathered in order to accurately assess the above and, having done so, to propose new source performance standards based on the most current and most reliable data available.

almost ¼ mile

Proposed New Source Performance Standards

The presence of particulate matter in the atmosphere can result in a reduction in visibility. This reduction in visibility is primarily due to two factors, light scattering and simple blockage of light. However, it must be pointed out that water vapor or mist can also reduce visibility. Particulate matter larger than about 30 micrometers can reduce the intensity of light transmitted through the air.

Large particulate matter generated by the processing of construction aggregates may block light and give a corresponding reduction in visibility; however, these particles will only carry a short distance from the source and should not be counted as total suspended particulate. The transport of large particulate matter is a function of the wind speed passing over an open source. From the work of MRC it is apparent that particles greater than 30 microns fall within 320 feet of the source. Most open sources of emissions, such as the mining and crushing industries, encompass large surface areas where the distance from the source of emissions to the property line may be well over 1000 feet. Because it was determined that much of the particulate matter generated by the processing of construction aggregates is of a size that will settle out within the plant boundary, any opacity reading taken at the source of said emission must be predicated upon an appropriate opacity standard.

The nature of particulate emissions generated through the processing of construction aggregates and the diverse nature of the industry

must be recognized, and the installation of a specific type of emission control equipment should not be required. The only logical requirement should be that the emission limits be met. The two types of control systems common in the industry are baghouses and wet suppression. Wet suppression may be appropriate in meeting the emission limits in many cases while baghouses and combination systems of wet suppression and baghouses may be appropriate in other cases. Wet suppression systems will have to comply with only the fugitive emission limits; while baghouse systems will have to comply with both the stack and fugitive emission limits. Therefore, recognizing the fact that EPA must write NSPS standards (employing the best technological system of continuous emission reduction which has been adequately demonstrated) for non-metallic minerals processing plants, the following is proposed.

Process equipment covered

Crushers
Grinders
Screens
Conveyor Transfer Points
Bucket Elevators
Storage Bins
Bagging Operations
Fine Product Truck and Railcar Loading Stations

Emission Limits

Stack Emission	If particulate collection equipment is used, emissions from such equipment shall not exceed 0.04 gr/dscf and 20 percent opacity.
Fugitive Emissions:	No person shall emit or cause to be emitted any particulate matter which, at or from the source of said emission, is of such a shade or density on the property of emission origination so as to obscure an observer's vision to a degree in excess of 20 percent opacity.

The clean air benefits which will be derived from the aggregate industries' switch to baghouse collection systems are exaggerated, uneconomical, and control has been confused with efficiency. A collection efficiency of 99+% will not produce an identical reduction in total suspended particulates.

A comparison of the NSPS support document, AP-42, MRC's source assessment study and the present MRC-TRC study indicates that baghouse controlled emissions from aggregate crushing operations are often higher than uncontrolled emissions. This is apparently due to the suspension of fine particles which are associated with large particles that are not normally released to the atmosphere, except through baghouse stack emissions. Also, the velocity of stack emissions and the elevated point of release have to be carefully considered.

Huh? Large particles won't escape bag house

EPA's document "Source Assessment Crushed Stone" and the present MRC-TRC study are evidence that the particle size of the majority of material which is collected by aggregate industry baghouses is not transportable beyond plant boundaries. All this evidence gives reason to believe that a baghouse standard would be a cosmetic approach which could actually increase the volume of total suspended particulates beyond plant boundaries.

In the development of the NSPS support document EPA assumed that the production of crushed stone and sand and gravel were sufficiently similar to other types of non-metallic mineral processing to apply

Same AQ standards apply everywhere — confusion with NSPS — 2. different stds.

the same air quality standards. The dissimilarities of the raw materials, however, question this logic. Many asphalt plants are located at stone quarries and sand and gravel operations where the emissions from the two sources are virtually indistinguishable. Hot mix asphalt which contains an average of 95% aggregates is covered by a different set of standards. NSPS not applicable

The stack emission standard for the crushed stone, sand and gravel and the industrial sand industries should be substantially the same as the standard previously set by the EPA for the hot mix asphalt industry. That is 0.04 gr/dscf and 20% opacity.

Top executives of three companies which specialize in the manufacture of baghouses for the construction aggregate industry were contacted regarding the proposed standards of 0.02 gr/dscf and 1% opacity. With permission, their letters of reply are attached. All were in agreement that the proposed standards were unrealistic.

BARBER-GREENE COMPANY 400 NORTH HIGHLAND AVENUE / AURORA, ILLINOIS U.S.A. 60507

[redacted]

DAVID B. HIPP
GROUP VICE PRESIDENT,
CONSTRUCTION MACHINERY

October 15, 1979

Mr. W.I. Fridley, P.E.
Chief Environmental Engineer
Vulcan Materials Company
P.O. Box 7497
Birmingham, Alabama 35223

Dear Walt:

I appreciated the opportunity to talk with you about regulatory standards and environmental codes.

Barber-Greene is the world's largest producer of asphalt plants and one of the major manufacturers of aggregate processing equipment produced from Telsmith division. With this market position we have developed many years of experience in manufacturing and applying pollution control technology to these processing installations.

Technically, the asphalt plant industry is easier to apply baghouse technology than crushing installations. The process is such that many of the finer particles can be contained in the process equipment and collected at a single point through the addition of a baghouse. We have produced over 500 total asphalt plants and many, many retrofit baghouse installations since the early 70's when the .04 code became required in the asphalt plant industry. We are confident in our ability to meet the code and, as a result, offer the attached guarantee with new equipment.

The actual results from testing will range from well below .01 to marginally below .04. The variations in types of aggregate found around the country as well as the mix designs and capacity ranges being used during the test, and the difficulty in testing techniques themselves, all combine to make the .04 standard extremely difficult even for new equipment installations. To be able to maintain the .04 standard for the life of the installation requires good maintenance of equipment and normal operation conditions.

In aggregate processing and crushing installations our experience is much more limited. The primary reason for this is the extreme difficulty within the process of being able to channel all emissions into a single point of collection. With the number of transfer points involved, the level of ducting and enclosures required to channel the emissions into a single collector is not very practical. To put a separate small

collector at each transfer point becomes prohibitive from a return relative to investment although presumably the economics of regulations has little impact on environmental issues in today's political world. Our total experience is less than 10 installations in these applications and we are not in a position to guarantee meeting a .04 standard as we do with asphalt plants because of our lack of experience.

To establish a .02 code rather than the .04 that is already in effect in the asphalt plant industry or a more practical higher limitation is counterproductive to the purpose of environmental improvement. It can only impede further investment in the new equipment because of lack of finding anyone willing to guarantee it will meet this code or someone able to make the required investment to meet such a code and still produce a competitive end product. The irony of the establishment of such an impractical code is that aggregate will continue to be produced by older less productive equipment kept in service by the protection of grandfather clauses while newer equipment investment with cleaner operations are banned from the marketplace.

Very truly yours,

BARBER-GREENE COMPANY

David B. Hipp
Group Vice President
Construction Machinery

DBH/jss

65 EAST VULCAN AVENUE BETHLEHEM [illegible] 215-865-2771

October 16, 1979

Mr. W. I. Fridley, P.E.
Chief Environmental Engineer
Vulcan Materials Company
P. O. Box 7497
Birmingham, Alabama 35223

Dear Walt:

Brooks-McMichaels Corp. designs and manufactures baghouses primarily for the crushed stone industry. Our unit is of all welded construction with positive sealing of the bags and is considered the "best available technology".

While emission tests of .02 and lower are common when the units are new and "prepared" for testing, I believe that a "surprise" random sampling of collectors operated more than 3000 hours would find few units operating under .04 and none meeting .02. if so, then they are not complying with the NSPS.

Also, it should be noted that particle size to be collected is extremely important and variable. In some parts of the country .04 could be a problem, while in others .02 would not be a problem.

In my opinion, no matter how much is spent to meet the initial code, the bag house owner is not going to spend money on maintenance of the unit until visible emissions are apparent. For most dusts, this is in the range of .04 to .05; hence, any initial monies spent to meet lower codes would have been wasted. The regulation of .02 is a perfect example of the cause of inflation- "Significant expenditures resulting in zero benefit to society."

If we can be of any further service, please do not hesitate to contact us.

Very truly yours,

Brooks-McMichaels Corp.

RGBrooks

Roger G. Brooks
President

RGB:JDW

ASTEC INDUSTRIES, INC.
P.O. BOX 2787 4101 JEROME AVE. CHATTANOOGA, TENN. 37407 615-867-4210 TWX 810-573-5260

October 18, 1979

Mr. W. I. Fridley, P.E.
Chief Environmental Engineer
Vulcan Materials Company
P. O. Box 7497
Birmingham, Alabama 35223

Dear Walt:

Confirming our conversation of September 20th, ASTEC Industries manufactures approximately 60 baghouses per year for use on hot mix asphalt plants and other aggregate processing equipment. We have manufactured over 200 baghouses of the design that we are presently building and consider it to be the latest technology available. Our baghouses are all-welded construction and we use excellent sealing techniques for the bags. We have been able to meet .04 grains per cubic foot on all of our new type asphalt plants utilizing these baghouses; however, we are on the ragged edge in many cases. As we discussed, there is great variation in particle size of different materials around the country. In areas where we have extremely fine particles it is difficult to meet the code. While I can submit reports showing test results of lower than .01, these were under ideal conditions with the baghouse in new and perfect operating condition.

I think a code more restrictive than .04 would be totally impractical and unnecessary. Although the environmentalists seem to put little emphasis on economics, the difference in a code of .02 and .04 cost-wise in equipment is not double but more like four to ten times as much. (This is assuming that it is obtainable on a continuous basis.) Unfortunately, when you call a salesman, you will always get the best test report that the company has available. When you are referring to regulations they should be based on the average operating conditions.

If we can be of further help, please let us know.

Yours very truly,
ASTEC Industries, Inc.

J. Don Brock

J. Don Brock
President

JDB:sms

Introduction to MRC/TRC Documents

Ambient air quality contributions of aggregate crushing operations have been misunderstood. Estimates have been made in the past of the emission rate of various operations within the aggregate plant. However, application of these estimates to conventional dispersion modeling results in predicted contributions to ambient air quality which are high and often in disagreement with observations.

where? What model.

Since 1973, MRC has been evaluating the ambient air quality contribution of open sources such as crushing operations. This research resulted in several new techniques for sampling open sources. MRC's research for EPA (among others, "Source Assessment: Crushed Stone", EPA-600/2-78-004L, May 1978) indicated that ambient air quality contributions due to aggregate crushing operations were two to four orders of magnitude lower than previous estimates. Previous work had included estimates based upon material balances and surveys in enclosed operations where the fines (<100 µm, normally in the products) were removed along with normal emissions (<10 µm). Although limited, this was the only definitive work in the area.

MRC's previous work was limited by EPA funding, but good preliminary data were obtained. The objective of the joint studies by MRC and TRC was to verify the previous work by MRC and to calibrate the dispersion which was occurring in the plants. Additional data were needed to quantify the emissions from

aggregate crushing, especially the mass of emissions below 10 μm. Tracer gas release and sampling were utilized to verify the dispersion so that emission rates could be accurately determined from ambient concentrations.

Seven plants were selected for study including one plant previously sampled by MRC. The plants represented various types of stone crushing operations. During testing a device shown in Figure A-1, (described in the Monsanto document), the "Quick Reaction Sampler" was located immediately downwind as close to the source as feasible. A four to ten minute sample was collected (including background concentrations of ambient particulate) while the wind direction remains essentially constant. It should be noted that, while wind direction may vary throughout the day (affected by terrain, wind speed, movement of weather fronts and other meteorology considerations), periods of constant wind direction and speed, between about 9 in the morning and 4 o'clock in the afternoon, are not uncommon.

In order to essentially eliminate background levels only the particle size range of interest needs to be sampled at the source for calculation of ambient air quality contribution. For example, if the source generates 50 to 100 micrometer particles and these particles remain in the plant, then collection of these particles is not required. Since over 90% of the mass found on high volume air sampler stations, which are used to determine ambient air quality, are particles smaller than 10

Not necessarily

What data? Basis?

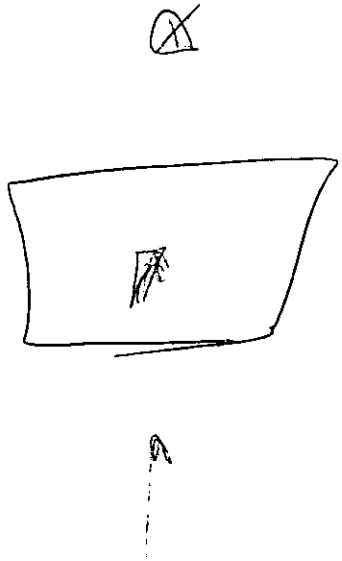
Is this refering to normal rural conditions or "urban" area?

Many plants do not have 1/4 mile buffer zone!

micrometers, only this size fraction is required for an assessment of contributions to ambient air quality. Few particles but some are beyond 15 micrometers are transported any distance due to dispersion. Studies of particle size distributions in coal mines and rock quarries indicate that the distribution is log-normal. Thus, if the emission rate for particles less than a specified size is known, then the emission rate for other size ranges can be accurately determined. reference data? ±

The previous MRC work used the computer dispersion model to convert the ambient concentration to emission rates. All sampling was conducted within the field-validated portion of the model, that is, 10 to 100 meters away from the source and with stability classes of B or C at wind speeds of 3 to 15 mph. (These are atmospheric conditions which exist throughout the United States during a work day.) What are SRAB's comments? ? What % of time? data? reference?

The purpose of the work performed by TRC was to provide new source measurements that more accurately represent emissions associated with the various crusher operations. TRC worked with Monsanto Research Corporation in undertaking the measurement task. Monsanto Research made dust concentration measurements utilizing a GCA Model RDM 101-4 dust monitor. beta gauge What does it measure? TRC made simultaneous dispersion measurements utilizing a tracer gas technique. The tracer measurements permit calculation of source emissions directly, without relying upon dispersion models. This report summarizes the field measurements made by TRC and provides an interpretation of those measurements.



Two pieces of equipment have been used in these assessments. An SF_6 tracer gas generator is used to calibrate the dispersion model. The primary instrument is the quick reaction sampler which consists of a GCA dust monitor (RDM-101-4) and a wind meter. (See Figure A-1 in MRC's report.) The sampler utilizes a cyclone to remove particles greater than 10 micron or a vertical elutriator to remove particles greater than 15 micron. Air containing the particle size of interest enters the instrument and impacts on a grease coated plate. The attenuation of beta radiation is used to measure the depth of the deposit and the mass of particles collected. From this mass and a measurement of the volumetric flow, a self contained computer calculates the ambient concentration. This instrument was developed for EPA and has been shown to represent the true value within 25% for 95% of the time. ref? As a comparison, high volume sampling is only accurate within 50% for 70% of the time; ref? therefore, it is not unusual to see discrepancies of a factor of 2 due to the lack of particle size cutoff at the high volume sampler inlet.

Same Comb

Several upwind/downwind studies have been conducted which utilize high volume samplers in mines and quarries. Because of the low level of particulate emissions, sampling has been conducted for 4 to 24 hours over a wide variation in unit operations. While attempting to relate the ambient concentrations of particulates to the frequency of various operations, the investigators have found that a correlation is not possible. To some extent this can be ascribed to wide variations in wind directions, speed,

or atmospheric stability. However, the major problem has been the lack of a technique which is accurate enough to characterize the small changes in ambient concentrations due to changes in frequency of a unit operation or production rate. For example, samplings conducted over 24-hour periods of time are not useful since changes in wind direction can dramatically affect the readings on an individual sampler. Attempts have been made to utilize cyclones to attempt to eliminate some of these problems. Two problems with this approach are: 1) the cycling on and off of the sampler allows large particles collected in the cyclone to carry through to the high volume filter, 2) the wind direction sensitive sampler cannot respond to true variations in wind directions. In a mine there are a wide variety of canyons and wind turbulence which, for example, could cause the wind to flow toward the north while the sampler might see wind coming from the east. This factor essentially destroys any correlation which might be possible.

The TRC-MRC assessment strategy offers several advantages over conventional techniques. These are: 1) increased accuracy of the ambient air quality measurements along with the ability to relate the changes in concentration to changes in the unit operation, 2) the flexibility to combine changes in frequency of operation of the unit operation for different mining rates, 3) the use of a "calibrated" dispersion model since ambient air quality measurements are used to predict ambient air quality, 4) the elimination of inaccuracies caused by variations in wind directions and other atmospheric conditions.

Conclusions

Comparison between the NSPS background document, AP-42, MRC's source assessment studies and the present joint MRC-TRC study indicates:

1. AP-42 emission factors are from ten to ten thousand times higher than the measurement of uncontrolled emissions. Not enough data are available for AP-42 emission factors to compute standard deviations.
2. Baghouse emissions from aggregate crushing operations are often higher than uncontrolled emissions. This is apparently due to the suspension of fine particles which are normally associated with larger particles and are not normally released to the atmosphere. Only large particles are captured by baghouses. Not true
3. Emission factors developed by MRC in the source assessment study are within one order of magnitude (ten times) of the emission factors developed under the joint MRC-TRC study. Since the MRC assessment study was only intended to quantify these sources within an order of magnitude, the data are believed to be highly reliable.
4. Statistical analysis of the MRC and MRC-TRC data indicates that individual measurements are within a factor of two. Variations in emission factors are due to the variability of the source and not due to the method of sampling. document?
5. Between 80 and 90% of the emissions from crushers can be controlled with wet suppression.

6. Controlled emissions using wet suppresssion would be lower than controlled emissions in the NSPS background document which is based on a baghouse.

Sand and Gravel Processing and Ambient Air Quality

A sand and gravel production facility has operated in an area east of Boulder, Colorado, since 1973. The site, called the White Rocks Mine, is located in rural surroundings east of the Rocky Mountains, approximately 5 miles east of Boulder and 20 miles north of Denver, Colorado. The operation includes mining, crushing, screening and stockpiling of sand and gravel, transportation of materials from the site by truck, and reclamation of mined areas. Production takes place during the winter season only; over the past four mining seasons production has averaged 280,000 tons per year, or approximately 300 tons per hour.

Concentration of total suspended particulate has been monitored at the White Rocks site since the beginning of operations. Three hi-vol samplers have been operated on an every-fourth-day schedule (originally every-sixth-day), and 775 measurements are now available for a five-year period. These data have been analyzed to determine the air quality impact of mining operations.

plot plan – wind roses etc ?

The arithmetic mean total suspended particulate (TSP) concentration for all samplers during the 41 months when no mining or production was occurring is 46.0 $\mu g/m^3$ (489 individual 24-hour measurements). The mean concentration for 22 operational months

(285 measurements) is 40.3 $\mu g/m^3$. The higher concentration during non-production periods is a reflection of seasonal variations in natural background fugitive dust.

How about wind blown fugitive from stockpiles, etc?

During the 1975-76 winter season, no mining was performed at White Rocks. The mean TSP concentration for that season was 32.1 $\mu g/m^3$ compared to 40.3 $\mu g/m^3$ during the four winters of active sand and gravel production. This comparison can be interpreted as suggesting that the average impact of sand and gravel production is only 8 $\mu g/m^3$. However, in view of year-to-year weather variations, the difference is probably not significant. But it does indicate that the presence of sand and gravel production with crushers, screens, conveyors, stockpiles, haul roads, topsoil removal and associated activities does <u>not</u> lead to significantly higher particulate air pollution.

Again need wind rose and photo for two time periods

In an attempt to better define the TSP impact of the White Rocks crusher and other facilities, measurements during the mining seasons were divided according to whether they were generally upwind of the crusher. Sampler locations with respect to the crusher are given below:

East sampler	1000-1500 ft. east	(1973-78)
North sampler	1000 ft. north	(1973-76)
Northwest sampler	800 ft. northwest	(1973-76)
	2800 ft. northwest	(1977-78)
West sampler	2400 ft. west	(1977-78)

Frequencies of various wind directions are known from two years which two?

Local site descriptions & photos?

of on-site meteorological data. The following table indicates the climatological frequency of wind directions within $\pm$ 56° of the axis from the crusher to each hi-vol sampler.

West wind	46%
South wind	27%
Southeast wind	26%
East wind	29%

On the basis of wind frequencies and sampler locations, it can be concluded that the east sampler is likely to show the maximum impact of particulate from sand and gravel operations. The other sampler locations were usually farther removed from dust sources and/or upwind of those sources. For the 98 twenty-four hour measurements at the east sampler location during mining seasons, the arithmetic average TSP concentration is 39.3 $\mu g/m^3$. The arithmetic average concentration for 187 samples from the other samplers on the same days is 40.8 $\mu g/m^3$. This comparison indicates that the particulate contribution from the White Rocks facilities is undetectable at the downwind site boundary (1000 ft. from the crusher).

During the five years of data collection at White Rocks, 24-hour state and federal ambient air quality standards were exceeded only at one station in one year. This occurred at the northwest sampler in October, 1976, while some excavation and topsoil removal were taking place within 10 feet of the sampler. Annual standards have likewise not been exceeded, except at the east sampler in 1977. (The annual average slightly exceeded the Colorado standard of 55 $\mu g/m^3$, but not the federal secondary

standard of 60 $\mu g/m^3$). Sand and gravel production took place at White Rocks in 1977 during January, February, March and December; examination of the year's data shows that high concentrations at the samplers occurred simultaneously at all samplers on particular days in spring and summer, when very dry conditions and strong winds were experienced in eastern Colorado.

Conclusion

On the basis of five years of experience and detailed analysis of monitoring data, it has been concluded that sand and gravel processing at White Rocks does not have a detectable impact on air quality.

Monsanto Environmental Services Report

National Industrial Sand Association
Associated General Contractors of America
National Sand and Gravel Association
National Crushed Stone Association
c/o NSPS Steering committee
1415 Elliott Place
Washington, D.C. 20007

PARTICULATE EMISSIONS FROM STONE CRUSHING OPERATIONS

APPROVED BY: R. E. Opferkuch

DATE: November 15, 1979

MRC JOB NO.: 215.1000

WRITTEN BY: E. C. Eimutis, T. R. Blackwood, R. Wachter

Monsanto Research Corporation, Station B, Box 8 □ Dayton, Ohio 45407
(513) 268-3411

ABSTRACT

This report is a compilation of fugitive dust concentrations, emission rates, and factors, obtained by air pollution sampling downwind of stone crushing operations at seven different aggregate plants. Fugitive dust levels of both <10 μm and <50 μm particle size were obtained in this study.

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APPENDICES

A. GCA/RDM 101-4 Sampling
B. Tracer Gas Sampling Method
C. Sampling Site Data
D. Fugitive Dust Sampling with GCA/RDM 101-4 Field Data
E. Tracer Study Results - Emission Rates
F. Data Sheets - Opacity Readings

1. Objectives and Scope of Work

The objectives of this project were to determine representative particulate emission factors for various stone crushing operations, and to measure the efficiency of wet dust suppression techniques for particulate emission control.

A total of 287 mass concentration measurements were conducted downwind from 16 different stone crushing operations at 7 different plants. These concentration data were converted to emission factors by the methods described in Section 2 of this report, and are presented in Section 3. Altogether, 4 primary crushing operations, 7 secondary crushing operations, 3 tertiary crushing operations, and 2 fines milling operations were sampled. (Primary, secondary, and tertiary refer to sequence of crushing). This encompassed the activities at 1 granite plant, 2 sand and gravel plants, 1 traprock plant, and 3 limestone plants.

One of the limestone processing plants sampled during this study employs a wet dust-suppression technique to control particulate emissions. This plant's operations were sampled with and without control application to determine the efficiency of wet dust suppression technique.

2. Sampling and Analysis Methods

A GCA[a] RDM 101-4 dust monitor was used to measure the downwind mass concentrations (C_D) of fugitive dust generated by stone crushing operations. This is an instrument for on-the-spot measurement of mass concentrations of <10 μ particulates or <50 μ particulates. It is a portable, automated unit with digital readout of the mass concentration of airborne particulates. Readings of 4 minutes to 30 minutes can be taken. Results are obtained by electronic measurement of the *beta* absorption of the collected sample. A cyclone collection system is used as a first stage for removal of the >10μ particulates when <10 μ-particle mass concentration measurements are desired. The cyclone is removed from the train for <50 μ-particle mass concentration measurments. A more detailed discussion of the sampling apparatus is presented in Appendix A.

Emission rates were determined by using a tracer, sulfur hexafluoride (SF_6), which was released at a known emission rate (Q_T) from the source and collected downwind in Tedlar® bags. The collection point was located adjacent to the GCA RDM 101-4. The bag samples were analyzed by a gas chromatograph equipped with an electron capture detector, and the concentration of SF_6 (C_T) was quantified by comparison to standards. The emission rate of dust (Q_D) was then determined by the simple proportion:

$$\frac{Q_D}{C_D} = \frac{Q_T}{C_T} \tag{1}$$

therefore;

$$Q_D = \frac{Q_T \bullet C_D}{C_T} \tag{2}$$

Further details of the tracer technique are presented in Appendix B.

When average emission rates from each crushing unit operation were established, the corresponding emission factors were calculated by dividing these emission rates by the throughput rates for each operation.

$$\text{Emission factor, g/kg} = \frac{\text{Emission rate } (Q_D)\text{, g/hr}}{\text{Throughput rate, kg/hr}} \tag{3}$$

---

[a]GCA Corporation, Bedford, Massachusetts.

3. Results

The mean dust concentrations obtained from sampling various crushers at the seven aggregate sites are presented in Tables 1 and 2. The data in Table 1 are <10 μ-particle concentrations measured at approximately 30 feet from each crusher. The mean dust concentrations of <50 μ particles obtained at four of these same sites are presented in Table 2.

Appendix C shows the layout of each plant listed in Tables 1 and 2 along with the sampling logistics. Sampling points and individual concentration measurements at each point are shown on the diagrams. The actual field data sheets for the GCA RDM 101-4 dust monitor are presented in Appendix E.

Mean emission rates and emission factors calculated from the <10 μ and <50 μ dust concentrations and tracer data (see Appendix E) are shown in Tables 3, 4, 5, and 6. Very similar emission levels were observed for Plants B and C, the two sand and gravel processing plants. However, the emission factors for the two limestone processing plants (E and G) differed by more than two orders of magnitude because Plant E employs a wet processing technique. Plant G normally uses a wet dust suppression system for particulate control (see Figure D-8, Appendix D for details), however this system was deactivated for a portion of the testing period so that uncontrolled emission levels could be measured. Tables 3-6 present these uncontrolled emission rates and emission factors.

Testing was also performed at Plant G with the wet dust suppression system in operation so that its efficiency could be determined. A comparison between the controlled and uncontrolled emission levels at this plant is shown in Table 7.

Opacity readings were also taken at Plant G during the controlled and uncontrolled conditions for both the secondary and tertiary crushers. These readings were taken in conjunction with the tracer studies. The average opacity readings for these conditions are listed in Table 8. Individual readings are listed in Appendix G.

TABLE 1. MEAN <10 μ DUST CONCENTRATIONS 30 FEET DOWNWIND FROM CRUSHERS (STD. DEV.), μg/m³ (UNCONTROLLED)

Plant	Stone type	Primary crusher	Size, inches	Secondary crusher	Size, inches	Tertiary crusher	Size, inches	Fines crusher	Size, inches
A	Granite	200 (±85)	<10	350 (±210)	<7	1,140 (±740)	<2	1,600 (±290)	3/4
B	Sand and gravel	130 (±170)	1-1/2 to 2	440 (±390)	1	-	-	-	-
C	Sand and gravel	170 (±140)	<3	570 (±200)	<3/4	-	-	-	-
D	Traprock	640 (±590)	<12	930 (±640)	<4	210 (±290)	<1-1/2	410 (±280)	<1
E	Limestone	-	-	68[a] (±43) Wet	<1-1/2	-	-	-	-
F	Limestone	-	-	170 (±640)	-	-	-	-	-
G	Limestone	-	-	2,200 (±1,000)	3	810 (±450)	5/8	-	-

[a]Wet process.

TABLE 2. MEAN <50 μ DUST CONCENTRATIONS 30 FEET DOWNWIND FROM CRUSHERS (UNCONTROLLED) (STD. DEV.), μg/m³

Plant	Aggregate	Primary crusher	Secondary crusher	Tertiary crusher	Fines crusher
D	Traprock	420 (±400)	1,100 (±410)	390 (±240)	810 (±300)
E	Limestone wet	-	62[a] (±29) wet	-	-
F	Limestone	-	950 (±550)	-	-
G	Limestone	-	6,500 (±1,100)	910 (±620)	-

[a]Wet process.

TABLE 3. MEAN EMISSION RATES FOR <10 μm DUST FROM STONE CRUSHING OPERATIONS (UNCONTROLLED)

Plant and type[a]	Primary crusher Emission rate (Standard deviation) kg/hr	lb/hr	Secondary crusher Emission rate (Standard deviation) kg/hr	lb/hr	Tertiary crusher Emission rate (Standard deviation) kg/hr	lb/hr	Fines crusher Emission rate (Standard deviation) kg/hr	lb/hr
A - Granite	3.7 (±1.1)	8.2 (±2.4)	5.5 (±1.8)	12.1 (±4.0)	16.6 (±6.5)	36.6 (±14.3)	1.1 (±0.3)	2.4 (±0.7)
B - Sand and gravel	0.2 (±0.1)	0.4 (±0.2)	0.7 (±0.1)	1.5 (±0.2)	-	-	-	-
C - Sand and gravel	0.1 (±0.07)	0.2 (±0.2)	0.2 (±0.02)	0.4 (±0.04)	-	-	-	-
D - Traprock	0.3 (±0.3)	0.7 (±0.7)	0.3 (±0.4)	0.7 (±0.9)	0.1 (±0.03)	0.2 (±0.07)	0.1 (±0.05)	0.2 (±0.1)
E - Limestone[b] wet	-	-	0.02 (±0.04)	0.04 (±0.09)	-	-	-	-
G - Limestone	-	-	12 (±4.9)	27 (±10.8)	0.3 (±0.09)	0.7 (±0.2)	-	-

[a]Plant F data, no tracer used for emission rate determination.

[b]Wet process.

TABLE 4. MEAN EMISSION RATES FOR <50 μm DUST FROM STONE CRUSHING OPERATIONS (UNCONTROLLED)

Plant and type	Primary crusher Emission rate (Standard deviation) kg/hr	Primary crusher Emission rate (Standard deviation) lb/hr	Secondary crusher Emission rate (Standard deviation) kg/hr	Secondary crusher Emission rate (Standard deviation) lb/hr	Tertiary crusher Emission rate (Standard deviation) kg/hr	Tertiary crusher Emission rate (Standard deviation) lb/hr	Fines crusher Emission rate (Standard deviation) kg/hr	Fines crusher Emission rate (Standard deviation) lb/hr
D - Traprock	0.6 (±0.07)	1.3 (±0.15)	0.2 (±0.03)	(0.4) (±0.07)	0.2 (±0.04)	0.4 (±0.09)	0.1 (±0.02)	0.2 (±0.04)
E - Limestone	-	-	0.03 (±0.06)	0.07 (±0.13)	-	-	-	-
G - Limestone	-	-	17 (±13.3)	37 (±28.9)	0.4 (±0.1)	0.9 (±0.2)	-	-

TABLE 5. MEAN EMISSION FACTORS FOR <10 μm DUST FROM STONE CRUSHING OPERATIONS (UNCONTROLLED)

Plant and type[a]	Primary crusher Emission factor (Standard deviation) g/kg	Primary crusher Emission factor (Standard deviation) lb/ton	Secondary crusher Emission factor (Standard deviation) g/kg	Secondary crusher Emission factor (Standard deviation) lb/ton	Tertiary crusher Emission factor (Standard deviation) g/kg	Tertiary crusher Emission factor (Standard deviation) lb/ton	Fines crusher Emission factor (Standard deviation) g/kg	Fines crusher Emission factor (Standard deviation) lb/ton
A - Granite	0.005 (±0.0002)	0.01 (±0.005)	0.01 (±0.002)	0.02 (±0.005)	0.04 (±0.017)	0.07 (±0.03)	0.004 (±0.001)	0.008 (±0.002)
B - Sand and gravel	0.003 (±0.00015)	0.0006 (±0.0003)	0.001 (±0.0001)	0.002 (±0.0003)	-	-	-	-
C - Sand and gravel	0.0005 (±0.0004)	0.001 (±0.001)	0.001 (±0.0001)	0.002 (±0.0002)	-	-	-	-
D - Traprock	0.0004 (±0.0004)	0.0008 (±0.0008)	0.0005 (±0.0007)	0.001 (±0.0013)	0.0004 (±0.0001)	0.0008 (±0.0002)	0.0007 (±0.00035)	0.0014 (±0.0007)
E - Limestone[b]	-	-	0.00005 (±0.0001)	0.0001 (±0.0002)	-	-	-	-
G - Limestone	-	-	0.03 (±0.01)	0.06 (±0.02)	0.003 (±0.0009)	0.006 (±0.002)	-	-

[a]Plant F data, no tracer used for emission rate determination.
[b]Wet process.

TABLE 6. MEAN EMISSION FACTORS FOR <50 μm DUST FROM STONE CRUSHING OPERATIONS (UNCONTROLLED)

Plant and type	Primary crusher Emission factor (Standard deviation) g/kg	Primary crusher lb/ton	Secondary crusher Emission factor (Standard deviation) g/kg	Secondary crusher lb/ton	Tertiary crusher Emission factor (Standard deviation) g/kg	Tertiary crusher lb/ton	Fines crusher Emission factor (Standard deviation) g/kg	Fines crusher lb/ton
D - Traprock	0.0007 0.7 (±0.00008)	0.0015 (±0.002)	0.0003 0.3 (±0.00005)	0.0006 (±0.0001)	0.0008 0.8 (±0.0002)	0.0016 (±0.0004)	0.0008 0.8 (±0.0002)	0.0016 (±0.0003)
E - Limestone	-	-	0.00009 0.09 (±0.0002)	0.00018 (±0.0003)	-	-	-	-
G - Limestone	-	-	0.045 45.0 (±0.04)	0.09 (±0.07)	0.0035 3.5 (±0.0008)	0.007 (±0.002)	-	-

need kg/Mg

TABLE 7. MEAN <10 μ AND <50 μ-PARTICLE EMISSION FACTORS AND RATES FOR CONTROLLED (WET SUPPRESSION) VERSUS UNCONTROLLED LIMESTONE CRUSHERS

Particle cut -operating mode	Secondary crusher Emission rate, lb/hr	Secondary crusher Emission factor, lb/ton	Tertiary crusher Emission rate, lb/hr	Tertiary crusher Emission factor, lb/ton
<10 μm Uncontrolled	27	0.064	0.76	0.006
<10 μm Controlled	2.0	0.0048	0.14	0.0011
<50 μm Uncontrolled	37	0.088	0.89	0.007
<50 μm Controlled	6.4	0.015	0.20	0.0016
Control efficiency <10 μm, percent		92		81
Control efficiency <50 μm, percent		83		77

TABLE 8. AVERAGE OPACITY READINGS AT PLANT G

Operation	Percent opacity Controlled	Percent opacity Uncontrolled
Secondary crusher	8	91
Tertiary crusher	13	92

lb/Ton x 454 gm/lb ~~850~~ kg/Ton

Although these readings indicate that the wet dust suppression system reduced opacity to a considerable degree, they may not reflect the extent of opacity reduction. The opacity readings were taken at the crusher discharge points where the highest dust concentrations were noted, rather than at the plume dispersal points.

In the absence of this control method, dust was emitted around the entire perimeter of the discharge. With the wet suppression system operating, dust was only emitted from a small area where the conveyor transports the material out of the chute. Thus, this wet suppression method removes more visible particles than the numbers from the opacity tests indicate.

4. Discussion

The first two columns of Tables 9 and 10 show the emission factors developed during this study and those previously developed by MRC during the Source Assessment program. Both sets of emission factors are based on the downwind concentrations of <10 μ particles measured with a GCA RDM 101-4 dust monitor, however fundamentally different methods were used ro convert these downwind concentrations to emission rates. Dispersion modeling was used in the Source Assessment program to calculate emission rates, while tracer analysis was used in the present study.

The third column of Tables 9 and 10 present the suspended particulate emission factors specified in AP-42 for each general type of crushing operation. These emission factors are based on total particulate emissions, as determined by baghouse sampling, and the assumption that approximately 40% of these emissions settle out within the plant boundaries.

The fraction of uncontrolled emissions that fallout within the plant boundaries is important in determining emission factors because the NSPS standards are concerned with "ground level particulate concentrations that occur at and beyond the plant boundaries..." [5]. The NSPS document further states that "property boundaries are assumed to be a minimum distance of 300 meters from any stack." Thus, if the particle size distributions of uncontrolled emissions from various types of crushing operations were known, the actual fallout percentage within typical plant boundaries (e.g., 300 m from source) could be estimated by a series of settling velocity calculations for various particle sizes assuming typical wind speeds, plume centerline heights, etc. Without good particle size distribution data for uncontrolled emissions, however, this procedure cannot be directly utilized.

As an alternative to this procedure, the following series of calculations are performed.

The settling velocity of particles at a granite plant is computed to verify the validity of considering only the <10 μ particles at crushing locations. Particles larger than 10 μ are removed to a great extent by gravity and other inertial processes [6].

Settling times in the atmosphere are computed in the Stokes-Law region by the following expression:

$$u_t = \frac{gD_p^2 (\rho_p - \rho)}{18 \mu} \quad (4)$$

where D_p = diameter of the particle, ft
g = local acceleration due to gravity, ft/s²
ρ_p = density of particle, lb/ft³
ρ = density of air, lb/ft³
μ = fluid viscosity, lb/ft-s
u_t = settling velocity, ft/s

The following values are derived for granite dust in air:

D_p = 2.38×10^{-5} ft, for a 10 μ particle
4.92×10^{-5} ft, for a 15 μ particle
6.56×10^{-5} ft, for a 20 μ particle
9.84×10^{-5} ft, for a 30 μ particle
1.64×10^{-4} ft, for a 50 μ particle
g = 32.2 ft/s²
ρ_p = 165 lb/ft³, using specific gravity, 2.65
ρ = 0.08 lb/ft³
μ = 1.24×10^{-5} lb/ft-s

allowing calculation of the settling velocity shown in Table 11.

The distance within which various particle sizes will drop is then calculated from:

$$x = \frac{h}{u_t} \bullet v \quad (5)$$

where x = distance downwind, ft
h = height of the plume centerline, ft
v = wind velocity, ft/s
u_t = terminal settling velocity, ft/s

Assuming an average plume height of 10 feet from a crusher, and a typical windspeed of 5 mph, the values of Table 11 are computed.

TABLE 9. PARTICULATE EMISSION FACTORS FOR STONE CRUSHING OPERATIONS (STANDARD DEVIATION)

Operation	Emission factors, g/kg: Tracer analysis (<10 μm particulate) (uncontrolled)	Source assessment (<10 μm particulate) (uncontrolled)	AP-42 (suspended particulate) (uncontrolled)	NSPS Background document (Baghouse outlet (controlled)
Primary crushing				
-Granite	0.005 (±0.0002)		0.05[c]	
-Limestone	-	0.00017[c]		0.00078[c]
	-	unknown		
-Sand and gravel	0.0004[a] (±0.0003)			
-Traprock	0.0004 (±0.0004)	0.0013[c]		
Secondary crushing				
-Granite	0.01 (±0.002)	0.003 (±0.00008)	0.3[c]	
-Limestone	0.00005[b] (±0.0001)	0.00008 (±0.00009)		0.00017[c]
	0.032[b] (±0.01)			
-Sand and gravel	0.001 (±0.0001)			
-Traprock	0.0005 (±0.0007)	0.0006 (±0.0003)		
Tertiary crushing				
-Granite	0.04 (±0.017)		1.8[c]	
-Limestone	0.003 (±0.0009)			
-Traprock	0.0004 (±0.0001)	0.0001[c]		0.0028 (±0.001)
Fines crushing				
- Granite	0.004 (±0.001)		2.25[c]	
-Traprock	0.0007 (±0.0035)	0.0002[c]		

[a]Average of the emission factors for two separate crushing operations.

[b]Values not averaged due to wide disparity, one process wet, one dry.

[c]Not enough data points to compute a standard deviation value.

TABLE 10. PARTICULATE EMISSION FACTORS FOR STONE CRUSHING OPERATIONS (STANDARD DEVIATION) ENGLISH UNITS (lb/ton)

Operation	Tracer analysis (<10 μm particulate) (uncontrolled)	Source assessment (<10 μm particulate) (uncontrolled)	AP-42 (Suspended particulate) (uncontrolled)	NSPS Background document (Baghouse outlet particulate) controlled)
Primary crushing				
-Granite	0.01 (±0.0004)		0.10[c]	
-Limestone		0.00034[c]		0.00156[c]
-Sand and gravel	0.0008[a] (±0.0006)			
-Traprock	0.0008 (±0.0008)	0.0026[c]		
Secondary crushing				
-Granite	0.02 (±0.004)	0.0006 (±0.00016)	0.6[c]	-
-Limestone	0.0001[b] (±0.0002)	0.00016 (±0.00018)		0.00034[c]
	0.064 (±0.02)			
-Sand and gravel	0.002 (±0.0002)			
-Traprock	0.001 (±0.0014)	0.0012 (±0.0006)		
Tertiary crushing				
-Granite	0.08 (±0.034)		3.6[c]	
-Limestone	0.006 (±0.0018)			
-Traprock	0.0008 (±0.0002)	0.0002[c]		0.0056 (±0.002)
Fines crushing				
-Granite	0.008 (±0.002)		4.5[c]	
-Traprock	0.0014 (±0.007)	0.0004[c]		

[a]Average of the emission factors for two separate crushing operations.
[b]Values not averaged due to wide disparity, one process wet, one dry.
[c]Not enough data points to compute a standard deviation value.

TABLE 11. SETTLING VELOCITIES AND DISTANCES FROM CRUSHERS

Particle size, μm	Settling velocity, ft/s	Distance downwind, ft
10	0.026	2,800
15	0.057	1,300
20	0.10	730
30	0.23	320
50	0.64	110

Thus, particles larger than 15-20 μ would be expected to fallout within typical plant boundaries under the conditions assumed in the preceding analysis. This suggests that representative emission factors for stone crushing operations should be based on the rate at which <20 μ particles are emitted from the source. Although MRC's emission factors are based on <10 μ particulate, corresponding emission factors for <20 μ particulate should not be much higher. This contention is based on the concentration data presented in Tables 1 and 2, which indicate that approximately 50% of the <50 μ particulate collected 30 ft from the source consisted of <10 μ particulate.

The fourth column of data in Table 9 lists several emission factors presented in the NSPS background study [5]. These emission factors were derived by measuring particulate concentrations in baghouse outlet streams, and thus are "controlled" emission factors for suspended particulate from stone crushing operations. These emission factors are approximately the same order of magnitude as the uncontrolled emission factors derived by MRC during the present study and/or during the Source Assessment program. This implies that a very large percentage of the baghouse catch consists of large particles which would settle out within the plant boundaries if no control was applied.

Grab samples of baghouse catches were collected by industry technicians from baghouses connected to five different stone crushing plants. MRC conducted a particle size analysis of these catches by optical microscopy. This analysis generated a particle number distribution which was converted to a weight distribution using equation D-1:

$$w = nd^3 \tag{6}$$

where w = relative weight of the particle fraction
n = number of particles
d = diameter of the particle

The average diameter was used to represent each particle size range. The resultant particle weight distribution is presented in Table D-1. The average weight percentages of particles less than the 19.2 and 9.6 micron ranges are 3.9% and 0.95%, respectively.

TABLE D-1. PARTICLE SIZE DISTRIBUTION (by wt) OF BAGHOUSE DUST COLLECTED AT FIVE LIMESTONE CRUSHERS

Particle size range, μ	Location I Limestone	II Limestone	III Marble	IV Limestone	V Gneiss
0-1.2	0.0004	0.0008	0.0002	0.0002	0.0002
1.2-2.4	0.0004	0.04	0.012	0.01	0.01
2.4-4.8	0.49	0.21	0.062	0.10	0.077
4.8-9.6	1.65	0.87	0.245	0.68	0.29
9.6-19.2	4.66	4.23	1.44	2.58	2.01
19.2-38.4	26.89	21.98	9.97	9.24	6.75
38.4-76.8	66.27	40.62	58.62	73.91	41.61
greater than 76.8	0	32.04	29.64	13.47	49.24
composite % less than 19.2 μ	6.8	5.3	1.8	3.4	2.4
composite % less than 9.6 μ	2.1	1.1	0.32	0.79	0.38

APPENDIX A

GCA RDM 101-4 SAMPLING METHOD

A GCA Model RDM 101-4 dust monitor[a] was used to sample the downwind concentration of particulates from the stone crushing operations. This is an advanced instrument for on-the-spot measurement of mass concentrations of (<10 μm) particulates or total (<50 μm) particulate mass loading of particulates. It is a portable and fully automated unit with direct digital readout of the mass concentration of airborne particulates. Readings of 4 minutes to 30 minutes can be taken, and a traverse of points around a source of interest can be accomplished quickly. Results are obtained by electronic measurement of the beta absorption of the collected sample. A cyclone collection system is used as a first stage for removal of the >10-μm particulates.

During the GCA sampling, using the sampling apparatus shown in Figure A-1, all the data for each unit operation were recorded on the form shown in Table A-1.

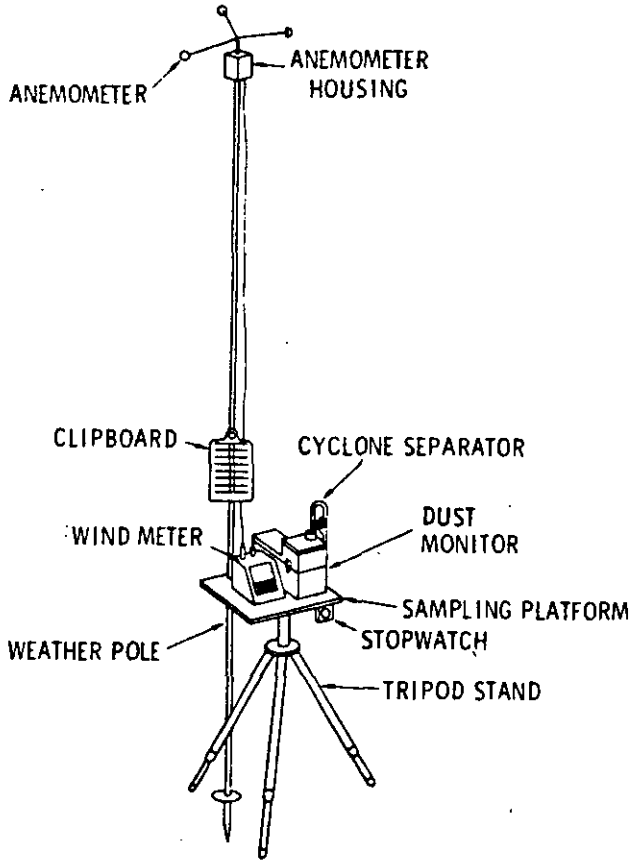

Figure A-1. Sampling apparatus.

[a]GCA Corporation, Bedford, Massachusetts.

TABLE A-1. FIELD DATA FORM

MODEL: POINT = 1
LINE = 2
DOSE = 3

SOURCE TYPE _____

DATE _____
BY _____

UNIT OPERATION	WIND SPEED, MPH	DISTANCE, FT. X	Y	Z	TIME, MIN.	READ., mg/m^3	CONC., μg/m^3	R/T	BGD, μg/m^3	Δ, μg/m^3	Q, g	S'	M	COMMENTS

TIME OF DAY ____ ____ ____ ____ ____
ATM. STABILITY ____ ____ ____ ____ ____

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.23
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

A meteorological station was employed to monitor the wind speed direction, and temperature for each concentration reading. Wind speeds were determined by averaging 30-second readings of a wind meter in a 4-minute interval. This meter was connected to an anemometer set atop a 3.05-m (10-ft.) pole. The downwind distance, X, was measured by physically pacing the shortest length to the source. Periodically the time and atmospheric stability class (using Figure A-2) were recorded on the bottom of the form. Set-up distance is determined by following the guidelines of Table A-3 in conjunction with the sampling guidelines of Figure A-4. ? Source ?

The GCA RDM 101-4 was maintained within the plume throughout the 4-minute sampling period. ?

TABLE A-2. EXPLANATION OF FIELD DATA FORM TERMS

Term (units)	Meaning
Read (mg/m³)	Digital readout of concentration
Conc. (μg/m³)	Converted concentration for sampling times greater than 4 minutes (per list in lower right hand corner of form)
R/T	R = <10 μm reading T = <50 μm reading
BDG (μg/m³)	Background concentration
Δ (μg/m³)	The difference between the converted concentration and the background
Q (g or g/s)	Calculated emission rate
S'	Stability for the time and day the unit operation was sampled
M	The model used and referenced as 1, 2, or 3 (point, line, or dose, respectively)

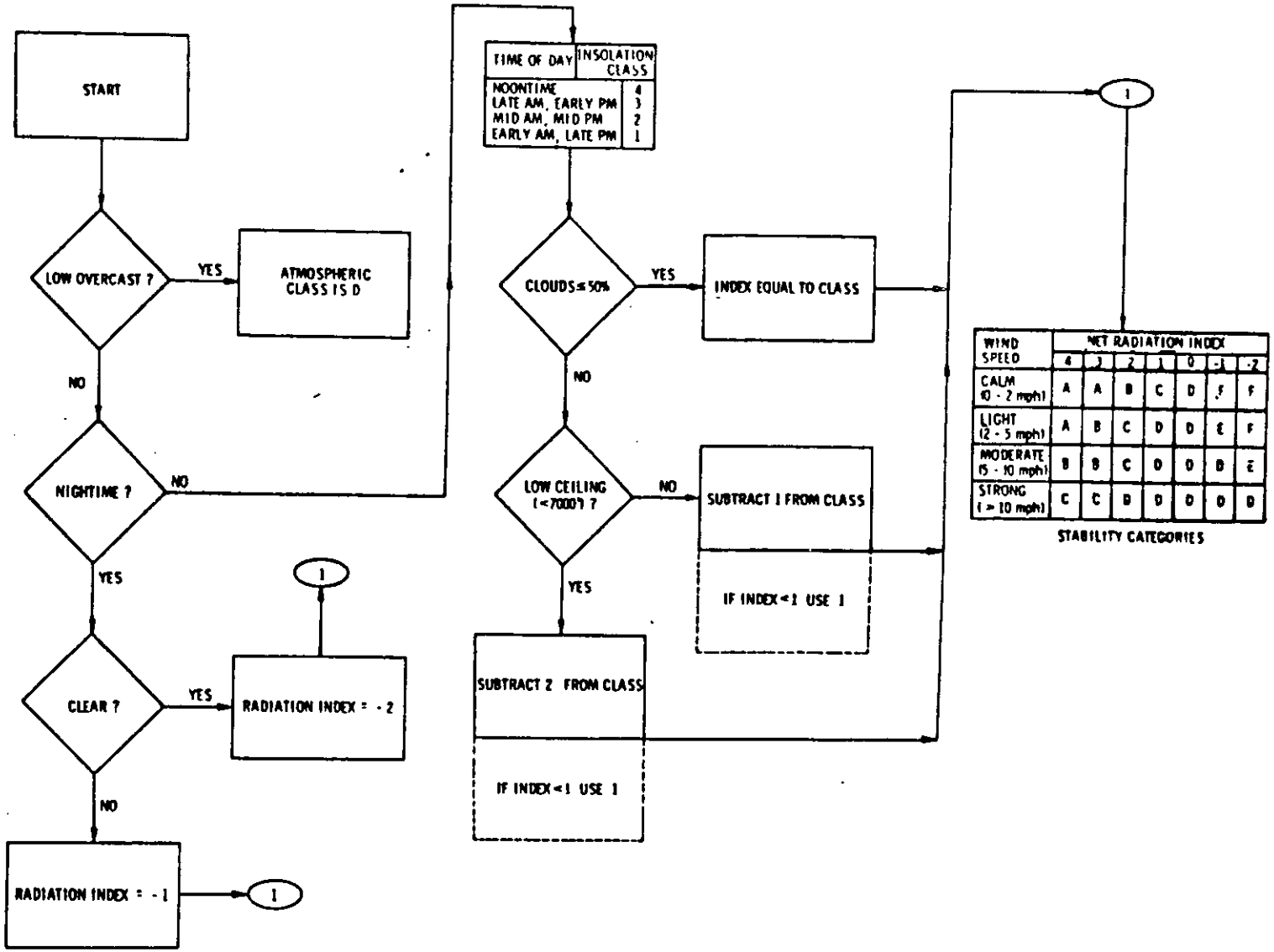

Figure A-2. Flow chart of atmospheric stability class determination (22).

TABLE A-3. PLACEMENT OF SAMPLES DOWNWIND OF OBSTRUCTIONS

1. Both the open source height and the obstructions must meet the required minimum distance criteria.
2. Stability class is determined from cloud cover, wind speed, and time of day (see Figure A-2).
3. The height of obstruction or source equals H.

Stability class	Minimum distance downwind from obstruction peak
A	5H
B	7H
C	10H
D	17H
E	25H[a]
Other classes	Cannot be done

[a]Requires an additional sampler at least 15H downwind for backup.

TABLE A-4. OPEN SOURCES SAMPLING GUIDELINES

1. Determine predicted wind direction and speed from:
   a. U.S. Weather Bureau and/or
   b. Field estimate
2. Determine atmospheric stability class expected - see table on worksheet (Figure A-2.)
3. Locate positions of samplers around source. Use guidelines for downwind distance (Table (A-3)
4. Place upwind sampler (background) and start sampling.
5. Place wind instrument and downwind samplers for source monitoring.
6. Monitor wind direction and speed every 15 minutes and stability class every 2-3 hours; note time sampler flow rates were checked at first 1/2 hour and then every 1-1/2 hours. If wind direction is off centerline by more than 0.78 rad (45°) in two consecutive readings, stop sampler until direction returns within 0.78 rad (45°) for 15 minutes.
7. Complete sampling in minimum sampling time determined by project leader.

APPENDIX B

TRACER GAS SAMPLING METHOD

Using this technique, the emission rate of dust from the source can be determined in conjunction with downwind concentration readings of dust concentration (Appendix A, GCA RDM 101-4). In short, a tracer gas (SF_6) is released at the pollutant source of interest at a known emission rate (Q_T). Concentration measured of both the dust level (C_D) and a bag sample of the air are collected concurrently downwind of the source. The GCA RDM 101-4 is used to obtain the concentration readings of the <10 μ particulates. The bag sample is analyzed in the same day after sampling by a gas chromatograph equipped with an electron capture detector. Determining the dust emission rate (Q_D) is then an equivalent ratio problem since both the tracer gas and the dust are subject to the same dispersion forces. The resulting expression:

$$\frac{Q_T}{C_T} = \frac{Q_D}{C_D} \qquad \text{(B-1)}$$

becomes

$$Q_D = \frac{Q_T}{C_T} \bullet C_D \qquad \text{(B-2)}$$

where $\frac{Q_T}{C_T}$ = D = Dilution Factor (B-3)

Q_T = known tracer emission rate, g/s

C_T = measured tracer concentration, μg/m³

C_D = measured dust concentration, μg/m³

Q_D = dust emission rate, g/s

Since the RDM 101-4 functioned best (remained within the linear range) using a four-minute sampling time, it was decided to bridge three measurements of dust concentration with a single bag sample for SF_6. This enabled observation of the variance of emission measurements between dust readings. In addition, three bag samples were obtained at each downwind distance to observe the variance of SF_6 concentrations between bag samples.

The dilution factors for each dust reading were determined by assuming the following:

$$\overline{C}_T = \frac{C_{T_1} + C_{T_2} + C_{T_3}}{3} \qquad \text{(B-4)}$$

where $\bar{C}_T$ = average SF_6 concentration over the three tests

C_{T_1}, C_{T_2}, C_{T_3} = computed SF_6 concentration for each bag sample

and;

$$\bar{C}_D = \frac{C_{D_1} + C_{D_2} + C_{D_3}}{3} \qquad \text{(B-5)}$$

where $\bar{C}_D$ = average dust concentration over the three tests

C_{D_1}, C_{D_2}, C_{D_3} = three dust readings made per bag sample

$$\frac{C_{T_1}}{\bar{C}_T} = \frac{C_{D_1}}{\bar{C}_D} \qquad \text{(B-6)}$$

therefore:

$$C_{T_1} = C_{D_1} \bullet \frac{\bar{C}_T}{\bar{C}_D} \qquad \text{(B-7)}$$

Next, it is assumed that the ratio of the dust and tracer concentrations are the same for each test (this assumption is valid since both sources are constant over the test period). As an example:

The dilution factors for the three samples/bag are:

$$D_1 = \frac{Q_T}{C_{T_1}},\ D_2 = \frac{Q_T}{C_{T_2}},\ \text{and}\ D_3 = \frac{Q_T}{C_{T_3}} \qquad \text{(B-8)}$$

Using equation B-2 then, three dust emission rates are determined as:

$$Q_{D_1} = D_1 \bullet C_{D_1},\ Q_{D_2} = D_2 \bullet C_{D_2},\ \text{and}\ Q_{D_3} = D_3 \bullet C_{D_3} \qquad \text{(B-9)}$$

APPENDIX C

SAMPLING SITE DATA

Seven aggregate processing plants were sampled during the course of this study. At each location, the sampling crew awaited the optimal sampling conditions; wind speed adequate for dispersion, stable wind direction, normal crushing operation, and maintenance of the sampler in a position to isolate the source from interferences. Haul roads were wetted to negate this source from the crushing emissions. Upwind dust concentrations were taken as a check on the isolation of the source and to subtract this value from the downwind dust readings.

The layouts of the seven plants, labeled plants A-G, are shown in Figure C-1 - C-7. Each figure is marked with the location of the sampling points (i.e., Plant A, points A1-A10 downwind of tertiary crusher. Each drawing also contains the production rate for each crusher. Arrows indicate the flow of stone throughout the plants. Plant D was a facility tested previously under the Source Assessment program to be used in a comparison with the results from this testing program.

Sampling was conducted at Plant G under controlled (wet suppression) and uncontrolled conditions. This enabled a comparison of emission levels for these states, to obtain data on control efficiency.

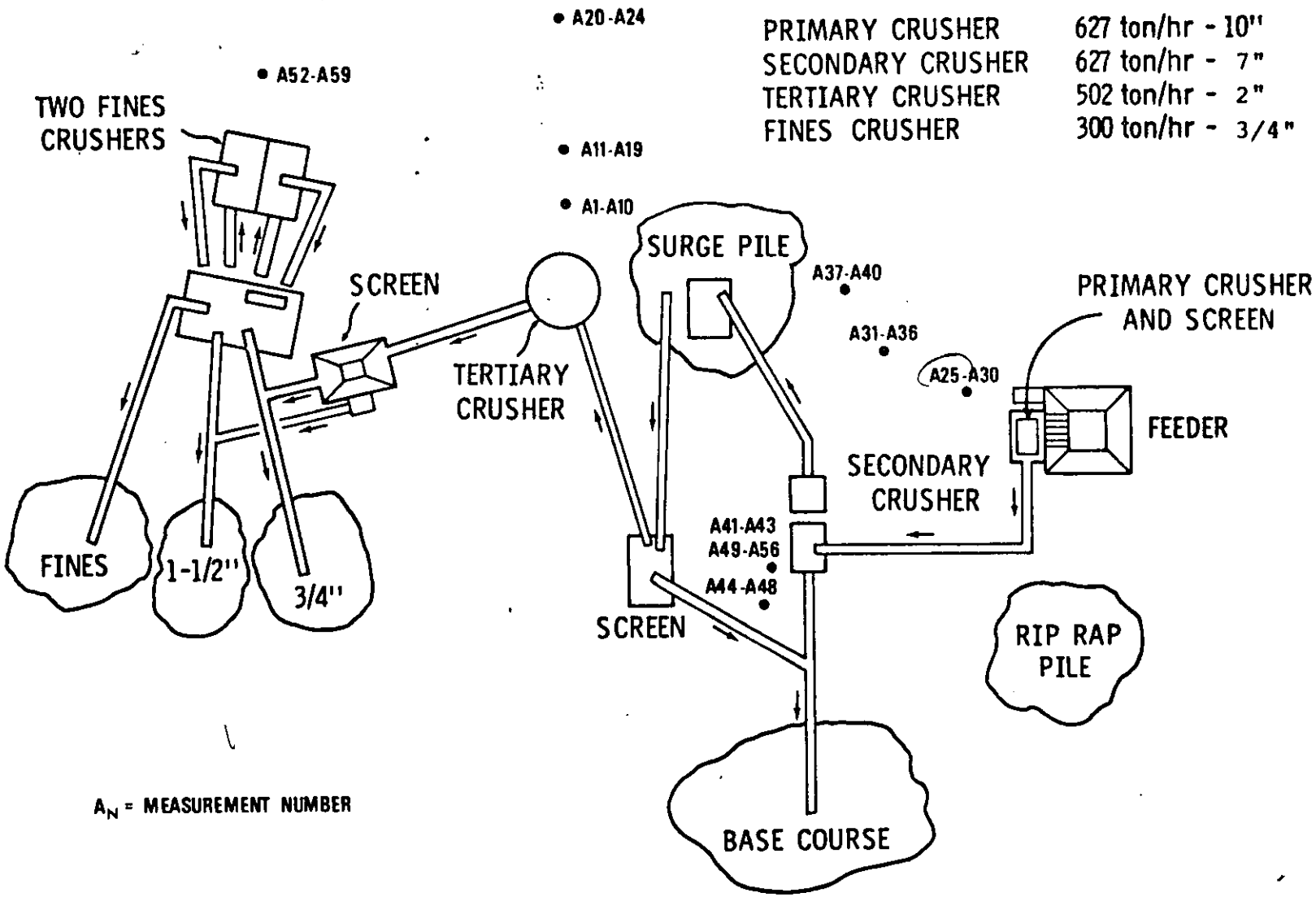

Figure C-1. Plant A sampling site.

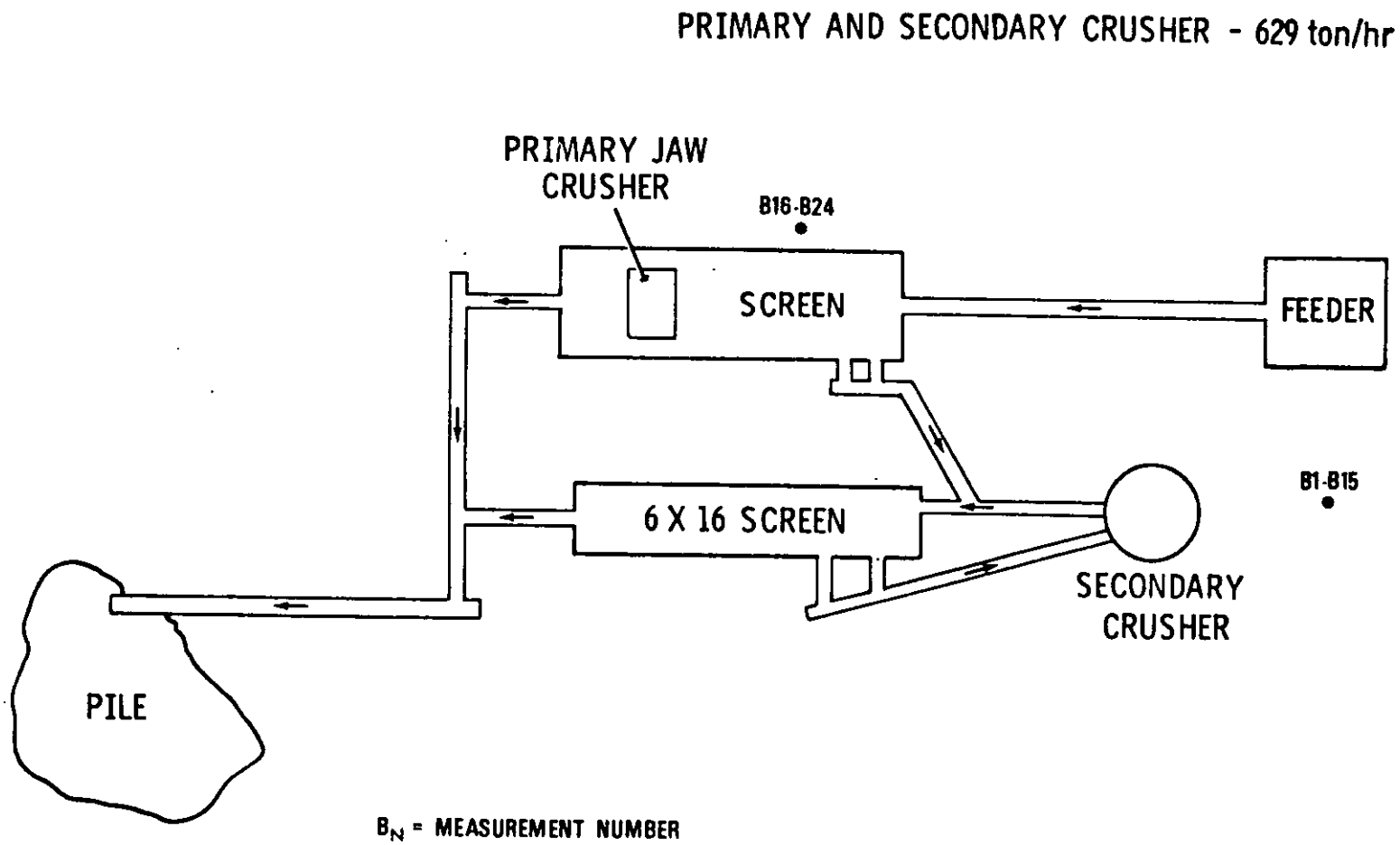

Figure C-2. Plant B sampling site.

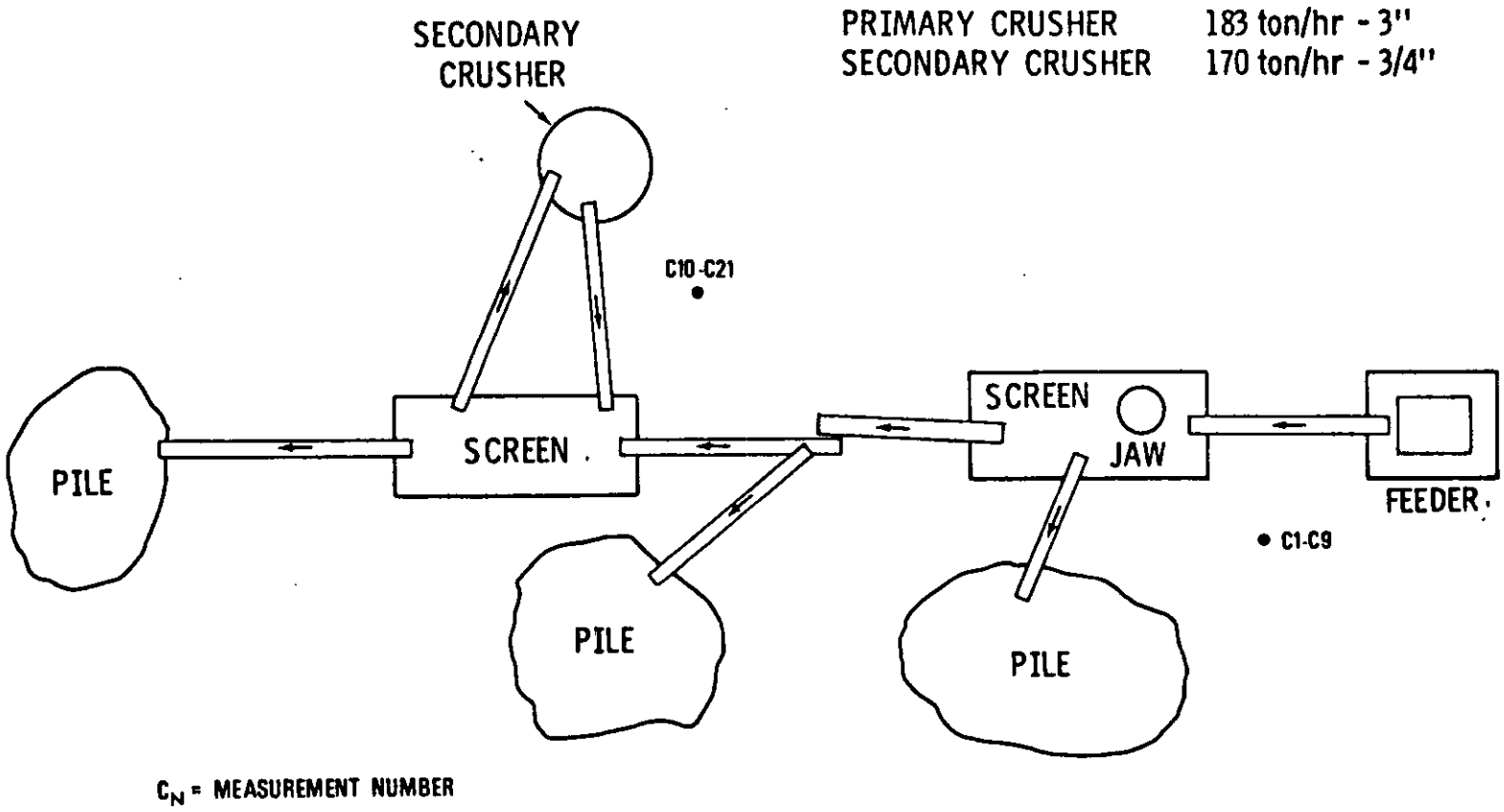

Figure C-3. Plant C sampling site.

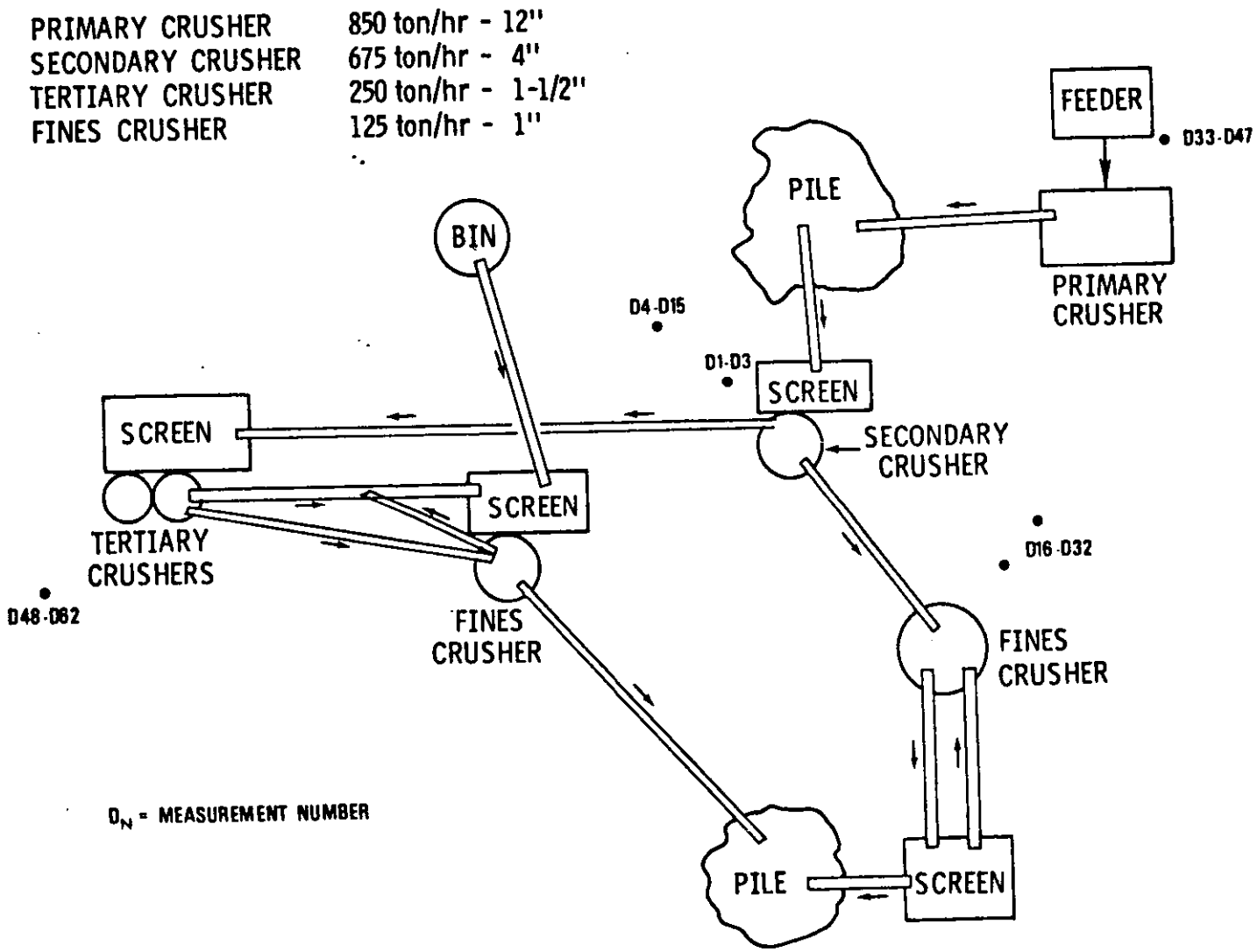

Figure C-4. Plant D sampling site.

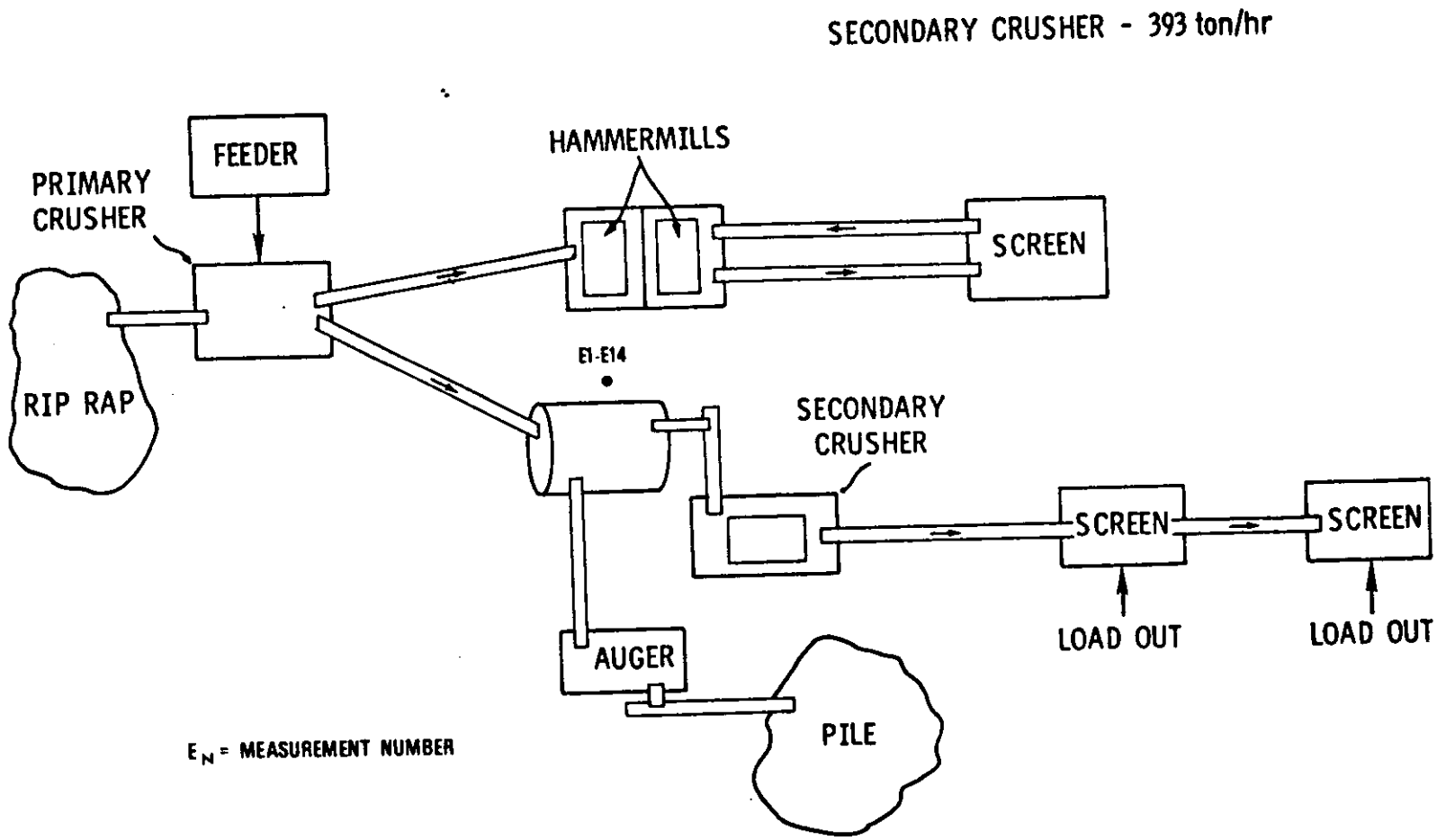

Figure C-5. Plant E sampling site.

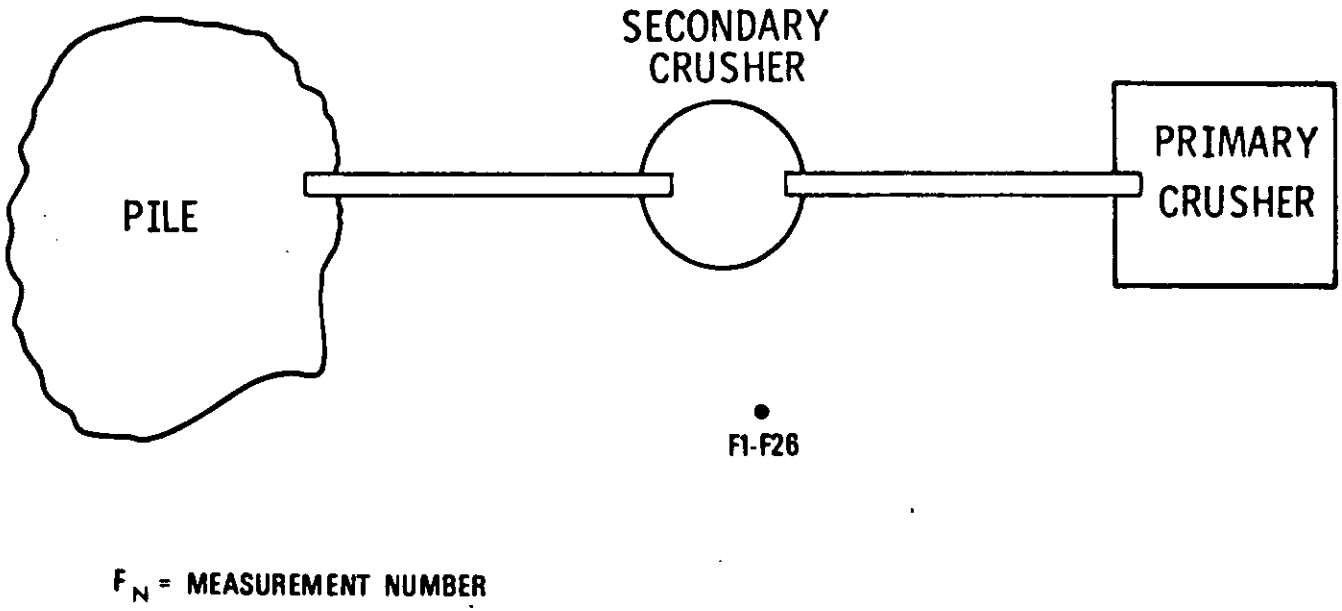

Figure C-6. Plant F sampling site.

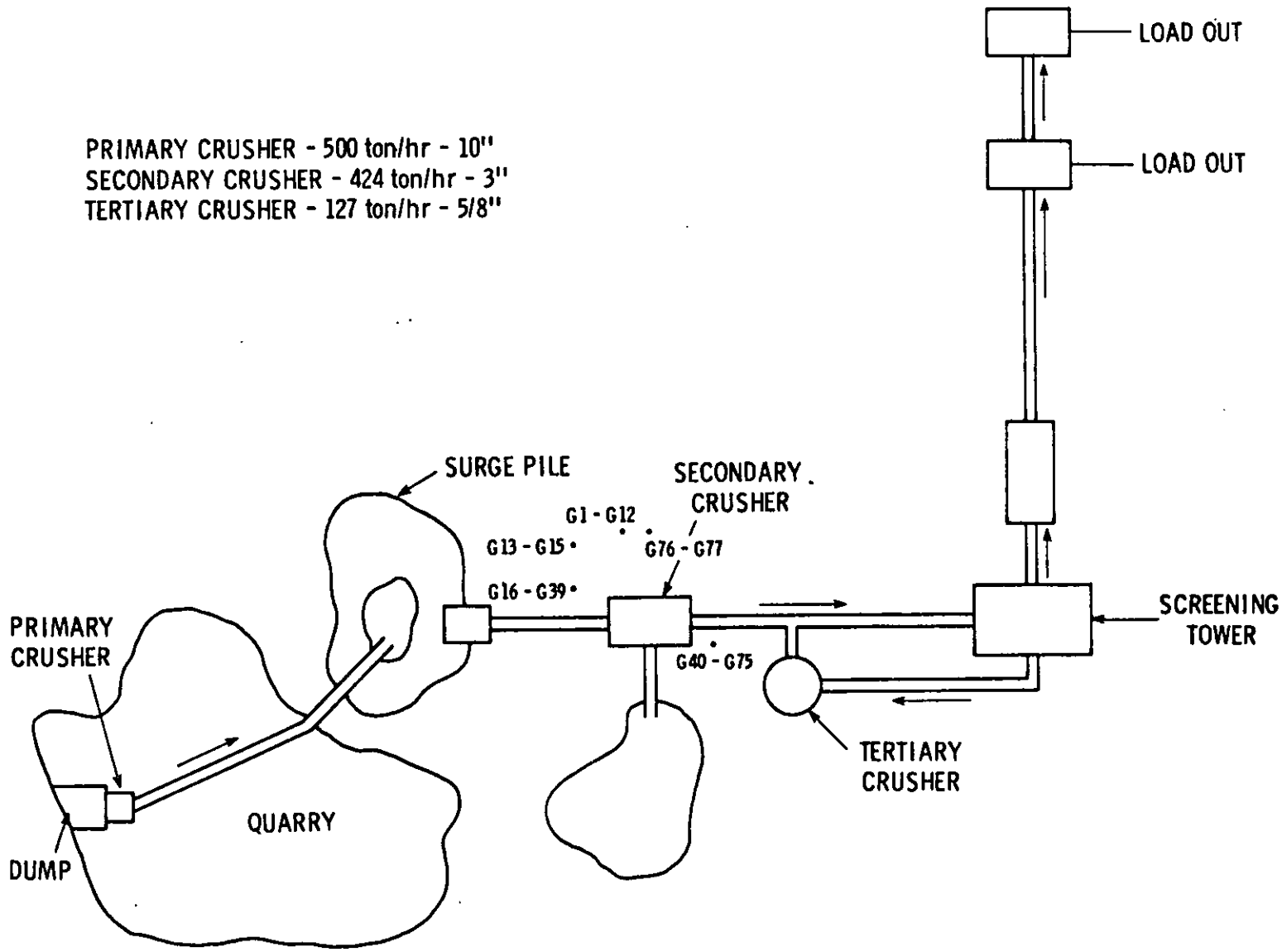

Figure C-7. Plant G sampling site.

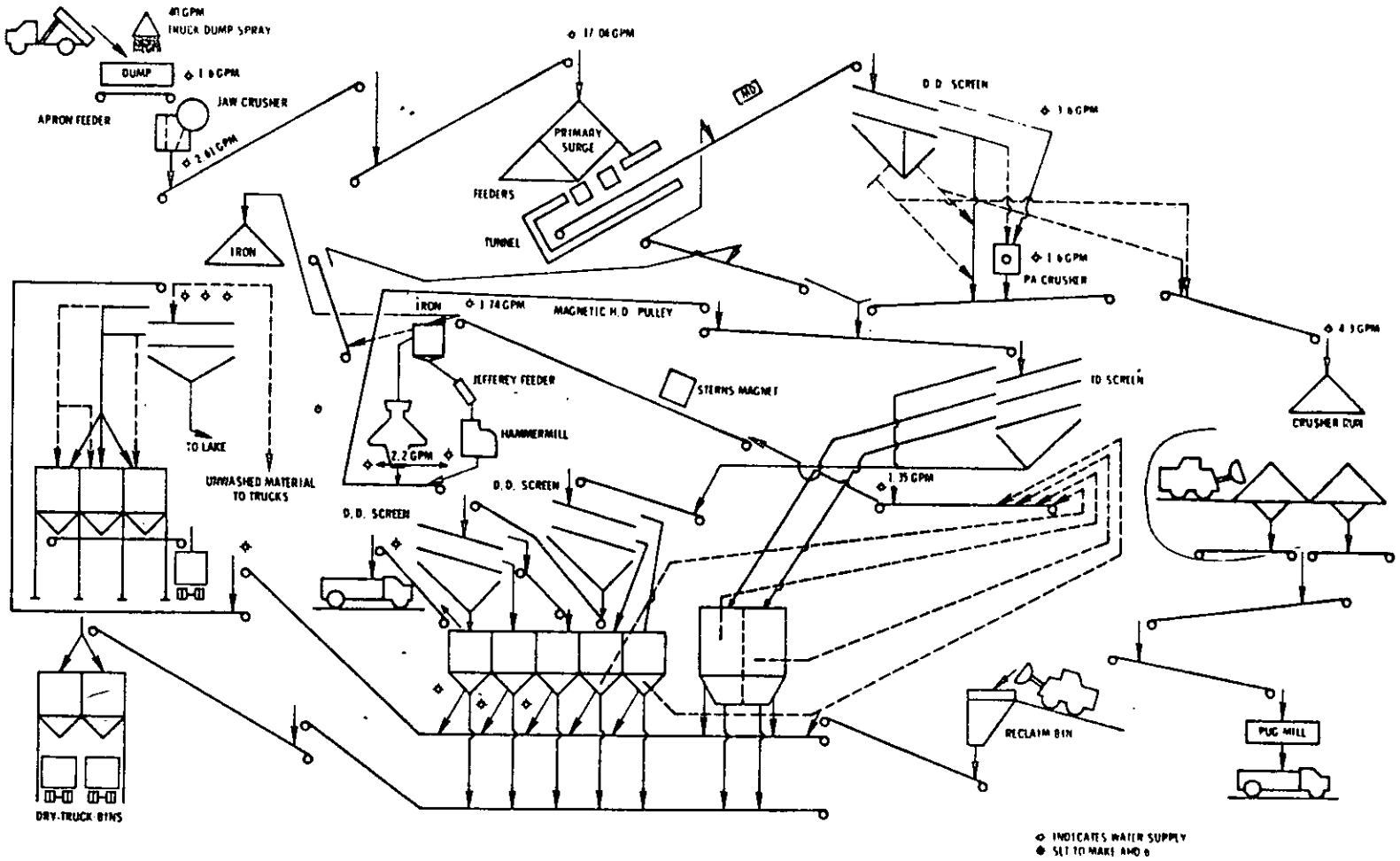

Figure C-8. Plant G - Wet Suppression System.

APPENDIX D

FUGITIVE DUST SAMPLING WITH GCA/RDM 101-4

FIELD DATA

S clear sky
No wind

FIELD DATA FORM

DATE 6/18/79
BY Wachter

MODEL: POINT = 1
LINE = 2
DOSE = 3

SOURCE TYPE Plant A

		UNIT OPERATION	WIND SPEED, MPH	DISTANCE, FT. X	Y	Z	TIME, MIN.	READ. µg/m³	CONC. µg/m³	R/T	BGD. µg/m³	Δ, µg/m³	BAG NO.	S'	M	WIND SPEED READINGS COMMENTS
10:57	A1	~~Secondary~~ Crusher	0.2	30	3	15	20	680	1140	R	40	1100	B-11	B	1	0-1-0-2-4-0
12:48	A2	" "	2.1	30	3	5	20	5.890	1084	R	40	679	B-9	C	1	0-4-2-1-4-3-5-1-0-2-4
1:11	A3	" "	2.5	30	3	0	20	7.07	862	R	40	822	B-18	C	1	See Attached Sheet #1
1:33	A4	" "	3.8	30	3	0	4	2.15	2150	R	40	2110	B-25	C	1	" "
1:37	A5	" "	3.5	30	3	0	4	1880	1880	R	40	1840	"	C	1	" "
1:41	A6	" "	3.2	30	3	0	4	1890	1890	R	40	1850	"	C	1	" "
1:46	A7	" "	3.7	30	3	0	4	680	680	R	40	640	B-29	C	1	" "
1:51	A8**	" "	2.9	30	3	0	4	270	270	R	40	230	"	C	1	" "
2:13	A9	" "	4.2	30	3	0	4	2040	2040	R	40	2000	B-3	C	1	" "
	A10**	" "	4.0	30	3	0	4	219	219	R	40	179	"	C	1	" "
3:27	A11	" "	6.5	30	18	0	4	820	820	R	85	735	B-32	C	1	" "
3:31	A12	" "	6.1	60	18	0	4	830	830	R	85	745	"	C	1	" "
	A13	" "	5.7	60	18	0	4	1010	1010	R	85	925	"	C	1	" "

TIME OF DAY	MORN	AFTER				
ATM. STABILITY	B	C				

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.23
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

Sa 2 cr 0
Mersy

* clear sky
low wind ~5 miles phour

** A-10, A-8 process

BGD R
µg/m³
60 120 & 50 85
30 0 & 80 40

FIELD DATA FORM

MODEL: POINT = 1
LINE = 2
DOSE = 3

SOURCE TYPE PLANT A

DATE 6/18/79
BY Wechter

	UNIT OPERATION	WIND SPEED, MPH	DISTANCE, FT. X	Y	Z	TIME, MIN.	READ., µg/m³	CONC., µg/m³	R/T	BGD, µg/m³	I, µg/m³	BAG NO.	S'	M	WIND SPEED READINGS COMMENTS
3:40	Crusher	5.0	60	10	3	4	930	930	R	85	845	B20	C	1	See Attached #1
3:45 A15	" "	5.6	60	10	3	4	1200	1200	R	85	1115	B-20	C	1	" #2
3:51 A16	" "	4.6	60	10	3	4	1420	1420	R	85	1335	B-20	C	1	" "
3:52 A17	" "	5.6	60	10	3	4	690	690	R	85	605	B-16	C	1	" "
4:00 A18	" "	5.6	60	10	3	4	890	890	R	85	805	B-16	C	1	" "
4:04 A19	" "	5.3	60	10	3	4	900	900	R	85	815	B-16	C	1	" "
4:09 A20	" "		120	0	3	4	580	580	R	85	695	B-35	C	1	" "
4:13 A21	" "		120	0	3	4	980	980	R	85	895	B-35	C	1	" "
4:17 A22	" "		120	0	3	4	1010	1010	R	85	925	B-35	C	1	" "
4:21 A23	" "		120	0	3	4	860	860	R	85	775	B-12	C	1	" "
4:25 A24	" "		120	0	3	4	790	790	R	85	705	B-12	C	1	" "
~~[illegible]~~	~~[illegible]~~		~~[illegible]~~												

TIME OF DAY After
ATM. STABILITY C

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.[illegible]
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

1 of 3

FIELD DATA FORM

MODEL: POINT = 1
LINE = 2
DOSE = 3

SOURCE TYPE PLANT A

DATE 6/19/79
BY Wachter

	UNIT OPERATION	WIND SPEED, MPH	DISTANCE, FT. X	Y	Z	TIME, MIN.	READ., µg/m³	CONC., µg/m³	R/T	BGD, µg/m³	A, µg/m³	BAG NO.	S'	M	COMMENTS
9:40 A-25	Primary Crusher	2.6	30	10	13	4	110	110	R	0	110	B-7	C	1	Batch operation (-22 sec) * Total Run Time ~~2:45~~
9:44 A-26	" "	3.7	30	10	13	4	180	180	R	0	180	"	C	1	" " " 1:45
9:49 A-27	" "	7.1	30	10	13	4	190	190	R	0	190	"	C	1	" " " ~~3:15~~ 2:45
10:13 A-28	" "	5.3	30	10	13	4	210	210	R	0	210	B-26	C	1	" " " ~~4:00~~
10:17 A-29	" "	8.5	30	10	13	4	160	160	R	0	160	"	C	1	" " " ~~2:50~~
10:22 A-30	" "	8.8	30	10	13	4	360	360	R	0	360	"	C	1	" " " ~~3:40~~
10:41 A-31	" "	7.9	60	10	13	4	280	280	R	0	280	B-13	C	1	" " 3:45
10:45 A-32	" "	6.5	60	10	13	4	90	90	R	0	90	B-13	C	1	" " 3:43
10:50 A-33	" "	3.1	60	10	13	4	290	290	R	0	290	B-13	C	1	" " 4:00
11:00 A-34	" "	3.2	60	10	13	4	140	140	R	0	140	B-17	C	1	" " 3:40
11:04 A-35	" "	0.7	60	10	13	4	110	110	R	0	110	"	C	1	" " 3:15
11:08 A-36	" "	1.5	60	10	30	4	40	40	R	0	40	"	C	1	" " 2:50
11:15 A-37	" "	2.6	20	15	30	4	90	90	R	0	90	B-4	C	1	" " 4:00

TIME OF DAY	9:30 AM	11:10			
ATM. STABILITY	C	C			

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.23
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

6/19

BGD 0 µg/m³

$$\bar{R}_B = \frac{\text{BGD } 0}{0} \ \mu g/m^3$$

2 of 2

FIELD DATA FORM

MODEL: POINT = 1
LINE = 2
BOSE = 3

SOURCE TYPE Plant A

DATE 4/19/79
BY Wechter

	UNIT OPERATION	WIND SPEED, MPH	DISTANCE, FT. X	Y	Z	TIME, MIN.	READ., mg/m³	CONC., µg/m³	R/T	BGD, µg/m³	A, µg/m³	BAG No.	S'	M	COMMENTS
															Batch operation
11:19 A-38	Primary Crusher	2.1	120	15	20	4	80	80	R	0	80	B-4	C	1	Total Run Time 2:38
11:23 A-39	" "	2.2	120	15	20	4	340*	340*	R	0	340*	B-4	C	1	" " " 3:37
A-40	" "	2.5	120	15	20	4	0**	0**	R	0	0	B-15	C	1	" " " 3:45
~~A-41~~	~~" "~~		~~120~~	~~15~~	~~20~~	~~4~~			~~R~~	~~0~~		~~"~~	~~C~~	~~1~~	~~" "~~ "
~~A-42~~	~~" "~~		~~120~~	~~15~~	~~20~~	~~4~~			~~R~~	~~0~~		~~"~~	~~C~~	~~1~~	~~" "~~
2:13 A-41	Secondary Crusher	2.7	30	30	5	4	280	280	R	0	280	B-6	D	1	Run Time 4 MIN
2:17 A-42	" "	3.6	30	30	5	4	140	140	R	0	140	B-6	D	1	" " "
A-43	" "	2.5	30	30	5	4	170	170	R	0	170	B-6	D	1	" " "
A-44	" "	2.1	60	30	5	4	120	120	R	0	120	B-5	D	1	" " "
A-45	" "	1.9	60	30	5	4	180	180***	R	0	180	"	D	1	" " "
~~A-46~~	~~" "~~											~~"~~	~~D~~	~~1~~	~~" "~~
~~A-46~~	~~Secondary Crusher~~		~~60~~	~~30~~	~~5~~	~~4~~			~~R~~	~~0~~			~~D~~	~~1~~	
4:10 A-46	Secondary Crusher		60	30	15	4	200	200	R	0	200	0	C	1	Run Time 4 MIN

TIME OF DAY	2:10	4:10	—	—	—
ATM. STABILITY	D	C	—	—	—

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.23
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

~~NO TRACER USED~~

* MAY HAVE PICKED UP SOME OF SECONDARY CRUSHER, WIND SHIFTED SLIGHTLY

** WIND IS SHIFTING

*** Total Fluoride ran-out, tracer empty.

3 of 3

FIELD DATA FORM

DATE 6/19/7_
BY Wachter

MODEL: POINT = 1
LINE = 2
DOSE = 3

SOURCE TYPE Plant A

	UNIT OPERATION	WIND SPEED, MPH	DISTANCE, FT. X	Y	Z	TIME, MIN.	READ., µg/m³	CONC. µg/m³	R/T	BGD, µg/m³	Δ, µg/m³	BAG NO.	S'	M	COMMENTS
4:15 A-47	Secondary Crusher		60	20	15	4	340	340	R	0	340	B-33	C	1	Total in process, 4 min
4:20 A-48	" "		60	10	15	4	130	130	R	0	130	B-33	C	1	" " " "
4:30 A-49	" "	3.1	30	5	15	4	350	350	R	0	350	B-21	C	1	" " "
4:34 A-50	" "	2.8	30	5	10	4	500	500	R	0	500	"	C	1	Operating time 2:58
~~A-51~~	~~" "~~		~~30~~	~~5~~	~~15~~	~~4~~			~~R~~	~~0~~		~~"~~	~~C~~		~~" "~~
A-51	Secondary Crusher	2.1	30	5	5	4	680	680	R	0	680	B-27	C	1	Operating 4 min
~~A-52~~	~~" "~~		~~30~~	~~5~~	~~5~~	~~4~~			~~R~~	~~0~~		~~B-27~~	~~C~~		~~" "~~
~~A-53~~	~~" "~~		~~30~~	~~5~~	~~5~~	~~4~~			~~R~~	~~0~~		~~B-27~~	~~C~~		~~" "~~

3:39
−41
8

TIME OF DAY 4:10
ATM. STABILITY C

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.23
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

⊥ to WIND DIRECTION
OPPOSITE OF CRUSHER

FIELD DATA FORM

MODEL: POINT = 1
LINE = 2
DOSE = 3

SOURCE TYPE Plant A

DATE 6/21/79
BY Wachter

	UNIT OPERATION	WIND SPEED, MPH	DISTANCE, FT. X	Y	Z	TIME, MIN.	READ., mg/m³	CONC. µg/m³	R/T	BGD, µg/m³	N, µg/m³	BAG	S'	M	COMMENTS
A-52(2)	Fines Crusher*	0.01	30	5	20	4	720	720	R	50	670	B-33	C	1	
A-53	" "	0.01	30	5	20	4	540	540	R	50	490	"	C	1	
A-54	" "	0.01	30	5	20	4	320	320	R	50	270	"	C	1	
A-55	" "	0.01	40	0	20	4	1020	1020	R	50	970	B-3	C	1	
A-56	" "	0.01	40	0	20	4	410	410	R	50	360	"	C	1	
A-57	" "	0.01	40	0	20	4	580	580	R	50	530	"	C	1	
A-58	" "	0.01	40	0	20	4	1180	1180	R	50	1130	B-27	C	1	
A-59	" "	0.01	40	0	20	4	700	700	R	50	650	"	C	1	
A-60	" "	0.01	40	20	20	4	320	380	R	50	330	B-29	C	1	
A-61	" "	0.01	40	20	10	4	380	380	R	50	330	"			
A-62	" "	0.01	40	20	10	4	110	110	R	50	60	"			
Background												B-22			

TIME OF DAY	9:41	11:02	—	—	—
ATM. STABILITY	C	C	—	—	—

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.3[illegible]
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

* Note: 2 crushers together

360
40
60
50

FIELD DATA FORM

MODEL: POINT = 1
LINE = 2
DOSE = 3

SOURCE TYPE Plant B

DATE 6/20/79
BY Wachter

	UNIT OPERATION	WIND SPEED, MPH	DISTANCE, FT. (est.) X	Y	Z	TIME, MIN.	READ., μg/m³	CONC., μg/m³	R/T	BGD, μg/m³	N, μg/m³	BAG NO.	S'	M	COMMENTS
9:51 BP-1	Secondary Crusher**	1.8	30	10	5	4	10	10	R	40	—	B-32	C	1	<1" material
9:55 BP-2	" "	1.1	30	10	5	4	770	770	R	40	730	"	C	1	"
9:59 BP-3	" "	1.8	30	10	5	4	0	0	R	40	—	"	C	1	"
10:13 BP-4	" "	0	30	15	5	4	540	540	R	40	500	B-11	C	1	"
10:17 BP-5	" "	0.1	30	15	5	4	540	540	R	40	500	"	C	1	"
10:21 BP-6	" "	0.8	30	15	5	4	280	280	R	40	240	"	C	1	"
10:25 BP-7	" "	1.0	30	10	5	4	1270	1270	R	40	1230	B-16	C	1	"
10:29 BP-8	" "	0.6	30	10	5	4	290	290	R	40	250	"	C	1	"
10:34 BP-9	" "	0.03	30	10	5	4	900	900	R	40	860	"	C	1	"
10:40 BP-10	" "	1.1	30	5	5	4	120	120	R	40	80	B-21	C	1	"
10:44 BP-11	" "	0.1	30	15	5	4	1090	1090	R	40	1050	"	C	1	"
10:49 BP-12	" "	0.5	30	15	5	4	620	620	R	40	580	"	C	1	"
10:55 BP-13	" "	0.03	30	15	5	4	380	380	R	40	340	B-9	C	1	"

TIME OF DAY	9:42	11:10	—	—	—
ATM. STABILITY	C	C	—	—	—

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.23
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

BGD
30
50
40

* BAG DID NOT FILL, NOT B-21 SAMPLE, ALONE

** CONE CRUSHER

FIELD DATA FORM

MODEL: POINT = 1
LINE = 2
DOSE = 3

SOURCE TYPE PLANT B

DATE 6/20/79
BY WACHTER

	UNIT OPERATION	WIND SPEED, MPH	DISTANCE (est.) X	Y	FT. Z	TIME, MIN.	READ., µg/m³	CONC. µg/m³	R/T	BGD. µg/m³	Δ, µg/m³	BAG NO.	S'	M	COMMENTS
10:59 BP-14	Secondary Crusher	0.1	30	15	5	4	130	130	R	40	90	B-9	C	1	4-1" SIZE
11:04 BP-15	" "	0.01	30	15	5	4	180	180	R	40	140	"	C	1	"
1:50 BP-16	Primary Crusher*	0.01	30	10	20	4	140	140	R	40	100	B-12	C	1	1½-2" SIZE
BP-17	" "	0.01	30	10	20	4	570	570	R	40	530	B-12	C	1	"
BP-18	" "	0.02	30	10	20	4	60	60	R	40	20	B-12	C	1	"
BP-19	" "	0.02	30	10	20	4	220	220	R	40	180	B-15	C	1	"
BP-20	" "	0.1	30	10	10	4	120	120	R	40	80	"	C	1	"
BP-21	Primary Crusher*	0.01	30	10	20	4	140	140	R	40	40	"	C	1	"
BP-22	Primary Crusher	0.01	30	10	20	4	110	110	R	40	70	B-18	C	1	"
BP-23	" "	0.01	30	10	20	4	20	20	R	40		B-18	C	1	"
BP-24	" "	0.01	30	10	20	4	60	60	R	40	20	B-18	C	1	"
~~BP-25~~			30			4			R	40			C	1	
~~BP-26~~			30			4			R	40			C	1	

TIME OF DAY 1:10
ATM. STABILITY C

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.23
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

* JAW CRUSHER

Pg -

FIELD DATA FORM

MODEL: POINT = 1
LINE = 2
DOSE = 3

SOURCE TYPE Plant C

DATE 6/26/79
BY Wachter

	* UNIT OPERATION	WIND SPEED, MPH	DISTANCE, FT. X	Y	Z	TIME, MIN.	READ. µg/m³	CONC. µg/m³	R/T	BGD µg/m³	Δ, µg/m³	BGG NO.	S'	M	COMMENTS
9:24 C1	Primary Crusher	0.01	30	10	13	4	150	150	R	40	110	B-34	D	1	Tracer used SF6
9:25 C2	" "	0.01	30	10	13	4	90	90	R	40	50	"	D	1	"
9:29 C3	" "	0.01	30	10	13	4	0	0	R	40	0	"	D	1	"
9:35 C4	" "	0.01	30	10	13	4	200	200	R	40	160	B-9	D	1	"
9:39 C5	" "	0.01	30	10	13	4	210	210	R	40	170	"	D	1	"
9:44 C6	" "	0.01	30	10	13	4	320	320	R	40	280	"	D	1	"
9:48 C7	" "	0.01	30	10	13	4	390	390	R	40	350	B-24	D	1	"
9:52 C8	" "	0.01	30	10	13	4	140	140	R	40	100	"	D	1	"
9:56 C9	" "	0.01	30	10	13	4	120	120	R	40	80	"	D	1	"
10:04 C10	Secondary Crusher	0.2	30	5	5	4	0	0	R	40	-0	B-27	D	1	"
10:08 C11	" "	0.2	30	5	5	4	410	410	R	40	370	"	D	1	"
10:12 C12	" "	0.2	30	5	5	4	170	170	R	40	130	"	D	1	"
10:14 C13	" "	0.2	30	5	5	4	710	710	R	40	670	B-25	D	1	"

TIME OF DAY	9:13	10:30	—	—	—
ATM. STABILITY	D	D	—	—	—

BGD R – 0 µg/M³
R – 0 "
T – 0 "
T – 0

R̄ = 0 µg/m³

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.2[illegible]
20 MINUTES	0.19[illegible]
30 MINUTES	0.122
37 MINUTES	0.1

* PLANT NOT IN OPERATION ALL MORNING

2 of 2

FIELD DATA FORM

MODEL: POINT = 1
LINE = 2
DOSE = 3

SOURCE TYPE Plant C

DATE 6/26/79
BY Wachter

	UNIT OPERATION	WIND SPEED, MPH	DISTANCE, FT. X	Y	Z	TIME, MIN.	READ. mg/m³	CONC. μg/m³	R/T	BGD. μg/m³	Δ, μg/m³	BAG NO.	S'	M	COMMENTS
10:18 C14	Secondary Crusher	0.01	30	0	5	4	520	520	R	40	480	B-25	D	1	tracer used SF_6
10:22 C15	" "	0.01	30	0	5	4	670	670	R	40	630	"	D	1	"
10:26 C16	" "	0.01	30	0	5	4	500	500	R	40	460	B-16	D	1	"
10:30 C17	" "	0.01	30	0	5	4	910	910	R	40	870	"	D	1	"
10:35 C18	" "	0.01	30	0	5	4	660	660	R	40	620	"	D	1	"
10:39 C19	" "	0.01	30	0	5	4	920	920	R	40	880	B-14	D	1	"
10:45 C20	" "	0.01	30	0	5	4	800	800	R	40	760	"	D	1	"
10:49 C21	" "	0.01	30	0	5	4	960	960	R	40	920	"	D	1	"
1:32 C22	Primary Crusher	0.8	30	5	5	4	460	460	R	40	420	B-32	B	1	
1:36 C23	" "	1.2	30	5	5	4	480	480	R	40		"	B	1	
1:40 C24	" "	0.6	30	5	5	4	330	330	R	40		"	B	1	

TIME OF DAY 1:10
ATM. STABILITY B

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.23
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

1 of 3

FIELD DATA FORM

DATE 7/20/79

BY Wachter

SOURCE TYPE PLANT D

B-32 BACKGROUND

	LOCATION	WIND SPEED MPH	DISTANCE X	Y	Z	TIME MIN.	PLAD. µg/m3	CONC. µg/m3	R T	B µg/m3	A µg/m3	BAG No.	S'	M	COMMENTS
D1 -	Secondary Crusher	0.1	30	10	10	4	1490	1490	R	90	1400	B-27	D	1	SF6 tracer very low wind
D2 -	" "	0.1	30	10	10	4	2310	2310	R	90	2220	"	D	1	"
D3 -	" "	0.1	30	10	10	4	1400	1400	R	90	1310	"	D	1	"
D4 -	" "	0.1	60	20	20	4	750	750	R	90	660	B-29	D	1	"
D5 -	" "	0.1	60	20	20	4	820	820	R	90	730	"	D	1	"
D6 -	" "	0.1	60	20	20	4	180	180	R	90	90	"	D	1	"
D7 -	" "	0.1	60	20	20	4	1000	1000	R	90	910	B-13	D	1	"
D8 -	" "	0.1	60	20	20	4	850	850	R	90	760	B-13	D	1	"
D9 -	" "	0.1	60	20	20	4	410	410	R	90	320	B-13	D	1	"
D10 -	" "	0.1	60	20	20	4	1060	1060	T	160	900	B-4	D	1	"
D11 -	" "	0.1	60	20	20	4	1050	1050	T	160	890	"	D	1	"
D12 -	" "	0.1	60	20	20	4	1300	1300	T	160	1140	"	D	1	"
D13 -	" "	0.1	60	20	20	4	1640	1640	T	160	1480	B-14	D	1	"

TIME OF DAY 10:15

AIR STABILITY D

TOTAL SAMPLING TIME	MINUTES BY SAMPLING BY
4 MINUTES	1
8 MINUTES	0.5
16 MINUTES	[illegible]
20 MINUTES	0.154
30 MINUTES	0.122
37 MINUTES	0.1

* B60 Secondary - B60

R 160 µg/m3 Total 170 µg/m3

20 µg/m3 150 µg/m3

$\bar{R}_n = 90$ $\bar{T}_n = 160$

** Readings too high, moved to 60 ft after D3

2 of 3

FIELD DATA FORM

TOWER POINT = 1
TRS = 2
TOP = 3

SOURCE TYPE: PLANT D

DATE: 7/20/79
BY: Wachter

	EUT OF RATION	WIND SPEED, MPH	DISTANCE, FT. X	Y	Z	TIME, MIN.	READ. µg/m3	CONC. µg/m3	RT	BGD µg/m3	µg/m3	BAG NO.	S'	M	COMMENTS
D-14	Secondary Crusher	0.5	60	20	20	4	1900	1900	I	160	1740	B-14	D	1	SF6 tracer - low wind
D-15	" "	0.5	60	20	20	4	800	800	I	160	640	"	D	1	" "
D-16	TERNS Crusher	0.5	30	10	20	4	930	930	R	0	930	B-11	D	1	" "
D-17	" "	0.5	30	10	20	4	600	600	R	0	600	"	D	1	" "
D-18	" "	0.5	30	40	20	4	50	50*	R	0	50	"	D	1	" "
D-19	" "	0.5	30	40	10	4	80	80	R	0	80	B-12	D	1	" "
D-20	" "	0.5	30	40	10	4	220	220*	R	0	220	B-13	D	1	" "
D-21	" "	0.5	30	40	10	4	110	110*	R	0	110	B-33	D	1	" "
D-22	" "	0.5	30	10	10	4	560	560	R	0	560	B-33	D	1	" "
D-23	" "	0.5	30	10	10	4	340	340	R	0	340	B-33	D	1	" "
D-24	" "	0.5	30	10	10	4	430	430	R	0	430	B-31	D	1	" "
D-25	" "	0.5	30	10	10	4	470	470	R	0	470	B-31	D	1	" "
D-26	" "	0.5	30	10	10	4	710	710	R	0	710	B-31	D	1	" "

TIME OF DAY	0	D			
ATM. STABILITY	11:30	1:15			

TOTAL SAMPLING TIME	MULTIPLY BY FACTOR
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.[illegible]
20 MINUTES	0.1[illegible]
30 MINUTES	0.12
37 MINUTES	0.1

* WIND SHIFTED, OUT OF PLUME

3 of 3

FIELD DATA FORM

SOURCE POINT = 1
FUG = 2
DOSE = 3

SOURCE TYPE Plant D

DATE 7/19/79
BY Wachter

	UNIT OPERATION	WIND SPEED, MPH	DISTANCE, FT. X	Y	Z	TIME, MIN.	READ., µg/m³	CONC., µg/m³	RH	B.G., µg/m³	V, µg/m³	BAG No.	S'	M	COMMENTS
027	Fines Crusher	0.5	30	10	10	4	1170	1170	T	305	865	B-22	D	1	SF6 Tracer
028	" "	"	"	"	"	4	1140	1140	T	305	835	"	D	1	"
029	" "	"	"	"	"	4	870	870	T	305	565	"	D	1	"
030	" "	"	"	"	"	4	1630	1630	T	305	1325	B-24	D	1	"
031	" "	"	"	"	"	4	750	750	T	305	445	"	D	1	"
032	" "	"	"	"	"	4	950	950	T	305	845	"	D	1	"

TIME OF DAY D D
ATM. STABILITY 1:30 3:10

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.29
20 MINUTES	0.184
30 MINUTES	0.127
37 MINUTES	0.1

$\overline{R}_{B60} = 0 + 0 = 0\ \mu g/m^3$

$\overline{T}_{B60} = 360 + 250 = 305\ \mu g/m^3$

B-6
BACKGROUND

183

FIELD DATA FORM

DATE 7/23/79
BY Wachter

MODEL: POINT = 1
LINE = 2
FOSS = 3

SOURCE TYPE PLANT D

	UNIT OPERATION	WIND SPEED MPH	DISTANCE, FT X	Y	Z	TIME MIN.	READ. µg/m³	CONC. µg/m³	R I	BGD. µg/m³	I. µg/m³	BAG* NO.	S'	M	COMMENTS
D-33	Primary Crusher	0.1	30	10	30	4	1580	1580	R	0	1580	B-18	D	1	very low wind, SFC
D-34	" "	0.1	30	10	30	4	1400	1400	R	0	1400	"	D	1	" " " "
D-35	" "	0.1	30	10	30	4	400	400	R	0	400	"	D	1	" " " "
D-36	" "	0.1	30	10	30	4	60	60	R	0	60	B-9	D	1	" " " "
D-37	" "	0.1	30	10	30	4	0	0	R	0	0	"	D	1	" " " "
D-38	" "	0.1	30	10	30	4	410**	410**	R	0	410**	"	D	1	" " " "
D-39	" "	0.1	30	10	30	4	90	90	R	0	90	B-6	D	1	" " "
D-40	" "	0.1	30	10	30	4	990	990	R	0	990	"	D	1	" " "
D-41	" "	0.1	30	10	30	4	840	840	R	0	840	"	D	1	" " "
D-42	" "	0.1	30	10	30	4	1680	1680	T	100	1680	B-25	D	1	" " "
D-43	" "	0.1	30	10	30	4	780	780	T	0	780	"	D	1	" " "
D-44	" "	0.1	30	10	30	4	70	70	T	100	~~70~~	"	D	1	" " "
D-45	" "	0.1	30	10	30	4	90	90	T	100	—	B-33	D	1	" " "

TIME OF DAY 9:10
ATM. STABILITY D

TOTAL SAMPLING TIME	MULTIPLY READINGS BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.23
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

6 DOWN 26 seconds

7/ DOWN 1:34

** B-27 BACKGROUND

R-BGD
0 µg/m³
0 µg/m³

T-BGD
100 µg/m³
100 µg/m³

= -100 µg/m³

** Shut-down for 1:22
3 " " " 570
4/ " " 15 seconds
5 " "

2 of 3

FIELD DATA FORM

DATE 7/23/79
BY Wachter

SOURCE TYPE Plant D

	EMITTER DESCRIPTION	WIND SPEED MPH	DISTANCE, FT X	Y	Z	TIME MIN.	READING	CORR.	RH	FOG		BAG NO.	S'	W	COMMENTS
D-46	Primary Crusher	0.1	30	20	30	4	1100	1100	T	100	1000	B-33	D	1	Very low wind
D-47	" "	0.1	30	20	30	4	350	350	T	100	250	"	D	1	" " "
	Background										220	B-14			
D-48	Tertiary Crusher	0.1	50	10	10	4	220	220	R	0	220	B-4	D	1	very low wind
D-49	" "	0.1	50	10	10	4	90	90	R	0	90	"	D	1	" " "
D-50	" "	0.1	50	10	10	4	40	40	R	0	40		D	1	" " "
D-51	" "	0.1	50	10	10	4	90	90	R	0	90	B-12	D	1	" " "
D-52	" "	0.1	50	10	10	4	300	300	R	0	300	"	D	1	" " "
D-53	" "	0.1	50	10	10	4	50	50	R	0	50	"	D	1	" " "
D-54	" "	0.1	50	10	10	4	80	80	R	0	80	B-3	D	1	" "
D-55	" "	0.1	50	10	10	4	950	950	R	0	950	"	D	1	" "
D-56	" "	0.1	50	10	10	4	90	90	R	0	90	"	D	1	" "
D-57	" "	0.1	50	10	10	4	660	660	T	230	430	B-31	D	1	

TIME OF DAY	10:45	2:10	—	—	—
ATMOSPHERIC STABILITY	D	D	—	—	—

TOTAL SAMPLING TIME	SUBTITLE READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.23
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

1/ ~~1:44~~ 1:54 shut down
2/ 0:50 " "

* COULDN'T GET CLOSER, TRUCK TRAFFIC

VC

FIELD DATA FORM

MODEL: POINT = 1
LINE = 2
BOSE = 3

SOURCE TYPE PLANT D

DATE 7/23/79
BY Wachte

	UNIT OPERATION		WIND SPEED MPH	DISTANCE, FT. X	Y	Z	HEIGHT MIN.	READ. µg/m³	CONC. µg/m³	R T	BGD. µg/m³	L. µg/m³	BGI NO.	S'	M	COMMENTS
0-58	Tertiary Crusher		0.1	50	10	10	4	1030	1030	T	230	800	B-31	D	1	low wind
0-59	"	"	"	50	10	10	4	680	680	T	230	450	"	D	1	" "
0-60	"	"	"	50	10	10	4	330	330	T	230	100	B-22	D	1	" "
0-61	"	"	"	50	10	10	4	510	510	T	230	280	"	D	1	" "
0-62	"	"	"	50	10	10	4	520	520	T	230	290	"	D	1	" "

TIME OF DAY 3:30
ATM. STABILITY D

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.33
20 MINUTES	0.187
30 MINUTES	0.122
37 MINUTES	0.1

R-BGD
0 µg/m3
0 µg/m³
$\overline{R}_B = 0$

T-BGD
230 µg/m³
200 µg/m³
$\overline{T}_B = 230$

1 of 2

FIELD DATA FORM

DATE 7/24/79
BY Wachter

MODEL: POINT = 1
LINE = 2
DOSE = 3

SOURCE TYPE PLANT E

UNIT OPERATION	WIND SPEED MPH	DISTANCE, FT X	Y	Z	TIME MIN.	READ. µg/m³	CONC. µg/m³	R-T	BGD µg/m³	T µg/m³	BAG # NO.	S'	M	COMMENTS
E1 - Secondary Crusher	0.1	30	10	20	4	50	50	R	0	50	B-11	D	1	SF6 tracer
E2 - " "	"	"	"	"	4	120	120	R	0	120	"	D	1	" "
E3 - " "	"	"	"	"	4	120	120	R	0	120	"	D	1	" "
E4 - " Tertiary "	0.1	30	"	"	4	110	110	R	0	110	B-29	D	1	" "
E5 - " " "	"	"	"	"	4	60	60	R	0	60	"	D	1	" "
E6 - " " "	"	"	"	"	4	10	10	R	0	10	"	D	1	" "
E7 - " " "	"	"	"	"	4	40	40	R	0	40	B-35	D	1	" "
E8 - " " "	"	"	"	"	4	30	30	R	0	30	"	D	1	" "
~~E9 - " " "	"	"	"	"	4~~	110	110	T	80	30	"	D	1	" "
E10 - " "	"	"	"	"	4	130	130	T	80	50	B-22	D	1	" "
E11 - " "	"	"	"	"	4	160	160	T	80	80	"	D	1	" "
E12 - " "	"	"	"	"	4	110	110	T	80	30	"	D	1	" "
E13 - " "	"	"	"	"	4	180	180	T	80	100	B-25	D	1	" "

TIME OF DAY D
AIR STABILITY 10:38

TOTAL SAMPLING TIME	MULTIPLY BACKGROUND BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.33
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

R-BGD
0 µg/m³
0 µg/m³
$\bar{R}$ = 0 µg/m³

T-BGD
110 µg/m³
50 µg/m³
$\bar{T}$ = 80 µg/m³

* B-26 BACKGROUND

202

FIELD DATA FORM

DATE 7/24/79

BY Wachter

MODEL: POINT = 1
LINE = 2
POSE = 3

SOURCE TYPE PLANTE

UNIT OPERATION	WIND SPEED, MPH	DISTANCE, FT. X	Y	Z	TIME, MIN.	READ., μg/m³	CONC., μg/m³	R.T	BGD., μg/m³	V., μg/m³	BAL NO.	S'	M	COMMENTS
E4 Secondary + Tertiary	0.1	30	10	20	4	160	160	4	80	80		D	1	
					4			4	80			D	1	
					4			4				D	1	

TIME OF DAY ——
ATM. STABILITY ——

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.35
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

D6

TABLE #2

SAMPLING CONDUCTED AT PLANT F

FIELD DATA FORM

Plant F

SOURCE TYPE S+G

DATE 7/11/76

BY Weakliter

MODEL POINT = 1
LINE = 2
DOSE = 3

	UNIT OPERATION	WIND SPEED MPH	DISTANCE, FT X	Y	Z	TIME MIN	READ. mg/m³	CONC. mg/m³	R-T	BGD. mg/m³	Δ, mg/m³	Q, q	S'	M	COMMENTS
12:30 - F1	Secondary Crush.	2.3	30	8	3	4	270	270	R	5	265		D	1	
12:45 - F2	" "	3.2	"	"	3	4	0	0	R	5	0			1	
1:00 - F3	" "	3.4	"	"	3	4	30	30	R	5	25			1	
1:15 - F4	" "	1.9	"	"	3	4	290	290	R	5	285			1	
1:30 - F5	" "	3.2	"	"	3	4	200	200	R	5	195			1	
1:45 - F6	" "	3.0	"	"	3	4	310	310	R	5	305			1	
2:00 - F7	" "	3.2	"	"	3	4	340	340	R	5	335			1	
2:15 - F8	" "	2.4	"	"	3	4	130	130	R	5	125			1	
2:30 - F9	" "	1.2	"	"	3	4	330	330	R	5	325			1	
2:45 - F10	" "	1.6	"	"	3	4	0	0	R	5	0			1	
3:00 F11	" "	0.5	"	"	3	4	0	0	R	5	0			1	
3:15 F12	" "	2.2	"	"	3	4	290	290	R	5	285			1	
3:30 F13	" "	2.4	"	"	3	4	910	910	R	5	905			1	

TIME OF DAY D
ATM. STABILITY 1800 D 2-3c

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.23
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

* Process Down

Resp.
BGD (μg/m³)

10
0

06

TABLE ~~[illegible]~~ (Continued)

SAMPLING CONDUCTED AT PLANT F

FIELD DATA FORM

SOURCE TYPE Plant F SD6

DATE 7/11/79

BY Wachter

MODEL: POINT = 1
LINE = 2
BOSE = 3

	UNIT OPERATION	WIND SPEED MPH	DISTANCE, FT X	Y	Z	TIME MIN.	READ. mg/m³	CONC. µg/m³	R.T	BGD. µg/m³	Y. µg/m³	Q. q	S'	M	COMMENTS
12:35 - FT1 -	Secondary Crusher	3.3	30	0	3	4	1825	1825	T	250	575		D	1	
FT2 -	" "	3.2	30	0	3	4	1910	1910	T	250	1660			1	
FT3 -	" "	3.4	30	0	3	4	1710	1710	T	250	460			1	
FT4 -	" "	1.9	30	0	3	4	580	580	T	250	330			1	
FT5 -	" "	3.2	30	0	3	4	830	830	T	250	580			1	
FT6 -	" "	3.0	30	0	3	4	1690	1690	T	250	1440			1	
FT7 -	" "	3.2	30	0	3	4	370	370	T	250	120			1	
FT8 -	" "	2.4	30	0	3	4	1580	1580	T	250	1330			1	
FT9 -	" "	1.2	30	0	3	4	570	570	T	250	320			1	
FT10 -	" "	1.6	30	0	3	4	1200	1200	T	250	950			1	
FT-11	" "	0.5	30	0	3	4	800	800	T	250	550			1	
FT-12	" "	2.2	30	0	3	4	1010	1010	T	250	760			1	
FT-13	" "	2.4	30	0	3	4	1570	1570	T	250	1320			1	

TIME OF DAY: D D
AIR CHARGED: 12:00 3:30

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.35
20 MINUTES	0.196
30 MINUTES	0.127
37 MINUTES	0.1

TOTAL BGD (µg/m³)
240
260

Sierra Model 244
Total Sampling time 191.4 min

1 of 3

FIELD DATA FORM

SOURCE TYPE: Plant G (LIMESTONE)

DATE 8/15/79

BY Wachter

10:57	61 - Secondary Crusher		2.2	30	10	8	4	1650	1650	R	0	1650				
11:01	62 -	"	"	1.0	30	10	8	4	970	970	R	0	970	14	C	1	Uncontrolled
11:05	63 -	"	"	1.4	30	10	8	4	2420	2420	R	0	2420	"	C	1	"
~~11:09~~	~~64 -~~	~~"~~	~~"~~	~~0.8~~	~~30~~	~~10~~	~~8~~	~~4~~	~~3250~~	~~3250~~	~~R~~	~~0~~	~~3250~~	~~"~~	~~C~~	~~1~~	~~"~~
~~11:13~~	~~65 -~~	~~"~~	~~"~~	~~2.5~~	~~30~~	~~10~~	~~8~~	~~4~~	~~2650~~	~~2650~~	~~R~~	~~0~~	~~2650~~	~~77~~	~~C~~	~~1~~	~~"~~
11:17	66 -	"	"	1.3	30	10	8	4	1740	1740	R	0	1740	"	C	1	"
11:22	67	"	"	1.1	30	10	8	4	1400	1400	R	0	1400	91	C	1	"
11:26	68	"	"	1.4	30	10	8	4	1800	1800	R	0	1800	"	C	1	"
11:30	69	"	"	1.6	30	10	8	4	4190	4190	R	0	4190	"	C	1	"
11:34	610	"	"	1.6	30	10	8	4	7260	7260	T	195	7065	58	C	1	"
11:38	611	"	"	0.8	30	10	8	4	6220	6220	T	195	6025	"	C	1	"
11:42	612	"	"	1.6	30	10	8	4	6200	6200	T	195	6200	"	C	1	"
11:46	613	"	"	0.3	45	15	8	4	6360	6360	T	195	6165	42	C	1	"

Shut down for 1:22

Shut down for 1:40

Shut down for 2:53

Shut down for 4:00

10AM

R-BGD 8/15 AM

0 μg/M³

0 μg/M³

R_B = 0 μg/M³

T-BGD 8/15 AM

320 μg/M³

70 μg/M³

T_B = 195 μg/M³

BGD Bag 41

FIELD DATA FORM

DATE 8/15/79
BY Wachter

Plant 6
(LIMESTONE)

614	11:50	Secondary Crusher		35	15	8	4	5590	5590	T	195	5445	42	C	1	UNCONTROLLED
615	11:54	"	" *	35	15	8	4	6290	6290	T	195	6095	42	C	1	"
616	11:58	"	"	35	15	8	4	4450	4450	T	1010	3455	6	C	1	"
617	12:02	"	"	35	15	8	4	7880	7880	T	1010	6870	"	C	1	"
618	12:06	"	"	35	15	8	4	6930	6930	T	1010	5920	"	C	1	"
619	12:10	"	"	35	15	8	4	8250	8250	T	1010	7240	114	C	1	"
620	12:14	"	"	35	15	8	4	5050	5050	T	1010	4040	"	C	1	"
621	2:08	"	"	35	15	8	4	7170	7170	T	1010	6160	"	C	1	"
622	2:09	"	"	35	15	8	4	670	670	R	50	620	18	C	1	Controlled
623	2:13	"	"	35	15	8	4	260	260	R	50	210	"	C	1	"
624	2:17	"	"	35	15	8	4	450	450	R	50	400	"	C	1	"
625	2:22	"	"	35	15	8	4	340	340	R	50	290	20	C	1	"
626	2:26	"	"	35	15	8	4	470	470	R	50	420	20	C	1	"
2020		"	12:00 C													

T-BGD (616-621)
890 μg/m³
1130 μg/m³

* MOVED TO DIFFERENT LOCATION

** BAG DID NOT FILL

FIELD DATA FORM

MODEL: POINT - 1
LINE - 2
CONE - 3

SOURCE TYPE Plant 6

DATE 8/15/79
BY Wachter

	UNIT OPERATION	WIND SPEED, MPH	DISTANCE, FT. X	Y	Z	TIME MIN.	READ. µg/m³	CONC. µg/m³	R-T	BGD. µg/m³	µg/m³	BAG NO.	S'	M	COMMENTS
2:34 627	Secondary Crusher		35	15	8	4	1450	1450	R	50	1400	20	C	1	Controlled
2:34 628	" "		35	15	8	4	1840	1840	R	50	1790	76	C	1	"
2:38 629	" "		35	15	8	4	1300	1300	R	50	1250	"	C	1	"
2:42 630	" "		35	15	8	4	2280	2280	R	50	2230	"	C	1	"
2:46 631	" "		35	15	8	4	1850	1850	T	195	1655	7	C	1	"
2:50 632	" "		35	15	8	4	2120	2120	T	195	1925	"	C	1	"
2:54 633	" "		35	15	8	4	1780	1780	T	195	1585	"	C		"
2:58 634	" "		35	15	8	4	1900	1900	T	195	1705	118	C		"
3:02 635	" "		35	15	8	4	2420	2420	T	195	2225	"	C		"
3:06 636	" "		35	15	8	4	1770	1770	T	195	1575	"	C		"
3:10 637	" "		35	15	8	4	1220	1220	R	50	1170	15	C		"
3:14 638	" "		35	15	8	4	1400	1400	R	50	1350	"	C		"
3:16 639	" "		35	15	8	4	1110	1110	R	50	1060	"	C		"

TIME OF DAY 2:00
ATM. STABILITY C

TOTAL SAMPLING TIME	MULTIPLY READING BY
4 MINUTES	1
8 MINUTES	0.46
16 MINUTES	0.23
20 MINUTES	0.184
30 MINUTES	0.122
37 MINUTES	0.1

R-BGD
60 µg/m³
40 µg/m³

LOADING SURGE PILE BY BULLDOZER NOT WETTED MATERIAL
DATA MAY HAVE POSITIVE SKEW

$\bar{R}_{BGD} = 50$ µg/m³

631-639, $\bar{T}_{BGD}$ assumed 195 as per last test

T-BGD
µg/m³
µg/m³

$\bar{T}_{BGD} =$ µg/m³

FIELD DATA FORM

PLANT G

DATE 8/16/79

Wachita

											BAG #				
8:31	640	Tertiary Crusher	30	15	8	4	90	90	R	15	75	112	C	1	Controlled
8:35	641	" "	30	15	8	4	350	350	R	15	335	"	C	1	"
8:39	642	" "	30	15	8	4	320	320	R	15	305	"	C	1	"
8:44	643	" "	30	15	8	4	350	350	T	45	305	122	C	1	"
8:48	644	" "	30	15	8	4	290	290	T	45	245	"	C	1	"
8:52	645	" "	30	15	8	4	480	480	T	45	445	"	C	1	"
8:56	646	" "	30	15	8	4	530	530	R	15	515	33	C	1	"
9:00	647	" "	30	15	8	4	360	360	R	15	345	"	C	1	"
9:04	648	" "	30	15	8	4	140	140	R	15	125	"	C	1	"
9:08	649	" "	30	15	8	4	510	510	R	15	495	108	C	1	"
9:12	650	" "	30	15	8	4	350	350	R	15	335	"	C	1	"
9:16	651	" "	30	15	8	4	370	370	R	15	355	"	C	1	"
9:20	652	" "	30	15	8	4	570	570	T	45	525	39	C	1	"

8:15AM

1 MINUTES	0.50
10 MINUTES	0.5
20 MINUTES	0.183
30 MINUTES	0.122
37 MINUTES	0.1

R-BGO

30 µg/m³

0 µg/m³

= - 15 ug/m³

T-BGO

90 µg/m³

0 µg/m³

= - 45 ug/m³

2 of 4

FIELD DATA FORM

DATE 8/16/79

BY Wadsler

Plant G

9:24	653	Tertiary Crusher		30	15	8	4	610	610	T	45	565	39	C	1	Controlled
9:28	654	"	"	30	15	8	4	540	540	T	45	505	"	C	1	"
9:32	655	"	"	30	15	8	4	770	770	T	45	725	71	C	1	"
9:36	656	"	"	30	15	8	4	590	590	T	45	545	"	C	1	"
9:40	657	"	"	30	15	8	4	230	230	T	45	185	"	C	1	"
9:44	~~658~~	Boundary Pt #1		7.0	all draining		4	370	370	T					1	Controlled
	~~659~~	"	"	7.0	"	"	4	0	0	T					1	"
	~~660~~	"	"	7.0	"	"	4	0	0	T					1	"
	~~661~~	"	"	7.0	"	"	4	0	0	T					1	"
	662	"	"	7.0	"	"	4	610	610	T					1	"
	~~663~~	"	"	7.0	"	"	4			T					1	"
	~~664~~						4									
	~~658~~	~~Boundary Pt #1~~		7.0	30		4			T	0		21		1	

TOTAL CONTAINERS

MULTIPLY READING BY

CONTAINERS	1
CONTAINERS	0.46
CONTAINERS	0.23
CONTAINERS	0.183
CONTAINERS	0.127
CONTAINERS	0.1

* PLANT SHUT-DOWN

3 of 4

FIELD DATA FORM

Plant 6

											BAG NO.				
658 1:00	Tertiary Crusher		30	15	8	4	800	800	R	0	800	21	C	1	Unconfined
659 1:04	"	"	30	15	8	4	1420	1420	R	0	1420	"	C	1	"
660 1:08	"	"	30	15	8	4	1140	1140	R	0	1140	"	C	1	"
661 1:12	"	"	30	15	8	4	190	190	R	0	190	55	C	1	"
662 1:16	"	"	30	15	8	4	500	500	R	0	500	"	C	1	"
663 1:21	"	"	30	15	8	4	780	780	R	0	780	"	C	1	"
664 1:25	"	"	30	15	8	4	1390	1390	R	0	1390	10	C	1	"
665 1:29	"	"	30	15	8	4	250	250	R	0	250	"	C	1	"
666 1:33	"	"	30	15	8	4	820	820	R	0	820	"	C	1	"
667 1:37	"	"	30	15	8	4	1670	1670	T	0	1670	35	C	1	"
668 1:41	"	"	30	15	8	4	1950	1950	T	0	1950	"	C	1	"
669 1:45	"	"	30	15	8	4	1050	1050	T	0	1050	"	C	1	"
670 1:49	"	"	30	15	8	4	680	680	T	0	680	34	C	1	"

1:10
C

TOTAL CAPTURED	MULTIPLIED BY
[illegible]	
[illegible]	0.56
[illegible]	0.52
[illegible]	0.18
[illegible]	0.122
[illegible]	0.1

R-BGO 1AM

0 µg/m³
0 µg/m³
= 0 µg/m³

T-BGO 1AM

0 µg/m³
0 µg/m³
= 0 µg/m³

4 of 4

FIELD DATA FORM

Plant G — Date 8/16/79 — By Wichita

																COMMENTS
G71	Tertiary Crusher		30	15	8	4	100	100	T	0	100	34	C	1		Uncontrolled
G72	1:57	"	"	30	15	8	4	480	480	T	0	480	"	C	1	"
G73	2:01	"	"	30	15	8	4	250	250	T	0	250	40	C	1	"
G74	2:05	"	"	30	15	8	4	1150	1150	T	0	1150	"	C	1	"
G75	2:10	"	"	30	15	8	4	850	850	T	0	850	"	C	1	"

18 —

FIELD DATA FORM

DATE 8/17/79
BY Wachter

SOURCE Plant G

												BAG NO			
												1			
9:13*	G76 -	Secondary Crusher	<0.1	30	15	10	4	120	120	R		13		1	Controlled
9:17	G77 -	" "	<0.1	30	15	10	4	0	0	R		11		1	"
9:21	G78 -	" "	~~<0.1~~	30	15	10	4	0	0	R		11		1	"
9:25	G79 -	" "	<0.1	30	15	10	4	120	120	R		1		1	"
	G80 -	" "	<0.1	30	15	10	4	80	80	R		11		1	"
	G81 -	" "	<0.1	30	15	10	4	0	0	R		"		1	"
	G82 -	" "					4							1	"
	G83 -	" "					4							1	"
	G84 -	" "					4							1	"
	G85 -	" "					4							1	"
	G86 -	" "					4							1	"
	G87 -	" "					4							1	"
	G88 -	" "					4							1	"

TIME OF DAY 8:15AM
ACCESSIBILITY D.

TOTAL SAMPLING TIME	SAMPLING RATE
[illegible] MIN	[illegible]
[illegible] MIN	[illegible]
[illegible] MIN	[illegible]
20 MINUTES	0.1[illegible]
30 MIN. MIN	0.12
[illegible] MIN	0.1

R-BGD

350 μg/m³
220 μg/m³

$\bar{T}_{...}$ = 285 μg/m³

T-BGD

500 μg/m³
350 μg/m³

$\bar{T}_{o}$ = 425 μg/m³

* READINGS REPEATED FROM BEFORE, PRIMARY WATER SPRAY WAS NOT RUNNING BEFORE

APPENDIX E

TRACER STUDY RESULTS - EMISSION RATES

The results of the tracer study are presented in Tables G1 through G-6 for Plants A, E, and G, respectively. The test numbers on these sheets correspond to the concentration readings in Appendix D.

[redacted]

TABLE 6T — PLANT A DATA

LOCATION [redacted] (PLANT A) PROCESS TERTIARY CRUSHER DATE 6/18/7[illegible]

TEST NO.	SF_6 SOURCE Q_T (gms/min)	SF_6 CONC. $\overline{C_T}$ (µg/m³)	EFFECTIVE C_{Tm} (µg/m³)	DILUTION FACTOR (D_m)	CORRECTED DUST CONC. (C_m)	EMISSION RATE $D_m \times C_m \times 60$ (gms/hr)	COMMENTS
A-1	25.0	88	88	.284	1100	18750	
A-2		88	88	.284	679	11570	
A-3		93	93	.269	822	13267	
A-4			104	.240	2140	30816	
A-5		94	89	.281	1840	31022	
A-6			90	.277	1850	30747	
A-7		93	136	.184	640	7066	
A-8			49	.510	230	7038	
A-9		93	170	.147	2000	17640	
A-10			15.3	1.630	179	17506	
A-11			78	.321	735	14156	
A-12		85	79	.316	745	14125	
A-13			98	.255	925	14153	
A-14			68	.368	845	18658	
A-15		88	89	.281	1115	18799	
A-16			107	.234	1335	18743	
A-17			69	.362	605	13141	
A-18		85	92	.272	805	12993	
A-19			93	.269	815	13154	
A-20			51	.490	495	14553	
A-21		80	93	.269	895	14445	
A-22			95	.263	925	14597	
A-23		73	73	.342	775	15903	
A-24			M	M	M	—	

[redacted]

TABLE 61-(CONT.)

LOCATION [redacted] (PLANT A) PROCESS PRIMARY CRUSHER DATE 6/19/79

TEST NO.	SF_6 SOURCE Q_T (gms/min)	SF_6 CONC. $\overline{C_T}$ (µg/m³)	EFFECTIVE C_{TM} (µg/m³)	DILUTION FACTOR (D_m)	CORRECTED DUST CONC. (C_m)	EMISSION RATE $D_m \times C_m \times 60$ (gms/hr.)	COMMENTS
A-25	20.3		50	.406	182	4434	RUN 2'-25"
A-26		94	157	.129	576	4458	1'-15"
A-27			76	.267	276	4422	2°-45"
A-28			71	.286	210	3604	
A-29		93	76	.267	225	3605	
A-30			132	.154	393	3631	
A-31			105	.193	299	3462	
A-32		80	34	.597	97	3475	
A-33			102	.199	290	3463	
A-34			93	.218	153	2001	
A-35		66	71	.286	117	2008	
A-36			34	.597	56	2006	
A-37			20	1.015	90	5481	
A-38		16	28	.725	122	5307	
A-39			0	∞	(376)	∞	CONTAMINATED - OMIT
					AVERAGE	3668 gms/hr.	

[redacted]

TABLE 61 - (CONT.)

LOCATION [redacted] (PLANT A) PROCESS SECONDARY + FINES CRUSHERS DATE 6/19/79

TEST NO.	SF_6 SOURCE Q_T (gms/min)	SF_6 CONC. $\overline{C_T}$ (µg/m³)	EFFECTIVE C_{TM} (µg/m³)	DILUTION FACTOR (D_M)	CORRECTED DUST CONC. (C_M)	EMISSION RATE $D_M \times C_M \times 60$ (gms/hr.)	COMMENTS
	SECONDARY	CRUSHER					
A-40	—	—	—		—	—	NOT VALID TEST
A-41	20.3		61	.333	280	5594	
A-42		43	31	.655	140	5502	
A-43			37	.549	170	5600	
A-44		26	21	.976	120	7027	
A-45			31	.651	180	7031	
A-46			72	.283	200	3396	
A-47		80	122	.166	340	3386	
A-48			47	.432	130	3370	
A-49		0.15			350	—	SUSPECT SF_6 SAMPLE
A-50					500	—	WIND WRONG ?
A-51		98	98	.207	680	8451	
	FINES	CRUSHERS					
A-52	1.72		54.8	.031	670	1246	
A-53		39	40.1	.043	490	1264	
A-54			22.1	.0778	270	1260	
A-55			95.5	.0180	970	1048	
A-56		61	35.4	.0486	360	1050	
A-57			52.1	.0330	530	1050	
A-58		66	83.8	.0205	1130	1390	
A-59			48.2	.0360	650	1404	
A-60			42.9	.040	270	648	
A-61		35	52.5	.0327	330	647	
A-62			9.5	.181	60	652	

[redacted]

TABLE 62 - PLANT B DATA

LOCATION [redacted] (B) PROCESS PRIMARY - SECONDARY CRUSHERS DATE 6/20/79

TEST NO.	SF_6 SOURCE Q_T (gms/min)	SF_6 CONC. $\overline{C}_T$ (μg/m³)	EFFECTIVE C_{TM} (μg/m³)	DILUTION FACTOR (D_m)	CORRECTED DUST CONC. (C_m)	EMISSION RATE $D_m \times C_m \times 60$ (gms/hr)	COMMENTS
	SECONDARY CRUSHER						
BP-1	4.57		0	∞	0	–	WIND WRONG
BP-2		98	294	.0155	730	679	
BP-3			0	∞	0	–	WIND WRONG
BP-4			171.8	.0266	500	798	
BP-5		142	171.8	.0266	500	798	
BP-6			82.5	.0554	240	798	
BP-7			392.7	.0116	1230	856	
BP-8		249	79.7	.0573	250	860	
BP-9			274.5	.0166	860	857	
BP-10					80	–	
BP-11		MISSING			1050	–	NO SF_6 SAMPLE
BP-12					580	–	
BP-13			161	.0284	340	579	
BP-14		90	42.7	.1070	90	578	
BP-15			66.3	.0689	140	579	
	PRIMARY CRUSHER						
BP-16	4.57		78.9	.0579	100	347	
BP-17		171	418	.0109	530	347	
BP-18			16	.2856	20	343	
BP-19			241.5	.0189	180	204	
BP-20		161	107.3	.0430	80	206	
BP-21			134.2	.0340	100	204	
BP-22			525	.0087	70	36.5	SUSPECT DUST
BP-23		225	0	∞	0	–	MEASUREMENT.
BP-24			150	.0305	20	36.6	

[redacted]

TABLE 63 - PLANT C DATA

LOCATION [redacted] (PLANT C) PROCESS PRIMARY - SECONDARY CRUSHERS DATE 6/26/79

TEST NO.	SF_6 SOURCE Q_T (gms/min)	SF_6 CONC. $\overline{C_T}$ (µg/m³)	EFFECTIVE C_{TM} (µg/m³)	DILUTION FACTOR (D_M)	CORRECTED DUST CONC. (C_M)	EMISSION RATE $D_M \times C_M \times 60$ (gms/hr.)	COMMENTS
	PRIMARY	CRUSHER					
C-1	1.24		713	.00174	110	11.5	QUESTIONABLE !!
C-2		346	324	.00383	50	11.5	
C-3			0	∞	0	–	FOGGY - NO WIND
C-4			66	.0188	160	180	
C-5		84	70	.0177	170	181	
C-6			116	.0107	280	180	
C-7			285	.0044	350	92	
C-8		144	82	.0150	100	90	
C-9			65	.0191	80	92	
	SECONDARY	CRUSHER					
C-10	1.24		0	∞	0	–	NEAR CALM
C-11		60	166	.0075	370	167	
C-12			14	.0919	30	165	
C-13			242	.0051	670	205	
C-14		214	173	.0072	480	207	
C-15			227	.0055	630	208	
C-16			171	.0073	460	201	
C-17		242	324	.0038	870	198	
C-18			231	.0054	620	201	
C-19			357	.0035	880	184	
C-20		346	308	.0040	760	182	
C-21			373	.0033	920	182	
C-22			144	.0086	420	217	
C-23		131	150	.0083	440	219	
C-24			99	.0125	290	218	

[redacted]

TABLE 64 - PLANT D DATA

LOCATION [redacted] (PLANT D) PROCESS PRIMARY CRUSHER DATE 07/23/79

TEST NO.	SF_6 SOURCE Q_T (gms/min)	SF_6 CONC. $\overline{C_T}$ (µg/m³)	EFFECTIVE C_{TM} (µg/m³)	DILUTION FACTOR (D_M)	CORRECTED DUST CONC. (C_M)	EMISSION RATE $D_M \times C_M \times 60$ (gms/hr)	COMMENTS
D-33	1.43		757	.0019	1580	180	RESPIRABLE VERY
D-34		540	671	.0021	1400	176	PARTICLES LIGHT
D-35			192	.0074	400	177	WINDS
D-36			0	∞	0	—	
D-37		25	7	.204	60	735	QUESTIONABLE
D-38			68	.021	623	786	(DOWN 1'-22")
D-39			34	.0386	90	209	
D-40		312	409	.0035	990	208	
D-41			488	.00293	1186	209	(DOWN 1'-10")
D-42			202	.00708	1685	716	TSP (DOWN 15")
D-43		114	130	.011	1088	718	(DOWN 1'-8")
D-44			10	.143	79	678	(DOWN 26")
D-45			22	.065	148	577	(DOWN 1'-34")
D-46		126	289	.0049	1905	566	(DOWN 1'-54")
D-47			66	.0217	442	575	
			(8)	AVERAGE RESPIRABLE		- 335 gms/hr	σ = 263 gms/hr
				95% CONF		MAX = 861 gms/hr	
			(6)	AVERAGE TSP		- 638 gms/hr	σ = 73 gms/hr
				95% Conf. MAX		784 gms/hr	

[redacted]

TABLE 64 (CONT.)

LOCATION [redacted] (PLANT D) PROCESS SECONDARY CRUSHER DATE 07/20/7

TEST NO.	SF_6 SOURCE Q_T (gms/min)	SF_6 CONC. $\overline{C_T}$ (µg/m³)	EFFECTIVE C_{TM} (µg/m³)	DILUTION FACTOR (D_M)	CORRECTED DUST CONC. (C_M)	EMISSION RATE $D_M \times C_M \times 60$ (gms/hr)	COMMENTS
D-1	1.26		124	.0102	1400	854	
D-2		438	197	.00639	2220	851	
D-3			116	.0109	1310	854	
D-4			738	.0017	660	68	
D-5		552	817	.0015	730	68	
D-6			101	.0125	90	67	
D-7			617	.00204	910	112	
D-8		450	516	.00244	860	111	
D-9			217	.0058	320	111	
D-10			328	.0038	970	224	
D-11		354	325	.0039	960	223	
D-12			409	.0031	1210	224	
D-13			535	.0024	1550	219	
D-14		468	624	.00202	1810	219	
D-15			245	.00514	710	219	

(15) AVERAGE RESPIRABLE - 295 gms/hr σ = 296

MAX = 887 gms/hr

[redacted]

TABLE 64 (CONT.)

LOCATION [redacted] (PLANT D) PROCESS TERTIARY CRUSHER DATE 07/20/79 07/23/79

TEST NO.	SF_6 SOURCE Q_T (gms/min)	SF_6 CONC. $\overline{C_T}$ (µg/m³)	EFFECTIVE C_{TM} (µg/m³)	DILUTION FACTOR (D_m)	CORRECTED DUST CONC. (C_m)	EMISSION RATE $D_m \times C_m \times 60$ (gms/hr)	COMMENTS
D-16	1.26		445	.00283	930	158	RESPIRABLE
D-17		252	287	.00439	600	158	PARTICLES
D-18			24	.0525	50	158	
D-19		660	660	.0019	80	9	
D-20		552	552	.00229	220	30	
D-21			180	.007	110	46	
D-22		552	918	.00137	560	46	
D-23			556	.00227	340	46	AVERAGE
D-24			442	.00285	430	74	σ
D-25		552	483	.00261	470	74	MAX
D-26			730	.00173	710	74	
D-27			619	.00204	1010	123	TSP
D-28		552	601	.00209	980	123	
D-29			435	.00289	710	123	
D-30			724	.00174	1470	153	
D-31		468	290	.00433	590	153	
D-32			389	.00324	790	153	
D-48	1.43		169	.00846	220	112	RESPIRABLE (07/23/79)
D-49		90	69	.0207	90	112	PARTICLES
D-50			31	.0461	40	111	
D-51			83	.0172	90	93	
D-52		135	276	.0052	300	93	
D-53			46	.0311	50	93	RAINED 7 MIN
D-54			41	.0349	80	167	
D-55		96	489	.0029	950	167	
D-56			46	.0311	90	168	

[redacted]

TABLE 64 (CONT.)

LOCATION [redacted] (PLANT D) PROCESS TERTIARY CRUSHER DATE 07/23/79

TEST NO.	SF_6 SOURCE Q_T (gms/min)	SF_6 CONC. $\overline{C_T}$ (µg/m³)	EFFECTIVE C_{Tn} (µg/m³)	DILUTION FACTOR (D_n)	CORRECTED DUST CONC. (C_n)	EMISSION RATE $D_n \times C_n \times 60$ (gms/hr)	COMMENTS
D-57	1.43		212	.0067	430	174	TSP TRUCK
D-58		138	394	.00363	800	174	TRAFFIC
D-59			222	.00644	450	174	NEAR
D-60			35	.04086	100	245	SAMPLER
D-61		78	98	.01459	280	245	
D-62			102	.01402	290	244	

(20) AVERAGE RESPIRABLE = 99 gms/hr σ = 50

MAX = 199

(12) AVERAGE TSP = 174 gms/hr σ = 47

MAX = 268

[redacted]

TABLE 65-PLANTE

LOCATION [redacted] (PLANTE) PROCESS SECONDARY CRUSHER DATE 07/26/79

TEST NO.	SF_6 SOURCE Q_T (gms/min)	SF_6 CONC. $\overline{C_T}$ (µg/m³)	EFFECTIVE C_{TM} (µg/m³)	DILUTION FACTOR (D_M)	CORRECTED DUST CONC. (C_M)	EMISSION RATE $D_M \times C_M \times 60$ (gms/hr)	COMMENTS
E-1	1.28		176	.00727	50	22	RESPIRABLE PARTICLES VERY LIGHT WINDS
E-2		340	422	.00303	120	22	
E-3			422	.00303	120	22	
E-4			660	.00194	110	13	
E-5		360	360	.00356	60	13	LOTS OF CONTROL SPRAY
E-6			60	.02111	10	13	
E-7		140	160	.0080	40	19	
E-8			120	.0107	30	19	8
E-9			293	.00437	110	29	TSP
E-10		355	346	.00370	130	29	
E-11			426	.00459	160	29	
E-12			279	.00459	110	30	
E-13		380	456	.00281	180	30	
E-14			406	.00315	160	30	6
			(8)	AVERAGE	RESPIRABLE	18 gms/hr	σ = 4.2
					MAX	26 gms/hr	
			(6)	AVERAGE	TSP	30 gms/hr	σ = 0.77
					MAX	32	

Pollution [illegible]

T #	SF_6 SOURCE Q_s (g/min)	SF_6 CONCENTRATION χ (µg/m³)	DILUTION FACTOR g, m³/µg min	DUST EMISSION [illegible]
1	0.300	6.30	0.0476	0.028
2	"	3.71	0.0810	0.024
3	"	4.71	0.0375	0.024
4	"	4.98	0.0603	0.061
5	"	4.06	0.0739	0.061
6	"	2.66	0.1126	0.061
7	"	3.75	0.0800	0.035
8	"	4.82	0.0622	0.035
9	"	11.22	0.0267	0.035
10	"	8.35	0.0359	0.078
11	"	6.65	0.0451	0.078
12	"	6.59	0.0455	0.078
13	"	3.04	0.0985	0.173
14	"	2.61	0.1148	0.173
15	"	2.98	0.1007	0.173
16	"	24.99	0.0120	0.014
17	"	48.44	0.0062	0.014
18	"	41.73	0.0072	0.014
19	"	0	∞	∞
20	"	0	∞	∞
21	"	0	∞	∞
22	"	no sample	—	—
23	"	"	—	—
24	"	"	—	—

Dilution data

	SF_6 Source Q_s (g/min)	SF_6 concentrations T_s (µg/m³)	Dilution µg/m³/µg/min	Emission Factor lbs/Ton
25	0.300	6.55	0.0458	0.00414
26		6.49	0.0316	0.00414
27		31.54	0.0095	0.00414
28		34.84	0.0086	0.00481
29		24.33	0.0123	0.00481
30		43.40	0.0069	0.00481
31		8.36	0.0359	0.01853
32		9.72	0.0309	0.01853
33		8.01	0.0375	0.01853
34		14.77	0.0203	0.01080
35		[illegible]	0.0156	0.01080
36		13.64	0.0220	0.01080
37		17.89	0.0168	0.00536
38		21.03	0.0143	0.00536
39		15.97	0.0188	0.00536
40	0.314	31.79	0.0099	0.00080
41		138.68	0.0023	0.00080
42		126.44	0.0025	0.00080
43		61.31	0.0051	0.00168
44		49.73	0.0063	0.00168
45		86.86	0.0036	0.00168
46		112.35	0.0028	0.00151
47		75.58	0.0042	0.00151
48		27.44	0.0112	0.00151

50		"	—	—
51	"	"	—	—
52	"	107.18	0.0029	0.00165
53	"	115.23	0.0027	0.00165
54	"	101.48	0.0031	0.00165
55	"	159.27	0.0020	0.00153
56	"	120.52	0.0026	0.00153
57	"	43.80	0.0072	0.00153
58	"	no sample	—	—
59	"		—	—
60	"		—	—
61	"	14.19	0.0221	0.00438
62	"	37.33	0.0084	0.00438
63	"	58.24	0.0054	0.00438
64	"	65.07	0.0048	0.00699
65	"	11.70	0.0268	0.00699
66	"	38.39	0.0082	0.00699
67	"	45.69	0.0069	0.01195 [1.0120]
68	"	53.35	0.0059	0.01195
69	"	28.73	0.0109	0.01195
70	"	66.04	0.0048	0.00337
71	"	4.71	0.0323	0.00337
72	"	46.61	0.0067	0.00337
73	"	14.70	0.0221	0.00576
74	"	65.30	0.0048	0.00576
75	"	48.26	0.0065	0.00576
76	.425	Dust background greater than samples		

COMPUTED EMISSION FACTORS

		NUMBER OF TESTS	EMISSION FACTOR (AVERAGE) LBS/TON	ESTIMATED MAXIMUM EMISSION FACTOR LBS/TON (95% CONFIDENCE)
eration				
dry	Respirable	(6)	0.040	(.072)
	TSP	(6)	0.088	(.227)
ary	Respirable	19	~~0.00440~~ .00477	.00593
	TSP	16	~~0.01515~~ 0.01467	(.02313)
ndary/				
dry	Respirable	(4)	0.00519	(.00854)
	TSP	(4)	0.00703	(.01470)
	Respirable	16	0.00116	(.00193)
	TSP	(4)	0.00162	(.00176)
y/dry	Respirable	3	0.035	

APPENDIX G

DATA SHEETS - OPACITY READINGS

This Appendix contains opacity test results obtained at a limestone crushing plant. This data was obtained with crushers and associated equipment operating; (1) in a totally uncontrolled mode, and (2) with the wet suppression system (shown in Figure C-8, Appendix C) in operation.

PLUME OBSERVATION RECORD

DATE 8/15/79 REFERENCE NO. Uncontrolled

OBSERVATION STARTED 11:11 A.M. AM/PM EMISSION POINT NO. [redacted]

OBSERVATION ENDED 12:11 A.M. AM/PM OBSERVER [redacted]

COMPANY [redacted] COUNTY

ADDRESS CITY ZIP CODE

OBSERVATION POINT Eye level APPROXIMATE FEET FROM SOURCE 30' DIRECTION FROM SOURCE ENE

STACK HEIGHT 6' FT SKY CONDITION Clear WIND SPEED 0-5 MPH DIRECTION ESE

SOURCE: PROCESS Secondary Cr. INCINERATOR Penn. Impactor Cr. % R.H.

FUEL BURNING NO FUEL

%	EQUIVALENT OPACITY TOTAL TIME
0	0 MIN
5	0 MIN
10	0 MIN
15	0 MIN
20	0 MIN
25	0 MIN
30	0 MIN
35	0 MIN
40	1/2 MIN
45	1/2 MIN
50	1 MIN
55	1/2 MIN
60	1-3/4 MIN
65	1/2 MIN
70	1 MIN
75	3 MIN
80	3-3/4 MIN
85	2-3/4 MIN
90	5-1/4 MIN
95	5-3/4 MIN
100	33-3/4 MIN

MIN \ SEC	0	15	30	45
0	100	100	100	100
1	100	100	100	80
2	60	100	60	50
3	60	75	80	80
4	80	60	70	70
5	50	40	40	50
6	90	100	100	100
7	90	100	100	100
8	100	100	80	90
9	90	80	85	90
10	100	85	80	85
11	100	100	100	100*
12	100*	100	100	100
13	100	100	100	100
14	100	100	100	100
15	100	100	100	100
16	100	100	100	100
17	100	95	100	100
18	75	100	100	90
19	100	100	100	90

MIN \ SEC	0	15	30	45
20	100	100	100	90
21	90	95	75	100
22	75	95	95	85
23	95	100	100	90
24	95	85	95	100
25	85	95	95	95
26	90	100	90	90
27	95	100	100*	90
28	90	95	95	100
29	85	100	95	95
30	95	95	95	95
31	100	100	100	100
32	100	95	90	100
33	100	100	100	100
34	100	100	100	100
35	100	100	100	100
36	100	100	100	100
37	100	100	100	100
38	100*	100*	100*	100*
39	100*	100*	100*	100*

MIN \ SEC	0	15	30	45
40	100*	100*	100*	100*
41	100*	100*	100	100
42	100	90	95	80
43	85	80	65	80
44	85	80	95	90
45	60	70	60	75
46	75	80	80	75
47	75	75	45	50
48	60	55	45	55
49	70	75	85	75
50	80	80	65	75
51	85	90	90	90
52	100	100	100	100
53	95	100	100	100
54	100	100	100	100
55	100	100	100	100
56	100	100	100	100
57	100	100	100	100
58	100	100	100	100
59	100	100	100	100

91% Average Opacity

COLOR OF PLUME White COLOR CHANGE: YES [ ] NO [X] IF YES, DESCRIBE

[redacted]

PH-0441
APC 1/77

PLUME OBSERVATION RECORD

DATE 8/15/79 REFERENCE NO. Controlled

OBSERVATION STARTED 2:20 P.M. AM/PM EMISSION POINT NO. [redacted]

OBSERVATION ENDED 3:20 P.M. AM/PM OBSERVER [redacted]

COMPANY [redacted] COUNTY

ADDRESS CITY ZIP CODE

OBSERVATION POINT Eye Level APPROXIMATE FEET FROM SOURCE 20' DIRECTION FROM SOURCE W

STACK HEIGHT 6' FT SKY CONDITION Clear WIND SPEED 0-5 MPH DIRECTION ENE to N

SOURCE: PROCESS Secondary Cr. INCINERATOR % R.H.

FUEL BURNING NO FUEL

%	EQUIVALENT OPACITY TOTAL TIME
0	9-1/4 MIN
5	22-3/4 MIN
10	15 MIN
15	9-1/4 MIN
20	3-1/4 MIN
25	1/2 MIN
30	0 MIN
35	0 MIN
40	0 MIN
45	0 MIN
50	0 MIN
55	0 MIN
60	0 MIN
65	0 MIN
70	0 MIN
75	0 MIN
80	0 MIN
85	0 MIN
90	0 MIN
95	0 MIN
100	0 MIN

MIN \ SEC	0	15	30	45
0	05	05	05	05
1	10	10	10	05
2	0	05	0	0
3	05	05	0	05
4	0	0	05	10
5	10	15	10	05
6	05	10	05	10
7	05	05	10	0
8	05	15	05	0
9	15	10	05	05
10	05	05	10	10
11	10	05	05	05
12	10	05	10	15
13	05	05	10	05
14	15	05	05	05
15	10	05	05	20
16	10	10	10	05
17	05	15	05	0
18	0	0	0	0
19	0	0	10	10

MIN \ SEC	0	15	30	45
20	05	05	15	05
21	05	15	15	10
22	0	05	05	10
23	05	20	05	05
24	10	0	15	05
25	05	15	20	15
26	05	10	15	10
27	10	0	15	10
28	15	15	10	05
29	0	0	0	0
30	0	0	0	0
31	05	0	05	05
32	05	15	05	05
33	0	0	05	10
34	05	0	05	15
35	20	05	0	10
36	15	05	05	10
37	10	0	05	05
38	10	10	05	20
39	10	05	10	0

MIN \ SEC	0	15	30	45
40	0	0	05	05
41	05	05	05	10
42	10	15	05	10
43	15	05	15	15
44	20	15	15	15
45	15	15	15	10
46	10	15	10	05
47	05	05	05	10
48	05	10	05	15
49	15	25	20	15
50	10	20	20	20
51	20	15	15	25
52	20	10	05	05
53	10	10	10	10
54	10	15	05	05
55	05	10	05	10
56	15	10	10	10
57	10	10	05	20
58	05	05	0	0
59	05	05	05	05

8% Average Opacity

COLOR OF PLUME COLOR CHANGE: YES [ ] NO [X] IF YES, DESCRIBE

SOME BACKGROUND HAZE

SOME BACKGROUND TRUCK TRAFFIC CAUSING SOME

BACKGROUND PUFFS

[redacted]

PH-0441
APC 1/77

DATE 8/16/79 REFERENCE NO. Controlled

OBSERVATION STARTED 8:50 A.M. AM/PM EMISSION POINT NO. [redacted]

OBSERVATION ENDED 9:50 A.M. AM/PM OBSERVER [redacted]

COMPANY [redacted] COUNTY

ADDRESS CITY ZIP CODE

OBSERVATION POINT On conveyor walkway 10' above ground APPROXIMATE FEET FROM SOURCE 15 DIRECTION FROM SOURCE W

Fugitive
~~SOURCE~~ HEIGHT 8' FT SKY CONDITION Overcast (clearing last 10 min.) WIND SPEED 0-5 MPH DIRECTION NNE

SOURCE: PROCESS INCINERATOR % R.H.

FUEL BURNING NO FUEL

%	EQUIVALENT OPACITY TOTAL TIME
0	1/4 MIN
5	9-3/4 MIN
10	20 MIN
15	17-3/4 MIN
20	7-3/4 MIN
25	4 MIN
30	1/2 MIN
35	0 MIN
40	0 MIN
45	0 MIN
50	0 MIN
55	0 MIN
60	0 MIN
65	0 MIN
70	0 MIN
75	0 MIN
80	0 MIN
85	0 MIN
90	0 MIN
95	0 MIN
100	0 MIN

MIN \ SEC	0	15	30	45
0	15	10	05	05
1	10	15	05	10
2	15	10	15	15
3	15	10	10	10
4	10	05	15	10
5	05	15	15	20
6	15	10	20	20
7	15	20	10	10
8	05	25	20	30
9	25	20	20	25
10	15	20	20	15
11	15	15	15	05
12	05	15	15	20
13	20	25	25	25
14	25	20	20	25
15	15	15	20	20
16	10	15	15	20
17	25	10	15	20
18	15	20	10	10
19	15	10	15	20

MIN \ SEC	0	15	30	45
20	25	25	25	30
21	20	15	15	15
22	15	15	20	20
23	25	20	05	15
24	15	25	25	20
25	20	25	20	20
26	20	05	20	10
27	15	10	15	15
28	10	10	10	10
29	15	15	20	15
30	15	05	10	05
31	10	05	10	05
32	10	05	10	05
33	15	05	15	05
34	15	10	15	10
35	10	10	15	05
36	10	0	10	10
37	15	05	10	05
38	10	05	10	05
39	05	10	10	10

MIN \ SEC	0	15	30	45
40	05	15	15	15
41	10	15	10	15
42	05	15	05	15
43	15	15	10	15
44	05	10	10	15
45	10	15	10	20
46	05	15	05	15
47	05	15	10	10
48	05	10	05	10
49	05	15	05	10
50	10	15	05	10
51	10	15	10	15
52	10	10	10	15
53	10	15	10	10
54	10	10	10	10
55	10	10	10	05
56	05	05	10	15
57	10	15	10	15
58	10	15	10	10
59	10	10	10	10

13% Average Opacity

COLOR OF PLUME White COLOR CHANGE: YES [ ] NO [x] IF YES, DESCRIBE

Background was dark posts in tower in shade

Dust was in shade

[redacted]

PH-0441
APC 1/77

PLUME OBSERVATION RECORD

DATE 8/16/79

REFERENCE NO. Uncontrolled

OBSERVATION STARTED 1:38 P.M. AM/PM

EMISSION POINT NO. [redacted]

OBSERVATION ENDED 1:54 P.M. AM/PM

OBSERVER [redacted]

COMPANY [redacted]

COUNTY

ADDRESS

CITY

ZIP CODE

OBSERVATION POINT Eye Level

APPROXIMATE FEET FROM SOURCE 70'

DIRECTION FROM SOURCE S

STACK HEIGHT 8' FT

SKY CONDITION Scattered

WIND SPEED 0-5 MPH

DIRECTION NE

SOURCE: PROCESS

INCINERATOR

% R.H.

FUEL BURNING NO

FUEL

%	EQUIVALENT OPACITY TOTAL TIME
0	0 MIN
5	0 MIN
10	0 MIN
15	0 MIN
20	0 MIN
25	0 MIN
30	0 MIN
35	0 MIN
40	0 MIN
45	0 MIN
50	0 MIN
55	0 MIN
60	0 MIN
65	0 MIN
70	1/4 MIN
75	1-1/4 MIN
80	2-1/4 MIN
85	1 MIN
90	1-1/4 MIN
95	2-1/4 MIN
100	7-3/4 MIN

MIN \ SEC	0	15	30	45
0	100	95	100	100
1	100	100	95	100
2	100	90	100	100
3	100	100	100	100
4	100	100	100	100
5	100	100	100	100
6	90	100	95	95
7	100	100	100	100
8	100	100	95	95
9	100	100	100	95
10	95	95	90	85
11	90	90	85	80
12	75	80	75	80
13	70	75	75	80
14	80	85	80	75
15	85	80	80	80
16	--	STOP	--	
17				
18				
19				

MIN \ SEC	0	15	30	45
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				

MIN \ SEC	0	15	30	45
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				
51				
52				
53				
54				
55				
56				
57				
58				
59				

92% Average Opacity

COLOR OF PLUME White

COLOR CHANGE: YES [ ] NO [X] IF YES, DESCRIBE

BACKGROUND TREES AND BLUE SKY VERY GOOD

BACKGROUND CONDITIONS

[redacted]

PH-0441
APC 1/77

	Uncontrolled	Controlled
Monsanto Test Numbers	G1-G21	G22-G39
Average Percent Opacity	91%	8%

%	Equivalent Opacity Total Time	%	Equivalent Opacity Total Time
0	0 MIN	0	9-1/4 MIN
5	0 MIN	5	22-3/4 MIN
10	0 MIN	10	15 MIN
15	0 MIN	15	9-1/4 MIN
20	0 MIN	20	3-1/4 MIN
25	0 MIN	25	1/2 MIN
30	0 MIN	30	0 MIN
35	0 MIN	35	0 MIN
40	1/2 MIN	40	0 MIN
45	1/2 MIN	45	0 MIN
50	1 MIN	50	0 MIN
55	1/2 MIN	55	0 MIN
60	1-3/4 MIN	60	0 MIN
65	1/2 MIN	65	0 MIN
70	1 MIN	70	0 MIN
75	3 MIN	75	0 MIN
80	3-3/4 MIN	80	0 MIN
85	2-3/4 MIN	85	0 MIN
90	5-1/4 MIN	90	0 MIN
95	5-3/4 MIN	95	0 MIN
100	33-3/4 MIN	100	0 MIN

The second source tested was a 4-ft. Symons Cone Crusher. The test on the controlled condition ran for an hour while the uncontrolled was for sixteen (16) minutes.

	UnControlled	Controlled
Monsanto Test Numbers	G40-G57	G58-G75
Average Percent Opacity	92%	13%

%	Equivalent Opacity Total Time	%	Equivalent Opacity Total Time
0	0 MIN	0	1/4 MIN
5	0 MIN	5	9-3/4 MIN
10	0 MIN	10	20 MIN
15	0 MIN	15	17-3/4 MIN
20	0 MIN	20	7-3/4 MIN
25	0 MIN	25	4 MIN
30	0 MIN	30	1/2 MIN
35	0 MIN	35	0 MIN
40	0 MIN	40	0 MIN
45	0 MIN	45	0 MIN
50	0 MIN	50	0 MIN
55	0 MIN	55	0 MIN
60	0 MIN	60	0 MIN
65	0 MIN	65	0 MIN
70	1/4 MIN	70	0 MIN
75	1-1/4 MIN	75	0 MIN
80	2-1/4 MIN	80	0 MIN
85	1 MIN	85	0 MIN
90	1-1/4 MIN	90	0 MIN
95	2-1/4 MIN	95	0 MIN
100	7-3/4 MIN	100	0 MIN

SOURCE MEASUREMENTS
CRUSHED STONE -
SAND AND GRAVEL PLANTS

TRC

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I. Introduction

Proposed new standards for regulating crushed stone and sand and gravel operations are currently under consideration by the EPA. The industry is concerned with the new rule making because it appears to be overly restrictive and to be based upon non-representative data.

The purpose of the work performed by TRC was to provide new source measurements that more accurately represent emissions associated with the various crusher operations. TRC worked with Monsanto Research Corporation in undertaking the measurement task. Monsanto Research made dust concentration measurements utilizing a GCA Model RDM 101-4 dust monitor. TRC made simultaneous dispersion measurements utilizing a tracer gas technique. The tracer measurements permit calculation of source emissions directly, without relying upon dispersion models. This report summarizes the field measurements made by TRC and provides an interpretation of those measurements.

It is believed that the tracer method leads to emission estimates that are more accurate than can be obtained using dispersion modeling. This is especially true when working in the complex flow that exists around conveyors, stock piles, and crusher equipment structures. The tracer method also makes it feasible to work in light wind conditions that would preclude employing dispersion equations.

II. The Measurement Method

The measurement technique involves making dust concentration measurements and corresponding tracer gas measurements downwind of sources (within a range of 30 to 100 feet). Sulfurhexafluoride (SF_6) tracer gas was used in this series of measurements. The tracer gas source was placed in such a manner that the gas source closely simulated the dust source. For each crusher operation tested, the tracer gas was injected into the input stream to the crusher. The gas was thus entrained and carried into the crusher along with the raw material. The tracer gas was well mixed with entrained air in the machine, and in turn, diffused along with the dust that was emitted from the crusher.

adsorption?

The gas source is accurately known through dispensing at a constant rate and measuring the weight loss from the cylinder during the test period. SF_6 can be detected and measured at very low concentrations (<<1PPB), and lends itself to precise determination of source emission by gravimetric methods.

The air samples are collected in Tedlar bags by special sampling equipment. These samples are then analysed for SF_6 concentrations utilizing an AID Model 621-06 gas chromatograph (GC) equipped with an electron capture detector. The useable range of the GC is .001 to 100 PPB. with a calibration accuracy of $\pm 5\%$. The method for calibrating the GC is given in Appendix B.

With the dust source accurately simulated by the tracer gas, the ratio of source strength to downwind concentration at a given point is equal for both the tracer and the dust.

$$\text{i.e.,} \quad \frac{Q_T}{X_T} = \frac{Q_d}{X_d} \qquad (1)$$

where: Q_T = Tracer emission rate (g/hr)

X_T = Measured tracer concentration ($\mu g/m^3$)

Q_d = Dust emission rate (g/hr)

X_d = Dust concentration ($\mu g/m^3$)

The dust emission rate can then be calculated utilizing the expression:

$$Q_d = X_d \frac{Q_T}{X_T} \qquad (2)$$

The ratio Q_T/X_T is termed the dilution factor. The task undertaken by TRC was primarily to measure dilution factors for each of the dust concentration measurements made by Monsanto Research.

At the onset of the test series, it was found that the Monsanto test method was not immediately compatible with the TRC tracer method. The GCA dust monitor used by Monsanto functioned best with a four minute sample time, whereas the TRC samplers required 10 to 15 minutes to obtain a large enough air sample for accurate analysis. To compensate for this difference in sample duration, three consecutive dust samples were taken during each SF_6 sample period. This procedure necessitated the development of an analytical method for deriving an SF_6 concentration to accompany each dust sample. The analytical method is covered in Appendix A.

III. TEST RESULTS

The results of the measurement task undertaken by TRC are given in Table I. These results have been transmitted to Monsanto Research Corporation as required. The entries marked "M" indicate missing samples or data that have been removed as the result of a quality assurance review.

As a backup measure, TRC has chosen to do an independent analysis of the emission measurements. The emission factors obtained are given in Table II. Estimates of the accuracy of the derived factors are reflected in the column labelled "Estimated Maximum Emission Factors." The values given in this column have been computed by adding twice the standard deviation of the sample population to the arithmetic mean. They represent the estimated maximum emission rate at the 95% confidence level.

DILUTION DATA

TEST NO.	SF_6 SOURCE Q_T (g/min)	SF_6 CONCENTRATION χ_n ($\mu g/m^3$)	DILUTION FACTORS g $m^3/\mu g$ min
	SPECIFICATION AGGREGATE (PLANT A)		
A-1	25.0	88	.284
A-2	"	88	.284
A-3	"	93	.269
A-4	"	104	.240
A-5	"	89	.281
A-6	"	90	.277
A-7	"	136	.184
A-8	"	49	.510
A-9	"	170	.147
A-10	"	15	1.630
A-11	"	78	.321
A-12	"	79	.316
A-13	"	98	.255
A-14	"	68	.368
A-15	"	89	.281
A-16	"	107	.234
A-17	"	69	.362
A-18	"	92	.272
A-19	"	93	.269
A-20	"	51	.490
A-21	"	93	.269
A-22	"	95	.263
A-23	"	73	.342
A-24	"	M	M
A-25	20.3	50	.406
A-26	"	157	.129
A-27	"	76	.267
A-28	"	71	.286
A-29	"	76	.267
A-30	"	132	.154
A-31	"	105	.193
A-32	"	34	.597
A-33	"	102	.199
A-34	"	93	.218
A-35	"	71	.286
A-36	"	34	.597
A-37	"	20	1.015
A-38	"	28	.725
A-39	"	0	∞
A-40	"	M	M
A-41	"	61	.333
A-42	"	31	.655
A-43	"	37	.549
A-44	"	21	.976
A-45	"	31	.651
A-46	"	72	.283
A-47	"	122	.166
A-48	"	47	.432
A-49	"	M	M
A-50	"	M	M
A-51	"	98	.207

DILUTION DATA

TEST NO.	SF_6 SOURCE Q_T (g/min)	SF_6 CONCENTRATION χ_n ($\mu g/m^3$)	DILUTION FACTORS g $m^3/\mu g$ min
A-52	1.72	55	.031
A-53	"	40	.043
A-54	"	22	.078
A-55	"	96	.018
A-56	"	35	.049
A-57	"	52	.033
A-58	"	84	.021
A-59	"	48	.036
A-60	"	43	.040
A-61	"	53	.033
A-62	"	10	.181
	PLAINS AGGREGATE (PLANT B)		
B-1	4.57	0	∞
B-2	"	294	.016
B-3	"	0	∞
B-4	"	172	.027
B-5	"	172	.027
B-6	"	83	.055
B-7	"	393	.012
B-8	"	80	.057
B-9	"	275	.017
B-10	"	M	M
B-11	"	M	M
B-12	"	M	M
B-13	"	161	.028
B-14	"	43	.107
B-15	"	66	.069
B-16	"	79	.058
B-17	"	418	.011
B-18	"	16	.286
B-19	"	242	.019
B-20	"	107	.043
B-21	"	134	.034
B-22	"	525	.009
B-23	"	0	∞
B-24	"	150	.031
	GILVIN TERRILL (PLANT C)		
C-1	1.24	713	.0017
C-2	"	324	.0038
C-3	"	0	∞
C-4	"	66	.0188
C-5	"	70	.0177
C-6	"	116	.0107
C-7	"	285	.0044
C-8	"	82	.0150
C-9	"	65	.0191
C-10	"	0	∞
C-11	"	166	.0075
C-12	"	14	.0919

DILUTION DATA

TEST NO.	SF_6 SOURCE Q_T (g/min)	SF_6 CONCENTRATION X_n ($\mu g/m^3$)	DILUTION FACTORS $\dot{g}$ $m^3/\mu g$ min
C-13	1.24	242	.0051
C-14	"	173	.0072
C-15	"	227	.0055
C-16	"	171	.0073
C-17	"	324	.0038
C-18	"	231	.0054
C-19	"	357	.0035
C-20	"	308	.0040
C-21	"	373	.0033
C-22	"	144	.0086
C-23	"	150	.0083
C-24	"	99	.0125
		LUCK QUARRY (PLANT D)	
D-1	1.26	124	.0102
D-2	"	197	.0064
D-3	"	116	.0109
D-4	"	738	.0017
D-5	"	817	.0015
D-6	"	101	.0125
D-7	"	617	.0020
D-8	"	516	.0024
D-9	"	217	.0058
D-10	"	328	.0038
D-11	"	325	.0039
D-12	"	409	.0031
D-13	"	535	.0024
D-14	"	624	.0020
D-15	"	245	.0051
D-16	"	445	.0028
D-17	"	287	.0044
D-18	"	24	.0525
D-19	"	660	.0019
D-20	"	552	.0023
D-21	"	180	.0070
D-22	"	918	.0014
D-23	"	556	.0023
D-24	"	442	.0029
D-25	"	483	.0026
D-26	"	730	.0017
D-27	"	619	.0020
D-28	"	601	.0021
D-29	"	435	.0029
D-30	"	724	.0017
D-31	"	291	.0043
D-32	"	389	.0032

DILUTION DATA

TEST NO.	SF_6 SOURCE Q_T (g/min)	SF_6 CONCENTRATION X_n ($\mu g/m^3$)	DILUTION FACTORS g $m^3/\mu g$ min
D-33	1.43	757	.0019
D-34	"	671	.0021
D-35	"	192	.0074
D-36	"	0	∞
D-37	"	7	.2040
D-38	"	68	.0210
D-39	"	34	.0386
D-40	"	409	.0035
D-41	"	488	.0029
D-42	"	202	.0071
D-43	"	130	.0110
D-44	"	10	.1430
D-45	"	22	.0650
D-46	"	289	.0049
D-47	"	66	.0217
D-48	"	169	.0085
D-49	"	69	.0207
D-50	"	31	.0461
D-51	"	83	.0172
D-52	"	276	.0052
D-53	"	46	.0311
D-54	"	41	.0349
D-55	"	489	.0029
D-56	"	46	.0311
D-57	"	212	.0067
D-58	"	394	.0036
D-59	"	222	.0064
D-60	"	35	.0409
D-61	"	98	.0146
D-62	"	102	.0140
	MEDFORD QUARRY (PLANT E)		
E-1	1.28	176	.0073
E-2	"	422	.0030
E-3	"	422	.0030
E-4	"	660	.0019
E-5	"	360	.0036
E-6	"	60	.0211
E-7	"	160	.0080
E-8	"	120	.0107
E-9	"	293	.0044
E-10	"	346	.0037
E-11	"	426	.0046
E-12	"	279	.0046
E-13	"	456	.0028
E-14	"	406	.0032

DILUTION DATA

TEST NO.	SF_6 SOURCE Q_T (g/min)	SF_6 CONCENTRATION X_n ($\mu g/m^3$)	DILUTION FACTORS g $m^3/\mu g$ min
	VULCAN MATERIALS (PLANT G)		
G-1	0.300	6.30	0.048
G-2	"	3.71	0.081
G-3	"	4.24	0.033
G-4	"	4.98	0.060
G-5	"	4.06	0.074
G-6	"	2.66	0.113
G-7	"	3.75	0.080
G-8	"	4.82	0.062
G-9	"	11.22	0.027
G-10	"	8.35	0.036
G-11	"	6.65	0.045
G-12	"	6.59	0.046
G-13	"	3.04	0.099
G-14	"	2.61	0.115
G-15	"	2.98	0.100
G-16	"	24.99	0.012
G-17	"	48.44	0.006
G-18	"	41.73	0.007
G-19	"	0	∞
G-20	"	0	∞
G-21	"	0	∞
G-22	"	M	----
G-23	"	M	----
G-24	"	M	----
G-25	"	6.55	0.046
G-26		9.49	0.032
G-27	"	31.64	0.010
G-28	"	34.84	0.009
G-29	"	24.33	0.012
G-30	"	43.40	0.007
G-31	"	8.36	0.036
G-32	"	9.72	0.031
G-33	"	8.01	0.038
G-34	"	14.77	0.020
G-35	"	19.27	0.016
G-36	"	13.64	0.022
G-37	"	17.89	0.017
G-38	"	21.03	0.014
G-39	"	15.97	0.019
G-40	0.314	31.79	0.010
G-41	"	138.68	0.002
G-42	"	126.44	0.003
G-43	"	61.31	0.005
G-44	"	49.73	0.006
G-45	"	86.89	0.004
G-46	"	112.35	0.003
G-47	"	75.58	0.004
G-48	"	27.99	0.011

DILUTION DATA

TEST NO.	SF_6 SOURCE Q_T (g/min)	SF_6 CONCENTRATION X_n ($\mu g/m^3$)	DILUTION FACTORS g $m^3/\mu g$ min
G-49	0.314	M	----
G-50	"	M	----
G-51	"	M	----
G-52	"	107.18	0.003
G-53	"	115.23	0.003
G-54	"	101.48	0.003
G-55	"	159.27	0.020
G-56	"	120.82	0.003
G-57	"	43.80	0.007
G-58	"	M	----
G-59	"	M	----
G-60	"	M	----
G-61	"	14.19	0.022
G-62	"	37.33	0.008
G-63	"	58.24	0.005
G-64	"	65.07	0.005
G-65	"	11.70	0.027
G-66	"	38.39	0.008
G-67	"	45.69	0.007
G-68	"	53.35	0.006
G-69	"	28.72	0.011
G-70	"	66.04	0.005
G-71	"	9.71	0.032
G-72	"	46.61	0.007
G-73	"	14.20	0.022
G-74	"	65.30	0.005
G-75	"	48.26	0.007

TABLE II

COMPUTED EMISSION FACTORS

PLANT LOCATION	OPERATION	NUMBER OF TESTS	EMISSION FACTOR (AVERAGE) (LB/TON)		ESTIMATED MAXIMUM EMISSION FACTOR (LBS/TON (95% CONFIDENCE)	
				Kg/MT		Kg/MT
Specification Aggregate Golden, Colo.	Primary Crusher	14	.013	.0065	.021	.0105
	Secondary Crusher	9	.019	.0095	.032	.016
Granite	Tertiary Crusher	23	.073	.0365	.130	.065
Control-Partial Wet Suppression	Fines Crusher	11	.008	.004	.012	.006
Plains Aggregate Loveland, Colo.	Primary Crusher	8	.001	.0005	.002	.001
Sand and Gravel	Secondary Crusher	10	.003	.0015	.004	.002
Gilvin Terrill Amarillo, Texas	Primary Crusher	8	.001	.0005	.003	.0015
Sand and Gravel	Secondary Crusher	14	.002	.001	.003	.0015
Luck Quarry Fairfax, Va.	Primary Crusher	Particles ≤10μ 8	.001	.0005	.002	.001
Traprock		Particles ≤50μ 6	.001	.0005	.002	.001
	Secondary Crusher	Particles ≤10μ 15	.001	.0005	.002	.001
	Tertiary Crusher	Particles ≤10μ 20	.001	.0005	.001	.0005
		Particles ≤50μ 12	.001	.0005	.002	.001

TA[redacted] II [redacted]nt[redacted]

COMPUTED EMISSION FACTORS

** Emissions from Secondary an[redacted] Fines Crushers combined

PLANT LOCATION	OPERATION	NUMBER OF TESTS	EMISSION FACTOR (AVERAGE) (LB/TON)	ESTIMATED MAXIMUM EMISSION FACTOR (LB/TON (95% CONFIDENCE)
Medford Quarry Westminster, Md. Limestone Control-Wet Suppression	Secondary Crusher	Particles ≤10μ 8	7.7×10^{-5} **	1.1×10^{-5} **
		Particles ≤50μ 6	1.3×10^{-4} **	1.3×10^{-4} **
Vulcan Materials Birmingham, Alabama Limestone Control-Wet Suppression	Secondary Crusher (Controls off)	Particles ≤10μ 9	.040 .02	.072 .036
		Particles ≤50μ 9	.088 .044	.227 .1135
	Secondary Crusher (Controls on)	Particles ≤10μ 9	.005 .0025	.006 .003
		Particles ≤50μ 6	.016 .008	.023 .0115
	Tertiary Crusher (Controls off)	Particles ≤10μ 6	.006 .003	.009 .0045
		Particles ≤50μ 9	.007 .0035	.015 .0075
	Tertiary Crusher (Controls on)	Particles ≤10μ 6	.001 .0005	.002 .001
		Particles ≤50μ 9	.002 .001	.002 .001

APPENDIX A

Method of computing SF_6 concentrations for each dust sample.

Assumptions

1. Assume the SF_6 concentration measured over three consecutive dust samples (X_T), is the average of the three concentrations associated with each sample.

   i.e., $$\bar{X}_T = \frac{X_{T1} + X_{T2} + X_{T3}}{3} \qquad (1)$$

2. Assume that the ratio between test values are the same for both dust and SF_6.

   i.e., $$\frac{X_{T1}}{X_{T2}} = \frac{X_{d1}}{X_{d2}} \quad \text{and} \quad \frac{X_{T1}}{X_{T3}} = \frac{X_{d1}}{X_{d3}} \qquad (2)$$

Analytical Steps

1. Compute ratios $\frac{X_{d2}}{X_{d1}}$ and $\frac{X_{d3}}{X_{d1}}$ from the observed data.

2. Compute concentrations from (1) and (2)

   $$X_{T1}\left(1 + \frac{X_{d2}}{X_{d1}} + \frac{X_{d3}}{X_{d1}}\right) = 3\bar{X}_T$$

   $$X_{T_2} = T_1\left(\frac{X_{d2}}{X_{d1}}\right) \quad \text{and} \quad X_{T_3} = X_{T_1}\left(\frac{X_{d3}}{X_{d1}}\right)$$

CALIBRATION OF THE GAS CHROMATOGRAPH

The GC is calibrated for SF_6 concentration measurements utilizing a dynamic dilution device (DDD).

A. Principle of Operation

A known volume of a known concentration of tracer gas (SF_6) is diluted with a constant known flowrate of clean, dry air. The result is a concentration decay with time of the following form:

$$C = C_o \exp\left[- F\, t/V\right]$$

where C = concentration (volume per unit volume) at time t (t in seconds)

C_o = initial concentration (calibration gas)

F = flowrate (cc/sec)

V = volume of flask (cc)

B. General Description of the DDD

The primary concentration C_o of SF_6 is fed into the flask at sufficient flowrate for sufficient length of time to ensure that 10 flask volumes have passed through the flask. For example, a flask volume of 500 cc would require 0.25 liters per minute for 20 minutes. This will ensure that the concentration in the flask, initially at zero, will indeed reach C_o. The primary concentration charge is then shut off and dilution air is then started through a restricting orifice through the flask and directly into the AID gas chromatograph sample loop. This air stream is then sampled at prescribed times following the initiation of dilution.

Three different dilution air flowrates can be obtained (for a given ambient air pressure and a given dilution air pressure) with the orifice selection switch (orifice 1, 2 or 3). Before each use of the DDD, the orifice flowrates must be measured with a bubble flowmeter at air pressure gauge readings of 15 and 30 (as read on the pressure gauge on the front of the DDD).

As a reference, the following data show the decay at selected flowrates of an initial 10 ppm concentration (flask volume = 506 cc):

Dilution Air Flowrate		Time		Concentration
cc/sec	liter/min	sec	min	ppb
2.00	0.120	900	15	285
		1200	20	87
		1500	25	26.6
		1800	30	8.1
		2100	35	2.5
		2400	40	0.76
		2700	45	0.23
3.00	0.180		15	48
			20	8.1
			25	1.4
			30	0.23
			35	0.039
			40	0.0066
			45	0.0011

SEMI-ANNUAL REPORT
AMBIENT AIR MONITORING PROGRAM
CANNON-ERTL SITE

Report Prepared for

FLATIRON COMPANIES

By

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SUMMARY

This report examines aerometric data collected at the Flatiron Companies' Cannon-Ertl sand and gravel mining site during the calendar year 1978. During this time, the Flatiron Companies have made a pronounced effort to control fugitive dust emissions from the mine site and surrounding access roads. The observed reduction in ambient particulate concentrations appears to be either a result of these control efforts or due to above average precipitation that occurred in 1978.

Annual average dustfall rates at the six sampling locations around the Cannon-Ertl site are only slightly higher than the background rate measured at the Hilltop (7) dustfall bucket.

CALENDAR YEAR AVERAGE DUSTFALL, Tons/Sq. Mi/Mo.

1978

(1)	(2)	(3)	(4)	(5)	(6)	(7)
21.3	17.7	31.4	24.5	22.4	32.9	16.1

All hi-vol measurements of total suspended particulate (TSP) are in compliance with applicable Federal and Colorado Standards.

TSP CONCENTRATIONS, $\mu g/m^3$

1978

	EAST	NW	SW
Arith. Mean	44.4	38.1	48.2
Geom. Mean	34.3	25.5	39.8
2nd Highest	94.6	91.1	93.5

Colorado State long and short-term standards applicable to the Cannon-Ertl site are 55 $\mu g/m^3$ (annual arithmetic average), and 180 $\mu g/m^3$ (2nd highest daily concentration), respectively. Federal Secondary Standards are 60 $\mu g/m^3$ (geometric annual average), and 150 $\mu g/m^3$ (2nd highest).

An analysis of the ratio of dustfall flux to suspended particulate concentrations, at sites with both hi-vol and dust buskets, yields a mean particulate deposition velocity.

MEAN PARTICULATE DEPOSITION VELOCITY, cm./sec

1978		
EAST	NW	SW
4.04	7.31	4.80

These computations, not performed in previous White Rocks monitoring reports, provide a measure of the mean particle size of the airborne TSP. The low deposition velocities computed for 1978 suggest that only small particles remain in the air at the mining site boundary, while larger particles settle out within the mine property.

Two changes were made to the monitoring program in 1978 in an attempt to bring the program in line with the Colorado State Air Pollution Control Division's Ambient Air Monitoring Requirements: 1.) The hi-vol sampling schedule was changed from every-sixth day to every-fourth day, with specific days coinciding with the States' pre-selected sampling days, and 2.) the reporting period for data gathered at White Rocks was changed from six (6) months to one (1) year, making comparison of calculated annual averages with annual standards easier. This Report is the last Semi-Annual Report that will be issued.

In the near future the hi-vol samples at the Cannon-Ertl mine will be mounted on 1-meter platforms to comply with the Ambient Monitoring Guidelines for Prevention of Significant Deterioration.

1.0 INTRODUCTION

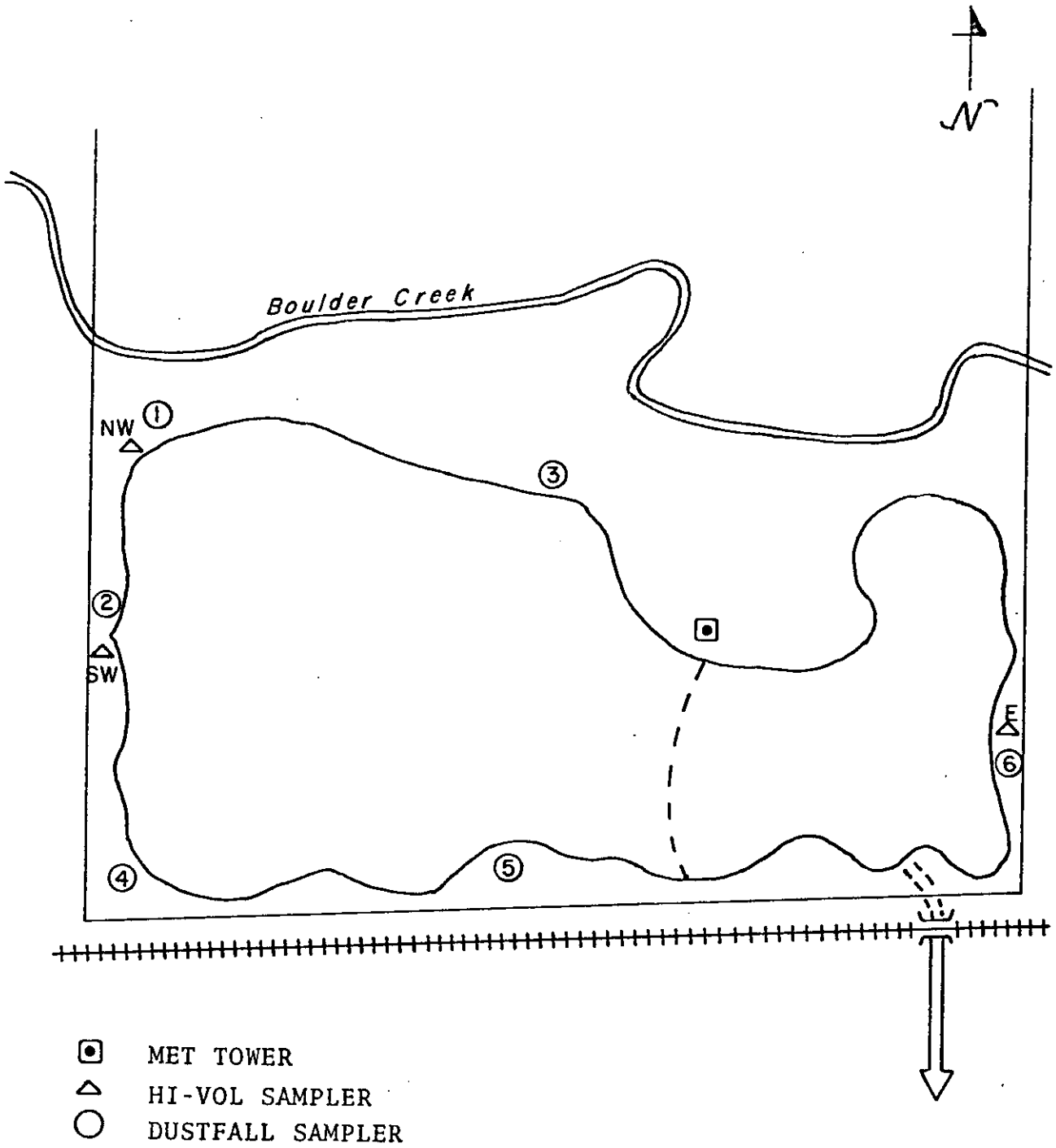
This report, prepared by TRC-Denver, summarizes data gathered at the Flatiron Companies' Cannon-Ertl Site during 1978. Emphasis is placed upon quantitatively assessing the atmospheric impact of the sand and gravel mining operations at the site. Measured particulate concentrations are compared with applicable State and Federal long and short-term standards. Dustfall measurements are similarly tabulated and compared. Because an extensive wind speed/wind direction data base already exists at the White Rocks Mine, wind data are not included in this Report. Dustfall bucket, hi-vol samples, and meteorological tower locations are illustrated in Figure 1.

2.0 DATA SUMMARY AND INTERPRETATION

2.1 DUSTFALL DATA

Seven dustfall buckets were available for analysis during the 12 consecutive months ending December 1978. These dustfall buckets, indicated by circles in Figure 1, measure only particulate with a finite settling velocity; suspended particulate, discussed in the next section, is collected with hi-volume samplers. Because particulate in the size range captured by dustfall buckets usually poses no threat to human health (it is too large to be respirable) there are no Federal or Colorado State regulations which prohibit activities that generate dustfalls above a specific rate. Instead, fallout of fugitive dust is considered a nuisance, and standards are geared to employing control techniques, and in the case of open mining, to limiting the total mining area exposed. Dustfall data from January 1, 1978 through December 31, 1978, are summarized in Table 1. The Hilltop sampler (Number 7) is far enough removed from the mining operation, and its wind direction orientation is such that dust generated at the mine site does not reach the Hilltop sampler. Consequently, Hilltop dustfall rates act as a measure of background rate.

The North (3) and the East (6) dustfall buckets exhibit annual average dustfall rates, and peak monthly dustfall rates, that are generally higher than those at other dustfall bucket locations. High dustfall at the East (6) bucket may be a result of particulate entrained from the adjacent dirt access road; dustfall at the North (3) bucket may be the result of construction activity performed at the western edge of the mine site, combined with prevailing westerly winds. May 1978 is an interesting month--during May, the Flatiron Companies' work force at the White Rocks Mine were on strike, so that no activity (mining, crushing, loading, reclamation) occurred. Dustfall rates during May are generally higher than average, with annual peak dustfall rates recorded at the SW (4) and East (6) buckets.



Site Map

Figure 1

TABLE 1

DUSTFALL, Tons/Square Mile/Month

	(1) NW	(2) W	(3) N	(4) SW	(5) S	(6) E	(7) HILLTOP
Jan 1978	35.9	63.8	64.6	8.8	49.9	13.2	22.0
Feb	36.9	34.9	12.7	14.1	22.0	3.9	6.9
Mar	19.4	7.5	18.2	3.4	22.6	26.0	17.0
Apr	17.4	5.3	34.1	5.9	6.3	15.5	4.2
May	14.1	32.9	23.8	77.8	45.7	112.4	1.7
June	32.4	3.4	33.0	16.1	28.0	8.1	25.7
July	14.4	N.A.	19.4	53.3	8.8	17.0	N.A.
Aug	3.5	2.6	40.0	40.7	1.4	99.8	20.9
Sept	2.2	23.6	29.9	37.0	32.0	10.6	9.0
Oct	45.5	7.4	28.3	0.2	6.3	31.3	12.7
Nov	24.7	0.2	2.5	28.6	39.6	43.0	51.3
Dec	8.9	13.0	70.6	8.0	6.3	13.7	5.6
Maximum	45.5	63.8	70.6	77.8	49.9	112.4	51.3
Minimum	2.2	0.2	2.5	0.2	1.4	3.9	1.7
Arith. Mean	21.3	17.7	31.4	24.5	22.4	32.9	16.1

N.A. NOT AVAILABLE

It appears that the lack of activity at White Rocks during May induced high dustfall rates. Possibly the ameliorative efforts of the water truck crew (also on strike) do more to reduce wind-entrained particulate than the production activity of the other employees do to increase fugitive dust emissions. Unfortunately, hi-vol data are not available during the strike period to substantiate this theory.

Overall, dustfall rates during 1978 are lower than those measured during 1977.

ANNUAL AVERAGE DUSTFALL, Tons/Sq. Mi/Mo.

	NW (1)	W (2)	N (3)	SW (4)	S (5)	E (6)	BACKGRD (7)
1977	36.3	47.1	46.8	43.9	55.9	44.4	38.6
1978	21.3	17.7	31.4	24.5	22.4	32.9	16.1

The difference in annual average dustfall rates from 1977 to 1978 is accounted for by the decrease in background rate, as measured at the Hilltop (7) site. A similar decrease in TSP concentration, discussed in the next section of this report, was observed from 1977 to 1978.

While decreases in background dustfall (and particulate concentrations, too) provide a satisfactory explanation for the drop in dustfall (particulate) values at the White Rocks Mine, an obvious question is "Why did the background levels drop?" Most likely the abrupt change in precipitation accounts for the change in background fugitive dust. The total precipitation in Boulder during 1977 was 13.49 inches; in 1978 the total precipitation was nearly twice that amount, 23.97 inches (source: conversation with Assistant Colorado State Climatologist Nolan Doesken, January 23, 1979). Furthermore, ground snow cover during the winter 1976-1977 was very short lived, and average wind speeds in Boulder during 1977 were over 10% higher than those in 1978. Each of these factors---precipitation, snow cover, and wind speed---could explain disparities in background fugitive dust levels, as each influences the total mass of particulate matter entrained.

2.2 SUSPENDED PARTICULATE

Suspended particulate is the chemically undifferentiated matter that remains in the atmosphere, transported by winds. Suspended particulate is one of the EPA designated primary pollutants, and as such, is regulated by Federal and State standards. The suspended particulate regulations applicable to the Cannon-Ertl site are listed below:

TABLE 2

PARTICULATE CONCENTRATIONS, g/m^3

	24-Hour*	Annual Average
Federal Primary	260	75 (Geometric Mean)
Federal Secondary	150	60 (Geometric Mean)
Colorado 1976	180	55 (Arith. Mean)

* Not to be exceeded more than once per year

Colorado State particulate standards are detailed in Appendix II. Compliance with the long term regulations is tested by comparing the average (geometric average for Federal, arithmetric average for Colorado) of twelve consecutive months' data to the appropriate standard. Testing compliance with 24-hour standards is much more difficult, because the frequency of sampling affects the magnitude of the highest and second highest 24-hour concentrations. Obviously, the more frequently 24-hour particulate samples are gathered, the greater the possibility of violating the short term standard. Current State interpretation of the short term standards calls for samples to be taken every fourth day, so that every day of the week is uniformly represented in the sample population. This is the procedure adopted by Flatiron Paving Companies at its Cannon-Ertl Site.

Individual hi-vol concentrations and summary values for the 12 months ending July 1978 are shown in Appendix I. Summary statistics are displayed in Table 3.

TABLE 3

PARTICULATE DATA, $\mu g/m^3$
CALENDAR YEAR 1978

SITE	ARITHMETIC MEAN	GEOMETRIC MEAN	2nd HIGHEST 24-HOUR CONCENTRATION
NW	38.1	25.5	91.1
SW	48.2	39.8	93.5
E	44.4	34.3	94.6

All of the means and peak measurements in Table 3 comply with State and Federal standards. Furthermore, TSP concentrations in 1978 are lower than those measured during the calendar year 1977, as indicated in Table 4.

TABLE 4

PARTICULATE DATA - GEOMETRIC MEAN, $\mu g/m^3$

	1977	1978
NW	44.9	25.5
SW	40.1	39.8
E	49.9	34.3

The decreases in mean particulate concentrations are due to efforts by Flatirons to reduce fugitive dust emissions in 1978, and to more favorable overall meteorological conditions in 1978 discussed in the previous section.

3.1 CALCULATED DEPOSITION VELOCITY

Particulates suspended in the atmosphere are influenced by many forces. In the vertical direction, at distances more than a few centimeters above the surface of the ground, these forces are gravitational (constant force acting down), bouyant force (constant force up), and drag force (force resisting movement, proportional to vertical velocity squared). As the particles approach the ground, atmospheric turbulence alters the paths of the particles, and brings some of them into contact with solid surfaces---grass, leaves, rocks, etc.---where adhesion and adsorption forces may predominate, causing the particles to deposit on the ground. The forces are not completely understood, and certainly not well quantified, but the net effect of these processes is extremely important, for these processes are the ones which remove

particulate from the atmosphere. To simplify the study of particle removal, a fictitious value called deposition velocity is introduced. Deposition velocity is given by:

$$v_d = \omega/\chi$$

Where v_d is deposition velocity (m/sec), ω is vertical mass flux (gm/m^2 sec), and χ is mass concentration of particulate (gm/m^3). Deposition velocity, v_d, is a measure of the mean speed at which particles are impacting the ground and consequently being removed from the air. Deposition velocity is strongly influenced by particle size, and can in fact be used to infer particle size indireclty.

Values of vertical flux, ω, and particulate concentration, χ, are gathered routinely at White Rocks. The dustfall buckets yield a direct measure of vertical flux, and the hi-vols yield particulate concentration. With appropriate changes in units, and with the use of the deposition velocity defining equation, values of v_d at White Rocks can be easily calculated where hi-vols and dustfall buckets are coincident. Values of v_d are given in Table 5 for 1977 and 1978.

TABLE 5

DEPOSITION VELOCITY, v_d, m/sec

HI-VOL SITE	1977	1978
EAST	0.099	0.040
NW	0.092	0.073
SW	0.141	0.048

Deposition velocities are a function of particle size; large particles deposit out faster than small particles, so that the v_d values in Table 5 can be used to estimate particle size.