CONTROL OF FUGITIVE EMISSIONS FROM
OPEN COAL STORAGE IN
NEWPORT NEWS, VIRGINIA

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A mathematical supplement to this report may be obtained by writing to John Stewart, State Air Pollution Control Board, Old Greenbrier Village, Suite A, 2010 Old Greenbrier Road, Chesapeake, Virginia 23320-2168.

The supplement contains updated data including refinements to the optimized system and a more detailed mathematical explanation of the development of the control system.

DISCLAIMER

This report contains the findings, conclusions, and opinions of the Hampton Roads Regional Office of the State Air Pollution Control Board of the Commonwealth of Virginia. In addition, this Final report contains corrections and modifications which were prompted by comments on the Draft Report by both citizens and members of industry. This report does not necessarily reflect the conclusions or policies of the State Air Pollution Control Board or its other staffs.

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ABSTRACT

When two large bulk storage coal export terminals began operation in Newport News, Virginia in 1983 - 1984, fugitive emissions from the storage piles became a chronic problem to nearby residents. This study evaluated the factors contributing to high emission rates and what methods most effectively controlled the emissions. It was determined that the effective wind forces (K_t) on the piles were influenced by wind speed (SP), temperature (T), relative humidity (RH), air density (P), and the air viscosity (μ). This relationship can be mathematically represented by the equation:

$$K_t = SP(T/RH)(P/\mu 1.68)$$

Through monitoring and analysis of High Volume sampler filters for coal dust, a mathematical model was developed that may be utilized to predict coal dust emissions under various conditions. The application of water sprays to control coal was optimized based on the above model and is anticipated to result in attainment of ambient air quality standards if utilized as presented in this report.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Hampton Roads area of Virginia has been a world leading coal export center since the early 1900's. During the years 1979 - 1980 the demand for coal from this area grew immensely. Indeed, at one time nearly 150 colliers were anchored in Hampton Roads waiting to be loaded. As a consequence, two new coal export facilities were built in the Newport News, Virginia, area (See Figure 1). However, their mode of operation differed distinctly from the two existing coal export facilities located in Hampton Roads, Chessie (CSX), and Norfolk and Western (N & W).

Prior to 1983, only one terminal owned and operated by CSX operated in Newport News, and a similar terminal, N & W, in Norfolk, Virginia. These terminals receive and store coal in rail cars. Ship loading is direct from railcars by conveyor to ships. These sources must take reasonable precautions to prevent fugitive dust from becoming airborne as required by the State Air Pollution Regulations[1]. This control strategy consists of a water spray applied at the railcar dumper. The fugitive emissions from CSX, prior to the new terminals, did not interfere with maintenance of national ambient air quality standards, as shown by monitoring results at station 180-G from 1977 to 1979 located at the Newport News Marine Resources Commission just west of the existing City Hall Complex.

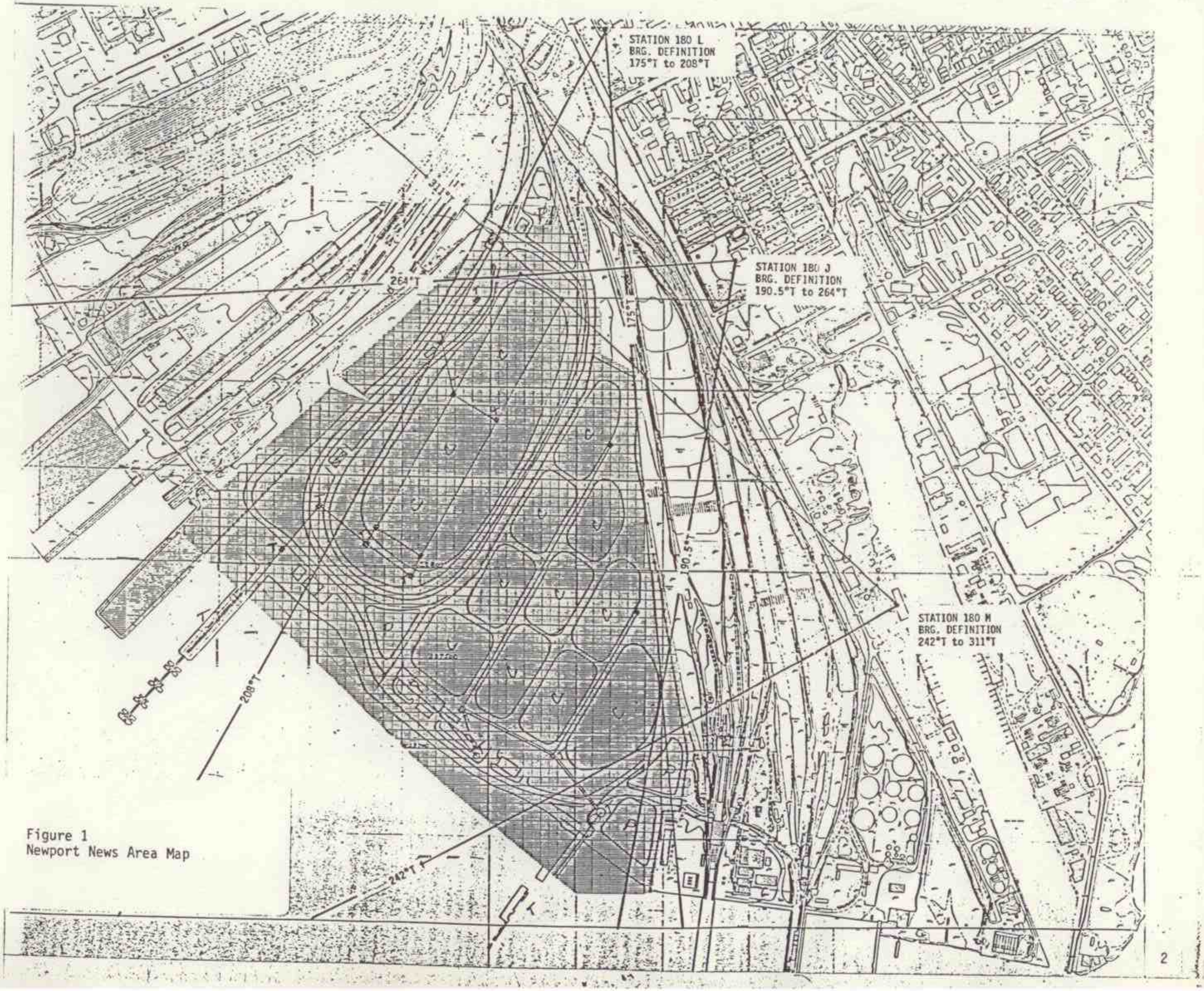

Figure 1
Newport News Area Map

In early 1983, a new terminal owned and operated by Massey Coal Company began operation. This modern facility was designed to meet Best Available Control Technology (BACT) Standards, as then determined. There are no applicable New Source Performance Standards (NSPS) for such facilities. The new terminal dumps the coal on receipt and stores it in large stock piles until a ship is ready for loading. Early in 1984 another terminal, similar to Massey and owned by a consortium of coal companies began operating with BACT as Dominion Terminal Associates (DTA). Usually there are about one million tons of coal in open storage at Dominion and Massey combined. Together, the new terminals are permitted to store 5 X 10^6 tons at any one time. Usually this coal storage is composed of about 85% metallurgical coal.

The engineering analysis for each new terminal indicated that there should be no significant degradation of ambient air quality. It appears that the most significant factor which contributed to this faulty conclusion is that the control efficiency of 90%[2], suggessted by EPA for wet suppression of coal piles, as then implemented, was drastically overestimated. As a result of inefficient controls, high wind speeds, and a long dry period, a major emission of coal dust from the Massey Coal Company Terminal occurred in the spring of 1983, as reported by local residents. This prompted a reevaluation of storage pile emissions. As a result of this incident and monitoring which confirmed higher than expected emission rates, a permanent water spray system was added to the permit conditions for both new terminals. This appeared to adequately control the coal pile emissions. However, following the start of operations by DTA, another major emission incident occurred in the spring of 1984, as observed by staff members and was attributed to incomplete controls at DTA. A new course of monitoring was initiated which also indicated higher than expected emission rates. Consequently, this led to the conclusion that controls as implemented at both Massey and Dominion were much less efficient than originally predicted.

Therefore, further control measures were imposed which consisted of truncating the tops of the piles and compacting the piles with bulldozers[3]. During the remainder of 1984 the nuisance to an adjacent housing area (Harbor Homes) became chronic. In February of 1985 the Virginia General Assembly by joint resolution (HJR274) directed that a study of fugitive coal dust emissions be undertaken by the State Air Pollution Control Board. This task was assigned to the Hampton Roads Regional Staff.

Although the initial intent of HJR274 was to determine if existing State Regulations were stringent enough to control fugitive coal dust, it was determined that in order to solve the problem a new control methodology would have to be developed. The latter is the central focus of this study.

ENVIRONMENTAL PARAMETERS AND COAL DUST PROPERTIES

In general, it is believed that coal particulate emissions from coal storage piles vary with the ability of the terminals to effectively use wet suppression controls (water and chemical additives). The atmospheric conditions in the coal storage area either enhance or diminish the effectiveness of this control methodology. High ambient temperature, low relative humidity and high winds appear to be the major factors which rapidly diminish the effectiveness of water suppression. On hot days the coal storage piles reach temperatures in excess of 140°F, and this coupled with low relative humidity, rapidly decreases the effectiveness of the control, allowing the wind to suspend the coal dust.

Another factor that amplifies the control problem is the elasticity and porosity of the coal dust[4]. From this it has been concluded that the gases occupying the interstitial spaces in the coal particles appear to be lighter than ambient air. A possible hypothesis is that as the temperature of the coal piles increases, the gases expand, possibly distending the coal particles and causing a ballooning effect. These fine particles (metallurgical coal) also repel water (hydrophobic)[5] and are held in place only by the surface tension of the water. Once this tension or binding action is destroyed, the fines are free to move by the force of wind. Any movement of the pile surface tends to damage this binding action. One would expect the pile to settle and adjust itself to a stable condition, which may eventually happen. In the interim, the piles appear to be constantly settling and exposing new surfaces, which probably creates air gaps beneath the water crusted surface. It was assumed that the application of water at regular intervals during the most adverse periods (high temperature, high wind and low relative humidity) of the day would reduce the tendency of the dust to move especially from metallurgical coal piles which are much harder to control as compared to steam coal piles. This assumption led to the development of a control system to suppress the emissions under most meteorological conditions.

STUDY METHODS

In order to ascertain the effects of the terminals on ambient air quality, a monitoring network was established to provide data indicating the total coal contribution to Total Suspended Particulate (TSP) in the vicinity (See Figure 2). Sampling commenced on April 1, 1985. Although there are numerous sources of fugitive emissions in the area, the major contributors are believed to be: construction of a new interstate highway, the coal terminal complex, and background aerosols and botanicals.

During this study, data were collected for analysis by the following techniques: (a) TSP monitoring at four sites 180-J, 180-K, 180-L, and 180-M using High Volume Samplers (Hi Vols); (b) Anderson Cascade Impactor; (c) PM-10 Monitor; (d) hourly wind velocity, temperature, and relative humidity readings from the Dominion Terminal Associates meteorological station located 110 feet above the storage area; (e) continuous log of terminal operations; (f) log of unusual local dust producing activities; (g) a detailed record of water spray applied to the coal piles. In addition, a system for continuous monitoring of coal pile temperature and moisture content was attempted by the terminals but the results were inconclusive and unreliable.

The initial monitoring consisted of one station near the coal piles at the maintenance building for the Harbor Home Project located about 1,900 feet to the northeast from the center of the Massey and Dominion complexes. A second station was located 3.4

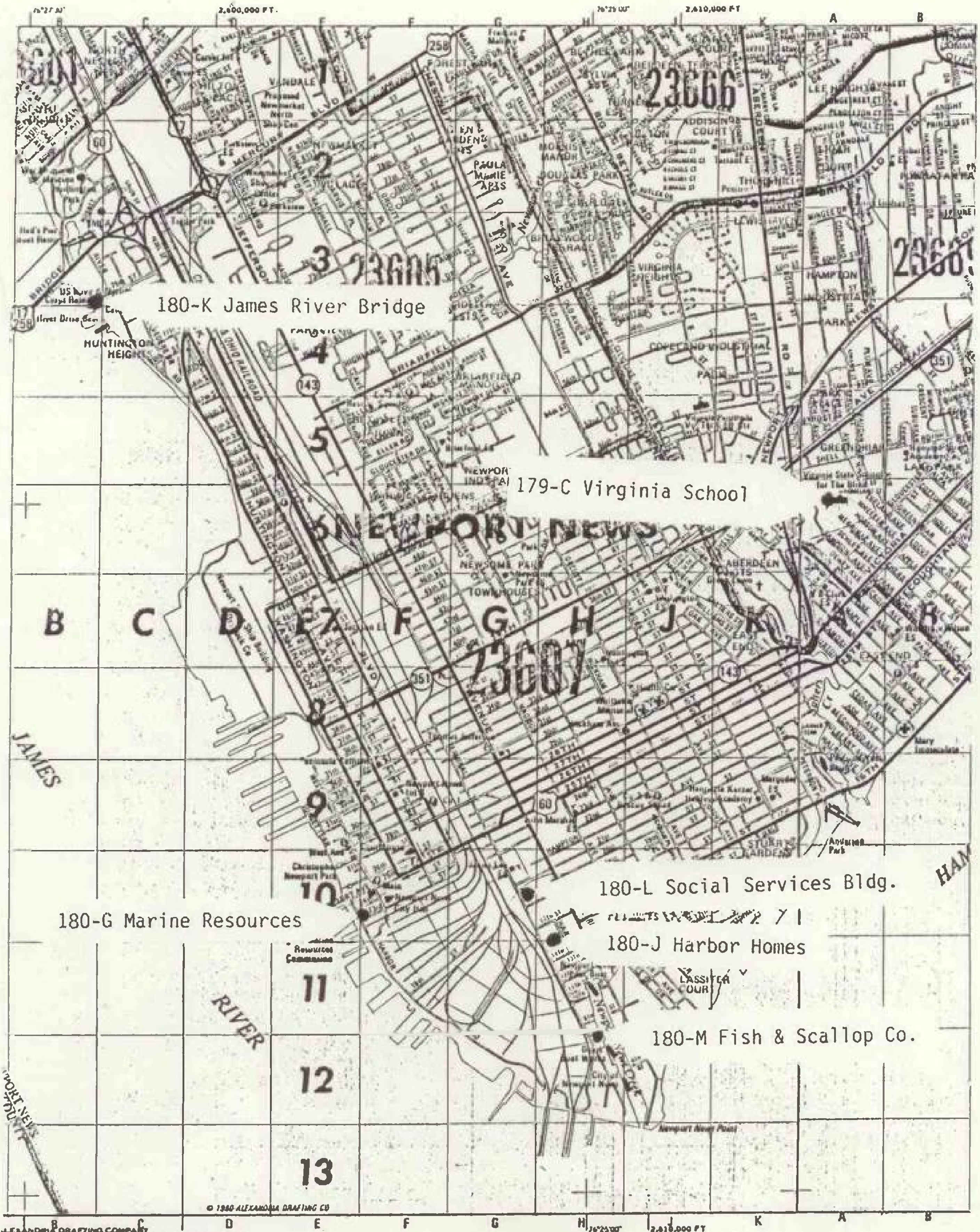
180-K James River Bridge
179-C Virginia School
180-L Social Services Bldg.
180-G Marine Resources
180-J Harbor Homes
180-M Fish & Scallop Co.
NEWPORT NEWS
23607
23605
23666
JAMES
RIVER
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Figure 2

miles to the northwest at the James River Bridge. The purpose of this station was to project the background levels of TSP. The samples were weighed, then combusted and re-weighed. By subtracting the combustible contribution assumed to be due to botanicals, in the background station from the Harbor Home samples, it was hoped that the fraction of coal could be determined. These results were then compared to those of optical microscopy; however, this approach was quickly abandoned because of vast inconsistencies between combusted and optical results.

To continue the study, a more refined analysis for determining coal concentration and particle size distribution on the Hi Vol filters was required. A survey of several candidate laboratories was conducted by the State Air Pollution Control Board's Hampton Roads Region and Division of Monitoring staffs. Although numerous laboratories could adequately analyze the samples, it was determined that the Illinois Institute of Technology, Research Institute (IITRI) had developed a standardized system that could separate coal from TSP and best meet the needs of the study. A detailed description of this procedure is furnished by IITRI as Appendix A.

After the monitoring network was established, a control methodology to effectively abate fugitive coal dust emissions had to be developed. Very early in the study it was assumed that wet suppression was the most economically feasable approach to the problem, but a system was needed that would apply water to the coal storage area at the right times and in quantities to best reduce the emissions (greatest efficiency). In short, a system needed to be developed that prompted the terminal operators to spray the piles based on environmental factors in the area of coal storage.

Based on coal dust physical properties and mathematical analysis of the monitoring data the tendency to emit appeared to be directly proportional to wind speed, temperature and air density, and inversely proportional to the relative humidity and air viscosity. Thus a "K" factor representing these conditions was established as:

$$K_t = SP(T/RH)(P/\mu 1.68)$$

where: SP = wind speed in miles per hour

T = temperature (°F)

RH = relative humidity

P = air density (lbs/ft^3)

μ = air viscosity (lbs/ft-hr)

The constant 1.68 is the value of air density (P) divided by air viscosity (μ) at standard conditions of 70°F; 60% RH; and 29.92 inches Hg.

The value T/RH represents the tendency of the coal pile to emit particulate. The remainder of the equation deals with the potential of the coal dust to be dislodged and become suspended.

RESULTS

The meteorological and other physical factors that affect a Hi Vol sample on a given day were processed in a 12 column, 24 hour day display format referred to as a coal data spreadsheet (CDS), samples of which appear in Appendix B. The calculations based on these data resulted in a predicted Hi Vol reading for that day and the expected total coal loading.

Between abandoning the background station on the James River, June 30, 1985 and receipt of the first IITRI coal analysis on June 25, 1986, all data collection was from station 180-J in the form of total weight of TSP.

There were 197 samples taken from station 180J of which, 77 samples had three or more hours of wind blowing from the coal terminal toward the Hi Vol, and of these, only 71 samples were analyzed for coal by IITRI due to economic constraints. Also, 20 samples from several stations were analyzed to evaluate background and to indicate the extent of the coal dust problem in other parts of Hampton Roads. Finally, 2 PM-10 samples were collected and sent to IITRI for analysis. The results of these two samples were utilized as a comparison to IITRI's particle size distribution.

It was found that the daily sum of the hourly K_t values (ΣK_t) related convincingly to the Hi Vol results for a 24 hour period. Evaluation of the Hi Vol concentrations ($\mu g/m^3$) versus ΣK_t has resulted in a graph (Figure 3) which generally varies only by the number of water suppression cycles administered during the same 24 hour period. A trace of rain (0.01 to 0.03 inches) was considered as a suppression cycle.

In order to use this relationship of TSP versus ΣK_t to determine the time and frequency of the spray applications, a start point had to be established that would approximate the uncontrolled emissions. Once this could be established, it then would be possible to determine the percent reduction attributed to any one cycle at that ΣK_t.

The standardization of suppression cycles, with both terminals starting to spray at the same time, was the first step in this process. The only recognized wind speed value (12 mph) at which dust may become significant was found in AP-42[6]. Consequently, a value of K_t equal to 12 for any one hour was established as the start point to initiate a spray cycle. The cycle would be repeated as long as the value of K_t remained above 12, with a one hour delay between cycles. As an experimental condition, if the hourly K_t value reached 28, hourly spray cycles would be employed as long as this condition existed. In addition, if K_t did not exceed 12, an assurance cycle would be applied at 11:00 AM and 2:00 PM. This system eliminated the independent, random cycling of both terminals and simplified the problem of developing the relationship between the Hi Vol concentrations and ΣK_t.

In order to effectively control coal dust during extreme meteorological conditions, a system for "crisis management" was

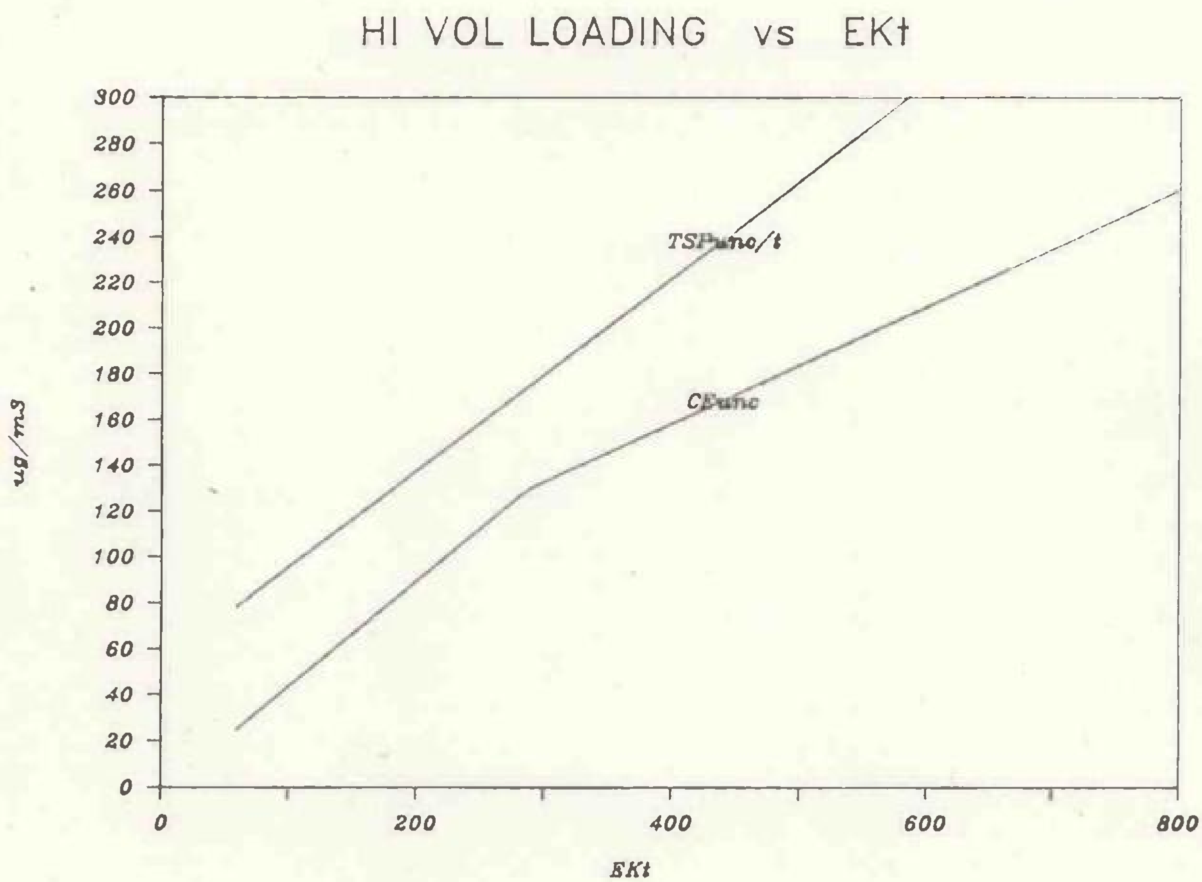


Figure 3. Graph depicting the relationship between Hi Vol concentration and the EK_t for those sample days (TSP). The second line (CE) represents only the coal loading for those samples.

developed. At present, the National Weather Service, provides both Terminals with information concerning any approaching frontal systems. Once the warning is issued, the Terminals initiate spray cycles every hour until precipitation occurs or the K_t drops below 12.

Prior to the assurance cycling requirement, several days were experienced without cycles which gave anchoring points for an uncontrolled emissions line. This line established the Total Uncontrolled Suspended Particulate, $TSP_{unc/t}$. This value, $TSP_{unc/t}$ in $\mu g/m^3$ is derived from the equation:

$$TSP_{unc/t} = 0.422\ \Sigma K_t + 53.24$$

Which represents all of the TSP (background and coal dust). As this ΣK_t changes, so will the values for the potential emissions.

When the weather is other than a clear day, the effect upon the predicted coal emissions is changed. Consequently, a factor was developed to account for occurrences of rain and fog during any 24 hour period (column 8, appendix B) known as F_c. The result of the value of F_c, when applied is a decrease in emissions. It is suspected that the main reason for this is the reduction of the radiant energy received by the coal piles. Rain also cools the piles, forms a water tension seal for fine particulate, and adds weight to larger particulate. Rain $\geq$ .03 inches results in an $F_c = 0$. Fog shields and cools the piles (visiblity $\leq$ 4 miles) and also results in an $F_c = 0$. Additionally, the atomized moisture droplets present a high probability of capture and encapsulation of the fine particles.

The value K_c represents the value of K_t X F_c for those hours when coal dust emissions from the terminal area would be expected to impact the Hi Vol at Harbor Homes Project (wind blowing from 180° to 270). The K_c is used to determine the Total Uncontrolled TSP through the terminal area (Coal Quadrant $TSP_{unc/c}$) that can be expected on the Hi Vol, corrected for weather conditions; where:

$$TSP_{unc/c} = (\Sigma K_c / \Sigma K_t) TSP_{unc/t}.$$

The difference between the theoretical uncontrolled concentration based on ΣK_t and the Hi Vol value, divided by the number of cycles performed, was used to determine the percent reduction per cycle which is represented by the equation:

$$\%R/C = 16 \times 10^{-0.0010279\ \Sigma K_t}$$

The value of "1" was used in the CDS (column 9, appendix B) to represent a cycle of 24,000 gallons of water.

The Control Attained (ATT.), which is a reduction in TSP from the coal quadrant for the ΣK_t, is the value determined from the product of the number of cycles applied (#C) and the percent reduction per cycle (%R/C).

$$ATT. = (\#C)(\%\ R/C)/100$$

$TSP_{unc/c}$ when multiplied by (1 - ATT.) will result in that part of the Hi Vol value that was attributed to the coal quadrant where:

$$TSP_{hv} = TSP_{unc/c}\ (1 - ATT.)$$

The Total Uncontrolled Coal emissions from the coal quadrant (CE_{unc}) is established by the equations:

$$CE_{unc} = \begin{cases} 0.461\ \Sigma K_t - 2.876 & : \quad \Sigma K_t < 288 \\ 0.256\ \Sigma K_t + 56.217 & : \quad \Sigma K_t \geq 288 \end{cases}$$

The expected coal contribution on the Hi Vol Sampler for that day is represented by the equation:

$$CE_{hv} = [(\Sigma K_c / \Sigma K_t)\ CE_{unc}] - [ATT.\ (TSP_{unc/c})].$$

The control efficiency per cycle, based on the emission of coal dust from the terminal complex, rather than TSP was then developed; where:

$$\%Eff/c \begin{cases} = 36.657 \times 10^{-0.00189215(\Sigma K_t)} & : \quad \Sigma K_t < 288 \\ = -0.015\Sigma K_t + 14.651 & : \quad \Sigma K_t \geq 288 \end{cases}$$

Overall control efficiency for the day is then described by the equation:

$$Eff = (\#C(\%Eff/c))/100$$

The results of IITRI analysis of individual Hi Vol samples are contained in Appendix C. The difference between the computed value CE_{hv} and value analyzed by IITRI is shown. Positive numbers indicate that calculated coal (CE_{hv}) is higher than IITRI and negative numbers indicate a calculated value lower than the IITRI analysis.

DISCUSSION

Diminished %R/C Effect.

From November 1, 1985 to January 10, 1986 the amount of water used for suppression was reduced from 24,000 gallons of water per cycle to 12,000 gallons of water per cycle. This was done in the belief that it was not the amount of water used but the pile coverage achieved, based upon several tests at wind speeds in excess of 12 mph. An unexpected increase in coal emissions resulted from this reduction. The effect of this reduction is listed in the CDS as cycles <1.0. As the value of ΣK_t increases, the %R/C diminishes to 0. Rather than reprogramming the CDS to a new %R/C for these days; cycle reduction was used. In general, these cycle reductions follow the equation: (Decrease in cycle performance @ 12,000 gals/cycle equals)

$$1.56 \times 10^{-0.0011786\ \Sigma K_t}.$$

Letting this equation equal 1 and solving the ΣK_t indicates the %R/C starts to diminish when the $\Sigma K_t > 160$.

Based on the data obtained for January 10, 1986 (when the amount of water used per cycle was increased to 17,000 gallons) effective limits were established for the amount of water per cycle required, based on ΣK_t. On this day 5 cycles appear at 0.5 per cycle in column 9 in Appendix B reflecting 12,000 gallons of water and 5 appear at 0.9 per cycle reflecting 17,000 gallons of water. From this it has been established that 12,000 gallons may be utilized for predicted ΣK_t 0 - 150, 17,000 gallons for predicted ΣK_t 151 - 500, and 24,000 gallons of water for predicted values above ΣK_t 500, but only on assurance cycles. These useful limits can be beneficially applied to the assurance cycling requirements to save water.

Cycle Delay Effect.

Cycle delay effects upon the emission levels of the coal piles were evaluated. The Hi Vols operated during 1983 and 1984 were discontinued during the winter months. It was believed that with the reduction of temperature the emissions would be minimal and easier to control. This proved to be invalid. Freezing weather prevented the wet suppression system from operating and resulted in an unexpected increase in coal emissions due to cycle delay.

During the spring, summer, and fall, water had been administered consistantly in a controlled manner. The result generally kept the surface and subsurface of the coal piles reasonably moist. When many hours or days went by without the addition of water (cycling or rain), the piles dried to a greater depth. The dry coal piles became more difficult to stablize. Consequently, emissions increased dramatically.

This percent increase over the expected emissions ($CE_{unc/ca}$) is generally defined by the following equation which was based on 11 sample days (see Appendix D):

$$CE_{unc/ca} = (\Sigma K_c / \Sigma K_t)\ (CE_{unc/t})\ \ (0.640 \times 10^{0.02077\ (Hrs)})$$

where: (Hrs) = the hours from the last "wetting" (rain or cycle) to the next.

This phenomena probably accounts for the two coal dust incidents of May 1983/1984, referenced in the Introduction. At that time, permanent installation of "rain-birds" (wet suppression system) had not been completed at both terminals. Water application was performed by watering trucks. This control method was insufficient and sporadic. When these incidents occurred, emission levels dramatically reduced visibility.

Additionally, this cycle delay action requires CE_{unc} to be redefined as "expected uncontrolled coal emissions with normal watering sequences". The normal watering sequence is now accomplished through four assurance cycles per day in non-freezing conditions and requires a heavy pre-wetting before freezing weather. After freezing conditions cease, normal cycling is continued. The above effects are reflected in Appendix D.

<u>Post Rain Effect</u>.

Post rain effects upon emission levels of the coal piles were evaluated as can also be seen in Appendix D. The effect of rain greater than 0.03 inches results in a decrease (for a finite period of time) in the expected uncontrolled emissions for any ΣK_t. This decrease is used in analysis as a percent of uncontrolled emissions or a "percent recovery." This is generally defined by the following equation:

$$CE_{unc/ca} = (\Sigma K_c/\Sigma K_t)(CE_{unc/t})[(-3979.932)(Rain/(\Sigma K_t(Hrs))) + 1]$$

where: Rain = the total inches of rain which fell prior to the day being analyzed

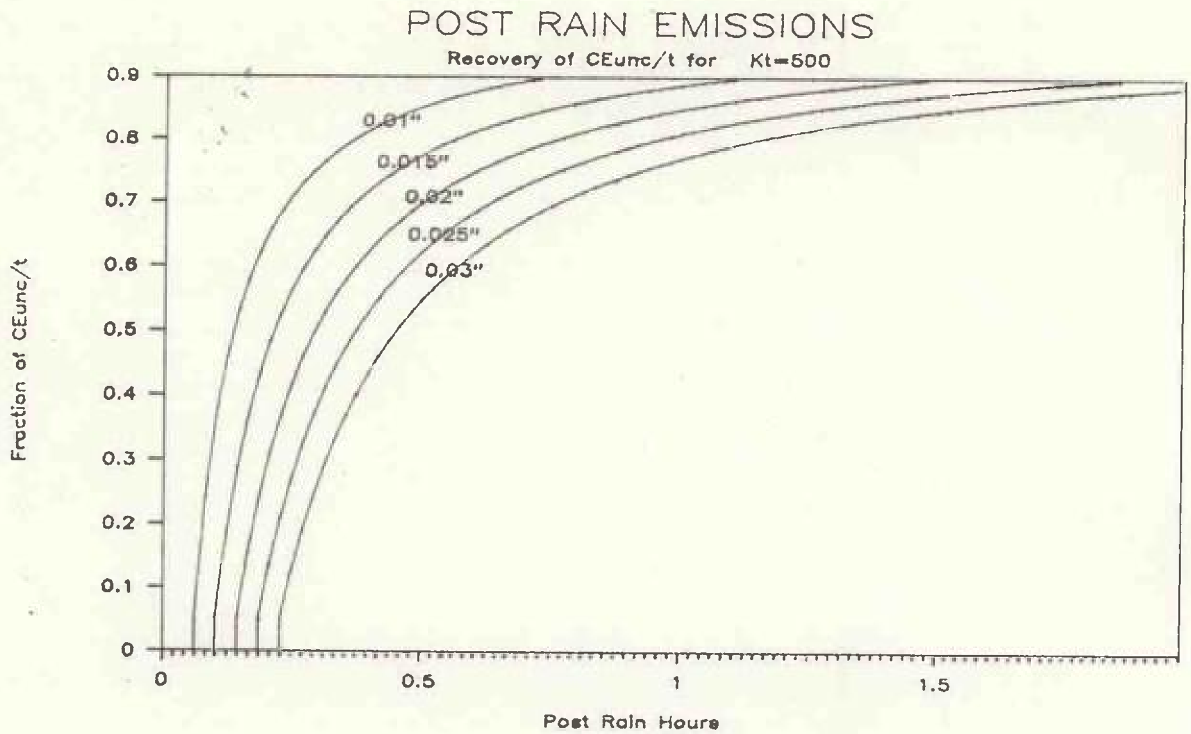
Hrs = the number of hours from the end of the rainfall until the beginning of the day being analyzed.

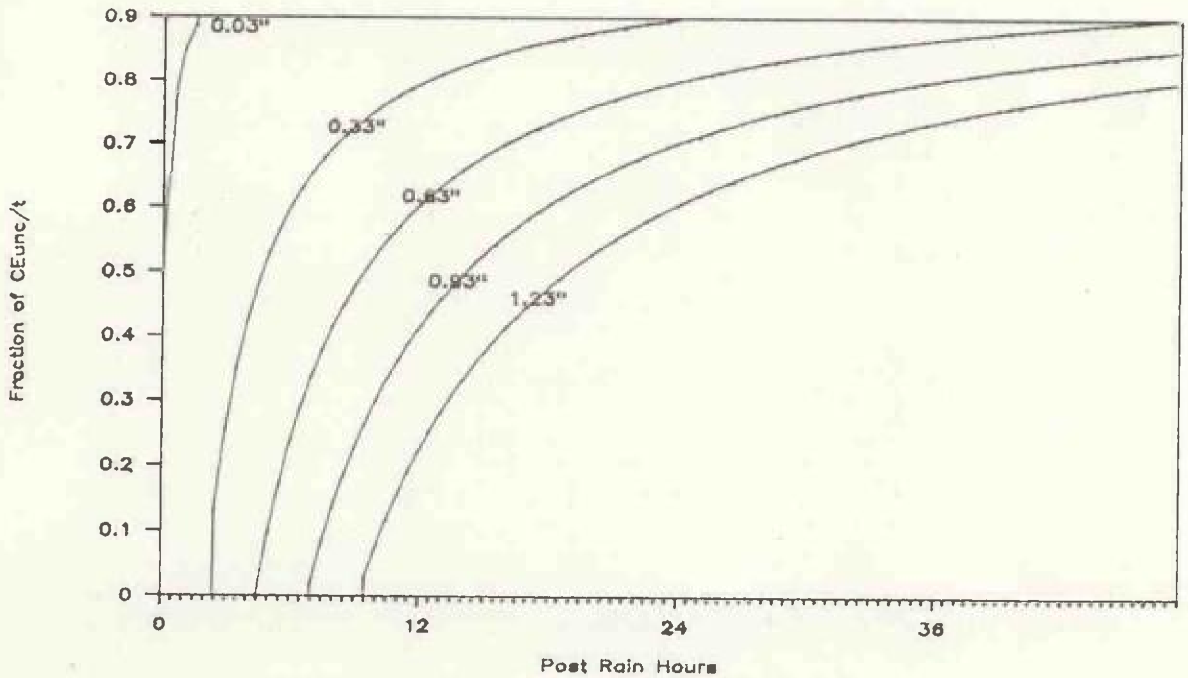
ΣK_t = ΣK_t for day being analyzed.

The accuracy of this equation is dependent upon the average K_t between the end of the rainfall and the beginning of the day being analyzed, being similar in value. Generally, this was observed to be true.

The percent recovery of the $CE_{unc/t}$ for various total inches of rain on a ΣK_t = 500 day is graphically represented in Figures 4 and 5. With heavy rainfall, the point where the individual curve crosses zero indicates little or no emissions for that amount of rainfall until that length of time has elapsed. In view of the fact that this equation reflects a general relationship and is asymptotic to the CE_{unc} line, the terminal point of the post rain effect is plotted at 90% of CE_{unc}.

This equation or its generated curves should not be used to evaluate cycling effects. Cycling is the application of water over the coal piles only. Rain attains 100% coverage of the piles





Figures 4 and 5. These two figures graphically depict the percent recovery of the (360°) coal emissions as affected by rain to the normal uncontrolled coal emissions that would be expected if rain had not occurred.

and performs ideal wetting. In addition to cooling the temperature of the piles and the surrounding areas, it cools the ambient air. Pile recovery times are estimated at 3 to 1 for the same amount of cycling water to rainfall i.e. (@ ΣK_T of 500) 0.03 inches of water from a cycle is equal to approximately 0.01 inches of rain (Trace). Rainfall of ≥ 0.03 inches has been used in this study analysis as an Fc = 0 which reflects 0 emissions for one hour.

Geographical Considerations.

The method for predicting the $\mu g/m^3$ of coal from the TSP weight on any High Volume Sample from station 180-J appears to be accurate. In large part, this method's reliability is based upon predictability of TSP, other than coal, that passes through the coal quadrant. The Terminals are bordered on the west by four miles of water which precludes re-entrainment from this direction.

When a coal storage area is bordered by a large body of water, obtaining weather data well above the piles is significant. It was found that the relative humidity at ground level was variable when compared to that at 110 feet. The relative humidity and temperature at 110 feet compared favorably with the National Weather Service, Norfolk which takes readings at airport runway level. The wind, passing over four miles of water, adds a significant amount of moisture to the air.

In support of this consider the following. The March 9, 1986 sample for 180-J had a weight of 224 $\mu g/m^3$. Another Hi Vol operated by the Simpson Weather Associates on the same day at coal pier height had a weight of 30 $\mu g/m^3$. This sample had a negligible amount of coal (1.67 $\mu g/m^3$). Being an ideal upwind-downwind situation, this should indicate that the coal weight on the 180-J Hi Vol would be 224-30 or 194 $\mu g/m^3$. The IITRI value for March 9, 1986 for 180-J was 163.63 $\mu g/m^3$. The difference between 194 - 163.63 is the difference in TSP other than coal, that most likely was removed by this additional moisture. In conclusion, it appears that weather stations in such geographical locations should be positioned at a sufficient height to yield reliable and consistent weather data.

Particle Size Analysis

In June, July, and August 1985 efforts were made to determine particle size distribution at Station 180-J to provide some basis for evaluating possible health effects. One Anderson Cascade Impactor was co-located with the Hi Vol sampler at Station 180-J. The results of these samples, shown in Table 1, was cause for concern since there appeared to be a high percentage of the TSP less than five micron size.

The Virginia State Air Pollution Control Board non-criteria pollutant rule[8] was employed as the basis for health hazard evaluation. Since coal dust has not been designated as a suspected carcinogen, one sixtieth of the ACGIH threshold limit value for occupational exposure[9] would be the limiting criteria at Station 180-J. This would be a maximum of 33 $\mu g/m^3$ of coal dust 5 micron size or less in any twenty four hour period.

The initial procedure for separating coal from TSP indicated ranges of 30% to 70% coal. The Anderson samples taken in August

Table 1. Particle size distribution at the Harbor Lane Hi Vol in microns, mass in micrograms for samples 6-12-85 through 7-30-85 (As indicated by the Anderson Cascade Impacter)

	SIZE RANGE				
Date	<1.1	1.1-2.0	2.0-3.3	3.3-7.0	>7.0
6-12	46.25	14.72	23.31	36.69	72.02
6-30	17.47	8.80	9.06	15.43	38.52
7-6	18.40	5.77	9.33	14.97	27.73
7-12	29.69	8.22	12.63	15.46	36.44
7-18	21.47	4.79	10.80	13.13	42.09
7-24	20.98	6.26	14.85	15.83	49.08
7-30	16.44	4.05	11.17	13.50	28.69
Mean	24.39	7.52	13.02	17.86	42.22
% of Mass	23.23	7.16	12.40	17.01	40.21

8-5-85 through 8-23-85

8-5	14.60	2.58	7.24	8.96	23.56
8-11	13.50	4.91	8.59	9.33	24.42
8-17	27.36	7.36	18.16	13.99	57.30
8-23	18.28	6.01	18.15	12.15	34.72
Mean	18.44	5.22	13.04	11.11	35.00
% of Mass	22.27	6.31	15.75	13.42	42.28

followed the introduction of the first prescribed spray cycles. While there was an indication that total coal dust was suppressed, there was no significant shift in particle size distribution and the matter of potential health hazard could not be resolved.

The results of analysis of the first five samples by IITRI indicated that the average coal contribution to TSP was 49.4% with only 8.9% of the total coal mass below 7.8 micron size.

The final results of sample analysis for station 180-J are shown in Table 2.

During September 1986, a PM-10 monitor was co-located with the Hi Vol at 180-J. Two PM-10 samples were sent to IITRI for analysis and comparison of particulate capture less than 10 micron size. The results are shown in Table 3.

Clearly, PM-10 reduces the total particulate collected, however, it should be noted that the coal collection by PM-10 contains high percentages of particulate greater than 10 micron size. In addition, there is an indication that through some process coal particles of less than 10 than micron size are generated by PM-10. Using averages of particulate less 10 micron size the ratio of PM-10 to Hi Vol is 1.48, or the PM-10 collects 50% more in this range than the Hi Vol.

<u>Re-entrainment</u>

An attempt was made to evaluate the coal contribution to TSP at station 180-J as a result of re-entrainment by wind from directions outside of the segment occupied by the coal stockpiles. It was arbitrarily decided that a difference of up to 3 $\mu g/m^3$

Table 2. Analysis of Particle Size Distribution which evaluates compliance with proposed PM10 and SAPCB non-criteria pollutant rule.
(Based on IITRI analysis)

DATE	%<2.5	%2.5-5	%5-7.8	%7.8-10	%10-20	%>20	COAL	NON-INHALABLE PARTICULATE (% of Coal)	INHALABLE PARTICULATE (ug/m3)	SAPCB PARTICULATE (ug/m3)
19-Apr-85	0.53	6.38	4.99	5.74	14.61	67.76	175.86	82.37	31.00	12.15
01-May-85	0.27	3.80	2.83	4.56	14.12	74.41	104.94	88.53	12.04	4.27
07-May-85	0.72	6.89	4.14	4.78	16.50	66.96	51.69	83.46	8.55	3.93
13-May-85	0.36	4.88	5.17	6.55	9.80	73.25	29.65	83.05	5.03	1.55
19-May-85	0.30	5.57	4.98	7.49	9.91	71.75	30.81	81.66	5.65	1.81
25-May-85	0.81	9.23	7.22	6.81	14.33	61.60	24.10	75.93	5.80	2.42
31-May-85	0.32	7.26	6.05	9.78	13.19	63.40	54.61	76.59	12.78	4.14
06-Jun-85	1.51	5.74	4.39	3.39	10.47	74.49	23.50	84.96	3.53	1.70
12-Jun-85	0.73	6.12	5.18	7.22	22.37	58.38	79.00	80.75	15.21	5.41
18-Jun-85	0.81	6.17	4.24	5.57	14.29	68.92	51.76	83.21	8.69	3.61
24-Jun-85	0.43	3.60	3.82	6.38	16.88	68.90	68.99	85.78	9.81	2.78
12-Jul-85	0.91	8.05	9.53	10.46	7.47	63.58	16.75	71.05	4.85	1.50
30-Jul-85	2.96	8.76	6.90	7.76	17.57	56.06	16.97	73.63	4.47	1.99
07-Aug-85	3.82	7.18	6.60	6.66	16.77	58.97	21.24	75.74	5.15	2.34
02-Sep-85	2.65	7.91	5.46	5.73	15.59	62.66	53.53	78.25	11.64	5.65
04-Sep-85	0.37	4.18	1.49	4.04	15.10	74.82	53.27	89.92	5.37	2.42
10-Sep-85	2.22	6.77	4.84	4.60	17.63	63.94	69.89	81.57	12.88	6.28
24-Sep-85	30.37	4.80	2.93	4.15	7.88	49.88	9.35	57.76	3.95	3.29
04-Oct-85	0.66	13.85	9.70	11.45	11.27	53.05	21.34	64.32	7.61	3.10
06-Nov-85	0.33	3.83	3.67	6.39	8.78	76.98	14.14	85.76	2.01	0.59
09-Nov-85	2.74	3.99	5.45	6.66	12.59	68.57	18.65	81.16	3.51	1.26
12-Nov-85	0.37	5.67	4.18	5.36	8.42	75.99	23.73	84.41	3.70	1.43
27-Nov-85	1.66	5.82	7.47	7.33	16.83	60.89	99.48	77.72	22.16	7.44
28-Nov-85	1.74	5.72	8.87	8.13	18.73	56.81	101.86	75.54	24.91	7.60
03-Dec-85	0.50	2.64	3.57	5.78	9.97	77.50	11.29	87.47	1.41	0.35
07-Dec-85	0.78	3.41	3.53	7.40	9.55	75.33	14.59	84.88	2.21	0.61
12-Dec-85	1.23	3.44	4.85	3.93	10.72	75.83	47.30	86.55	6.36	2.21
15-Dec-85	1.72	7.12	10.71	10.72	20.6	49.12	138.49	69.72	41.93	12.24
26-Dec-85	1.62	3.13	6.12	5.42	16.35	67.35	46.98	83.70	7.66	2.23
10-Jan-86	1.14	5.20	9.11	7.03	15.87	61.66	79.62	77.53	17.89	5.05
16-Jan-86	2.36	5.17	9.13	7.14	11.89	64.32	96.81	76.21	23.03	7.29
17-Jan-86	0.33	3.88	7.93	6.84	7.86	73.17	68.47	81.03	12.99	2.88
20-Jan-86	2.52	4.56	6.20	4.68	15.07	66.97	33.65	82.04	6.04	2.38
22-Jan-86	3.46	4.75	4.33	5.84	11.74	69.87	78.20	81.61	14.38	6.42
05-Feb-86	4.04	4.51	5.92	5.84	12.58	67.11	30.86	79.69	6.27	2.64
06-Feb-86	13.01	5.62	2.29	3.09	9.91	66.08	10.58	75.99	2.54	1.97
14-Feb-86	0.37	9.19	9.25	13.29	14.72	53.20	71.00	67.92	22.78	6.79
17-Feb-86	2.57	4.61	5.17	5.87	10.45	71.33	74.11	81.78	13.50	5.32
21-Feb-86	8.34	7.36	11.17	9.88	14.72	48.54	15.85	63.26	5.82	2.49
09-Mar-86	0.20	6.31	7.75	12.36	10.26	63.05	163.63	73.31	43.67	10.65
15-Mar-86	0.80	10.54	10.25	10.73	10.23	57.45	26.16	67.68	8.45	2.97
27-Mar-86	0.88	5.26	5.68	7.54	7.81	72.81	20.47	80.62	3.97	1.26
02-Apr-86	0.51	10.70	8.31	10.02	12.66	57.81	45.59	70.47	13.46	5.11
08-Apr-86	2.98	7.90	9.79	7.84	16.66	54.82	73.91	71.48	21.08	8.04
20-Apr-86	0.64	15.71	16.58	15.58	6.49	45.00	96.85	51.49	46.98	15.83
21-Apr-86	0.75	7.81	8.33	9.40	9.98	63.73	30.38	73.71	7.99	2.60
17-May-86	0.34	5.70	5.19	8.26	11.42	69.08	53.33	80.50	10.40	3.22
19-May-86	2.07	8.18	6.64	6.63	20.21	56.28	62.22	76.49	14.63	6.38
12-Jun-86	1.85	5.04	5.92	6.95	11.82	68.42	105.47	80.24	20.84	7.27
23-Jun-86	0.23	5.40	4.07	10.11	12.10	67.18	90.51	79.28	18.75	5.10
27-Jun-86	0.26	6.84	5.00	5.32	8.46	74.11	56.20	82.57	9.80	3.99
05-Jul-86	0.74	9.54	8.84	11.00	12.98	56.91	21.98	69.89	6.62	2.26
12-Jul-86	0.53	13.27	9.96	10.83	12.43	52.98	64.15	65.41	22.19	8.85
AVERAGE	2.16	6.51	6.46	7.40	12.95	64.51	55.54	77.46	12.53	4.40

Table 3. A comparative analysis of particle size of two Hi Vol samples and a co-located PM-10 monitor as indicated by IITRI.

Sample Site	#1(180-J)	180-J-PM10	#1(180-J)	180-J-PM10
Sample Date	11-Sep-86	11-Sep-86	23-Sep-86	23-Sep-86
Aerosol Conc.				
$\mu g/m^3$	197	97	214	114
Total Coal				
$\mu g/m^3$	53.31	31.09	97.45	58.43
Coal Size Dist.				
as $\mu g/m^3$				
<2.5 µm	.13	.24	.13	.35
2.5-5.0 µm	2.56	4.35	2.53	7.41
5.0-7.8 µm	4.55	5.00	4.22	6.72
7.8-10.0 µm	4.44	4.23	7.99	10.94
10.0-20.0 µm	7.91	3.67	14.87	7.20
>20.0 µm	33.72	13.60	67.70	25.81

between the calculated coal contribution and the measured value would be disregarded. Negative differences greater than 3 $\mu g/m^3$ would be considered as possible re-entrainment or coal dust from another source. This evaluation indicated that winds from the northwest quadrant could contribute an average of 7.8 $\mu g/m^3$ while the northeast quadrant could contribute an average of 7.2 $\mu g/m^3$ (See Table 5). The south southeast sector presents an entirely different situation with an average concentration of 18.1 $\mu g/m^3$ (See Appendix E). This quadrant is not predominantly down wind of the coal piles but does include the CSX terminal. Any possible coal dust contribution by CSX will be addressed in a separate study.

Table 4. Random Re-entrainment Analysis.

DATE	Diff.	EKre	Northwest (270-000) EKc	Northwest (270-000) Coal ug/m3	Northeast (001-090) EKc	Northeast (001-090) Coal ug/m3	Southeast (091-150) EKc	Southeast (091-150) Coal ug/m3
07-May-85	-13.23	201.69	26.13	1.71	160.68	10.54	14.88	0.98
25-May-85	-18.13	171.93	112.30	11.84	57.35	6.05	2.28	0.24
06-Jun-85	-7.26	130.69	11.47	0.64	55.39	3.08	37.07	2.06
03-Dec-85	-4.05	367.35	349.16	3.85	9.62	0.11	8.58	0.09
12-Dec-85	-5.86	74.59	0.00	0.00	74.59	5.86	0.00	0.00
10-Jan-86	-6.23	46.89	0.00	0.00	46.89	6.23	0.00	0.00
07-Feb-86	-5.33	63.57	0.00	0.00	3.57	0.30	0.00	0.00
21-Mar-86	-13.21	271.80	0.00	0.00	271.80	13.21	0.00	0.00
01-Apr-86	-11.01	149.20	0.00	0.00	124.23	9.17	24.97	1.84
02-Apr-86	-18.72	189.32	7.76	0.77	156.62	15.49	24.94	2.47
03-Apr-86	-9.78	191.45	0.00	0.00	165.28	8.44	26.17	1.34
15-Apr-86	-4.17	106.59	0.00	0.00	0.00	0.00	106.59	4.17
03-May-86	-31.72	519.40	453.56	27.70	65.84	4.02	0.00	0.00
17-May-86	-4.06	47.63	0.00	0.00	21.11	1.80	26.52	2.26
03-Jun-86	-6.65	379.97	0.00	0.00	329.96	5.77	50.01	0.88
06-Jun-86	-6.39	132.04	0.00	0.00	45.08	2.18	86.96	4.21
21-Jun-86	-32.00	318.07	0.00	0.00	230.03	23.14	88.04	8.86
23-Jun-86	-3.54	20.72	0.00	0.00	0.00	0.00	20.72	3.54
AVERAGE of non-zero entries				7.75		7.21		2.53

↑
IITRI
or
K model

CONCLUSIONS

The primary source of fugitive emissions from the coal export terminals located in Newport News is the coal storage piles. The application of water suppression, in accordance with the optimized plan, presented in Appendix F, represents BACT. It appears, when this optimized plan is properly implemented, emissions of coal dust from the terminals will comply with all State and Federal air quality standards. It appears that the optimized control plan developed during this study can obtain a control efficiency of 85 - 95%. (See Figure 6 and Table 5).

The analysis of particle size distribution indicates that most of the dust emissions are larger than 20 µm and do not fall into the respirable range. As a consequence, no health hazard appears to exist. The quality of life, however, is subject to deterioration from the nuisance or soiling characteristics, when controls are not properly applied.

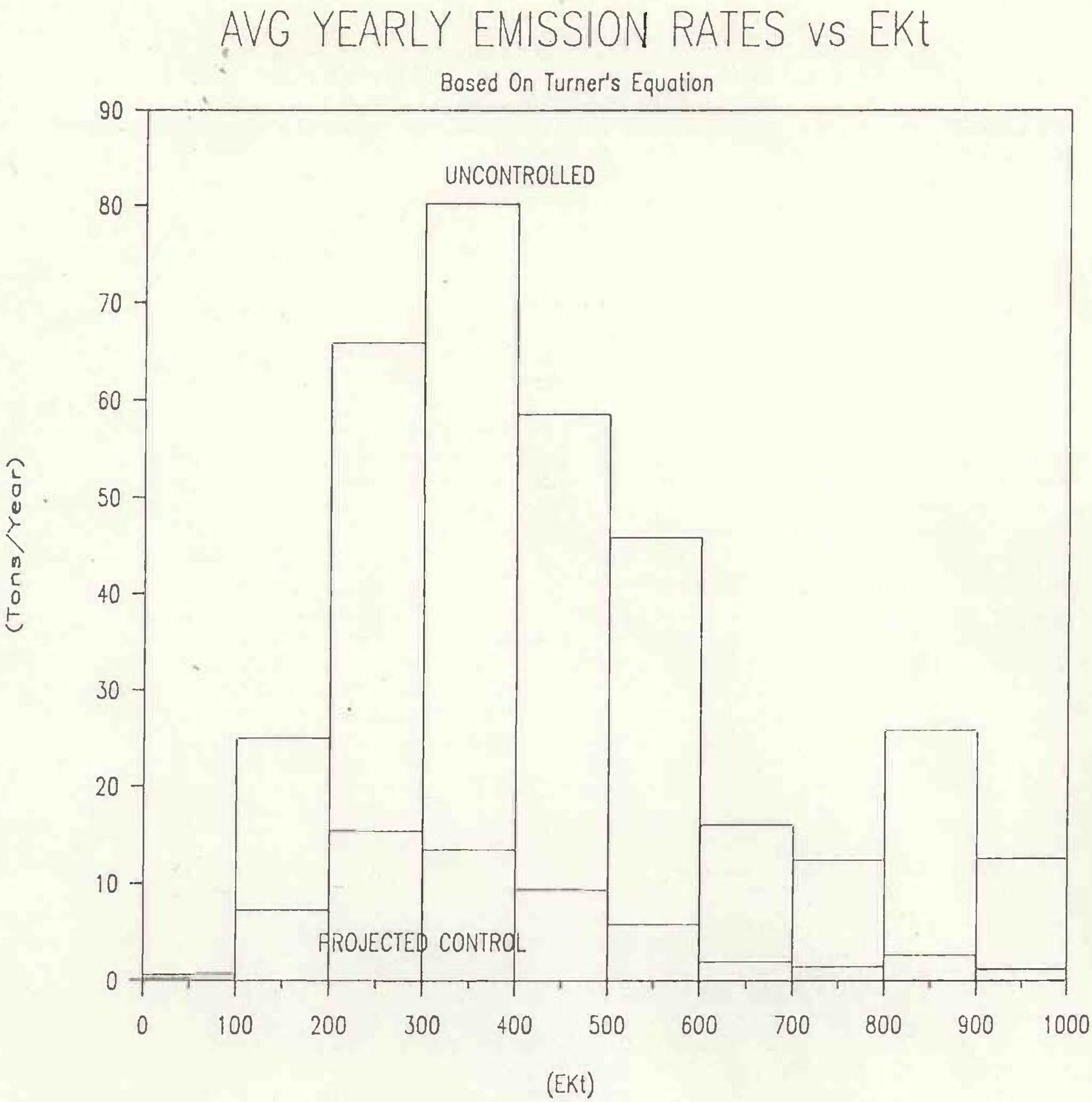


Figure 6. The combined mean annual emission rate for both terminals (uncontrolled and projected controlled) based on the various number of the EK_t days as reflected by Simpson Weather Associates in Table 1.

Table 5. Projected control efficiencies of coal loading to achieve permit emission limits.

EKt	CEunc/t	%EFF/C	#C	EFF	CEhv
60	25	28.22	4	1.13	6
70	29	27.02	4	1.08	6
80	34	25.87	4	1.03	6
90	39	24.77	4	0.99	6
100	43	23.71	4	0.95	6
110	48	22.70	4	0.91	6
120	52	21.73	4	0.87	7
130	57	20.81	4	0.83	10
140	62	19.92	4	0.80	13
150	66	19.07	4	0.76	16
160	71	18.26	4	0.73	19
170	75	17.48	4	0.70	23
180	80	16.73	4	0.67	26
190	85	16.02	4	0.64	30
200	89	15.34	5	0.77	21
210	94	14.68	5	0.73	25
220	98	14.06	5	0.70	29
230	103	13.46	6	0.81	20
240	108	12.88	6	0.77	24
250	112	12.33	6	0.74	29
260	117	11.81	7	0.83	20
270	122	11.31	7	0.79	25
280	126	10.82	7	0.76	31
290	130	10.39	8	0.83	22
300	133	10.24	8	0.82	24
310	135	10.10	8	0.81	26
320	138	9.95	8	0.80	28
330	141	9.80	8	0.78	30
340	143	9.66	9	0.87	19
350	146	9.51	9	0.86	21
360	148	9.36	9	0.84	23
370	151	9.21	9	0.83	26
380	153	9.07	9	0.82	28
390	156	8.92	10	0.89	17
400	158	8.77	10	0.88	19
410	161	8.63	10	0.86	22
420	164	8.48	10	0.85	25
430	166	8.33	10	0.83	28
440	169	8.19	11	0.90	17
450	171	8.04	11	0.88	20
460	174	7.89	11	0.87	23
470	176	7.75	12	0.93	12
480	179	7.60	12	0.91	16
490	181	7.45	12	0.89	19
500	184	7.30	12	0.88	23

EKt	CEunc/t	%EFF/C	#C	EFF	CEhv
510	187	7.16	13	0.93	13
520	189	7.01	13	0.91	17
530	192	6.86	13	0.89	21
540	194	6.72	14	0.94	12
550	197	6.57	14	0.92	16
560	199	6.42	14	0.90	20
570	202	6.28	15	0.94	12
580	204	6.13	15	0.92	16
590	207	5.98	15	0.90	21
600	210	5.84	16	0.93	14
610	212	5.69	16	0.91	19
620	215	5.54	16	0.89	24
630	217	5.39	17	0.92	18
640	220	5.25	17	0.89	24
650	222	5.10	18	0.92	18
660	225	4.95	18	0.89	24
670	227	4.81	18	0.87	31
680	230	4.66	19	0.89	26
690	233	4.51	20	0.90	23
700	235	4.37	20	0.87	30
710	238	4.22	21	0.89	27
720	240	4.07	22	0.90	25
730	243	3.93	23	0.90	24
740	245	3.78	24	0.91	23
750	248	3.63	24	0.87	32
760	250	3.48	24	0.84	41
770	253	3.34	24	0.80	50
780	256	3.19	24	0.77	60
790	258	3.04	24	0.73	70
800	261	2.90	24	0.70	79

Yearly Weighted Average EFF = 0.82

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Appendix A

IITRI
ANALYSIS METHODS

Sample Inspection

All samples were visually inspected for contaminants, defects, and sample loss. The visual inspection was supplemented with examination by stereomicroscopy for particle homogeneity on the filters.

Sample Reweighings

It is common for TSP samples to lose weight after final desiccation and weighing. The weight loss is usually not due to a loss of particles from the filter, but apparently is due to loss of condensed atmospheric water collected during sampling. The water is not totally removed during the normal desiccation period following collection of the sample before final weighing. The water apparently slowly evaporates during storage of the samples. Therefore, it is good practice to redesiccate and reweigh the filters before analyses are conducted.

Few of the filters in the first batch were received as whole, intact filters; small to large sections had been removed from most of the filters. Therefore, reweighings were not conducted on any of the filters. Approximately half of the filters in the second and third batches were received intact. These filters were redesiccated and reweighed. However, because none of the previously measured tare and final weights of these filters were provided, the aerosol mass data provided with the filters was used in all calculations.

Sample Sectioning

The ashing, total carbon and microscopy analyses to be conducted required sectioning of the filters. Sample sections were cut in a class 100 clean bench with a stainless steel scalpel. A template, specially designed for cutting TSP filter samples was used to produce sections 1 inch wide. The filters were folded in half, parallel to the 8-inch length and cuts were made at right angles to the fold. The sections produced were 10 inches long by

1 inch wide. However, because of the border on the filter produced by the hi-vol sampler gasket, the area over which particles were present on each section was 9 inches by 1 inch.

Low Temperature Ashing

Low temperature ashing (LTA) was employed to determine the mass of (total) organics and elemental carbon on the filters. Aerosol components such as elemental carbon from coal, vehicle exhausts, rubber tire fragments and organic carbon contained in these components and biological particles are oxidized by monatomic oxygen under vacuum at a temperature of approximately 150°C. The LTA consists of evacuated chambers (1-2 mm Hg) which are swept with oxygen a flow rate of 30 to 35 cc per minute, and a radio frequency generator. The radio frequency field dissociates the diatomic oxygen to monatomic oxygen which oxidizes (combusts) the organic and elemental carbon but has little or no effect on inorganic components.

The ashing was conducted in an LFE model LTA 504 low temperature oxygen plasma asher. Sample sections (including blanks) were desiccated for 24 hours prior to ashing and then weighed to the nearest 0.1 mg. The filter sections were ashed for two hours at a field strength of 500 watts. The ashed sections were then cooled in a desiccator before reweighing to determine mass loss.

The mass percent of the aerosol mass lost in ashing was calculated from the measured mass loss divided by the total aerosol mass present on the filter section ashed. The total aerosol mass is assumed to be evenly distributed over the entire 9-inch by 7-inch filter collection area. Therefore, the aerosol mass on a 10-inch by 1-inch filter (with a deposit area of 9 square inches) is assumed to be one-seventh of the total aerosol mass.

Total Carbon Analysis

Total carbon, volatile carbon and nonvolatile carbon concentrations were determined by controlled combustion with coulometric titration of the evolved CO_2. The combustion gases generated in each step of the combustion are sorbed in proprietary solutions for the coulometric analysis.

To determine the volatile carbon content, the samples were heated at 500°C in N_2; the evolved pyrolysis gases were then mixed with O_2 and combusted at 1000°C. After the volatile carbon was driven off (one-fourth to one-half hour), the samples were heated at 1000°C in oxygen to combust the nonvolatile carbon.

The total carbon mass is the sum of the carbon masses measured in the two combustion steps. Calculations of total carbon, volatile carbon and nonvolatile carbon concentrations in the TSP were made by methods analogous to those employed for the LTA analysis.

Optical Microscopy Analysis

Sections approximately 1 inch by 1 inch in size were cut from each filter with a stainless steel scalpel. The sections were placed onto a pool of immersion oil at the center of a standard glass microscope slide. To complete the mount, a cleaned glass coverslip was placed on top of each filter section once the immersion oil had soaked through to the front surface of the filter section. The immersion oil was selected so that the refractive index of the oil closely matched the refractive index of the fibers comprising the filter medium. This renders the filter transparent and allows transmission of light through the filter for direct polarized light microscopy (PLM) observation of the particles collected on the filter. The primary rationale for direct PLM analyses on the filter is that adhesive lift-off particle removal methods do not remove representative aliquots from the filter. Particle types lodged deeper in the filter - e.g., very small particles - are not removed by lift-off methods.

Particles were identified based on their unique morphological and optical features observed through the polarized light microscope. These observed physical (size, shape, surface texture, etc.) and optical (polarization colors, relative refractive index, luster, etc.) properties permit direct comparison to standard reference tables or reference samples for particle identification.

The particles of concern to this study were coal and other carbonaceous particles which would be combusted in the low temperature asher. These other combustible particles were grouped into two particle type categories on the basis of density, to simplify the quantitative microscopy analysis. The particles included in the two noncoal particle type categories are briefly discussed below.

"Other Carbon" - Partially combusted coal (and wood and paper) fragments, oil soot, diesel and gasoline combustion engine exhausts, and rubber tire fragments comprise this particle type category. These carbonaceous particles are common components of urban aerosols. Typically these carbonaceous particles consist mostly of nonvolatile carbon.

"Biologicals" - Tree and grass pollens, trichomes, mold spores and conidia, paper and textile fibers, plant tissue fragments, starch grains and insect parts comprise this particle type category. Most of these components contain a high proportion of volatile carbon.

The quantitative microscopy analysis employed a stratified counting technique for particle size analysis and for determining the relative proportions of each of the three (coal, other carbon, biologicals) carbonaceous particle types. In stratified counting, a British Standard Graticule (Figure 1) is used to define counting areas (the various sized boxes) and particle sizes (the various sized circles). Three different magnifications were employed to allow recognition of small particle types and to allow counting of sufficient numbers of large particles. For statistical validity, a minimum of 30 particles in a minimum of 20 fields of view (and a maximum of 100 fields of view) must be counted for each particle size and particle type category.

Magnifications were selected to provide easy recognition of particle types: particles in the two smaller particle size categories were counted at 625x, the 5.0-7.8 μm and 7.8-10.0 μm particles were counted at 391x and the particles in the two largest particle size categories were counted at 156x. The box size used to count each particle type in each particle size category was selected based on the size of the particles and the abundance of the particles to be counted; the box size must be at least three times larger than the particle diameter, and ideally one to three particles will be present in the box in each field of view. Typically, the smallest particles were counted in the smallest box size, while the greater-than-20-μm particles were counted in the largest box.

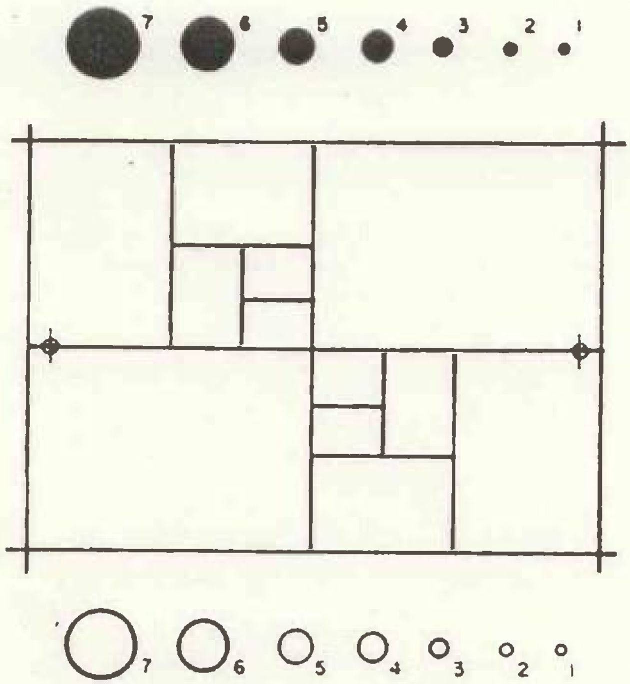

Figure 1. British Standard graticule

Data calculations involved normalizing all the count data, calculating particle types masses in each particle size category from particle volumes and densities, and normalization of the calculated mass data to the LTA (i.e., total possible combustible particle mass present) mass loss for each filter. All the count data produced were normalized to the largest box size at 156x for 20 fields of view. Particle volumes were calculated based on spherical particle shapes; because the particle diameter measured with the British Standard Graticule is an equivalent projected circular diameter rather than a feret (longest dimension) diameter, the spherical particle shape assumption is valid. The volumes for each particle type and size were then multiplied by density factors (2.20 g/cm^3 for Coal, 1.76 g/cm^3 for Other Carbon and 1.30 g/cm^3 for Biologicals) to yield the masses of particles. The individual masses for each particle size were summed to yield the total mass for each particle type. The total carbonaceous (combustible) particle mass measured microscopically was then normalized to the mass lost over the same filter area in the low temperature ashing. The mass percents of each of the three carbonaceous particle types present in the TSP were finally calculated from the particle type mass divided by the total aerosol mass present over the filter area examined microscopically.

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Pembroke IV-Suite 409
Virginia Beach, Virginia 23462-5480

Subject: Response to Norfolk Southern Corporations Comments on IITRI's Analysis of Coal Dust in Hivols Report.

Dear Mr. Minx:

This is a response to your letter of 6 April 1987 requesting our review of a critique by the Norfolk Southern Corporation of IITRI's report of the analysis of coal fragments in various TSP samples. IITRI's report appeared as Appendices A and C in a report by your Office entitled: "REPORT ON FUGITIVE EMISSIONS FROM STORAGE AND RAIL TRANSPORT OF COAL" (January, 1987). The critique was entitled, "Bias In The Analytical Method: Overestimation of Coal Dust As A Fraction of TSP:", and was not dated or referenced as part of a letter or report.

Our response to the critique is presented below, which will hopefully clarify the procedures and methods used in our analytical study.

RESPONSE TO COMMENTS

1. "Differentiating between coal dust and other particulates present on "Hi-Vol" filters is very difficult."

Coal is one of the easier aerosols to recognize in the super-micrometer size, and in fact, one can usually differentiate between partially-combusted coal and raw coal by polarized light microscopy. It is only in the submicrometer size that coal cannot be distinguished from other carbonaceous particles and must be determined by other methods. In TSP or PM-10 air quality studies, the principal mass is usually associated with the super-micrometer particles, as was the case for this study.

2. "The first bias is the use of a density for coal particles of 2.2g/cc ..., etc."

A density of 2.2g/cc is that listed for carbon/graphite in the Handbook of Chemistry and Chemical Engineering (61st edition) and in the Particle Atlas (1957). We believe this value is closer to the true value for discrete coal particles because the densities usually reported for coal are based on bulk samples which have substantial porosities and voids. Coal fragments in aerosol samples are usually below 100 um in diameter and thus have many fewer voids.

The density of sub-sieve (< 37um) coal fragments can be determined using a pycnometer, which should be done if one needs an exact value. However, Table A suggests that a more exact number may not be critical to this study.

Table A contains the computed mass concentrations for LTA components with a hypothetical LTA concentration of 200 ug/cubic meter. Three different densities were used for coal: 2.2 g/cc (the value used by IITRI), 1.58 g/cc (the average for bulk anthracite coal), and 1.35 g/cc (the value listed for N & W bituminous). A brief explanation of Table A will aid in understanding the magnitude of difference caused by the use of various densities.

The component volumes are the same for the three different coal densities. This agrees with the procedure of calculating volumes and then mass from the particle sizing/count data (see discussion 3. below for more details). The densities and volume are used to calculate mass by component. The sum of all LTA components masses are normalized to the LTA mass concentration of 200 ug/cubic meter, producing the normalized mass concentration for each component.

If the true coal concentration is based on a coal density of 1.35 g/cc, then the bias from using a density of 2.2 g/cc is 3.1 ug/cubic meter out of 192 ug/cubic meter, which is a bias of 1.6 %. The Norfolk & Southern critique stated that the bias is 39% based on a calculation of:

$$(2.2-1.35)/2.2 = 39\ \%.$$

This bias would only apply if the LTA data were being calculated without normalization (and perhaps, more properly, would have been a bias of 63 % by using the selected density of 1.35 g/cc in the divisor).

3. "The second bias is that microscopic particle counts of coal" ..., etc., "were normalized"..., etc.

The thrust of this comment is that normalizing the carbonaceous constituents to the low temperature ashing (LTA) data produces a bias because volatile non-carbonaceous constituents, such as ammonium nitrate, are not subtracted from the LTA loss. This would be correct as stated, if we had not had a means of assessing whether there was a significant concentration of ammonium nitrate.

TABLE A. CALCULATED COAL MASSES FOR VARIOUS DENSITIES

COMPONENTS	VOLUME-1	DENSITY-1	COMP.MASS	NORM %	NORM.MASS-1
LTA Coal	73.10	2.20	160.82	97.43	194.86
Other Carbon	1.22	1.76	2.15	1.30	2.61
Biologicals	1.61	1.30	2.09	1.27	2.53
SUM	75.93	NA	165.06	100.00	200.00

LTA MASS, ug/m^3 = 200.00

COMPONENTS	VOLUME-2	DENSITY-2	COMP.MASS	NORM %	NORM.MASS-2	MASS 2-1
LTA Coal	73.10	1.58	115.13	96.45	192.90	-1.97
Other Carbon	1.22	1.76	2.15	1.80	3.60	1.00
Biologicals	1.61	1.30	2.09	1.75	3.50	0.97
SUM	75.93	NA	119.37	100.00	200.00	0.00

LTA MASS, ug/m^3 = 200.00

COMPONENTS	VOLUME-3	DENSITY-3	COMP.MASS	NORM %	NORM.MASS-3	MASS 3-1
LTA Coal	73.10	1.35	98.69	95.88	191.76	-3.10
Other Carbon	1.22	1.76	2.15	2.09	4.18	1.57
Biologicals	1.61	1.30	2.09	2.03	4.06	1.53
SUM	75.93	NA	102.93	100.00	200.00	0.00

LTA MASS, ug/m^3 = 200.00

Ammonium nitrate has a very distinctive shape and high birefringence, making it possible to detect even submicrometer particles with ease. The samples contained negligible concentrations of ammonium nitrate.

All of the other volatile/combustible constituents were included in the microscopical count and were grouped into two categories. These categories included: "Other Carbon" (submicrometer carbon, principally vehicle exhausts and sorbed organics), and "Biologicals" (paper fibers, pollens, spores, fungal conidia, sap globules, etc.). Since the LTA includes total volatiles and combustibles, the microscopical components are equal to the LTA components. This is the strategy utilized for the project and all IITRI source/receptor studies.

All microscopical particle sizing utilizes a statistical diameter. The statistical diameter used for this project was the equivalent, circular, projected area. Particle size is determined by matching the projected particle area to the area of a calibrated circle or range of circles. Particle volume is calculated as a sphere from the equivalent circular diameter, and particle mass is simply the product of volume times density.

Aerosol particles are rarely spheres so that the equivalent spherical volume or mass computed from microscopical measurements is rarely equal to the exact volume or mass. This difference is simply ascribed to a shape factor difference. In order to compensate for this shape factor difference, IITRI uses the LTA data as a limiting value for combustible and volatile components.

In order to calculate individual component mass concentrations, the computed mass of each combustible/volatile component is calculated as a percentage of all combustible/volatile components. This percentage is multiplied by the total LTA mass concentration to determine the aerosol mass concentration for that component. This normalization to the LTA concentration minimizes the uncertainty about the shape factors and computed masses since the LTA value is a precise and accurate gravimetric value.

4. "The Report makes no attempt to determine the precision of the IITRI method."

The precision for these analyses is approximately 15% for major components based on particle count statistics; minor and trace components have precisions of 50 % and higher. The more correct presentation of values for these constituents would have been as rounded to the nearest microgram per cubic meter. The intent in reporting values to 0.01 ug/cubic meter was merely to show that other combustible/volatile components, in addition to coal, were not zero.

SUMMARY

This response was prepared in collaboration with Ms. Jean Graf-Teterycz who was engaged in a field study and was not able to prepare the response personally. We hope these comments help to clarify the approach used in measuring coal concentrations from your various samples.

For Jean Graf-Teterycz,

Respectfully submitted,

Ronald G. Draftz

Ronald G. Draftz
Science Advisor
Chemistry & Chemical Eng. Dept.

Appendix B. Column description for CDS sheets.

Column 1. The time of the day starting at the end of the first hour and continuing until the end of the day at 24.

Column 2. Average temperature for the 24 hours of each day from the Dominion weather station.

Column 3. Average relative humidity for the 24 hours of each day obtained from the Dominion weather station.

Column 4. Average wind speed for the 24 hours of each day obtained from the Dominion weather station.

Column 5. Average wind direction for the 24 hours of each day obtained from the Dominion weather station.

Column 6. Dew point for the 24 hours of each day from a psychometric chart, based on the average temperature and relative humidity for each hour.

Column 7. Average barometric pressure in inches of Hg for 24 hours of each day. obtained from the National Weather Service, Norfolk, Virginia.

Column 8. These values represent a multiplication factor that alters the value of Column 12. This is a function of the day's weather. The value of F_c for a standard day is normally 1. (no weather such as rain or fog) Rain $\geq$ .03 inches results in an $F_c = 0$. The above modifying values were used consistently throughout the evaluation to determine the movement potential of coal particulate.

Column 9. This number represents the effectiveness of wet suppression cycles for any given hour. These values are based upon the analysis of the Terminals' daily activity log. These entries are made on the hour for which the activity had an effect.

Column 10. These values represent the hourly air density (P) divided by air viscosity (μ), corrected to standard conditions by the constant 1.68.

Column 11. These values are determined by the equation $K_t = SP(T°F/RH)(P/\mu 1.68)$, independent of wind direction.

Column 12. These are K_c values which represent the product of (F_c X K_t) when the wind is from the southwest or coal quadrant. At the beginning of this study the location of the first Hi Vol station at 180-J (Harbor Homes) defined the coal quadrant, as those bearings from which the wind blew from 180° to 270°. When the average value for wind direction shifts out of this quadrant, the computer prints out a "0" value for K_c.

→ HI VOL 77.00 DATE apr0185

T	Tf	RH	SP	DIR	DPf	BAR	Fc	#c	P/u	Kt	Kc
1	54	100	10	306	51.0	29.58	0.0		1.041264	5.6228	0.0000
2	54	100	12	302	52.0	29.59	0.0		1.041405	6.7483	0.0000
3	54	100	12	299	51.0	29.59	0.0		1.041614	6.7497	0.0000
4	54	100	10	259	51.0	29.59	0.0		1.041614	5.6247	0.0000
5	52	100	11	252	50.0	29.60	0.0		1.055564	6.0378	0.0000
6	52	100	10	252	48.0	29.72	0.0		1.060051	5.5123	0.0000
7	52	100	10	259	50.0	29.63	0.0	0.0	1.056622	5.4944	0.0000
8	54	85	13	259	44.0	29.63	1.0	1.0	1.049202	8.6652	8.6652
9	59	60	15	266	47.0	29.63	0.0	0.0	1.028157	15.1653	0.0000
10	62	53	14	288	43.0	29.62	1.0		1.016267	16.6438	0.0000
11	64	44	13	270	41.0	29.60	0.0	0.0	1.007872	19.0579	0.0000
12	65	33	24	259	38.0	29.58	1.0	1.0	1.003731	47.4491	47.4491
13	66	31	25	259	38.0	29.56	1.0	1.0	0.999295	53.1883	53.1883
14	67	26	24	263	34.0	29.53	0.0	0.0	0.994976	61.5354	0.0000
15	67	24	18	266	26.0	29.52	0.0	0.0	0.997124	50.1055	0.0000
16	67	21	22	263	27.0	29.51	0.0	0.0	0.996791	69.9652	0.0000
17	67	21	24	272	28.0	29.52	0.0	0.0	0.997124	76.3512	0.0000
18	67	24	21	272	30.0	29.53	0.0		0.997456	58.4759	0.0000
19	64	26	16	272	29.0	29.55	0.0	0.0	1.009371	39.7537	0.0000
20	64	30	12	259	30.0	29.58	1.0		1.010406	25.8664	25.8664
21	62	36	13	271	32.0	29.61	0.0		1.019486	22.8252	0.0000
22	57	50	17	281	36.0	29.65	1.0		1.038431	20.1248	0.0000
23	55	63	13	29	40.0	29.67	1.0	0.0	1.046949	11.8820	0.0000
24	51	52	13	36	33.0	29.69	1.0	0.0	1.065239	13.5818	0.0000
AV	60	57									
								E #c		E Kt	E Kc
Visibility (fog) = < 4 = 0								3.0		652.4266	135.1689

Dominion 24hrs Transfer	TSPunc/t =	328.4988
Massey 8hrs Transf/13hrs Reclm.	TSPunc/c =	68.0580
Net Tons: D - 504,524	%R/C =	3.4158
M - 470,795	ATT.	0.1025
Kt values the "actual" bearing	TSPhv =	61.0838
limits of Massey (Ref. Fig. 2).		
Using only the bearings < 263 T or	CE unc =	222.9551
what the Hi Vol "actually sees" =	CE hv =	39.2174
39.21 ug/M3. This represents		
only 34% of the actual 360 degree	IITRI =	33.2400
coal emission for the day.		5.9774

→ HI VOL 117.00 DATE apr0785

T	Tf	RH	SP	DIR	DPf	BAR	Fc	#c	P/u	Kt	Kc
1	60	36	15	259	33.0	29.91	1.0		1.035609	25.8902	25.8902
2	59	41	14	317	36.0	29.93	1.0		1.040083	20.9539	0.0000
3	58	40	8	346	33.0	29.96	1.0		1.045615	12.1291	0.0000
4	56	32	5	22	28.0	29.98	1.0		1.057430	9.2525	0.0000
5	55	33	4	22	29.0	30.01	1.0		1.062706	7.0847	0.0000
6	55	32	5	14	28.6	30.03	1.0		1.063423	9.1388	0.0000
7	56	33	3	79	29.4	30.06	1.0	0.0	1.060287	5.3978	0.0000
8	58	30	5	130	27.0	30.07	1.0		1.052270	10.1719	0.0000
9	60	32	7	151	30.5	30.08	1.0		1.044314	13.7066	0.0000
10	61	24	8	137	21.0	30.05	1.0	0.0	1.039134	21.1291	0.0000
11	61	26	11	122	25.0	30.03	1.0		1.038434	26.7996	0.0000
12	63	26	14	119	28.0	29.98	1.0		1.028501	34.8899	0.0000
13	64	28	19	158	30.0	29.94	1.0		1.023051	44.4296	0.0000
14	65	29	20	158	33.0	29.90	1.0	0.0	1.015143	45.5064	0.0000
15	65	29	16	169	33.0	29.85	1.0		1.013425	36.3435	0.0000
16	65	32	15	173	34.8	29.83	1.0		1.012538	30.8508	0.0000
17	66	33	9	173	37.0	29.78	1.0		1.006781	18.1221	0.0000
18	60	38	19	256	33.0	29.79	1.0		1.031404	30.9421	30.9421
19	52	70	24	331	43.0	29.91	1.0		1.067723	19.0360	0.0000
20	49	82	23	317	44.5	29.96	1.0		1.082095	14.8722	0.0000
21	47	84	21	299	43.0	30.00	1.0		1.092439	12.8362	0.0000
22	47	87	12	252	43.6	29.99	1.0		1.091973	7.0790	7.0790
23	48	87	15	245	44.6	30.00	1.0		1.087852	9.0029	9.0029
24	48	84	19	252	43.5	30.00	1.0		1.088030	11.8129	11.8129
AV	57	44									

E #c	E Kt	E Kc
0.0	477.3778	84.7271

Dominion 16 hrs Transf.
Massey 8 hrs Transf.

Net Tons: D - 592,553
M - 285,284

TSPunc/t = 254.6457
TSPunc/c = 45.1957

%R/C = 5.1692
ATT. 0.0000

TSPhv = 45.1957

CE unc = 178.2184
CE hv = 31.6310

IITRI = no eval.

→ HI VOL 113.00 DATE apr1385

T	Tf	RH	SP	DIR	DPf	BAR	Fc	#c	P/u	Kt	Kc
1	55	63	5	173	45.0	30.33	1.0		1.070060	4.6709	0.0000
2	55	66	4	187	44.5	30.32	1.0		1.069781	3.5659	3.5659
3	54	75	5	169	47.0	30.30	1.0	0.0	1.072913	3.8625	0.0000
4	53	85	4	173	48.5	30.31	1.0		1.077298	2.6869	0.0000
5	53	88	6	194	50.0	30.31	1.0		1.077059	3.8921	3.8921
6	52	89	5	198	49.0	30.31	1.0		1.081499	3.1594	3.1594
7	52	90	3	205	49.3	30.33	1.0	1.0	1.082177	1.8758	1.8758
8	55	82	4	151	50.0	30.33	1.0		1.069268	2.8688	0.0000
9	56	78	3	187	49.0	30.33	1.0		1.065195	2.2943	2.2943
10	60	70	1	187	50.2	30.34	1.0		1.043520	0.8944	0.8944
11	64	61	4	101	50.5	30.31	1.0	0.0	1.026013	4.3059	0.0000
12	67	57	4	94	50.0	30.29	1.0		1.018846	4.7904	0.0000
13	66	59	9	86	50.0	30.28	1.0		1.022342	10.2927	0.0000
14	68	52	8	72	49.0	30.25	1.0		1.013807	10.6060	0.0000
15	68	50	7	79	48.5	30.22	1.0		1.012860	9.6424	0.0000
16	68	42	7	97	44.6	30.21	1.0	0.0	1.013106	11.4819	0.0000
17	65	58	8	94	50.0	30.22	1.0		1.024126	9.1818	0.0000
18	67	50	13	122	48.0	30.23	1.0		1.017095	17.7178	0.0000
19	64	61	13	133	49.7	30.24	1.0		1.028737	14.0313	0.0000
20	63	68	12	133	52.4	30.23	1.0		1.026914	11.4169	0.0000
21	61	74	9	126	52.5	30.23	1.0	0.0	1.035062	7.6790	0.0000
22	61	75	10	119	53.0	30.22	1.0		1.034608	8.4148	0.0000
23	60	77	8	108	53.0	30.22	1.0		1.038715	6.4751	0.0000
24	60	79	7	97	53.3	30.20	1.0		1.037722	5.5170	0.0000
AV	60	69									

	E #c	E Kt	E Kc
Dominion 24hrs Transf/24hrs Reclm Massey 9hrs Transf.	1.0	161.3240	15.6820

Net Tons: D - 762,835
M - 434,868

TSPunc/t =	121.3026
TSPunc/c =	11.7916
%R/C =	10.9218
ATT.	0.1092
TSPhv =	10.5037
CE unc =	71.4426
CE hv =	5.6569
IITRI =	no eval.

→ HI VOL 289.00 DATE apr1985

T	Tf	RH	SP	DIR	DPf	BAR	Fc	#c	P/u	Kt	Kc
1	63	50	24	223	44.5	30.03	1.0		1.026096	31.0291	31.0291
2	63	50	18	230	43.6	30.02	1.0	1.0	1.025887	23.2671	23.2671
3	63	49	16	234	43.0	30.02	1.0		1.025979	21.1059	21.1059
4	63	49	10	241	43.0	30.01	1.0		1.025633	13.1867	13.1867
5	63	46	15	238	42.0	30.01	1.0		1.025786	21.0732	21.0732
6	63	46	14	241	42.0	30.01	1.0		1.025786	19.6683	19.6683
7	64	46	13	252	43.0	30.02	1.0	1.0	1.021923	18.4835	18.4835
8	65	46	12	256	44.2	30.01	1.0		1.017547	17.2541	17.2541
9	68	46	10	266	47.0	30.01	1.0		1.005708	14.8670	14.8670
10	70	43	6	277	47.0	30.01	1.0		0.998167	9.7495	0.0000
11	73	41	4	259	48.5	30.00	1.0	1.0	0.986402	7.0251	7.0251
12	77	38	5	223	50.0	29.97	1.0		0.970445	9.8321	9.8321
13	82	32	6	191	49.0	29.96	1.0		0.952136	14.6391	14.6391
14	85	29	4	180	50.0	29.93	1.0		0.940315	11.0244	11.0244
15	85	27	15	216	47.0	29.90	1.0		0.939782	44.3786	44.3786
16	86	27	19	220	48.0	29.89	1.0	1.0	0.935781	56.6321	56.6321
17	86	24	20	227	45.0	29.88	1.0		0.935884	67.0717	67.0717
18	87	21	19	234	42.0	29.88	1.0	1.0	0.932773	73.4226	73.4226
19	86	21	16	230	42.0	29.89	1.0		0.936622	61.3711	61.3711
20	83	27	11	216	45.0	29.91	1.0		0.947511	32.0399	32.0399
21	80	33	16	220	50.0	29.93	1.0	1.0	0.958230	37.1677	37.1677
22	79	34	17	220	48.5	29.92	1.0		0.961741	37.9888	37.9888
23	77	35	18	223	47.6	29.92	1.0		0.969151	38.3784	38.3784
24	75	38	18	233	47.6	29.92	1.0		0.976483	34.6908	34.6908
AV	74	37									
								E #c		E Kt	E Kc
								6.0		715.3467	705.5972

Domínion 5 hr Transf/9hrs Reclm.
Massey 14 hr Transf/4hrs Reclm.

Net Tons: D - 713,586
M - 507,020

TSPunc/t =	355.0448
TSPunc/c =	350.2058
%R/C =	2.9432
ATT.	0.1766
TSPhv =	288.3630
CE unc =	239.0354
CE hv =	173.9347
IITRI =	175.8600
	-1.9253

→ HI VOL 116.00 DATE apr2585

T	Tf	RH	SP	DIR	DPf	BAR	Fc	#c	P/u	Kt	Kc
1	69	67	9	212	57.7	29.70	1.0		0.984789	9.1277	9.1277
2	69	66	15	223	57.0	29.69	1.0		0.984597	15.4403	15.4403
3	67	66	12	253	55.5	29.69	1.0	1.0	0.992331	12.0884	12.0884
4	64	100	11	281	64.0	29.69	0.0		1.006437	7.0853	0.0000
5	64	100	10	274	64.0	29.69	0.0		1.006437	6.4412	0.0000
6	64	100	11	288	64.0	29.70	0.0		1.006773	7.0877	0.0000
7	64	100	13	302	64.0	29.71	0.0	0.0	1.007110	8.3792	0.0000
8	64	97	12	295	64.6	29.71	0.0		1.006951	7.9726	0.0000
9	64	95	12	302	62.5	29.72	0.0		1.007843	8.1476	0.0000
10	64	88	12	302	60.5	29.73	1.0	0.0	1.008709	8.8033	0.0000
11	66	83	12	302	61.2	29.73	1.0		1.000953	9.5513	0.0000
12	66	81	12	284	60.2	29.72	1.0		1.000882	9.7864	0.0000
13	69	73	11	281	60.6	29.71	1.0		0.989214	10.2851	0.0000
14	71	60	11	284	56.5	29.69	1.0		0.977310	12.7213	0.0000
15	73	52	8	288	54.0	29.68	1.0	0.0	0.970136	10.8954	0.0000
16	75	46	8	302	52.5	29.68	1.0		0.963143	12.5627	0.0000
17	70	60	8	68	55.5	29.69	1.0		0.981191	9.1578	0.0000
18	69	65	8	83	56.7	29.71	1.0		0.985316	8.3676	0.0000
19	69	65	8	54	56.7	29.73	1.0	0.0	0.985976	8.3732	0.0000
20	69	61	6	32	55.2	29.76	1.0		0.987260	6.7004	0.0000
21	69	62	5	25	55.5	29.78	1.0		0.987862	5.4970	0.0000
22	69	59	6	338	54.0	29.79	1.0		0.988486	6.9362	0.0000
23	68	51	6	335	49.0	29.80	1.0	0.0	0.998273	7.9862	0.0000
24	66	52	6	331	48.4	29.81	1.0		1.006246	7.6629	0.0000
AV	68	73									

E #c	E Kt	E Kc
1.0	217.0566	36.6563

Visibility (fog)=<4=0
Dominion 17hrs Transf.
Massey 3 hrs Transf.

Net Tons: D - 570,695
M - 485,324

TSPunc/t =	144.8162
TSPunc/c =	24.4564
%R/C =	9.5721
ATT.	0.0957
TSPhv =	22.1154
CE unc =	97.1174
CE hv =	14.0601
IITRI =	no eval.

TABLE 1. VIRGINIA COAL DUST STUDIES: LTA CONCENTRATIONS

SAMPLE IDENTIFICATION	4226144	5038206	5038207	5038256	5038257	5038293	5038295	5038426	5038431	5038504
SAMPLE SITE	180-J	180-J	180-J	180-J	180-J	180-J	180-J	180-J	180-J	180-J
SAMPLE DATE	19-Apr-85	01-May-85	07-May-85	06-Jun-85	12-Jun-85	18-Jun-85	24-Jun-85	30-Jul-85	07-Aug-85	02-Sep-85
AEROSOL CONC., ug/m³	289	240	150	74	141	88	162	58	63	98
IITRI NUMBER	C08875-001	C08875-002	C08875-003	C08875-004	C08875-005	C08875-006	C08875-007	C08875-008	C08875-009	C08875-010
NET AEROSOL MASS, g	0.5720	0.4743	0.2942	0.1351	0.2589	0.1682	0.3008	0.1507	0.1132	0.1806
FILTER AREA, in²	80	80	80	80	80	80	80	80	80	80
SAMPLE AREA, in²	63	63	63	63	63	63	63	63	63	63
AREAL CONC., ug/in²	9079.37	7528.57	4669.84	2144.44	4109.52	2669.84	4774.60	2392.06	1796.83	2866.67
BLANK NUMBER	4167234	5039458	5039458	5039458	5039458	5039458	5039458	5039458	5039458	5039458
LTA FILTER AREA, in²	7	4.5	8.75	7	8	10	10	10	10	10
LTA SAMPLE AREA, in²	7	4.5	8.75	7	8	9	9	9	9	9
LTA SAMPLE MASS, g	0.0636	0.0339	0.0409	0.0150	0.0329	0.0240	0.0430	0.0215	0.0162	0.0258
LTA INITIAL WT., g	0.3988	0.2625	0.4895	0.3812	0.4509	0.5451	0.5476	0.5288	0.5395	0.5417
LTA FINAL WT., g	0.3613	0.2482	0.4730	0.3746	0.4326	0.5301	0.5288	0.5210	0.5325	0.5245
LTA NET LOSS, g	0.0375	0.0143	0.0165	0.0066	0.0183	0.0150	0.0188	0.0078	0.0070	0.0172
LTA BLANK CORR., g	0.0012	0.0005	0.0010	0.0008	0.0009	0.0011	0.0011	0.0011	0.0011	0.0011
LTA CORR. NET LOSS, g	0.0363	0.0138	0.0155	0.0058	0.0174	0.0139	0.0177	0.0067	0.0059	0.0161
LTA LOSS, %	57.13	40.75	38.03	38.84	52.99	57.85	41.19	31.12	36.48	62.40
LTA RESIDUE, %	42.87	59.25	61.97	61.16	47.01	42.15	58.81	68.88	63.52	37.60
LTA LOSS, ug/m³	165.11	97.80	57.04	28.74	74.71	50.91	66.73	18.05	22.98	61.16
LTA RESIDUE, ug/m³	123.89	142.20	92.96	45.26	66.29	37.09	95.27	39.95	40.02	36.84
LTA LOSS+RESIDUE, ug/m³	289	240	150	74	141	88	162	58	63	98
EST.ERR. LTA LOSS, ug/m³										

TABLE 1. VIRGINIA COAL DUST STUDIES: LTA CONCENTRATIONS

SAMPLE IDENTIFICATION	5038505	5038506	5162018	5162211	5162212	5162217	5162216	6165634	5037916	5037894
SAMPLE SITE	180-J	180-J	180-J	180-J	180-J	180-J	180-J	180-J	179-C	179-C
SAMPLE DATE	04-Sep-85	10-Sep-85	09-Nov-85	27-Nov-85	28-Nov-85	12-Dec-85	15-Dec-85	10-Jan-86	19-Apr-85	01-May-85
AEROSOL CONC., ug/m³	121	140	43	165	158	80	187	151	103	145
IITRI NUMBER	C08875-011	C08875-012	C08875-013	C08875-014	C08875-015	C08875-016	C08875-017	C08875-018	C08875-019	C08875-020
NET AEROSOL MASS, g	0.2125	0.2543	0.0777	0.2991	0.2970	0.1522	0.3412	0.2746	0.1941	0.2858
FILTER AREA, in²	80	80	80	80	80	80	80	80	80	80
SAMPLE AREA, in²	63	63	63	63	63	63	63	63	63	63
AREAL CONC., ug/in²	3373.02	4036.51	1233.33	4747.62	4714.29	2415.87	5415.87	4358.73	3080.95	4536.51
BLANK NUMBER	5039458	5039458	5161900	5161900	5161900	5161900	5161900	6166206	5039458	5039458
LTA FILTER AREA, in²	10	10	10	10	10	10	10	10	8	8
LTA SAMPLE AREA, in²	9	9	9	9	9	9	9	9	7	7
LTA SAMPLE MASS, g	0.0304	0.0363	0.0111	0.0427	0.0424	0.0217	0.0487	0.0392	0.0216	0.0318
LTA INITIAL WT., g	0.5595	0.5456	0.5472	0.5783	0.5688	0.5774	0.5905	0.5818	0.4203	0.4333
LTA FINAL WT., g	0.5447	0.5242	0.5407	0.5509	0.5400	0.5628	0.5533	0.5563	0.4102	0.4212
LTA NET LOSS, g	0.0148	0.0214	0.0065	0.0274	0.0288	0.0146	0.0372	0.0255	0.0101	0.0121
LTA BLANK CORR., g	0.0011	0.0011	0.0014	0.0014	0.0014	0.0014	0.0014	0.0013	0.0009	0.0009
LTA CORR. NET LOSS, g	0.0137	0.0203	0.0051	0.0260	0.0274	0.0132	0.0358	0.0242	0.0092	0.0112
LTA LOSS, %	45.13	55.88	45.95	60.85	64.58	60.71	73.45	61.69	42.75	35.33
LTA RESIDUE, %	54.87	44.12	54.05	39.15	35.42	39.29	26.55	38.31	57.25	64.67
LTA LOSS, ug/m³	54.61	78.23	19.76	100.40	102.04	48.57	137.35	93.15	44.03	51.23
LTA RESIDUE, ug/m³	66.39	61.77	23.24	64.60	55.96	31.43	49.65	57.85	58.97	93.77
LTA LOSS+RESIDUE, ug/m³	121	140	43	165	158	80	187	151	103	145
EST.ERR. LTA LOSS, ug/m³										

TABLE 1. VIRGINIA COAL DUST STUDIES: LTA CONCENTRATIONS

SAMPLE IDENTIFICATION	5038279	5038308	5038495	5038514	5162197
SAMPLE SITE	179-C	179-C	179-C	179-C	179-C
SAMPLE DATE	12-Jun-85	24-Jun-85	04-Sep-85	10-Sep-85	27-Nov-85
AEROSOL CONC., ug/m^3	45	73	75	96	54
IITRI NUMBER	C08875-021	C08875-022	C08875-023	C08875-024	C08875-025
NET AEROSOL MASS, g	0.0901	0.1420	0.1447	0.1879	0.1061
FILTER AREA, in^2	80	80	80	80	80
SAMPLE AREA, in^2	63	63	63	63	63
AREAL CONC., ug/in^2	1430.16	2253.97	2296.83	2982.54	1684.13
BLANK NUMBER	5039458	5039458	5039458	5039458	6166206
LTA FILTER AREA, in^2	10	8	10	10	10
LTA SAMPLE AREA, in^2	9	7	9	9	9
LTA SAMPLE MASS, g	0.0129	0.0158	0.0207	0.0268	0.0152
LTA INITIAL WT., g	0.5332	0.4401	0.5544	0.5451	0.5555
LTA FINAL WT., g	0.5271	0.4348	0.5462	0.5353	0.5480
LTA NET LOSS, g	0.0061	0.0053	0.0082	0.0098	0.0075
LTA BLANK CORR., g	0.0011	0.0009	0.0011	0.0011	0.0013
LTA CORR. NET LOSS, g	0.0050	0.0044	0.0071	0.0087	0.0062
LTA LOSS, %	38.85	28.01	34.35	32.41	40.90
LTA RESIDUE, %	61.15	71.99	65.65	67.59	59.10
LTA LOSS, ug/m^3	17.48	20.45	25.76	31.11	22.09
LTA RESIDUE, ug/m^3	27.52	52.55	49.24	64.89	31.91
LTA LOSS+RESIDUE, ug/m^3	45	73	75	96	54
EST.ERR. LTA LOSS, ug/m^3					

TABLE 2. VIRGINIA COAL DUST STUDIES: TOTAL &NONVOLATILE CARBON

SAMPLE IDENTIFICATION	4220144	5038206	5038207	5038256	5038257	5038293	5038295	5038426	5038431	5038504
SAMPLE SITE	180-J	180-J	180-J	180-J	180-J	180-J	180-J	180-J	180-J	180-J
SAMPLE DATE	19-Apr-85	01-May-85	07-May-85	06-Jun-85	12-Jun-85	18-Jun-85	24-Jun-85	30-Jul-85	07-Aug-85	02-Sep-85
AEROSOL CONC., ug/m³	289	240	150	74	141	88	162	58	63	98
IITRI NUMBER	C08875-001	C08875-002	C08875-003	C08875-004	C08875-005	C08875-006	C08875-007	C08875-008	C08875-009	C08875-010
NET AEROSOL MASS, g	0.5720	0.4743	0.2942	0.1351	0.2589	0.1682	0.3008	0.1507	0.1132	0.1806
FILTER AREA, in²	80	80	80	80	80	80	80	80	80	80
SAMPLE AREA, in²	63	63	63	63	63	63	63	63	63	63
AREAL CONC., ug/in²	9079.37	7523.57	4669.84	2144.44	4109.52	2669.84	4774.60	2392.06	1796.83	2866.67
BLANK NUMBER	4167234	5039458	5039458	5039458	5039458	5039458	5039458	5039458	5039458	5039458
Tot&Nonvol CARBON FILTER AREA, in²	7	8.5	8.75	7	8	10	10	10	10	10
Tot&Nonvol CARBON SAMPLE AREA, in²	7	8.5	8.75	7	8	9	9	9	9	9
Tot&Nonvol CARBON SAMPLE MASS, g	0.0636	0.0640	0.0409	0.0150	0.0329	0.0240	0.0430	0.0215	0.0162	0.0258
TOTAL CARBON, ug	21,600	16,000	8,000	2,900	12,350	5,200	9,300	4,430	4,414	9,000
TOTAL CARBON BLANK CORR., ug	364	289	298	238	272	340	340	340	340	340
NET TOTAL CARBON, ug	21,236	15,711	7,703	2,662	12,078	4,860	8,960	4,090	4,074	8,660
VOLATILE CARBON, ug	1,180	1,650	1,000	900	1,370	1,500	1,600	1,070	1,110	2,670
VOLATILE CARBON BLANK CORR., ug	280	204	210	168	192	240	240	240	240	240
NET VOLATILE CARBON, ug	900	1,446	790	732	1,178	1,260	1,360	830	870	2,430
NONVOLATILE CARBON BY DIFFERENCE,ug	20,336	14,265	6,913	1,930	10,900	3,600	7,600	3,260	3,204	6,230
% TOTAL CARBON	33.41	24.55	18.85	17.73	36.74	20.23	20.85	19.00	25.19	33.57
% VOLATILE CARBON	1.42	2.26	1.93	4.88	3.58	5.24	3.16	3.86	5.38	9.42
% NONVOLATILE CARBON BY DIFFERENCE	32.00	22.29	16.92	12.86	33.15	14.98	17.69	15.14	19.81	24.15
TOTAL CARBON, ug/m³	96.56	58.92	28.28	13.12	51.80	17.80	33.78	11.02	15.87	32.89
VOLATILE CARBON, ug/m³	4.09	5.42	2.90	3.61	5.05	4.61	5.13	2.24	3.39	9.23
NONVOLATILE CARBON BY DIFF.,ug/m³	92.47	53.50	25.38	9.51	46.75	13.18	28.65	8.78	12.48	23.66

TABLE 2. VIRGINIA COAL DUST STUDIES: TOTAL & NONVOLATILE CARBON

SAMPLE IDENTIFICATION	5038505	5038506	5162016	5162211	5162212	5162217	5162216	6165634	5037916	5037894
SAMPLE SITE	180-J	180-J	180-J	180-J	180-J	180-J	180-J	180-J	179-C	179-C
SAMPLE DATE	04-Sep-85	10-Sep-85	09-Nov-85	27-Nov-85	23-Nov-85	12-Dec-85	15-Dec-85	10-Jan-86	19-Apr-85	01-May-85
AEROSOL CONC., ug/m³	121	140	43	165	153	80	187	151	103	145
IITRI NUMBER	C08875-011	C08875-012	C08875-013	C08875-014	C08875-015	C08875-016	C08875-017	C08875-018	C08875-019	C08875-020
NET AEROSOL MASS, g	0.2125	0.2543	0.0777	0.2991	0.2970	0.1522	0.3412	0.2746	0.1941	0.2858
FILTER AREA, in²	80	80	80	80	80	80	80	80	80	80
SAMPLE AREA, in²	63	63	63	63	63	63	63	63	63	63
AREAL CONC., ug/in²	3373.02	4036.51	1233.33	4747.62	4714.29	2415.87	5415.87	4358.73	3080.95	4536.51
BLANK NUMBER	5039458	5039458	5161900	5161900	5161900	5161900	5161900	6166206	5039458	5039458
Tot&Nonvol CARBON FILTER AREA, in²	10	10	10	10	10	10	10	10	8	8
Tot&Nonvol CARBON SAMPLE AREA, in²	9	9	9	9	9	9	9	9	7	7
Tot&Nonvol CARBON SAMPLE MASS, g	0.0304	0.0363	0.0111	0.0427	0.0424	0.0217	0.0487	0.0392	0.0216	0.0318
TOTAL CARBON, ug	9,700	13,200	4,000	24,100	21,900	11,150	33,000	16,200	5,560	6,700
TOTAL CARBON BLANK CORR., ug	340	340	340	340	340	340	340	430	272	272
NET TOTAL CARBON, ug	9,360	12,860	3,660	23,760	21,560	10,810	32,660	15,770	5,288	6,428
VOLATILE CARBON, ug	940	2,200	870	2,190	1,210	1,400	4,190	3,800	1,840	2,400
VOLATILE CARBON BLANK CORR., ug	240	240	290	290	290	290	290	280	192	192
NET VOLATILE CARBON, ug	700	1,960	580	1,900	920	1,110	3,900	3,520	1,648	2,208
NONVOLATILE CARBON BY DIFFERENCE, ug	8,660	10,900	3,080	21,860	20,640	9,700	28,760	12,250	3,640	4,220
% TOTAL CARBON	30.83	35.40	32.97	55.61	50.81	49.72	67.00	40.20	24.52	20.24
% VOLATILE CARBON	2.31	5.40	5.23	4.45	2.17	5.11	8.00	8.97	7.64	6.95
% NONVOLATILE CARBON BY DIFFERENCE	28.53	30.00	27.75	51.16	48.65	44.61	59.00	31.23	16.88	13.23
TOTAL CARBON, ug/m³	37.31	49.56	14.18	91.75	80.29	39.77	125.30	60.70	25.25	29.35
VOLATILE CARBON, ug/m³	2.79	7.55	2.25	7.34	3.43	4.08	14.96	10.55	7.87	10.08
NONVOLATILE CARBON BY DIFF., ug/m³	34.52	42.01	11.93	84.41	76.86	35.69	110.34	47.15	17.38	19.27

TABLE 2. VIRGINIA COAL DUST STUDIES: TOTAL & NONVOLATILE CARBON

SAMPLE IDENTIFICATION	5038279	5038308	5038495	5038495	5162197
SAMPLE SITE	179-C	179-C	179-C	179-C	179-C
SAMPLE DATE	12-Jun-85	24-Jun-85	04-Sep-85	10-Sep-85	27-Nov-85
AEROSOL CONC., ug/m³	45	73	75	96	54
IITRI NUMBER	C08875-021	C08875-022	C08875-023	C08875-024	C08875-025
NET AEROSOL MASS, g	0.0901	0.1420	0.1447	0.1879	0.1061
FILTER AREA, in²	80	80	80	80	80
SAMPLE AREA, in²	63	63	63	63	63
AREAL CONC., ug/in²	1430.16	2253.97	2296.83	2982.54	1684.13
BLANK NUMBER	5039458	5039458	5039458	5039458	6166206
Tot & Nonvol. CARBON FILTER AREA, in²	10	8	10	10	10
Tot & Nonvol. CARBON SAMPLE AREA, in²	9	7	9	9	9
Tot & Nonvol. CARBON SAMPLE MASS, g	0.0129	0.0158	0.0207	0.0268	0.0152
TOTAL CARBON, ug	2,485	2,432	3,280	3,900	3,390
TOTAL CARBON BLANK CORR., ug	340	272	340	340	430
NET TOTAL CARBON, ug	2,145	2,160	2,940	3,560	2,960
VOLATILE CARBON, ug	890	960	1,300	1,700	1,300
VOLATILE CARBON BLANK CORR., ug	240	192	240	240	280
NET VOLATILE CARBON, ug	650	768	1,060	1,460	1,020
NONVOLATILE CARBON BY DIFFERENCE, ug	1,495	1,392	1,880	2,100	1,940
% TOTAL CARBON	16.66	13.69	14.22	13.26	19.53
% VOLATILE CARBON	5.05	4.87	5.13	5.44	6.73
% NONVOLATILE CARBON BY DIFFERENCE	11.61	8.82	9.09	7.82	12.80
TOTAL CARBON, ug/m³	7.50	9.99	10.67	12.73	10.55
VOLATILE CARBON, ug/m³	2.27	3.55	3.85	5.22	3.63
NONVOLATILE CARBON BY DIFF., ug/m³	5.23	6.44	6.82	7.51	6.91

TABLE 3. VIRGINIA COAL DUST STUDY: COAL CONCENTRATIONS

SAMPLE IDENTIFICATION	5037916	4226144	5037894	5038206	5038279	5038257	5038308	5038295	5038495	5038505
SAMPLE SITE	179-C	180-J	179-C	180-J	179-C	180-J	179-C	180-J	179-C	180-J
SAMPLE DATE	19-Apr-85	19-Apr-85	01-May-85	01-May-85	12-Jun-85	12-Jun-85	24-Jun-85	24-Jun-85	04-Sep-85	04-Sep-85
AEROSOL CONC., ug/m^3	103	289	145	240	45	141	73	162	75	121
IITRI NUMBER	C08875-019	C08875-001	C08875-020	C08875-002	C08875-021	C08875-005	C08875-022	C08875-007	C08875-023	C08875-011
MASS % LTA COAL	20.98	55.65	17.92	39.99	23.94	51.24	18.67	38.94	11.91	40.26
MASS % TOTAL COAL	22.94	60.85	19.59	43.72	26.18	56.03	20.41	42.58	13.02	44.03
MASS % OTHER CARBON	7.23	0.74	4.29	0.40	8.97	0.71	5.04	1.59	16.69	4.12
MASS % BIOLOGICALS	14.45	0.72	6.77	0.35	5.93	0.98	4.19	0.66	5.75	0.75
ug/m^3 LTA COAL	21.60	160.82	25.98	95.97	10.77	72.25	13.63	63.09	8.93	48.72
ug/m^3 TOTAL COAL	23.62	175.86	28.41	104.94	11.78	79.00	14.90	68.99	9.77	53.27
ug/m^3 OTHER CARBON	7.45	2.15	6.22	0.96	4.04	1.00	3.68	2.57	12.51	4.98
ug/m^3 BIOLOGICALS	14.89	2.09	9.81	0.83	2.67	1.37	3.06	1.07	4.31	0.91
COAL MASS % SIZE DISTRIBUTION										
<2.5 um	0.53	0.53	0.64	0.27	0.84	0.73	0.54	0.43	0.38	0.37
2.5-5.0 um	9.13	6.38	9.26	3.80	10.07	6.12	5.77	3.60	5.44	4.18
5.0-7.8 um	10.24	4.99	8.94	2.83	8.94	5.18	7.07	3.82	3.66	1.49
7.8-10.0 um	10.11	5.74	10.93	4.56	7.74	7.22	10.00	6.38	4.19	4.04
10.0-20.0 um	15.80	14.61	12.64	14.12	14.25	22.37	10.58	16.88	10.04	15.10
>20.0 um	54.19	67.76	57.58	74.41	58.17	58.38	66.04	68.90	76.30	74.82
COAL SIZE DISTRIBUTION AS ug/m^3										
<2.5 um	0.13	0.93	0.18	0.29	0.10	0.58	0.08	0.30	0.04	0.20
2.5-5.0 um	2.16	11.22	2.63	3.99	1.19	4.83	0.86	2.48	0.53	2.23
5.0-7.8 um	2.42	8.77	2.54	2.97	1.05	4.09	1.05	2.63	0.36	0.79
7.8-10.0 um	2.39	10.09	3.11	4.78	0.91	5.70	1.49	4.40	0.41	2.15
10.0-20.0 um	3.73	25.69	3.59	14.82	1.68	17.67	1.58	11.64	0.98	8.04
>20.0 um	12.80	119.17	16.36	78.09	6.85	46.12	9.84	47.53	7.45	39.86

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TABLE 3. VIRGINIA COAL DUST STUDY: COAL CONCENTRATIONS

SAMPLE IDENTIFICATION	5038514	5038506	5162197	5162211	5038207	5038256	5038293	5038426	5038431	5038504
SAMPLE SITE	179-C	180-J	179-C	180-J	180-J	180-J	180-J	180-J	180-J	180-J
SAMPLE DATE	10-Sep-85	10-Sep-85	27-Nov-85	27-Nov-85	07-May-85	06-Jun-85	18-Jun-85	30-Jul-85	07-Aug-85	02-Sep-85
AEROSOL CONC., ug/m³	96	140	54	165	150	74	88	58	63	98
IITRI NUMBER	C08875-024	C08875-012	C08875-025	C08875-014	C08875-003	C08875-004	C08875-006	C08875-008	C08875-009	C08875-010
MASS % LTA COAL	14.76	45.65	27.14	55.14	31.51	29.04	53.79	26.76	30.83	49.96
MASS % TOTAL COAL	16.14	49.92	29.68	60.29	34.46	31.76	58.82	29.27	33.71	54.63
MASS % OTHER CARBON	11.82	7.33	10.40	5.03	1.16	6.97	2.53	3.73	5.24	10.11
MASS % BIOLOGICALS	5.84	2.89	3.36	0.69	5.26	2.62	1.53	0.62	0.41	2.32
ug/m³ LTA COAL	14.17	63.91	14.66	90.97	47.27	21.49	47.34	15.52	19.42	48.96
ug/m³ TOTAL COAL	15.49	69.89	16.03	99.48	51.69	23.50	51.76	16.97	21.24	53.53
ug/m³ OTHER CARBON	11.34	10.26	5.61	8.29	1.74	5.16	2.23	2.17	3.30	9.91
ug/m³ BIOLOGICALS	5.60	4.05	1.82	1.13	7.88	1.94	1.34	0.36	0.26	2.28
COAL MASS % SIZE DISTRIBUTION										
<2.5 um	6.79	2.22	9.67	1.66	0.72	1.51	0.81	2.96	3.82	2.65
2.5-5.0 um	5.77	6.77	11.47	5.82	6.89	5.74	6.17	8.76	7.18	7.91
5.0-7.8 um	5.43	4.84	7.54	7.47	4.14	4.39	4.24	6.90	6.60	5.46
7.8-10.0 um	5.12	4.60	7.87	7.33	4.78	3.39	5.57	7.76	6.66	5.73
10.0-20.0 um	10.01	17.63	14.82	16.83	16.50	10.47	14.29	17.57	16.77	15.59
>20.0 um	66.88	63.94	48.63	60.89	66.96	74.49	68.92	56.06	58.97	62.66
COAL SIZE DISTRIBUTION AS ug/m³										
<2.5 um	1.05	1.55	1.55	1.65	0.37	0.35	0.42	0.50	0.81	1.42
2.5-5.0 um	0.89	4.73	1.84	5.79	3.56	1.35	3.19	1.49	1.53	4.24
5.0-7.8 um	0.84	3.39	1.21	7.43	2.14	1.03	2.19	1.17	1.40	2.92
7.8-10.0 um	0.79	3.22	1.26	7.29	2.47	0.80	2.88	1.32	1.41	3.07
10.0-20.0 um	1.55	12.32	2.38	16.74	8.53	2.46	7.40	2.98	3.56	8.35
>20.0 um	10.36	44.69	7.79	60.57	34.61	17.51	35.67	9.52	12.52	33.55

TABLE 3. VIRGINIA COAL DUST STUDY: COAL CONCENTRATIONS

SAMPLE IDENTIFICATION	5162018	5162212	5162217	5162216	6165634
SAMPLE SITE	180-J	180-J	180-J	180-J	180-J
SAMPLE DATE	09-Nov-85	28-Nov-85	12-Dec-85	15-Dec-85	10-Jan-86
AEROSOL CONC., ug/m³	43	158	80	187	151
IITRI NUMBER	C08875-013	C08875-015	C08875-016	C08875-017	C08875-018
MASS % LTA COAL	39.67	58.95	54.07	67.72	48.22
MASS % TOTAL COAL	43.37	64.47	59.12	74.06	52.73
MASS % OTHER CARBON	4.78	4.80	5.45	5.23	13.11
MASS % BIOLOGICALS	1.50	0.82	1.19	0.49	0.36
ug/m³ LTA COAL	17.06	93.15	43.25	126.65	72.82
ug/m³ TOTAL COAL	18.65	101.86	47.30	138.49	79.62
ug/m³ OTHER CARBON	2.06	7.59	4.36	9.78	19.79
ug/m³ BIOLOGICALS	0.64	1.30	0.95	0.92	0.54
COAL MASS % SIZE DISTRIBUTION					
<2.5 um	2.74	1.74	1.23	1.72	1.14
2.5-5.0 um	3.99	5.72	3.44	7.12	5.20
5.0-7.8 um	5.45	8.87	4.85	10.71	9.11
7.8-10.0 um	6.66	8.13	3.93	10.72	7.03
10.0-20.0 um	12.59	18.73	10.72	20.60	15.87
>20.0 um	68.57	56.81	75.83	49.12	61.66
COAL SIZE DISTRIBUTION AS ug/m³					
<2.5 um	0.51	1.77	0.58	2.39	0.91
2.5-5.0 um	0.74	5.82	1.63	9.86	4.14
5.0-7.8 um	1.02	9.04	2.29	14.83	7.25
7.8-10.0 um	1.24	8.28	1.86	14.85	5.60
10.0-20.0 um	2.35	19.08	5.07	28.53	12.63
>20.0 um	12.79	57.86	35.87	68.03	49.09

Appendix D. Is a data spread sheet which contains the computed values of coal directly from the established coal equations and its respective %EFF/C. In addition the computations for "cycle-delay" and/or "post-rain" effects are incorporated.

Appendix D Notations

COLUMN 1: Date. Day being analyzed.

COLUMN 2: ΣKt. ΣKt as previously annotated.

COLUMN 3: ΣKc. ΣKc as previously annotated.

COLUMN 4: In. Rain. The total inches of rainfall.

COLUMN 5: Hrs. The total number of hours from the end of the rainfall to 0001 (12:01 AM) of the day being analyzed (% recovery eq.)
Or
The total number of hours from the end of the last cycle/rainfall to the commencement of the next cycle/rainfall. (% increase eq.)

$$\% \text{ recov. from rainfall} = -3979.93(\text{In. Rain}/\text{Hrs}/\Sigma Kt) + 1$$

$$\% \text{ inc. from cycle-delay} = 0.63991 \times 10^{0.02077(\text{Hrs})}$$

COLUMN 6: #C. Number of cycles credited in Appendix B computations.

COLUMN 7: #C corr. Number of cycles actually performed (C = 1) after the CEunc/c was adjusted for prior rainfall <u>or</u> cycle-delay with the equations above.

COLUMN 8: IITRI. ITTRI as previously annotated.

COLUMN 9:

$$\text{CEunc} = \begin{cases} 0.2555668\ \Sigma Kt + 56.216517 & : \Sigma Kt \geq 288 \\ 0.4606790\ \Sigma Kt - 2.8759842 & : \Sigma Kt < 288 \end{cases}$$

COLUMN 10: CEunc/c = (ΣKc/ΣKt)(CEunc)

COLUMN 11: CEunc/ca = (CEunc/c) (% recov.) <u>or</u> (% inc.)

COLUMN 12:

$$\%\text{EFF/C} = \begin{cases} -0.0146913\ \Sigma Kt + 14.65059 & : \Sigma Kt \geq 288 \\ 36.657299 \times 10^{-0.00189215(\Sigma Kt)} & : \Sigma Kt < 288 \end{cases}$$

COLUMN 13: CE_{hv}. Computed value of coal on the high volume sampler <u>from</u> the coal terminals.

COLUMN 14: DIFF. The mathamatical difference of COLUMN 8 from COLUMN 13.

CODES: RE - RE-ENTRAINMENT
R - RAIN DURING EVALUATION DAY
H - HAZE DURING EVALUATION DAY
K - SMOKE DURING EVALUATION DAY
FRZ- FREEZING TEMPERATURE DURING EVALUATION DAY
F - FOG DURING EVALUATION DAY
TE - TERMINALS ERROR IN THE CONTROL OF EMISSIONS EITHER THROUGH BREAKDOWN OF EQUIPMENT OR PERSONNEL ERROR.

NO. EVAL. - SAMPLE NOT SENT TO ITTRI FOR COAL EVALUATION

APPENDIX D. Total Coal Loading with corrections for Cycle-Delay and Post-Rain Effects.

DATE	EKt	EKc	in. Rain	Hrs	#C	#C corr	ITRI	CEunc/t	CEunc/c	CEunc/ca	%EFF/C	CEhv	Diff.	Code
01-Apr-85	652.4266	135.1689	0.00	0	3.0	3.0	33.24	222.9551	46.1915	N/A	5.0653	39.1724	5.9324	
07-Apr-85	477.3778	84.7271	0.00	0	0.0	0.0	0.00	178.2184	31.6310	N/A	7.6370	31.6310	no. eval.	
13-Apr-85	161.3240	15.6820	0.00	0	1.0	1.0	0.00	71.4426	6.9448	N/A	18.1514	5.6842	no. eval.	
19-Apr-85	715.3467	705.5972	0.00	0	6.0	6.0	175.86	239.0354	235.7776	N/A	4.1409	177.1979	1.3379	
25-Apr-85	217.0566	36.6563	0.00	0	1.0	1.0	0.00	97.1174	16.4011	N/A	14.2383	14.0659	no. eval.	
01-May-85	581.5951	581.5951	0.00	0	8.0	8.0	104.95	204.8529	204.8529	N/A	6.1059	104.7885	-0.1615	
07-May-85	312.2276	110.5392	0.00	0	2.0	2.0	51.69	136.0115	48.1527	N/A	10.0632	38.4613	-13.2287	RE
13-May-85	114.6822	55.7668	0.00	0	1.0	1.0	29.65	49.9557	24.2921	N/A	22.2415	18.8892	-10.7608	RE
19-May-85	283.4936	93.8149	0.00	0	3.0	3.0	30.81	127.7236	42.2668	N/A	10.6598	28.7502	-2.0598	
25-May-85	185.3371	13.4091	0.00	0	0.0	0.0	24.10	82.5049	5.9692	N/A	16.3484	5.9692	-18.1308	RE
31-May-85	273.5700	268.6346	0.00	0	5.0	5.0	54.61	123.1520	120.9302	N/A	11.1308	53.6279	-0.9821	K
06-Jun-85	167.3121	36.6237	0.00	0	0.0	0.0	23.50	74.2012	16.2422	N/A	17.6840	16.2422	-7.2578	H
12-Jun-85	546.0821	413.1619	0.00	0	8.0	8.0	79.00	195.7770	148.1235	N/A	6.6276	69.5872	-9.4128	R
18-Jun-85	358.9081	237.4434	0.00	0	5.0	5.0	51.76	147.9415	97.8739	N/A	9.3774	51.9836	0.2236	R
24-Jun-85	485.9507	485.9507	0.00	0	8.0	8.0	68.99	180.4094	180.4094	N/A	7.5110	72.0048	3.0148	H
06-Jul-85	403.0196	265.8788	0.00	0	8.6	8.6	0.00	159.2149	105.0368	N/A	8.7294	26.1829	no. eval.	R
12-Jul-85	165.8166	25.0787	0.00	0	1.0	1.0	16.75	73.5122	11.1183	N/A	17.7996	9.1392	-7.6108	H
[illegible]-Jul-85	148.8671	36.5975	0.00	0	0.0	0.0	16.97	65.7040	16.1527	N/A	19.1638	16.1527	-0.8173	F
01-Aug-85	324.2151	90.6668	0.00	0	2.0	2.0	0.00	139.0751	38.8924	N/A	9.8871	31.2017	no. eval.	F
07-Aug-85	211.6392	166.4218	0.00	0	5.0	5.0	21.24	94.6218	74.4055	N/A	14.5783	20.1702	-1.0698	R
29-Aug-85	170.0085	122.1408	0.00	0	1.0	1.0	46.30	75.4434	54.2015	N/A	17.4775	44.7284	-1.5716	H
02-Sep-85	312.5759	307.7752	0.00	0	6.0	6.0	53.53	136.1005	134.0102	N/A	10.0581	53.1368	-0.3932	H
04-Sep-85	311.0674	311.0674	0.00	0	6.0	6.0	53.27	135.7150	135.7150	N/A	10.0803	53.6323	0.3623	HK
10-Sep-85	335.9269	307.3332	0.00	0	4.8	4.8	69.89	142.0683	129.9756	N/A	9.7151	69.3650	-0.5250	HK
24-Sep-85	251.5991	207.8925	0.74	19	7.5	6.0	9.35	113.0304	93.4403	36.3826	12.2489	9.6438	0.2938	H
02-Oct-85	141.9655	9.0618	0.00	0	0.0	0.0	0.00	62.5245	3.9910	N/A	19.7488	3.9910	no. eval.	RF
04-Oct-85	65.9447	47.9680	0.00	0	0.0	0.0	21.34	27.5034	20.0059	N/A	27.5032	20.0059	-1.3341	RHF
27-Oct-85	177.1373	177.1373	0.00	0	2.0	2.0	0.00	78.7275	78.7275	N/A	16.9430	52.0499	no. eval.	T.E.
06-Nov-85	226.2481	100.8387	1.12	30	0.8	0.8	14.14	101.3518	45.1724	15.7529	13.6793	13.9320	-0.2080	
09-Nov-85	284.5678	251.4239	0.00	0	5.0	5.0	18.65	128.2184	113.2847	N/A	10.6100	53.1871	34.5371	SC
12-Nov-85	82.7202	24.6159	0.00	0	0.0	0.0	23.73	35.2315	10.4842	N/A	25.5647	10.4842	-13.2458	RE
27-Nov-85	345.9254	345.9254	0.00	0	3.5	3.5	99.48	144.6236	144.6236	N/A	9.5682	96.1912	-3.2888	H
28-Nov-85	362.0444	334.4865	0.00	0	3.5	3.5	101.86	148.7430	137.4211	N/A	9.3314	92.5397	-9.3203	F
03-Dec-85	385.3766	18.0237	0.00	0	0.0	0.0	11.29	154.7060	7.2355	N/A	8.9886	7.2355	-4.0545	
07-Dec-85	143.7719	33.5446	0.00	0	0.0	0.0	14.59	63.3567	14.7823	N/A	19.5940	14.7823	0.1923	
12-Dec-85	334.2193	259.6269	0.00	0	6.4	6.4	47.30	141.6319	110.0219	N/A	9.7401	41.4376	-5.8624	RE
15-Dec-85	444.8975	395.7420	0.00	13	3.3	3.3	138.49	169.9175	151.1438	180.1249	8.1141	131.8935	-6.5965	FRZ
[illegible]-Dec-85	164.8225	47.5867	0.00	27	0.0	0.0	46.98	73.0543	21.0919	49.1064	17.8769	49.1064	2.1264	FRZ
[illegible]-Dec-85	295.9794	234.6173	0.00	41	7.0	7.0	0.00	131.8590	104.5222	475.4141	10.3019	430.7373	no. eval.	FRZ

DATE	EKt	EKc	in. Rain	Hrs	#C	#C corr	IITRI	CEunc/t	CEunc/c	CEunc/ca	%EFF/C	CEhv	Diff.	Code
10-Jan-86	454.4021	407.5115	0.00	0	6.8	6.8	79.62	172.3466	154.5618	N/A	7.9745	70.7482	-8.8718	RE
16-Jan-86	157.5991	92.4219	0.00	44	3.0	3.0	96.81	69.7266	40.8902	214.6873	18.4484	95.8680	-0.9420	FRZ
17-Jan-86	263.9777	233.6184	0.00	18	3.5	5.0	68.47	118.7330	105.0779	159.0618	11.6058	66.7598	-1.7102	RF
19-Jan-86	193.8544	75.8115	0.00	0	2.0	2.0	0.00	86.4287	33.8000	N/A	15.7528	23.1511	no. eval.	
20-Jan-86	454.3682	454.3682	0.00	0	10.4	10.4	33.65	172.3379	172.3379	N/A	7.9750	29.4009	-4.2491	
22-Jan-86	345.0667	305.8747	0.00	17	4.2	6.0	78.20	144.4041	128.0030	184.7143	9.5808	78.5319	0.3319	
05-Feb-86	299.9968	263.5342	0.12	22	7.4	7.0	30.86	132.8857	116.7344	108.9243	10.2429	30.8251	-0.0349	F
06-Feb-86	168.2512	28.5905	0.00	0	1.0	1.0	10.58	74.6338	12.6823	N/A	17.6118	10.4487	-0.1313	F
14-Feb-86	203.2713	156.6287	1.25	38	0.0	0.0	71.00	90.7668	69.9395	25.2760	15.1196	25.2760	-45.7240	PART
14-Feb-86	77.4498	59.6782	0.00	33	0.0	0.0	71.00	32.8035	25.2764	77.1423	26.1586	77.1423	6.1423	FRZ
17-Feb-86	404.1009	404.1009	0.00	25	9.0	9.0	74.11	159.4913	159.4913	337.4518	8.7135	72.8173	-1.2927	
21-Feb-86	176.1138	93.4433	0.00	0	4.0	4.0	15.85	78.2559	41.5214	N/A	17.0187	13.2558	-2.5942	F
09-Mar-86	522.9428	504.7935	0.00	13	3.6	3.6	163.63	189.8633	183.2739	218.4157	6.9675	163.6301	0.0001	FRZ
15-Mar-86	305.1142	274.2541	0.36	7	7.8	6.0	26.16	134.1936	120.6209	40.3622	10.1677	15.7387	-10.4213	RE
27-Mar-86	257.0083	75.1359	0.00	0	0.0	0.0	20.47	115.5223	33.7727	N/A	11.9636	33.7727	13.3027	
02-Apr-86	249.1503	59.8288	0.00	0	0.0	0.0	45.59	111.9023	26.8713	N/A	12.3803	26.8713	-18.7187	RE
08-Apr-86	443.1427	325.1330	0.00	16	4.9	7.0	73.91	169.4691	124.3392	171.0464	8.1399	73.5852	-0.3248	RHF
20-Apr-86	482.8588	431.2919	0.00	20	7.2	9.0	96.85	179.6192	160.4368	267.2436	7.5564	85.4968	-11.3532	RE
21-Apr-86	234.5833	101.2739	0.00	0	3.0	3.0	30.38	105.1916	45.4131	N/A	13.1915	27.4411	-2.9389	RHF
[illegible]-May-86	381.2259	267.1717	0.00	0	9.0	9.0	0.00	153.6452	107.6780	N/A	9.0496	19.9786	no. eval.	
[illegible]-May-86	273.5688	36.4768	0.00	0	2.0	2.0	0.00	123.1514	16.4206	N/A	11.1308	12.7651	no. eval.	
17-May-86	229.9976	169.4245	0.00	0	3.0	3.0	53.33	103.0791	75.9318	N/A	13.4577	45.2758	-8.0542	H/RE
18-May-86	407.1335	407.1335	0.00	0	11.4	11.4	127.62	160.2663	160.2663	N/A	8.6689	1.8817	-125.7383	T.E.
19-May-86	270.9016	178.4452	0.00	0	5.0	5.0	62.22	121.9227	80.3115	N/A	11.2609	35.0924	-27.1276	H/RE
24-May-86	208.0325	59.3199	0.00	0	2.0	2.0	0.00	92.9602	26.5074	N/A	14.8092	18.6563	no. eval.	
05-Jun-86	202.1614	34.7467	0.00	0	4.0	4.0	27.79	90.2555	15.5128	N/A	15.1929	6.0854	-21.7046	
12-Jun-86	508.9166	444.0279	0.00	0	10.0	10.0	105.47	186.2787	162.5275	N/A	7.1736	45.9366	-59.5334	T.E.
22-Jun-86	238.3218	88.8033	0.00	0	1.0	1.0	0.00	106.9139	39.8382	N/A	12.9784	34.6678	no. eval.	
23-Jun-86	400.0104	379.2951	0.00	0	4.8	4.8	90.51	158.4459	150.2405	N/A	8.7736	86.9694	-3.5406	HK
27-Jun-86	467.2114	467.2114	0.00	0	8.8	8.8	56.20	175.6202	175.6202	N/A	7.7863	55.2860	-0.9140	H
05-Jul-86	305.8802	259.1551	0.00	0	8.0	8.0	21.98	134.3893	113.8605	N/A	10.1565	21.3467	-0.6333	H
06-Jul-86	325.2913	301.7477	0.00	15	9.0	10.0	0.00	139.3502	129.2644	169.5161	9.8713	2.1816	no. eval.	
07-Jul-86	170.5072	98.6538	0.00	0	2.0	2.0	0.00	75.6731	43.7837	N/A	17.4395	28.5124	no. eval.	
11-Jul-86	192.9944	141.0248	0.00	0	4.0	4.0	0.00	86.0325	62.8656	N/A	15.8120	23.1044	no. eval.	
12-Jul-86	472.9097	407.8592	0.00	0	7.7	7.7	64.15	177.0765	152.7190	N/A	7.7026	62.1413	-2.0087	HF
13-Jul-86	485.0166	485.0166	0.00	0	12.0	12.0	0.00	180.1707	180.1707	N/A	7.5247	17.4823	no. eval.	
14-Jul-86	459.7842	236.5160	0.00	0	5.0	5.0	90.01	173.7221	89.3638	N/A	7.8954	54.0855	-35.9245	
16-Jul-86	194.2541	65.1623	0.00	0	1.0	1.0	0.00	86.6128	29.0542	N/A	15.7254	24.4853	no. eval.	
17-Jul-86	174.8997	50.1535	0.00	0	2.0	2.0	0.00	77.6966	22.2800	N/A	17.1090	14.6562	no. eval.	F

Appendix E. This Appendix is a report listing of those days from Appendix D whose computed values for coal emissions were a negative number and had wind directions from the South - Southwest.

Appendix E Notations

COLUMN 1: Date. Day being analyzed.

COLUMN 2: Diff. Difference of CEhv minus IITRI data from Appendix D for those days that were significant in unaccounted coal and had Kt hours between the bearing of 150° - 191° True.

COLUMN 3: ΣKt. ΣKt as previously annotated.

COLUMN 4: ΣKc/a. The sum of the Kc for coal attributed to the Massey and Dominion complexes that lie between the bearing of 263° - 192° T.

COLUMN 5: ΣKc/ch. The sum of the Kt for coal attributed to CSX that lies between the bearing of 191° - 150° T.

COLUMN 6: CEhv/a. The amount of coal loading attributed to Massey and Dominion adjusted with boundaries changed from 270° - 180° T to 263° - 192° T. CEhv/a = (ΣKc/a / ΣKt)(CEunc/t).

COLUMN 7: CEhv/ch. The amount of coal loading believed to have been attributed to CSX. Note: When ΣKt > 314, equation has limited validity due to little data.

$$CEhv/ch = \begin{cases} (\Sigma Kc/ch/\Sigma Kt)(0.0569\ \Sigma Kt+74.0) & : \Sigma Kt>314 \\ (\Sigma Kc/ch/\Sigma Kt)(0.2469\ \Sigma Kt+14.2) & : \Sigma Kt\leq 314 \end{cases}$$

COLUMN 8: IITRI. ITTRI as previously annotated.

COLUMN 9: ΣCEhv/i - IITRI. The sum of CEhv/a and CEhv/ch minus the IITRI analysis data.

APPENDIX E. Analysis of possible coal contribution from CSX Corporation.

DATE	-Diff. From APP. D	EKt	EKc/a (263-192)	EKc/ch (191-15	CEhv/a (263-19	CEhv/ch (191-150)	IITRI	CEhv/i-IITRI	Coal Cars Spotted (700-2400)	Coal Cars Static Chessie	Coal Cars Dumped
13-May-85	-10.7608	114.6822	35.3724	44.9682	11.9812	16.6899	29.65	-0.9788	590	665	
12-Jul-85	-7.6108	165.8166	17.9071	29.7315	6.5258	9.8957	16.75	-0.3286	165	1066	
12-Nov-85	-13.2458	82.7202	16.0708	13.3435	6.8447	5.5930	23.73	-11.2922	73	929	76
-Mar-86	-10.4213	305.1142	267.7876	32.5298	15.3676	9.5508	26.16	-1.2416	316	280	
01-Apr-86	N/A	166.4349	0.0000	17.2331	0.0000	5.7303	16.74	-11.0097	289	603	
15-Apr-86	N/A	203.8305	0.0000	97.2370	0.0000	30.8055	34.98	-4.1745	282	549	
20-Apr-86	-11.3532	482.8588	388.3176	94.5412	76.9778	19.8703	96.85	-0.0019	312	1133	
17-May-86	-8.0542	229.9976	169.4245	12.9391	45.2758	3.9963	53.33	-4.0579	481	269	
19-May-86	-27.1276	270.9016	130.1267	124.9238	25.5903	37.4148	62.22	0.7850	955	457	
05-Jun-86	-21.7046	202.1614	25.9164	86.2805	4.5389	27.3842	27.79	4.1331	102	913	
06-Jun-86	N/A	160.8574	0.0000	27.3134	0.0000	9.1632	15.55	-6.3868	546	1190	
26-Jun-86	N/A	224.0834	0.0000	202.1813	0.0000	62.7753	40.73	22.0453	413	839	

AVERAGE of CEhv/ch using calculated values not to exceed IITRI = 18.0687

APPENDIX F

Optimized Control Strategy for Open Coal Storage Piles

1. All procedures outlined herein as applicable to each are enforceable as a condition of operating.

2. The Terminal shall record the following on an hourly basis:

Average hourly temperature (T) in degrees Fahrenheit

Average hourly relative humidity (RH)

Average hourly wind speed in miles per hour (SP)

Average hourly wind direction (DIR)

Hourly rain in inches

Hourly occurrence of fog (visibility of 4 miles or less)

Density of air P from the equation $P = 0.0001478(T) + 0.0853$

Viscosity of air value (1.68 u) from the following equations

$-24.88 < T \leq 32$	$1.68\ u = 0.0001207(T) + 0.0655479$
$32.00 < T \leq 64.40$	$1.68\ u = 0.0001493(T) + 0.0646353$
$64.40 < T \leq 104$	$1.68\ u = 0.0001344(T) + 0.0655899$

K as determined by the equation: $K = SP(T/RH)\ (P/u\ 1.68)$.

3. The Terminal shall use the above listed data for a computerized spreadsheet in a format as described below, maintaining the records to be submitted to the Board upon request

Column 1. Record the time (TM) starting with 1 (1:00A.M.) and ending with 24 (12:00P.M.) to represent the hourly values of a 24 hour day.

Column 2. Record the RAINBIRD cycles (RBC) as they occur, in the hour that they occur from the computer controlled water suppression system. The sum of all cycles to be carried forward to each succeeding hour. Traces of rain between .01 inches and .03 inches as recorded from the rain gauges are to be counted as a suppression cycle.

Column 3. Compute and record the hourly value of K from the computer controlled suppression system.

Column 4. Compute and record the sum of the hourly values of K (SUMK) as follows:

$$K_1 + K_2 + K_3 \ldots \text{etc.}$$

Column 5. Compute and record the projected EK_t (KT) for the day as follows:

$$K_1 + K_2 + K_3 + K_3\ (24 - TM)$$

where TM is the end of the hour for which the calculations are intended.

Example: $K_1 = 10$

$K_2 = 10$

$K_3 = 20$

$K_3\ (24 - TM) = 420$

$KT = 460$

Column 6. Compute and record the hourly values of K_C as follows:

$$K_C = K \times F_C$$

F_C is a manual entry from the daily weather sheets. $F_C = 1$ in the absence of rain or fog as described above. $F_C = 0$ when rain equal to or in excess of 0.03 inches has occurred or fog with visibility less than or equal to 4 miles is present. In view of the percent recovery time for rainfall greater than 0.03 inches, $F_C = 0$ may be used for two hours after the end of any amount (inches) of continuous rainfall if 0.03 inches has been accumulated.

Note: K_C has no wind direction definition.

Column 7. Compute and record the sum of the hourly values of K_C (SUMKC) as follows:

$$K_{C_1} + K_{C_2} + K_{C_3} \ldots \text{etc.}$$

Column 8. Compute and record the projected EK_C (KCT) as follows:

NO RAIN OR FOG $F_C = 1$

$$K_{C_1} + K_{C_2} + K_{C_3} + K_{C_3}\ (24 - TM)$$

Example: same as for Column 5.

RAIN OR FOG and $F_C = 0$

$$K_{C_1} + K_{C_2} + K_{C_3} + K_{C_3}\ (24 - TM)$$

Example: $K_{C_1} = 10$

$K_{C_2} = 10$

$K_{C_3} = 0$ (RAIN 0.03)

KC_3 (24 - TM) = 0

KCT = 20

<u>Column 9</u>. Compute and record the sum of the hours uncontrolled coal loading (CEui) to the hour as follows:

CEui (KT < 288) = SUMK (0.460679KT - 2.8759842)/KT

CEui (KT ≥ 288) = SUMK (0.255568KT + 56.216517)/KT

<u>Column 10</u>. Compute and record the sum of the hours controlled loading (hvi) to the hour as follows:

hvi (KT < 288) = (SUMKC(0.460679KT - 2.8759842)/KT)

(1 - (RBCx%EFF/C)/100)

where % EFF/C = $36.657299 \times 10^{-0.00189215KT}$

hvi (KT ≥ 288) = (SUMKC(0.255568KT + 56.216517)/KT)

(1 - (RBCx%EFF/C)/100)

where % EFF/C = -0.0146913KT + 14.650259

NOTE: (Column 9 - Column 10)/Column 9 - control effectiveness to the hour.

<u>Column 11</u>. Compute and record the end of the day's projected uncontrolled coal loading (CEuct) on the hour as follows:

CEuct (KT < 288) = (0.460679KT - 2.8759842)

CEuct (KT ≥ 288) = (0.255568KT + 56.216517)

<u>Column 12</u>. Compute and record the end of the day's projected coal loading (hvT) on the hour as follows:

hvT (KT < 288) = (KCT(0.460679KT - 2.8759842)/KT)

(1 - (RBCx%EFF/C)/100)

where % EFF/C = $36.657299 \times 10^{-0.00189215KT}$

hvT (KT > 288) = (KCT(0.255568KT + 56.216517)/KT)

(1 - (RBCx%EFF/C)/100)

where % EFF/C = -0.0146913KT + 14.650259

4. When the value of "K" is equal to or greater than 11, the terminal will commence a full coverage "DEMAND I" water spray suppression cycle of at least 20,000 gallons of water on their respective metallurgical coal piles.

5. This "DEMAND I" cycling of the suppression water will be repeated as long as the value of "K" remains above 11, with one hour delays between cycles. Such times for commencement to be on the hour as dictated by the computed value of "K".

6. When the value of "K" equals or exceeds 17 as computed on the hour, a "DEMAND II" cycle will commence on all coal piles with no less than 24,000 gallons of water administered on the hour and continue each hour on the hour until the value drops below the value of 17. The normal one hour delay between cycles will then be resumed as a "DEMAND I" cycle until a value for "K" is lower than 11.

7. Each day will have at least four "ASSURANCE" cycles on all metallurgical coal piles regardless of the values of "K". On days when the hourly values of "K" are all below 11 prior to 4:00A.M. an "ASSURANCE" cycle will be conducted at that time. If the hourly values of "K" continue below 11 until 9:00A.M. a second "ASSURANCE" cycle will be conducted at that time. Similarly again at 1:00P.M. and 4:00P.M. "DEMAND I" cycle requirements or a trace of rain prior to or between 4:00A.M. and 4:00P.M. will count as one or more of these four "ASSURANCE" cycles required per day.

8. Each day on other than metallurgical coal piles (i.e., steam coal) at least one "ASSURANCE" cycle will be administered at 9:00A.M., of no less than 8,000 gallons of water unless the stipulations for "DEMAND II" have been reached prior to this time, then the "DEMAND II" requirements will count as this "ASSURANCE" requirement.

9. "ASSURANCE" cycles may be applied to the metallurgical coal piles with quantities of water less than 20,000 gallons per cycle in accordance with the following:

When: Projected value of KT at the end of the specified hour for application is equal to or less than 150, i.e., $KT \leq 150$, 12,000 gallons of water per cycle can be used.

When: Projected value of KT at the end of the specified hour for application is greater than 150 but equal to or less than 500, i.e., $150 \leq KT \leq 500$, 17,000 gallons of water per cycle can be used.

When: Projected value of KT at the end of the specified hour for application is greater than 500, i.e., $KT \geq 500$, 20,000 gallons of water must be used.

10. The terminal operators may request a change to the procedure outlined in this Agreement. Such requests should be accompanied by an explanation of the proposed changes and the anticipated effect they will have. These requests, if approved by the State Air Pollution Control Board, will be subject to a test and evaluation procedure prior to being accepted as permanent changes to the control procedures.

11. Copies of the Consent Agreement and Order shall be available for reference at the facility, and operating personnel shall be apprised and trained in the portions thereof related to their duties and the need to control coal emissions.

12. One person each shift shall be designated as responsible for compliance with the control procedures delineated herein. Required actions in support of these control procedures shall take precedence over routine coal handling procedures.

13. Operating personnel at the terminal will be informed of their companies respective responsibilities under this Agreement and of all applicable permit conditions as imposed by the SAPCB. With respect to compliance with the Agreement, operating personnel shall be informed by their supervisors that they, as individuals, as well as their employer, are responsible for compliance with the terms and conditions of this Consent Agreement and Order to the extent that their failure to perform their individual duties and responsibilities lead to noncompliance with the terms and conditions of this Order.

The following actions are considered as detrimental to the control of coal emissions, but are not limited to:

a. Failure to stop any coal movement operation at their respective companies when it becomes known that installed air pollution control systems are inoperative and would cause excess emissions.

b. Failure to stop a coal movement operation, at their respective companies when it becomes known that pieces of coal handling equipment needed for that operation are malfunctioning or operating at significantly below designed specifications.

c. Failure of equipment operators at their respective companies to take immediate precautions to preclude fugitive dust emissions from the operation of bulldozers, front-end loaders, automobiles or trucks (i.e., through the use of water suppressant to control the dust, or limiting the speed of movement to below 10 miles per hour).

d. Failure of personnel at their respective companies to give precedence to controlling fugitive dust emissions over routine coal operations to personnel designated the responsibility of controlling fugitive emissions.

14. The representatives of the terminal will meet on a regular basis to discuss the implementation of the above procedures.

15. Whenever the terminal is using a particular piece of coal handling equipment (e.g., a dumper, a conveyor, etc.), it will utilize the wet suppression controls for that piece of equipment unless the use of such equipment would cause a safety hazard or damage to the equipment from freezing.

16. Any significant malfunction of equipment that materially affect the operation of the water suppressant system of the coal piles will be reported to the SAPCB by telephone as soon as practicable. In the event of such malfunctions, auxiliary watering devices will be used until such time as the regular equipment is repaired, and a complete log of such action will be maintained for evaluation of impact.