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August 5, 2010

VIA ELECTRONIC FILING

Ms. Cynthia Brown
Chief, Section of Administration
Office of Proceedings
Surface Transportation Board
395 E Street, SW
Washington, DC 20423-0001

Re: *Petition of Arkansas Electric Cooperative Corporation for a Declaratory Order*, STB Finance Docket 35305

Dear Ms. Brown:

This letter responds to requests for BNSF Railway Company to provide additional information on two matters raised by Board members at the July 29, 2010 hearing in the above-referenced case.

First, in response to a request from Vice Chairman Mulvey, attached is a list of academic and industry articles and reports related to coal dust that we have been able to locate. We have identified whether the materials on our list were already included in the record in this proceeding, are readily available on the internet, or are being provided to the Board as attachments to this letter. We have seen references to a few other articles and reports, but have not included them on our list if we have been unable to locate a copy.

Second, Commissioner Nottingham asked BNSF to advise the Board whether BNSF loaded the railcars above the sill during its removal of coal dust that had accumulated near certain waterways in 2008. We confirmed that BNSF did not load the railcars above the sill. We note that one of the articles on the attached list addresses the question raised by Commissioner Nottingham as to whether loading coal below the sill would reduce coal dust emissions. This article indicates that this loading technique reduces the load capacity of each railcar by more than ten percent without a statistically significant reduction in coal dust emissions. *See* Edward M. Calvin, G. D. Emmitt & Jerome E. Williams, A Rail Emission Study: Fugitive Coal Dust Assessment and Mitigation, *Proceedings for the Seventh Annual Environment Virginia '96 Symposium*, 44, 48, Lexington, Virginia (April 11-12, 1996).

Please contact the undersigned if you have any questions regarding this letter.

Sincerely,

Samuel M. Sipe, Jr.
Counsel for BNSF Railway Company

cc: Chairman Daniel R. Elliott III
Vice Chairman Francis P. Mulvey
Commissioner Charles D. Nottingham
Parties of Record

Coal Dust Articles and Reports

Aurecon Hatch, Coal Leakage from Kwik-Drop Doors: Coal Loss Management Project Queensland Rail Limited Reference H327578-N00-EE00.08 Revision 1 (July 21, 2009) (available at http://www.qrnetwork.com.au/media-and-community-centre/environmental-policies/Coal-loss-management.aspx).

Kenneth Axtell & Chatten Cowherd, Environmental Protection Agency, Project Summary: Improved Emissions Factors for Fugitive Dust from Western Surface Coal Mining Surfaces, EPA-600/S7-84-048 (July 1984) (attached).

Christopher F. Blazek of Benetech Inc., The Role of Chemicals in Controlling Coal Dust Emissions, *presented at the American Coal Council, PRB Coal Use: Risk Management Strategies and Tactics Course*, Dearborn, Michigan (June 2003) (attached).

Edward M. Calvin, G. D. Emmitt, & Jerome E. Williams, A Rail Emission Study: Fugitive Coal Dust Assessment and Mitigation, *Proceedings for the Seventh Annual Environment Virginia '96 Symposium*, 44-53, Lexington, Virginia (April 11-12, 1996) (attached).

Connell Hatch, Barney Point Coal Terminal Dust Benchmarking Study: Gladstone Port Coal Dust Study, Reference HR02-03 Revision 0, *prepared for Gladstone Ports Corporation* (July 14, 2008) (available at http://www.gpcl.com.au/gpc_benchmarking_studies.html).

Connell Hatch, Final Report: Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains, Goonyella, Blackwater, and Moura Coal Rail Systems, Reference H327578-NOO-EE-00.00 Revision 1, *prepared for Queensland Rail Limited* (Mar. 31, 2008) (available at http://www.qrnetwork.com.au/media-and-community-centre/environmental-policies/Coal-loss-management.aspx).

Connell Hatch, RG Tanna Dust Benchmarking Study: Gladstone Port Coal Losses and Air Quality, Reference HR02-03 Revision 4, *prepared for Central Queensland Ports Authority* (March 12, 2008) (available at http://www.gpcl.com.au/gpc_benchmarking_studies.html).

Connell Hatch, Interim Report, Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains, Goonyella, Blackwater, and Moura Coal Rail Systems, Reference H-327578 Revision 0, *prepared for Queensland Rail Limited* (Jan. 31, 2008) (included in the workpapers of the Reply Verified Statement of Dr. Mark Viz).

Connell Hatch, Draft: Coal Loss Literature Review, Reference H327578-N00-CF00 Revision 0, *prepared for Queensland Rail Limited* (Jan. 11, 2008) (included in the workpapers of the Reply Verified Statement of Dr. Mark Viz).

Douglas L. Cope & Kamal K. Bhattacharyya, A Study of Fugitive Coal Dust Emissions in Canada, *prepared for The Canadian Council Ministers of the Environment* (Nov. 2001) (attached).

G. D. Emmitt, Fugitive Coal Dust: An Old Problem Demanding New Solutions, *Port Tech. Int'l.*, 9:125-128 (1999) (attached).

George D. Emmitt, Linnea S. Wood, Edward M. Calvin, & Steven Greco, Procontrol: Automated Fugitive Dust Control System, *Proceedings for the Seventh Annual Environment Virginia '96 Symposium*, 36-43, Lexington, Virginia (April 11-12, 1996) (attached).

George D. Emmitt, Minimizing Groundwater Consumption for Required Fugitive Dust Control Programs, *Proceedings for the Seventh Annual Environment Virginia '96 Symposium*, 244-251, Lexington, Virginia (April 11-12, 1996) (attached).

A.D. Ferreira, D.X. Viegas & A.C.M. Sousa, Full-Scale Measurements for Evaluation of Coal Dust Release from Train Wagons with Two Different Shelter Covers, *91 Journal of Wind Engineering & Industrial Aerodynamics*, 1271-1283 (2003) (included in the workpapers of the Reply Verified Statement of Dr. Mark Viz).

A.D. Ferreira & P.A. Paz, Wind Tunnel Study of Coal Dust Release from Train Wagons, *92 Journal of Wind Engineering & Industrial Aerodynamics*, 565-577 (2004) (included in the workpapers of the Reply Verified Statement of Dr. Mark Viz).

Claudio Guarnaschelli, Environmental Protection Service: Fisheries and Environment Canada, In-Transit Control of Coal Dust From Unit Trains, Report No. EPS 4-PR-77-1 (May 1977) (attached).

H. Huang, E. Tutumluer, & W. Dombrow, Laboratory Characterization of Fouled Railroad Ballast Behavior, *Transportation Research Record No. 2117: Journal of the Transportation Research Board, National Resource Council,* Washington, D.C., 93-101 (2009) (attached to the Opening Verified Statement of Dr. Erol Tutumluer, Exhibit 4).

Katestone Environmental & Introspec Consulting, Field Trial Program for the Observation of Potential Slip Failure or Other Movement in the Surface of Coal in Wagons During Transport From Mine to Port, *prepared for Queensland Rail Limited* (Feb. 3, 2009) (available at http://www.qrnetwork.com.au/media-and-community-centre/environmental-policies/coal-loss-management.aspx).

Ross Leeder, Wes Hutny & John Price, Train Transportation Coal Losses: A Wind Tunnel Study, *AISTech 2007: Proceedings of the Iron & Steel Technology Conference Volume I*, 129-138 (May 7-10, 2007) (included in the workpapers of the Reply Verified Statement of Dr. Mark Viz).

George Noble, Sander E. Sundberg, and Michael Bayard, Coal Particulate Emissions From Rail Cars, *Proceedings from the Air Pollution Control Association Specialty Conference on Fugitive Dust Issues in the Coal Use Cycle*, Rep. No. CONF-8304206, 82-92 (April 1983) (included in the workpapers of the Reply Verified Statement of Dr. Mark Viz).

QRNetwork, *Coal Dust Management Plan: Coal Loss Management Project*, Version Draft V10D (Feb. 22, 2010) (available at http://www.qrnetwork.com.au/media-and-community-centre/environmental-policies/coal-loss-management.aspx).

Report of the Joint Subcommittee Studying Ways to Reduce Emissions from Coal-Carrying Railroad Cars to the Governor and the General Assembly of Virginia, Senate Document No. 23 (Jan. 1997) (available at http://leg2.state.va.us/DLS/H&SDocs.NSF/Published+by+Year?OpenForm&StartKey=1997&ExpandView).

B. Roebuck, N. P. Vaughan, & K. Y. K. Chung, Performance Testing of the OSIRIS Dust Monitoring System, 34 (3) *Ann. Occup. Hyg.* 263-279 (1990) (included in the workpapers of the Rebuttal Verified Statement of Dr. Mark Viz).

Simitars: Queensland Government, A Business Unit of the Department of Mines and Energy, Gladstone Airborne Coal Dust Monitoring: Complete Report for QRNational, Report No. oe101776f3 (Jan. 18, 2008) (included in the workpapers of the Reply Verified Statement of Dr. Mark Viz).

Simpson Weather Associates, Norfolk Southern Rail Emission Study, *prepared for Norfolk Southern Corporation* (Dec. 30, 1993) (included in the workpapers of the Reply Verified Statement of Dr. Mark Viz).

E. Tutumluer, W. Dombrow, & H. Huang, Laboratory Characterization of Coal Dust Fouled Ballast Behavior, *Proc. AREMA 2008 Annual Conference*, Salt Lake City, Utah (September 21-24, 2008) (attached to the Opening Verified Statement of Dr. Erol Tutumluer, Exhibit 3).

Edmund P. Wituschek, & Douglas L. Cope, Environment Canada, Coal Dust Control: Recommended Practices for Loading, Unloading, and Transporting Coal by Rail, Regional Report No. 86-17 (April 1986) (attached to the Rebuttal Verified Statement of William VanHook, Exhibit 2).

United States
Environmental Protection
Agency

Research and Development

Industrial Environmental
Research Laboratory
Cincinnati, OH 45268

EPA-600/S7-84-048 July 1984

EPA

Project Summary

Improved Emission Factors for Fugitive Dust from Western Surface Coal Mining Sources

Kenneth Axetell, Jr. and Chatten Cowherd, Jr.

The primary purpose of this study was to develop emission factors for significant surface coal mining operations that would be applicable at Western surface coal mines and would be based on widely acceptable, state-of-the-art sampling and data analysis procedures. The approach was to develop emission factors for individual mining operations in the form of equations with correction factors to account for site-specific conditions. Factors were determined for three particle size ranges—less than 2.5 μm (fine particulate), less than 15 μm (inhalable particulate), and total suspended particulate.

A total of 265 tests were run at three mines during 1979 and 1980. The following sources were sampled: Drilling (overburden), blasting (coal and overburden), coal loading, bulldozing (coal and overburden), dragline operations, haul trucks, light- and medium-duty vehicles, scrapers, graders, and wind erosion of exposed areas and coal storage piles. The primary sampling method was exposure profiling; however, upwind-downwind, balloon, wind tunnel, and quasi-stack sampling methods were used on sources unsuitable for exposure profiling.

Several variables that might affect emission rates, such as vehicle speed, were monitored during the tests. Significant correction parameters in the emission factor equations were then determined by multiple linear regression analysis. Confidence intervals were also calculated for each of the factors.

Data for determination of deposition rates were obtained, but scatter in the data prevented the development of an algorithm. Control efficiencies for two unpaved road control measures were estimated.

The full report concludes with a comparison of the generated emission factors with previous factors, a statement regarding their applicability to mining operations, and recommendations for additional research in Western and other mines.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Operations of surface coal mines vary from mine to mine, and the relative amounts of dust produced by the different operations will vary greatly. A ranking of the sources was performed to determine which significant particulate sources warranted sampling, based on average mine conditions. The most significant dust-producing operations are shown in Table 1.

Sampling Program

The number of mines to be surveyed was set at three—a compromise between sampling over the widest range of mining/meteorological conditions by visiting a large number of mines and obtaining the most tests within the given budget and time limits by sampling at only a few mines. The three mines selected were in diverse geographic areas in the Western coal fields having the largest strippable reserves: Fort Union (North

Dakota), Powder River Basin (Montana-Wyoming), and San Juan River (New Mexico-Arizona). These mines had most of the significant dust-reproducing operations, and most operations could be sampled at more than one location in each mine. While sampling was limited to several weeks at each mine, seasonal variations in emission rates were considered by sampling during three of four seasons.

A total of 265 tests (245 of them on uncontrolled sources) were conducted during four sampling periods. Table 1 summarizes the tests by mine and by source. The total number of samples required for each source to achieve a 25 percent relative error at a 20 percent risk level was determined statistically. The calculated sample size could not be obtained from some sources because of difficulties encountered in the field, such as source inactivity, inability to place the sampling array in the required location due to topographical barriers, unstable wind directions, and low or high windspeeds. A major effort was made to obtain a statistically adequate sample size for haul trucks, the major dust-producing source.

Table 1. Summary of Tests Performed

Source	Sampling technique	Mine 1	Mine 2	Mine 1W[a]	Mine 3	Total
Drilling, ovb.[b]	Quasi-stack	11	-	12	7	30
Blasting, coal	Balloon	3	6		7	16
Blasting, ovb.	Balloon	2			3	5
Coal loading (shovel/truck or front-end loader)	Uw-dw[c]	2	8		15	25
Bulldozing, ovb.	Uw-dw	4	7		4	15
Bulldozing, coal	Uw-dw	4	3		5	12
Dragline	Uw-dw	6	5		8	19
Haul trucks	Profiling	7[d]	9	10[e]	9	35
Light- and medium-duty trucks	Profiling	5	5		3	13
Scrapers	Profiling	5[d]	6	2	2	15
Graders	Profiling		5		2	7
Exposed area, ovb.	Wind tunnel	11	14	3	6	34
Exposed area, coal	Wind tunnel	10	7	6	16	39
Total		70	75	33	87	265

[a]Winter sampling period.
[b]ovb. = overburden.
[c] Uw-dw = upwind-downwind.
[d]Five of these tests were comparability tests (profiling and upwind-downwind).
[e]Six of these tests were done by upwind-downwind.

Sampling Techniques

A thorough review of possible fugitive dust sampling techniques indicated that no one technique was adequate to sample all sources. Exposure profiling, designated as the preferred technique, was used whenever possible (63 profiling tests were performed). Each of the five different sampling techniques used in the study is described briefly in the following paragraphs.

The exposure profiler consisted of a portable tower (4 to 6 m in height) supporting an array of sampling heads Each sampling head was operated as an isokinetic exposure sampler The air-flow stream passed through a settling chamber that trapped particles larger than about 50 μm, and then flowed upward through a horizontally position, standard 8 x 10 in. glass fiber filter. Sampling intakes were positioned directly into the wind, and sampling velocities were adjusted to match the mean windspeed at each height (as determined immediately prior to the test). Windspeed was monitored by hot-wire anemometers throughout the test, and flow rates were adjusted for major changes in mean windspeed. Operating concurrently with the profiler, dichotomous samplers placed at two heights on the tower determined particle size distribution. Duplicate dustfall buckets located at the profiler and 20 and 50 m downwind of the source provided information on deposition.

The exposure profiler concept was modified for sampling blasting operations. The large horizontal and vertical dimensions of the blast plumes required a suspended array of samplers as well as ground-based samplers in order to sample over the plume cross-section in both dimensions. Five 47-mm polyvinyl chloride (PVC) filter heads and sampling orifices were attached to a line suspended from a tethered balloon. The samplers were located at different heights (2.5, 7.6, 15.2, 22.9, and 30.5m), and each sampler was attached to a wind vane so that the orifices would face directly into the wind. The samplers were connected to a ground-based pump with flexible tubing. The pump maintained an isokinetic flow rate for a windspeed of 5 mph. To avoid equipment damage from blast debris and to obtain a representative sample of the plume, the balloon-suspended samplers were located about 100 m downwind of the blast area. The balloon-supported samplers were supplemented with five hi-vol/dichotomous sampler pairs spaced 20 m apart and located on an arc at the same distance as the balloon from the edge of the blast area.

The upwind-downwind array used for sampling point sources included 15 samplers (10 hi-vol and 5 dichotomous). One of each sampler type was located upwind of any dust from the source. Initially, downwind samplers were placed at nominal distances of 30, 60, 100, and 200 m; however, these distances had to be frequently modified because of physical obstructions (e.g., highwall) or potential interfering sources. Two samplers of each type were placed at a distance of 30 m, three hi-vols and two dichotomous samplers at 60 m, three hi-vols at 100 m, and one hi-vol at 200 m. Both sampler types were mounted on tripod stands at a height of 2.5 m, the highest manageable height for this type of rapid-mount stand. The downwind array was modified slightly for sampling line sources. It consisted of two pairs of hi-vol/dichotomous samplers at 5, 20, and 50 m and two hi-vols at 100 m. The two rows of samplers were separated by 20 m. The upwind-downwind method allowed indirect measurement of deposition through calculation of apparent emission rates at a series of downwind distances.

A portable wind tunnel consisting of an inlet section, a test section, and an outlet diffuser was used to measure dust emissions generated by wind erosion of exposed areas and storage piles. The test section has a 1 by 1 ft cross section so it could be used with rough surfaces. The open-floored test section was placed directly on the 1 by 8 ft surface to be tested, and the tunnel air flow was adjusted to predetermined values that corresponded to the means of NOAA windspeed ranges. Tunnel windspeed was measured by a pitot tube at the downstream end of the test section and related to windspeed at the standard 10 m height by means of a logarithmic profile. An emission-sampling module was located between the tunnel outlet and the fan inlet to measure particulate emissions generated in the test section. The sampling train, which was operated at 15 to 25 ft^3/min, consisted of a tapered probe, cyclone precollector, parallel-slot cascade impactor, backup filter, and hi-vol motor. Interchangeable probe tips were sized for isokinetic sampling over the desired tunnel windspeed range.

For quasi-stack sampling of overburden drilling, a wooden enclosure with 4 by 6 ft end openings was fabricated in the field. During each test, the enclosure was placed adjacent to, and downwind of the drill platform. The cross section of the enclosure was divided into four rectangles of equal area, and a hot-wire anemometer measured wind velocity at the center of each rectangle. Four exposure profiler samplers with remote flow controllers were used to sample in the four enclosure subareas. Sampler flow rates were adjusted at 2-to 3-minute intervals to near-isokinetic conditions with the windspeed measurements. This sampling technique did not measure particle size distribution of deposition.

Source Characterization

Many independent variables influence particulate emission rates from mining sources. If these variables are to be quantified and included as parameters (correction factors) in the emission factor equations, suspected variables must be measured for each emission test.

Summary of Results

Total suspended particulate (TSP) and inhalable particulate (IP) emission rates are presented in Table 2. For some sources, the number of test values is lower than the number of tests reported in Table 1. This indicated elimination of data after a test was completed. For example, the plume may have missed the sampling array for most of the period or the sampler may have malfunctioned. Most of the tests for which no data are presented in Table 2 (36 out of 44) were run on exposed areas. These tests were unproductive because eroding particles could not be generated on the test surfaces, even at the highest windspeed simulated in the wind tunnel.

The geometric mean values in Table 2 are *not* emission factors; no consideration has been given to correction factors at this point.

The relative standard deviations of emission rates by individual sources ranged from 0.7 to 1.5. Relative standard deviation is a measure of sample variation.

Table 2. *Emission Rates by Source*

Source	No. of values	Units	Geometric mean emission rate		Range of emission rates from individual tests	
			TSP	IP	TSP	IP
Drilling, ovb.[a]	30	lb/hole	1.16		0.04-7.29	
Blasting, coal	14	lb/blast	28.7	10.5	1.6-514 0	0.4-142.8
Blasting, ovb.	4	lb/blast	74.3	40.0	35.2-270.0	16.9-93.9
Coal loading (shovel/truck or front-end loader)	25	lb/ton	0.039	0.010	007-1.090	0.002-0.378
Bulldozing, ovb.	15	lb/h	3.70	1.96	0.9-20.7	0.48-32.60
Bulldozing, coal	12	lb/h	46.0	20.5	3 0-439.0	0.9-236.0
Dragline	19	lb/yd^3	0.050	0.013	0.004-0.400	0.002-0.061
Haul trucks	33	lb/VMT	9.1	4.1	0.6-73 1	0.4-42.1
Light- and medium-duty trucks	11	lb/VMT	2.43	1.54	0.35-9.0	0.34-5.1
Scrapers	14	lb/VMT	24.3	11.7	3.9-355 0	1.4-217.0
Graders	7	lb/VMT	5.8	2.8	1.8-34.0	0.9-15.4
Exposed area, ovb.	10	lb/acre-s	0.0803	0.0549	0.0107-0.537	0.0073-0 336
Exposed area, coal	27	lb/acre-s	0.0980	0.0642	0.0096-2.27	0.0053-1.40

[a] *ovb. = overburden.*

For most sources with at least 10 data points, emission rates varied more than two orders of magnitude; however, similar variations were noted in independent variables thought to have an effect on emission rates.

Multiple Linear Regression Analysis

The method for developing correction factors was based on multiple linear regression (MLR). Briefly, values for all variables being considered as possible correction factors were first tabulated by source along with the corresponding TSP emission rates for each test. The data were then transformed to their natural logarithms (ln) because a preliminary analysis had indicated the emission rates were lognormally rather than normally distributed. The transformed data were applied to the MLR program, specifying the stepwise option and permitting entry of all variables that increased the multiple regression coefficient.

Wind Erosion Sources

The emission rates reported in Table 2 for wind erosion from coal pile surfaces and exposed ground areas were obtained by testing several naturally occurring surfaces at successively increasing windspeeds simulated in the wind tunnel. Analysis of SP (the size fraction less than 30 μm) and IP emission rates indicated that the rates (1) increased with windspeed above a threshold level on newly exposed surfaces and (2) decreased sharply with time after the onset of erosion.

Threshold velocities for detectable movement of surface particles were unexpectedly high. This was attributed to the presence of natural crusts on many of the surfaces tested. The decay in emission rates with time was explained by the limited quantity of particles in any specified particle size range present on the surface (per unit area) that could be removed by wind erosion at a particular windspeed. The available quantity, or erosion potential could be restored by a disturbance of the surface such as the addition or removal of material from a storage pile or the plowing of an exposed ground area.

Particle Size Distribution

Emission factors were developed for three size ranges—fine particulate (FP, <2.5 μm); inhalable particulate (IP, <15 μm); and total suspended particulate (TSP, no well-defined upper cut point, but approximated as 30 μm). Dichotomous samplers generated the FP and IP data and hi-vol samplers generated the TSP data. Suspended particulate (SP) emission rates determined from exposure profiling tests were not actually TSP; rather, these rates were the fraction of total particulates less the 30 μm in aerodynamic diameter. Only a calculated estimate of the suspended fraction could be made because the profiler samplers indiscriminately collect all particle sizes present in the plume.

Independent data analyses were performed on IP and TSP/SP data to derive emission factors for these two size ranges. Data analysis problems associated with the very low concentrations prevented determination of emission factors for the FP size fraction by calculation of emission rates followed by multiple linear regression. Instead, net FP concentrations for all tests were expressed as a fraction of TSP or SP, and the average fraction for each source was applied to the TSP/SP emission factor for that source to calculate an FP emission factor.

Table 3 shows the average ratios of FP and IP to TSP or SP emission rates by source. The IP fractions were reasonably consistent, varying from 0.30 to 0.67. In general, these ratios were lower than the frequently quoted average ratio of 0.65 for urban ambient monitoring. These ratios were based on measurements taken near the sources. As the emissions proceed downwind, greater deposition in the TSP fraction should increase the ratio.

The variation of FP/TSP ratios was much wider, from 0.026 to 0.196. The 0.196 value for bulldozing overburden appeared to be an anomaly, however. Exclusion of this value makes the range 0.026 to 0.074. The fairly consistent ratios of FP and IP to TSP for different sources indicate that the size distribution is similar in all fugitive dust sources at mines.

Three different particle sizing methods were evaluated early in the study—cascade impactors, dichotomous samplers, and microscopy. Side-by-side comparison of these methods showed that the cascade impactors and dichotomous samplers gave approximately the same particle size distributions. In contrast, the microscopy data varied widely. It was concluded that microscopy is a useful tool for semiquantitative estimates of various particle types, but it is inadequate for primary particle sizing of fugitive dust emissions. Despite several unresolved problems involved in the generation of fine particle data for fugitive dust sources, data from the present study are thought to be reasonable based on their consistency and the observed agreement between dichotomous and cascade impactor data.

Table 3. Average Particle Size Distributions by Source

Source	No. of tests	Average IP/TSP	Std. dev. of IP/TSP	Average FP/TSP	Std. dev. of FP/TSP
Blasting	18	0.46	0.29	0.051	0.039
Coal loading	24	0.30	0.15	0.030	0.035
Bulldozing, coal	12	0.49	0.24	0.031	0.033
Bulldozing, ovb.	14	0.54	0.50	0.196	0.218
Dragline	19	0.32	0.22	0.032	0.040
Haul trucks[a]	28	0.52	0.08	0.033	0.037
Light- and medium-duty vehicles[a]	11	0.65	0.16	0.074	0.078
Scrapers[a]	14	0.49	0.07	0.026	0.021
Graders[a]	7	0.48	0.10	0.055	0.041
Coal storage piles[a]	27	0.61	0.08		
Exposed areas[a]	10	0.67	0.06		

[a]Expressed as fractions of SP (<30 μm) rather than TSP.

Deposition

The emission factors in this study were all developed from sampling data obtained very near the source. Emissions are subject to deposition as distance from the source increases

A secondary objective of this study was to develop a deposition function specifically for use with the mining emission factors. Deposition rates were measured by two different methods—dustfall catch and apparent source depletion at successive distances from the source. Although initial side-by-side testing of the two methods indicated that apparent source depletion gave the better results, dustfall measurements were still taken at 5, 20, and 50 m from the source as part of the exposure profiling tests; these dustfall measurements proved to give much more reliable estimates of deposition rates during most of the sampling at the three mines.

The deposition rates by test were correlated with several potential variables such as windspeed and particle distribution. These analyses did not reveal any significant relationships that could form the basis for an empirical deposition function. Because these analyses were nonproductive and the primary method for measuring deposition (apparent source depletion in upwind-downwind sampling) gave unusable results, a deposition function cannot be presented at this time

If additional testing is performed to develop a deposition function, dustfall measurement is recommended as the sampling method. The main shortcoming of dustfall as a measurement of deposition is that it measures total particulate rather than the amount of deposition in the TSP or IP range.

Control Measures

Two mining control measures—application of water and application of a calcium chloride solution—were evaluated by comparing emission rates from treated and untreated areas. Testing was done on the same or adjacent lengths of roadway under similar traffic and meteorological conditions so that the only substantial variable between test pairs was application of the dust control. The number of tests available for determination of control efficiencies was limited and statistically inadequate.

The results of 1-hour test periods immediately after watering (shown in Table 4) indicate that water at a rate of 0.05 gal/yd^2 reduced particulate emissions from haul roads by 60 to 70 percent and those from coal loading by 78 percent. Maintenance of that range of efficiencies would require the reapplication of water at an approximate frequency of once per hour. Results showed that calcium chloride still reduced particulate emission rates from an access road by 95 percent about three months after its application, but no information was obtained on the life expectency of this control. Application rate for the 30 percent solution of calcium chloride was 0.6 gal/yd^2.

Table 4 shows that control efficiencies for IP were essentially the same as those for TSP, whereas those for FP were slightly lower. The 60 to 70 percent control efficiency for watering haul roads was higher than the 50 percent widely reported in the technical literature, possible because testing was done right after the water was applied.

Comparison of Sampling Techniques

The two major sampling techniques, exposure profiling and upwind-downwind sampling, were run simultaneously on a common source for several tests to determine relative performance.

Profiling towers and the upwind-downwind samplers (hi-vols and dichotomous samplers) were placed 5, 20, and 50 m downwind of the sources to measure the decrease in particulate flux with distance. This design allowed the indirect determination of deposition rates. Duplicate hi-vols and dichotomous samplers were placed at each of three distances, and two additional hi-vols were located 100 m downwind of the source. Upwind samplers consisted of three hi-vols and a dichotomous sampler,

Table 4. *Control Efficiencies for Watering and Calcium Chloride*

Source	Control measure	Size fraction	No. Tests: Uncontrolled	No. Tests: Controlled	Avg. Emission rate, lb/VMT[a]: Uncontrolled	Avg. Emission rate, lb/VMT[a]: Controlled	Mean control eff., %
Haul road, Mine 2	Watering	TSP[b]	4	4	5.3	2.2	59
		IP	4	4	2.8	1.1	61
		FP	4	4	0.19	0.08	58
Haul road, Mine 3	Watering	TSP[b]	4	5	16.3	5.0	69
		IP	4	5	8.9	2.4	73
		FP	3	5	0.21	0.10	54
Coal ldg., Mine 3	Watering	TSP	5	9	0.188	0.042	78
		IP	4	9	0.053	0.010	81
		FP	4	9	0.0028	0.0009	68
Access road, Mine 1	Calcium chloride	TSP[b]	3	2	6.8	0.35	95
		IP	3	2	5.4	0.34	95
		FP	3	2	0.74	0.09	88

[a]*Emission factors for coal loading are expressed in units of lb/ton.*
[b] *Measured as SP, the size fraction less than 30 μm.*

all located 20 m from the upwind edge of the source.

Haul trucks and scrapers were selected for sampling in the comparison study. Because they are ground-level moving point sources (line sources) that emit from relatively fixed boundaries, both sampling methods were applicable and the required extensive sampling array could be located without fear of the sources changing location. Also, haul trucks and scrapers are two of the largest fugitive dust sources at most surface coal mines.

Five tests of each source were run over a 15-day period. All five tests of each source were performed at the same site, so only two sites (one for each source) and one mine were involved in the comparison study.

These data were subjected to Analysis of Variance (ANOVA) to evaluate whether differences in emission rates by sampling method, source, and downwind distance were statistically significant. Sampling method and downwind distance were found to have significant effects ($\sigma = 0.20$) on both TSP and IP emission rates; emission source (haul truck or scraper) was not a significant variable. The emission rates produced by profiling averaged 24 percent higher for TSP and 52 percent higher for IP than corresponding upwind-downwind emission rates, according to the ANOVA results.

Both methods of sampling showed large overall reductions in TSP and IP emission rates with distance. In 6 of 10 tests, however, profiling showed lower emission rates at the closest sampling sites (5 m) than at the middle sites (20 m). These inverted values were attributed to a systematic bias between measurements taken by two contractors, each of whom operated one of these profilers. The reduction of IP emission rates with distance was surprising, because very little deposition of sub-15 μm particles was expected over a 50-m interval.

The reason for the relatively poor comparisons between emission rates obtained by the two sampling/calculation methods was traced primarily to the precision of the samplers. It was not possible to establish from the data which sampling method was more accurate because the paired results were compared with each other rather than a known standard. Error analyses performed, after the side-by-side sampling led to the conclusion that the accuracy of state-of-the-art testing of fugitive emissions is ±25 to 50 percent with either of these two sampling methods.

Conclusions

Resulting Emission Factors

The emission factors resulting from this study (Table 5) are in the form of equations with correction factors for independent variables that were found to have a significant effect (generally at the 0.05 risk level) on each source's emission rates. The range of independent variable values over which sampling was conducted, and for which the equations are valid, are also shown in the table. Any ambient air quality analysis using these emission factors should have some provision for considering deposition.

The 80 and 95 percent confidence intervals for TSP were presented in the report. The average 80 percent confidence interval was -20 to +24 percent, less than the relative error anticipated in the study design.

The emission factors are for uncontrolled emission rates. Control efficiencies of a few control measures were estimated in limited testing, of the report. These control efficiencies should be applied to the calculated emission factors in cases where such controls have been applied or are anticipated.

A comparison of the emission factors developed in this study with others based on actual testing in surface coal mines indicated ratios of new to existing factors ranging from 0.4 to 2.2.

Limitations to Applications of Factors

Although these emission factors were designed to be widely applicable through the use of correction factors, the following limitations should be considered in their application:

1. The factors should be used only for estimating emissions from Western surface coal mines. There is no basis for assuming they would be appropriate for other types of surface mining operations, or for coal mines located in other geographic areas, without further evaluation.
2. Correction factors used in the equations should be limited to values within the ranges tested (see Table 15-1 of the full report). This is particularly important for correction factors with a large exponent, because of the large change in the resulting emission factor associated with a change in the correction factor.
3. These factors should be combined with a deposition function for use in ambient air quality analyses. After evaluation of the deposition data from this study, no empirical deposition function could be developed. Any function subsequently developed from these data should have provision for further deposition beyond the distance of sampling in this study (100-200m).
4. The factors were obtained by sampling at the point of emission and do not address possible reductions in emissions from dust being contained within the mine pit.
5. As with all emission factors, these mining factors do not assure the calculation of an accurate emission value from an individual operation. The emission estimates are more reliable when applied to a large number of operations, as in the preparation of an emission inventory for an entire mine. The emission

Table 5. Summary of Western Surface Coal Mining Emission Factors

Source	TSP/IP	Prediction equation for emission factor	FP fraction of TSP	Units	Range of correction parameters
Drilling	TSP	1.3	None	lb/hole	None
Blasting	TSP	$\frac{961\ A^{0.8}}{D^{1.8}\ M^{1.9}}$	0.030	lb/blast	A = area blasted, ft² =1076 to 103,334; M = moisture, % =7.2 to 38
	IP	$\frac{2550\ A^{0.6}}{D^{1.5}\ M^{2.3}}$			D = depth of holes, ft = 20 to 135
Coal loading	TSP	$1.16/M^{1.2}$	0.019	lb/ton	M = 6.6 to 38
	IP	$0.119/M^{0.9}$			
Bulldozing, coal	TSP	$78.4\ s^{1.2}/M^{1.3}$	0.022	lb/h	s = silt content, % =6.0 to 11.3
	IP	$18.6\ s^{1.5}/M^{1.4}$			M = 4.0 to 22.0
Bulldozing, ovb.	TSP	$5.7\ s^{1.2}/M^{1.3}$	0.105	lb/h	s = 3.8 to 15.1
	IP	$1.0\ s^{1.5}/M^{1.4}$			M = 2.2 to 16.8
Dragline	TSP	$0.0021\ d^{1.1}/M^{0.3}$	0.017	lb/yd³	d = drop distance, ft =5 to 100
	IP	$0.0021\ d^{0.7}/M^{0.3}$			M = 0.2 to 16.3
Scrapers	TSP	$(2.7 \times 10^{-5}) s^{1.3} W^{2.4}$	0.026	lb/VMT	s = 7.2 to 25.2; W = vehicle weight, tons =36 to 64
	IP	$(6.2 \times 10^{-6}) s^{1.4} W^{2.5}$			
Graders	TSP	$0.040\ S^{2.5}$	0.031	lb/VMT	S = vehicle speed, mph =5.0 to 11.8
	IP	$0.051\ S^{2.0}$			
Light- and medium-duty vehicles	TSP	$5.79/M^{4.0}$	0.040	lb/VMT	M = 0.9 to 1.7
	IP	$322/M^{4.3}$			
Haul trucks	TSP	$0.0067\ w^{3.4} L^{0.2}$	0.017	lb/VMT	w = average number of wheels =6.1 to 10.0
	IP[a]	$0.0051\ w^{3.5}$			L = silt loading g/m² =3.8 to 254.0

[a]Silt loading was not a significant correction parameter for the IP fraction.

factors are also more reliable when estimating emission over the long term because of short-term source variation.

6. Appropriate adjustments should be made in estimating annual emissions with these factors to account for days with rain, snow cover, temperature below freezing, and intermittent control measures
7. The selection of mines and their small number may have biased final emission factors, but the analysis did not indicate that a bias exists.
8. The confidence intervals cited in Table 13-10 of the full report estimate how well the equations predict the measured emission rates at the geometric mean of each correction factor. For predicting rates under extreme values of the stated range of applicability of the correction factors, confidence intervals would be wider
9. Error analyses for exposure profiling and upwind-downwind sampling indicated potential errors of 30 to 35 percent and 30 to 50 percent, respectively, independent of the statistical errors due to source variation and limited sample size.
10. Geometric means were used to describe average emission rates because the data sets were distributed lognormally rather than normally. This procedure makes comparison with previous emission factors difficult, because previous factors were all arithmetic mean values.
11. Wind erosion emission estimates should be restricted to calculation of emissions relative to other mining sources; they should not be included in estimates of ambient air impact.

Recommendations

A comprehensive study that has evaluated alternative sampling and analytical techniques is bound to identify areas where additional research would be valuable. Also, some inconsistencies surface during the data analysis phase, when it is too late to repeat any of the field studies. Therefore, a brief list of recommendations for further study is presented here.

1. Sampling at Midwestern and Eastern coal mines is definitely needed so that emission factors applicable to all surface coal mines are available.
2. A resolution of which deposition function is most accurate in describing fallout of mining emissions is still needed. Closely related to this is the need for a good measurement method for deposition for several hundred meters downwind of the source (dustfall if recommended for measurements up to 100 or 200 m). In the present study, both the source depletion and dustfall measurement methods were found to have deficiencies.
3. A method for obtaining a valid size distribution of particles over the range of approximately 1 to 50 μm under near-isokinetic conditions is needed for exposure profiling. The method should utilize a single sample for sizing rather than building a size distribution from fractions collected in different samplers.
4. The emission factors presented herein should be validated by sampling at one or more additional

Western mines and comparing calculated values with the measured ones.

5. Standardized procedures for handling dichotomous filters should be developed. These should address such areas as numbering of the filters rather than their petri dishes, proper exposure for filters used as blanks, transporting exposed filters to the laboratory, equilibrating filters prior to weighing, and evaluation of filter media other than Teflon for studies where only gravimetric data are required.
6. One operation determined in the study design to be a significant dust-producing source, shovel/truck loading of overburden, was not sampled because it was not performed at any of the mines tested. Sampling of this operation at a mine in Wyoming and development of an emission factor would complete the list of emission factors for significant sources at Western coal mines (see Table 2-1 of the full report).
7. Further study of emission rate decay over time from eroding surfaces is needed. In particular, more information should be obtained on the effect of wind gusts in removing the potentially erodible material from the surface during periods when the average windspeed is not high enough to erode the surface
8. More testing of controlled sources should be done so that confidence in the control efficiencies is comparable to that for the uncontrolled emission rates.

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***Jonathan G. Herrmann** and **Thompson G. Pace** are the EPA Project Officers (see below).*

The complete report, entitled "Improved Emission Factors for Fugitive Dust from Western Surface Coal Mining Sources," (Order No. PB 84-170 802; Cost: $23.50, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
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The EPA Project Officer can be contacted at:

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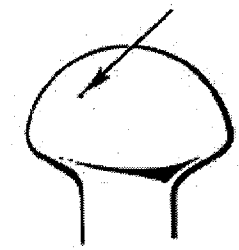
The Role of Chemicals in Controlling Coal Dust Emissions

By
Christopher F. Blazek, VP Marketing, Benetech Inc.
Presented at the American Coal Council
PRB Coal Use: Risk Management Strategies & Tactics Course
June 25, 26, 2003, Hyatt Regency Dearborn, Michigan

Defining the Dust Issue



A Micron-Size Dust Particle on a Pin Head

Dust consists of solid particles carried by air currents. Coal dust originates at impact points (including crushing and grinding), from previous accumulations, or from weathering. A wide range of particle sizes can be produced during a dust generating process. Larger particles settle more quickly than smaller particles, and the smallest particles can remain in the air indefinitely. Dust is typically measured in micrometers (commonly known as microns). Coal dust can range is size from over 100 µm to less than 2 µm. As a comparison, red blood cells are typical 8 µm and human hair ranges from 50-75 µm in size

In coal processing operations, dust is generated-

- When coal is broken by impact, abrasion, crushing, grinding, etc.
- Through release of previously generated dust during operations such as loading, dumping, and transferring
- Through recirculation of previously generated dust by wind or by the movement of workers and machinery

The amount of dust emitted by these activities depends on the physical characteristics of the material and the way in which the material is handled.

Fibrogenic dust, such as free crystalline silica or asbestos, is biologically toxic and, if retained in the lungs, can form scar tissue and impair the lungs' ability to function properly. PRB coal dust exceeds this 1% silica content as is regulated by OSHA to a level not to exceed 2.0 $\mu m/m^3$ of air volume. Furthermore, excessive concentrations of dust in the workplace may reduce visibility, may cause unpleasant deposits in eyes and nasal passages, and may cause injury to the skin or mucous membranes by chemical or mechanical action. From an occupational health view point, dust is classified by size into three primary categories:

- Respirable dust
- Inhalable dust
- Total dust

Respirable dust refers to those dust particles that are small enough to penetrate the nose, upper respiratory system, and travel deep into the lungs. Generally, the body has little ability to remove this respirable dust from the lungs. IMHA defines respirable dust as the fraction of airborne dust that passes a through a sieve, with 100% passing through 10 µm. The EPA describes inhalable dust as that size fraction of dust which

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enters the body, but is trapped in the nose, throat, and upper respiratory tract. The diameter of this dust is about 10 μm and greater. Total dust includes all airborne particles, regardless of their size or composition.

Excessive dust emissions can cause both health and work place problems including:

- Health hazards
  - Occupational respiratory diseases
  - Irritation to eyes, ears, nose and throat
  - Irritation to skin
- Risk of dust explosions and fire
- Damage to equipment
- Impaired visibility and accidents
- Unpleasant odors
- Problems in community relations
- Regulatory citations and fines

Healthy Lung Contaminated Lung

Excessive or long-term exposure to harmful respirable dusts may result in a respiratory disease called pneumoconiosis. Pneumoconiosis is a general name for a number of dust-related lung diseases including:

- **Silicosis** - Silicosis is a form of pneumoconiosis caused by the dust of quartz and other silicates. The condition of the lungs is marked by nodular fibrosis (scarring of the lung tissue), resulting in shortness of breath. Silicosis is an irreversible disease; advanced stages are progressive even if the individual is removed from the exposure.

- **Black Lung** - Black lung is a form of pneumoconiosis in which respirable coal dust particles accumulate in the lungs and darken the tissue. This disease is progressive. Although this disease is commonly known as black lung, its official name is coal worker's pneumoconiosis (CWP).

- **Asbestosis** - Asbestosis is a form of pneumoconiosis caused by asbestos fibers. This disease is also irreversible.

Chemical Dust Suppression Systems

Chemical Dust suppression systems can be used to reduce dust emissions. Although installing a dust control system does not assure total prevention of dust emissions, a well-designed dust control system can further protect workers and often provide other benefits such as:

- Reducing cleanup and maintenance costs
- Reducing equipment wear, especially for components such as bearings and pulleys on which fine dust can cause a "grinding" effect and increase wear or abrasion rates
- Increasing worker morale and productivity
- Assure continuous compliance with existing health and environmental regulations
- Increase plant availability and reliability
- Reduce plant water use relative to water only systems

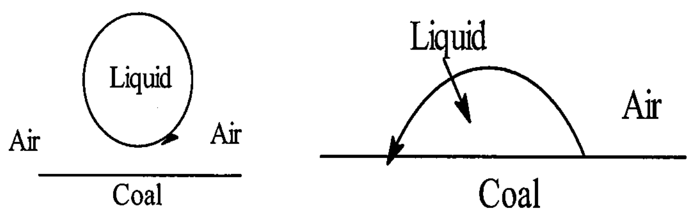
Proper planning, design, installation, operation, and maintenance are essential for an efficient, cost-effective, and reliable chemical dust suppression system. Applications for chemical dust suppression systems in the coal yard include:

- Coal transfer points
- Coal pile and car top residual, sealers & encrusting agents
- Haul road dust control
- Flow enhancers
- Washdown systems
- Yard spray systems

Application Issues

Surface Tension

Coal dust suppression is a complex phenomena; necessitating the use of surface active agents. Coal is water hating (hydrophobic), repelling water from the coal surface. In order to make the coal surface less hydrophobic, a surface active material is added to the water. The surface active material lowers the surface tension of the water to a value closer to that of the coal allowing it to be adsorbed on the surface of the coal. The water, by adsorbing on the coal surface, renders it less hydrophobic. The following figure depicts the phenomena.

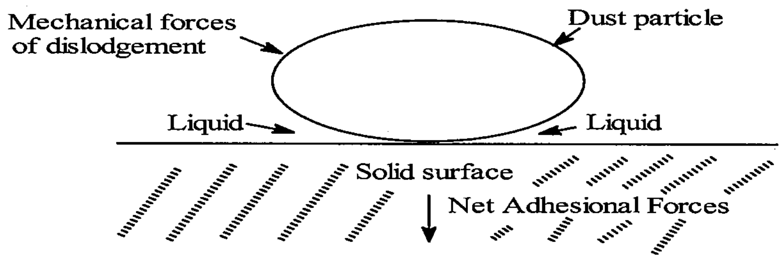


Untreated coal on the left and wet coal on the right.

The surface active agent forms a microscopic liquid film as a means of increasing the adhesion of the coal dust particles. An effective dust suppressant must wet (making it less water hating) the surface of the coal, maintaining a moist environment, and bind the coal dust particles to the coal to prevent regeneration of the dust. Benetech offers a full range of optimized dust suppression products based on our expertise in surface science. These non-flammable, non-toxic, non-explosive and biodegradable products can be used to suppress dust via wetting, foaming, residual, or emulsification processes.

By evaluating contact angles and spreading coefficients of numerous surfactant molecules, Benetech has identified the structure/ property relationships of commercial surfactants and their interaction, contributing to optimum wetting and adhesion. All Benetech formulations contain synergistic combinations of wetting agents, necessary for providing fast, efficient, and effective dust suppression as well as agents to enhance foam quality and overcome problems associated with hard or brackish waters.

The figure below depicts the adsorption and adhesion phenomena associated with effective dust suppression. The wetting of the coal involves the displacement of air from the surface by a liquid; namely, water or an aqueous solution. The addition of a surfactant to the water, by reducing the surface tension of water and perhaps the interfacial tension between the water and the coal particle making spontaneous spreading possible. This occurs in three steps involving adhesion (solid liquid interface at the expense of both liquid - gas and solid - gas) spreading (formation of liquid – gas and liquid - solid at the expense of solid – gas) and immersion (solid – gas interface is replaced by a solid – liquid) wetting.



Adsorption and adhesion phenomena associated with effective dust suppression.

Effective wetting of the coal dust can be achieved by-

- **Static Spreading** - The material is wetted while stationary. Important factors include the diameter and contact angle of water droplets. In general, surface coverage can be increased by reducing either the contact angle or droplet diameter.
- **Dynamic Spreading** - The material is wetted while moving. The droplet impact velocity, surface tension of the liquid, the material size, and the droplet diameter are important variables in dynamic spreading. The surface coverage can be Increasing the surface coverage can be achieved either by reducing the surface tension or by increasing the impact velocity.

Both static and dynamic spreading of a droplet can be increased by reducing the surface tension and thus decreasing the droplet diameter. However, the impact velocity of smaller droplets decreases faster due to frictional drag and less momentum, which, in turn, reduces dynamic spreading. An optimum droplet diameter for maximum material surface coverage must therefore be determined.

Factors Affecting Surface Wetting

Droplet Size

Surface wetting can be increased by reducing the droplet diameter and increasing the number of droplets. This can be achieved by reducing the surface tension/contact angle. The surface tension of pure water is 72.6 dyne/cm. It can be reduced from 72.6 to 28 dyne/cm by adding minute quantities of surfactants. This reduction in surface tension (or contact angle) results in-

- Reduced droplet diameter
- An increase in the number of droplets

- A decrease in the contact angle

Impact Velocity

Surface wetting can be increased by increasing the impact velocity. Impact velocity can be increased by increasing the system's operating pressure. Due to the frictional drag of the turbulent air, the impact velocity of the droplet is less than its discharge velocity from the nozzle. Smaller droplets lose velocity faster than larger ones. To cover the greatest surface area, the best impact velocity for a given droplet diameter must be determined for each operation.

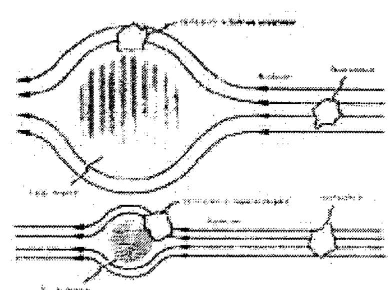
Factors Affecting Collision

The collision between dust particles and water droplets occurs due to the following three factors:

- Impaction/interception
- Droplet size/particle size
- Electrostatic forces

Impaction/Interception

When a dust particle approaches a water droplet, the airflow may sweep the particle around the droplet or, depending on its size, trajectory, and velocity; the dust particle may strike the droplet directly, or barely graze the droplet, forming an aggregate.



Effect of Droplet Size
Schowengerdt and Brown

Droplet Size/Particle Size

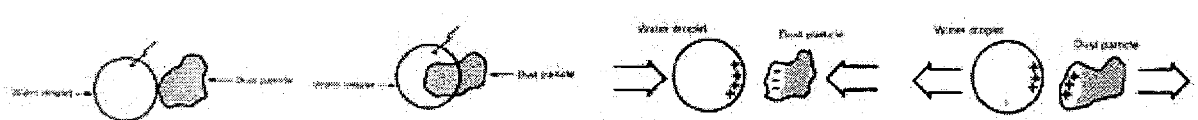
Droplets and particles that are similar in size have the best chance of colliding. Droplets or dust particles that are smaller in size relative to the particle or droplet being impacted may never collide but just be swept around one another.

Electrostatic Forces

The presence of an electrical charge on a droplet affects the path of a particle around the droplet. When particles have an opposite or neutral charge, collision efficiency is increased.

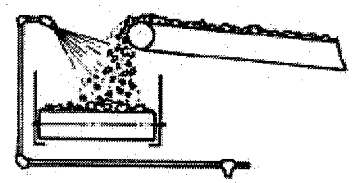
Airborne Dust Capture

When fine droplets are sprayed into the airborne dust, the droplets and dust particles collide and agglomerates are formed. When these agglomerates become too heavy to remain airborne, they settle. Wetting the bulk material also lowers the tendency to generate dust. Keeping the material damp immobilizes the dust, and very little material becomes airborne.



Collision Between Dust Particle and Water Droplet | **Coalescence or Adhesion Between Dust Particle and Water Droplet** | **'ppositely Charged Droplet and Particle Attract Each Other** | **Similarly Charged Droplet and Particle Oppose Each Other**

Finely atomized water sprays are normally used at transfer points without excessive turbulence or when the velocity of dust dispersion is less than 200 ft/min. The optimum droplet size, water usage, relative velocity, and number and location of nozzles depend on the conditions at individual transfer points.



Wet Dust Suppression System

Types of Dust Suppression Systems

Chemical Dust Suppression Systems fall into four broad categories:

- **Water Sprays with Surfactant** - This method uses surfactants to lower the surface tension of water. The droplets spread further and penetrate deeper into the coal. Surfactants can also be used to reduce the friction factor between wet coal particles and transfer surfaces to mitigate pluggage issues.
- **Foam** - Water and a special blend of surfactant make the foam. The foam increases the surface area per unit volume, which increases wetting efficiency.
- **Water Sprays with Binders, Humectants, and Surfactants** – This method uses a binder to create a longer residual suppression effect. The purpose of the humectant is to retard the moisture evaporation process. The surfactant enhances wetting.
- **Emulsions –** Emulsions of water and surfactants are used to suspend normally immiscible binders to create a residual effect suppressant. Oil and latex based emulsions are examples of suppression agents used as car top and pile sealers and road haul suppressants.

Suppression Chemicals

Based on its' expertise in surface science, Benetech offers a wide range of optimized dust suppression products in all of the above categories. These products are non-flammable, non-toxic, non-explosive and biodegradable and can be used to suppress dust via either foam or wetting action.

Coal dust suppression is a complex phenomena; necessitating the use of surface active agents. Coal is water hating (hydrophobic), repelling water from the coal surface. In order to make the coal surface less hydrophobic, a surface active material is added to the water. The surface active material lowers the surface tension of the water to a value closer to that of the coal allowing it to be adsorbed on the surface of the coal. The water by adsorbing on the coal surface renders it less hydrophobic.

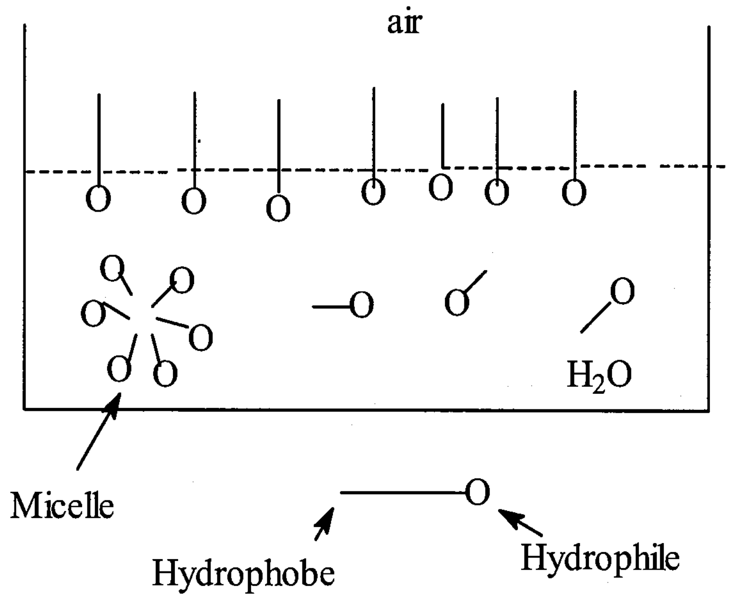
The surface active agent forms a microscopic liquid film as a means of increasing the adhesion of the coal dust particles. An effective dust suppressant must wet (making it less water hating) the surface of the coal, maintaining a moist environment, and bind the coal dust particles to the coal to prevent regeneration of the dust. By evaluating contact angles and spreading coefficients of numerous surfactant molecules, Benetech has identified the structure/ property relationships of commercial surfactants and their interaction, contributing to optimum wetting and adhesion. All Benetech formulations contain synergistic combinations of wetting agents, necessary for providing fast, efficient, and effective dust suppression for a variety of coal types under both hard and brackish water conditions.

Wetters

Coal, a hydrophobic substance, is difficult to be wet with hydrophilic water. In order to wet the surface of coal a surface active agent that lowers the coal air/ air water surface tension is required. A surfactant is a material that, when present at low concentration in a system, has the property of adsorbing onto the surface of the system and of altering to a marked degree the surface properties of the system. A surfactant molecule is a molecule containing two diverse groups. It is composed of a hydrophilic (water loving) head and a hydrophobic (water hating) tail. Two fundamentally dissimilar groups within a single molecule is the most fundamental characteristic of a surfactant. The surface activity is determined by the structural makeup of the two groups. Water is a highly structured substance because of the strong hydrogen bonds between hydrogen and oxygen. When added to water the hydrophobic tail is incompatible and is rejected by the water and is ejected to the surface or interface where it forms a monolayer, thereby lowering the surface tension (See Figure). If the molecule did not contain the water loving head, it would be completely ejected and form a separate immiscible phase. Upon saturation of the solid/ air interface the surfactant forms micelles in the water solution. The concentration of the surfactant at which micelles begin to form is known as the critical micelle concentration (CMC).

The most common hydrophobe is a hydrocarbon, specifically an eight to eighteen carbon chain. The hydrophile can be anionic, cationic or nonionic. Surfactants in which the hydrophilic moiety is a sulfate or sulfonate are anionic. When the hydrophilic group is a polyether group the surfactant is nonionic.

Wet dust suppression requires the formation of microscopic liquid films as a means of increasing the adhesion of coal dust particles through hydrogen bonding. The wetting agent, because of the large surface area must adsorb on the coal particles spontaneously and efficiently. This requires the surfactant to be a highly branched and symmetrical molecule such that it diffuses rapidly from the hydrophilic water environment to the interface where it is adsorbed at the coal/air interface. The highly branched hydrophobe makes micelle formation difficult, hence increasing the number of monomers in solution making diffusion to the interface more rapid and promoting better wetting.

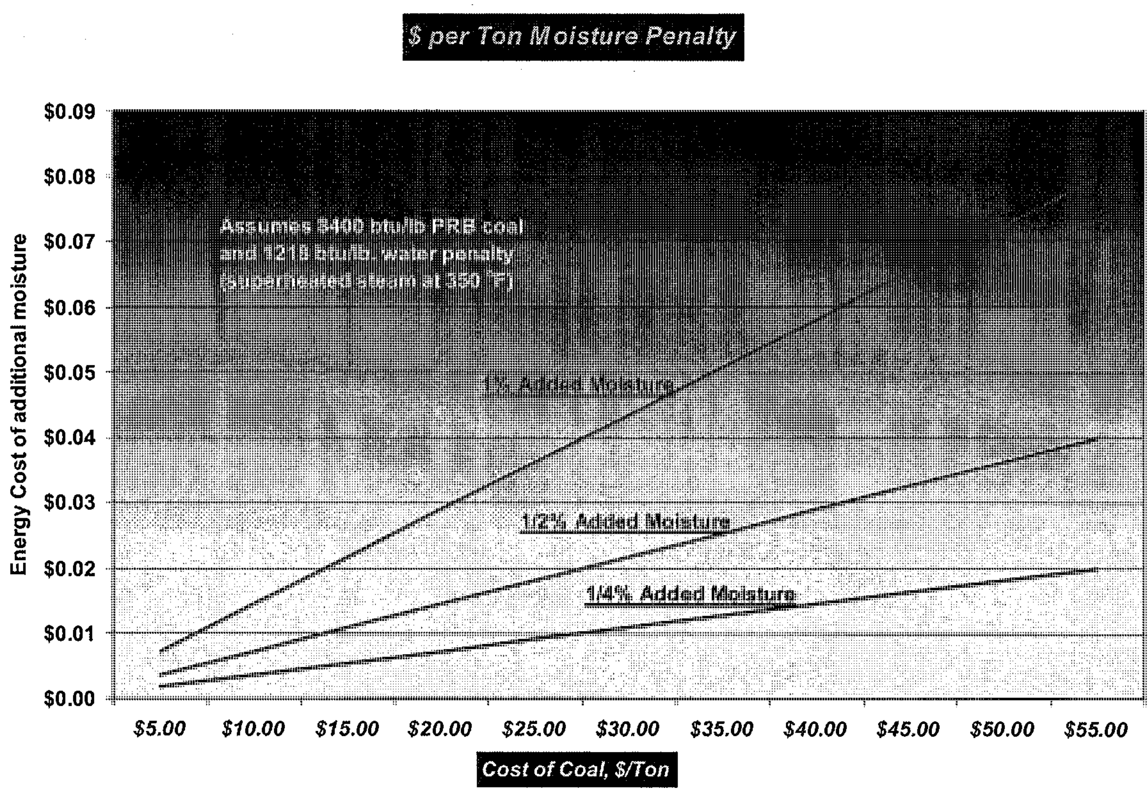


Foamers

Aqueous foamable compositions can be used to suppress coal dust particles. A unique property of foam is its ability to blanket a mass of coal, thereby forming a physical barrier against the dispersion of dust. The foam barrier makes it difficult for the coal dust particles to get airborne. It is preferable to trap the particles before they get airborne. Foam suppression is useful in situations where the quantity of available water is limited or it is desirable to limit the amount of water applied to the coal. The penalty for excess water addition is presented in the following Figure.

Foaming agent formulations frequently contain a wetting agent and a polymer to give body to the foam and reduce the chances of the coal particles becoming airborne after the foam has collapsed. The foam generated is preferably a small bubble foam (100 to 200 microns) allowing efficient trapping of dust particles. A stream of foam interacts with coal particles especially the larger fines. When the foam bubbles impact the coal dust particles, the particles are wetted by the imploding bubbles and captured. Many fine droplets are also released from the collapsing foam, which scrub more fine coal particles. The same principles governing the interaction of coal dust particles with surfactant solutions also govern their action with foam systems.

Foam is a non-equilibrium dispersion of gas bubbles in a relatively smaller volume of liquid. Pure liquids do not foam. Foam is produced when a gas is introduced into a solution whose surface film has viscoelastic properties. The resulting foam possesses a honeycomb arrangement. An essential ingredient in liquid based foam is surface active molecules. These materials reside at the air/ liquid interface and are responsible for both the tendency of a liquid to foam and the stability of the resulting dispersion of gas bubbles. Just as surfactants self-organize (form micelles) in the bulk solution as a result of their hydrophilic and hydrophobic segments, they also preferentially adsorb and organize at the solution – vapor interface. In the case of the aqueous surfactant solution, the tails protrude into the vapor and leave only the hydrophilic heads in contact with the solution. The favorable energetics of the arrangement can be observed and measured by the reduction in the interfacial surface tension. The surfactant concentration is at or slightly above the CMC in most optimized foam situations. At concentrations below the CMC the liquid/ air surface is not saturated and the foam effectiveness is reduced. At concentrations considerably above the CMC the solution loses its film elasticity and the bubbles will collapse. While, the reduced surface tension is not in itself responsible for the foaming; the primary benefit is that less mechanical energy need be supplied to create the large interfacial area in foam.



Many factors promote foam formation. Low equilibrium surface tension, the smaller the cross sectional area the molecule occupies at the air/liquid interface the lower the surface tension and the closer packed the film. A high bulk phase viscosity promotes a slow draining rate for the bubbles and hence more foam. A moderate surface phase viscosity, a moderate rate of attaining equilibrium surface tension and presence of electrical double layer in the surface film also contribute to increased foam. The design of an efficient foam dust suppressant formulation requires a delicate balance of foam wetting properties, as well as consideration of water hardness.

Residual Suppressants

In order to maintain the suppression of the dust for long periods of time, a polymeric hydrophilic material is added. The polymer whether it is anionic or nonionic forms mixed micelles and mixed monolayers with the primary wetting agent. The mixed monolayers are then adsorbed onto the coal. The high molecular weight polymeric material effectively forms a shield preventing the escape of the moisture and ensures that dust particles remain stuck or adhered to each other and to the bulk coal. The polymer also acts as a nucleating agent allowing the micelles to more efficiently form and holding them in the area of the coal. Due to the large molecular weight of the polymers and the presence of hydrophilic groups, they can bind with several coal particles increasing the effective density of the coal particles preventing dusting. Typical polymers include compounds such as ligninsulfonate and polyacrylamides. It is thought that polyacrylamides may serve to reduce the rate of evaporation of water and thereby extend the life of the treatment. In addition to ligninsulfonates, a wide range of other binding agents has been used for long term coal dust control. These major classes of binders include:

- Polymer solutions
- Polymer emulsions
- Oils and oil emulsions
- Asphalt and asphalt emulsions

Humectants

Residual dust suppressant systems must also maintain the moisture content to prevent regeneration of dust. Consequently, the Benetech formulation contains both a humectant and a binder. The humectant is a water loving material which forms strong hydrogen bonds with water making its' removal from the system difficult. When humectants are used alone, such as salts (commonly used for haul road dust control), they have to be used in large amounts. Commonly employed salts include calcium, magnesium, and sodium chlorides and their mixtures. Surfactants are frequently combined with hygroscopic salts to improve the extent of coal dust capture and binding.

Emulsions

<u>Polymer Emulsions</u>

The largest single application of polymer emulsions is for pile sealing and railcar top coating prior to shipment to prevent dust formation and coal loss from the car tops. Latex emulsions, similar to those used in the paint industry are typically deployed. Surfactants are usually added to improve its coal wetting ability.

<u>Asphalt and Asphalt Emulsions</u>

Asphalt or asphalt emulsions have also been used in coal dust control. The use of an asphalt emulsion, in combination with surfactants to wet the coal rapidly, has also been used for rail car top coating and stackout pile sealing. An interesting aspect of these emulsions is their ready ability to "break". Certain surfactant solutions can be used to pre-wet the coal, so that a subsequently applied asphalt emulsion will break to leave a dust suppressing film on the coal surface.

Oils and Oil Emulsions

The use of oil as a coal surface treatment has a long history. Not only does a thin oil film provide an antidusting effect, it also adds heating value to the coal and improves the coal's bulk density – a factor of importance in coke making. Oil emulsions have the advantage that they can be diluted with water for better dispersion. Oil-soluble surfactants can also improve the antidusting properties of oils for treating coal. Oil emulsions can also "break" when they come into contact with certain surfactants.

Laboratory Testing

The effectiveness of a surfactant in modifying the wetting properties of a liquid can be evaluated by determining the spreading coefficient of the surfactant solution. This can be done by measuring both the surface tension of the surfactant solution, and the contact angle the solution makes with the substrate. The Walker and "Drop Box" test represent other common methods for evaluating surfactant effectiveness. The Walker test, first proposed by Walker and co-workers in 1952 was the first laboratory procedure to measure coal dust wetting. In this procedure, approximately 1 gram (1/4 teaspoon) of <200 mesh coal is gently floated on the surface of an aqueous solution of water plus the wetting agent. The time it takes for the coal dust to completely sink is measured and reported. Pure water shows wetting times measured in hours, where even small concentrations of some wetting agents will give wetting times of less than five minutes. This test is useful for evaluating in the laboratory the effectiveness of a given wetting or residual formulation. There is a strong inverse correlation between wetting time and initial dust suppression.

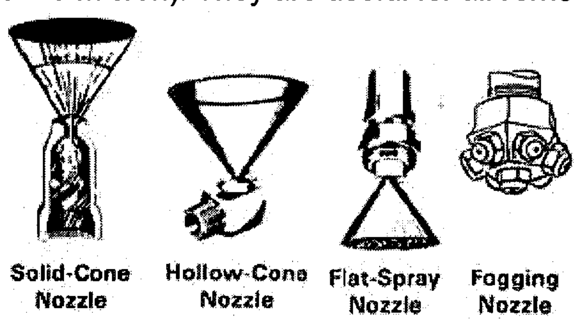
Surfactants are also known to interact with each other producing synergistic enhancement of wetting effects. Wetting agents, especially anionic and nonionic surfactants exhibit synergistic behavior, promoting a more rapid diffusion to the wetting front. Preferred surfactant systems have an optimized ratio of several surfactants. By using mixtures of surfactants one can use less surfactant than would be required for a single surfactant system.

Design of a Water-Spray System

Dust particles need to be trapped in the air and before they become airborne. An important factor in trapping air borne dust particles is the droplet size of the sprayed formulation. Droplets with a clean surface have higher capture efficiencies for dust particles than droplets already containing a trapped particle. The best surfactant system will rapidly remove the trapped dust particle to the interior of the droplet. Consequently, a coarse droplet will more efficiently capture dust than a smaller droplet. The droplet size must also be optimized with the surfactant wetting system for effective suppression. It is easiest and most desirable to knockdown the coal dust particles before they become airborne. This is accomplished by the wet dust suppression formulations.

The spray nozzle is the heart of a water-spray system. Therefore, the physical characteristics of the spray are critical. Factors such as droplet size distribution and velocity, spray pattern and angle, and water flow rate and pressure all vary depending on the nozzle selected. Following is a general discussion of these important factors:

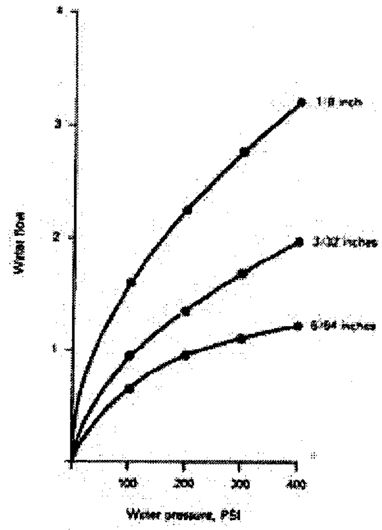
- **Droplet Size**- The nozzle's droplet size distribution is the most important variable for proper dust control. The droplet size decreases as the operating pressure increases. Information about the droplet size data at various operating pressures can be obtained from the nozzle manufacturer. For wet dust suppression systems, coarse droplets (200-500 µm) are recommended. For airborne dust capture systems, very fine droplets (10-150 µm) may be required. The fine droplets usually are generated by fogging nozzles, which may use either compressed air or high-pressure water to atomize water in the desired droplet range.
- **Droplet Velocity** - Normally, higher droplet velocities are desirable for both types of dust control through water sprays. Information on the droplet velocity can be obtained from the nozzle manufacturer.
- **Spray Pattern** - Nozzles are categorized by the spray patterns they produce:
  - Solid-cone nozzles product droplets that maintain a high velocity over a distance. They are useful for providing a high-velocity spray when the nozzle is located distant from the area where dust control is desired.
  - Hollow-cone nozzles produce a spray patter in the form of circular ring. Droplet range is normally smaller than the other types of nozzles. They are useful for operations where dust is widely dispersed.
  - Flat-spray nozzles produce relatively large droplets that are delivered at a high pressure. These nozzles are normally useful for wet dust suppression systems.
  - Fogging nozzles produce a very fine mist (a droplet size distribution ranging from submicron to micron). They are useful for airborne dust control systems.



- **Spray Angle** - Each nozzle has a jet spray angle. The size of this angle is normally available from the manufacturer. A knowledge of spray angle and spray pattern is essential to determine the area of coverage and, therefore, the total number of nozzles needed.
- **Flow Rate** - The flow rate of water through a nozzle depends on the operating pressure. The flow rate and operating pressure are related as follows:

$$\text{Water flow rate} = K^2\sqrt{\text{operating pressure}}$$

where K = nozzle constant



Water Flow/Pressure

Knowledge of the water flow rate through the nozzle is necessary to determine the percentage of moisture added to the material stream. The following factors should be considered in selecting the nozzle location:

- It should be readily accessible for maintenance.
- It should not be in the path of flying material.
- For wet dust suppression systems, nozzles should be **upstream** of the transfer point where dust emissions are being created. Care should be taken to locate nozzles for best mixing of material and water. For airborne dust capture, nozzles should be located to provide **maximum time** for the water droplets to interact with the airborne dust.

Water Flow and Compressed Airflow Rates

Once the nozzle is selected, its spray pattern and area of coverage can be used to determine water flow rate and/or compressed airflow rates and pressure requirements. These must be carefully coordinated with the maximum allowable water usage. Water flow rates will be highly variable depending on the size and type of coal, the application location, and the throughput of coal.

Piping Design

The piping should be designed so that each nozzle receives water or compressed air at specified flow rates and pressures. Drains must be provided at the lowest point in each sub circuit of the piping system to flush the air and water lines in winter months. Heat trace and insulation must also be provided at locations where the temperature may drop below 32° F. The heat tracing should be able to provide approximately 5 watts per linear foot for water pipes up to 2 in. in diameter. The pump and other hardware, such as valves and gauges, should also be placed in a heated enclosure or heat traced and insulated to prevent freezing during winter months.

Instruments

Pressure and flow gauges are recommended to monitor system performance. These instruments should be located as close to the point of application as possible. For situations where it is desirable to activate wet suppression systems only when the material is flowing (for example, if the belt conveyor is running empty, water sprays need not be on), a solenoid-activated valve may be installed in the water line. The solenoid can be activated by instruments such as the level controller or zero speed switch. This approach will reduce water usage, reduce maintenance and cleanup, and reduce or prevent freeze up problems. It is important that electrical, control, and instrumentation meet local condition electrical code requirements. This is typically NEMA 4/9 and Class 2, Div 1, Groups F for dust.

Application Locations

Chemical dust suppressants can be used to control dust at a number of locations. These include:

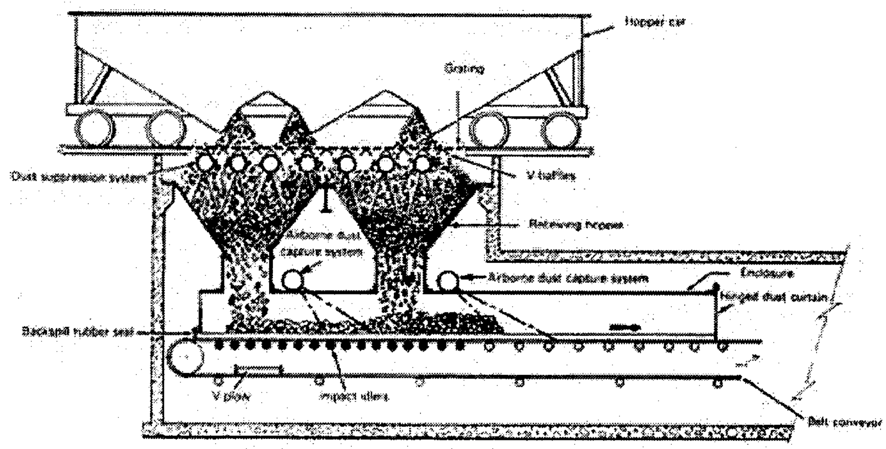
- Coal Transfer Points
- Coal Pile, Car Top, Residual, Sealers and Encrusting Agents
- Haul Road Dust Control
- Flow Enhancers
- Washdown Systems
- Yard Spray Systems
- Flyash Pug Mills

Selection of the application points will be based on a number of factors such as degree of needed dust control, need for downstream dust control, desire for residual control especially on piles and haul roads, restriction on water use, proper spray access to material, availability of support utilities (i.e., water, air, electricity), ease of support equipment placement (i.e., sheds, chemical storage tanks), and length of required supply piping.

In the coal yard, typical application locations include:

- Rail unloading system hopper area
- Barge unloading system hopper area
- Trestle rail unloading area
- Truck / payloader unloading hopper area
- Hopper reclaim feeders/transfer points
- Transfer chutes within towers
- Prior to stackout for stackout dust control as residual dust control from piles
- Bucket reclaim area on stacker / reclaimers
- Yard spray systems to provide residual effectiveness
- Sizing and crushing areas
- Washdown systems to enhance cleaning and reduce water consumption
- In chute areas to reduce wet coal pluggage
- At trippers, cascade, and reversing decks to control dust emissions within the plant and in bunkers and silos

The following diagram presents a typical chemical dust suppression arrangement at a bottom dump rail unloading system. As with all applications, site specific conditions will influence exact spray nozzle header locations to maximize contact with airborne dust and the bulk coal material. Good chemical dust suppression systems can reduce dust levels over 90%, reduce respirable dust below OSHA requirements of 2.0 $\mu m/m^3$, and maintain opacity levels below 10%.



Railroad Dump to Conveyor

E. CALVIN

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A RAIL EMISSION STUDY: FUGITIVE COAL DUST ASSESSMENT AND MITIGATION

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ABSTRACT

A four-year study on fugitive coal dust emissions has produced estimates of coal loss during rail transport and developed suppression techniques that can reduce dusting from rail cars by 95 to 99%. The critical issues of emission characterization and material loss quantification had to be resolved before cost effective dust control strategies could be implemented and evaluated. Laboratory assessments, computer-based simulations, and field experiments were used to model and quantify coal dust emissions. These methods revealed coal losses along a ~500 mile-long rail corridor of up to 0.6 tons/car, with typical losses of 0.2 to 0.4 tons/car from metallurgical coals occurring under sunny, dry and windy conditions. A combination of load-top grooming, surfactants, and chemical binding agents proved to be the most effective method for reducing fugitive coal dust emissions during transit.

INTRODUCTION

Fugitive coal dust from in-transit coal cars does not appear to violate ambient air-quality standards. In fact, track-side monitoring of PM-10/TSP yielded no firm basis for remedial action. At issue, however, is the railroad's goal to reduce coal dust emissions and their impact as a nuisance pollutant.

Most of the evidence of fugitive coal dust emissions comes from anecdotal reports of dust plumes or the observations of coal deposition along the rail corridors. Without any standards of objectivity, coal dust complaints have given rise to the perception of significant a coal dust problem. Accordingly, a study was designed to relate the perceived problem (i.e., visual emissions) to the existence of quantifiable material losses (i.e., material losses that may represent significant environmental impact and/or financial consequences).

Previous attempts to quantify material losses produced mixed and controversial results, (Brown and Speichert, 1976; Guarnaschelli, 1977; Hardy Associates, 1979; Cope, 1980; McCoy, 1980; Williams, et al., 1982; Nobel, et al., 1983; Morrison, Hershfield Ltd., 1983; Cope, et al., 1984; Swan Wooster Engineering Co. Ltd, 1985; Environmental Sciences Ltd., 1985; Cope, et al., 1986; Wituschek, et al., 1986; Stewart, et al., 1987; Mikula and Parsons, 1988). Therefore, the characterization and quantification of losses along Norfolk Southern's (NS) rail corridors were identified as critical issues to be resolved before prescribing effective control strategies. Since early 1991, NS and Simpson Weather Associates (SWA) have conducted numerous laboratory and field-rail experiments to assess the magnitude of material losses and develop techniques to mitigate fugitive coal dust emissions during transit. A coal shipper, CONSOL also contributed to the field studies. This paper presents an overview of the study's ongoing efforts and results to date.

GENERAL STUDY APPROACH

The Norfolk Southern Rail Emission Study (NSRES) was conducted within one rail corridor, through which primarily export metallurgical (met) coal was transported. The choice of the rail corridor was based on its variety of terrain, relatively heavy volume of coal traffic, and the number of coal-dust complaints received. Metallurgical coal was chosen since, in most cases, it is considered more dusty than steam coal.

Field Trials

In an attempt to overcome some of the problems encountered in previous studies, the NSRES employed a number of independent field measurements to 1) act as quality-assurance checks within data sets, 2) to identify and understand aberrant measurements, and 3) to corroborate findings between data sets. Much of the early field data was gathered using a specially designed research caboose. As the study progressed, the instrumentation became more compact, thus reducing the need for the research caboose.

Scale Weights

The first of the field data sets is car weights. These weights were measured using static, decoupled, electronic scales. The scales have a reported accuracy of 0.01%. The weights were taken of selected cars before transit and then again after transit. As a reference, a scale monitor car that traveled with each weighing experiment was weighed at both locations to determine a scale correction factor. In addition, a tarped coal car was used, on occasion, as a second reference. It was assumed that no coal was lost during transit from the tarped car, and moisture loss and gain was minimized. To accurately evaluate the weight changes in coal cars moving from mine to port, moisture variations were taken into account. To account for moisture changes, a water budget was developed containing all known variables of moisture movement in and out of coal cars. Measured rainfall and estimated evaporation values were assigned to the water budget variables so that moisture changes could be used to adjust the scale weight differences. Moisture change correction factors were also empirically generated from coal samples collected in the field. In spite of all the precautions taken to assure accurate scale weights, an uncertainty in coal losses $\pm$ 200 lbs. still remains. This is most likely due to inherent scale inaccuracies and moisture changes that cannot be precisely measured, such as water dripping out the bottom of hopper doors. Because similar problems with scale weights have been encountered in other railroad work, we decided not rely on scale weight changes as the sole determinate for material losses. Rather, we used scale weights and three other methods jointly to arrive at a material loss estimates. These other methods are described below.

Load-top Volume Changes

The second method used to estimate material losses involved measuring the volume changes on the top of the coal loads from the mine to port. For the first several fields trials, a series of photographic transects were taken in selected coal cars at various points along the rail corridor. Scaled photographs of the same cars were compared throughout the trip and material losses were calculated based on volume losses within a given car. Coal within each car settling was taken into account and samples were taken to obtain bulk densities for the mass-loss calculations. It should be noted, that as a part of these calculations, we assumed that no coal was detrained from the top, flat portion of the coal load during transit. Because of this assumption, mass-loss calculations based on volume losses tended to ***underestimate*** actual material losses.

The photographic method of calculating, while general successful, encountered problems related to the changes in bulk densities of coal as it dries and drifts and inadequate measurements in the fronts and rears of cars where significant erosion and redeposition can occur during transit. In addition, the photographic method was very labor intensive. Consequently, another method was developed to estimate volume changes and evaluate redistribution of coal within a car. This method, called the Coal Car Load Profiling System (CCLPS), used three cameras to produce a digital contour map of the coal surface and calculate volume changes from mine to port within a given car. Recently, the CCLPS data gathering process has evolved into an infrared laser-based system which is smaller, faster, and does not require special lighting as did the three-camera technology.

Real-time Observations

To characterize the nature of fugitive dust emissions and develop an understanding of the wind erosion processes on coal cars during transit, an instrument package was designed to monitor a variety of environmental parameters in real time as the cars moved down the rail corridor. The instrument package, Rail Transport Emissions Profiling System (RTEPS) measured the following variables: wind speed, wind direction, rainfall, coal surface temperature, coal temperature and moisture at two different depths, fugitive emissions (using a real-time aerosol sensor, or RAS), air temperature, and relative humidity. All of these data were collected and stored in a data logger attached to RTEPS and were retrieved via a lap top computer at various locations along the corridor. A time-lapse video camera was also part of RTEPS to provide visual records of emission events.

Passive Collection

To directly sample detrained material in transit, passive collectors were designed and built to mount on the rear sill of test cars. The passive collectors were sampled a various stops along the rail corridor to help identify the dustiest portions of the trip.

Dust Suppression Techniques

Once is was determined how much coal was being lost during transit, several mitigation techniques were evaluated, including:

- water only (40 to 100 gallons/car, depending on the experiment);
- grooming ("rounding" of the load profile) only;
- water and compaction;
- surfactants only;
- surfactants plus binding agents;
- binding agents only; and
- tarped cars (used as control cars for various experiments).

Experiments were also conducted where the average train speeds were decreased, and where trips were run mostly at night to decrease emissions. While lower train speeds and coal surface temperatures produced less stress on the coal loads and therefore lower emissions, such operational constraints were neither sufficiently effective nor practical and therefore were not seriously considered as permanent mitigation techniques. In addition, several load profile modifications were used alone, and with the treatments listed above, to abate fugitive dust emissions. Initially, a "normal" profile had a trapezoidal cross-section as shown in Figure 1a. After it was shown that profile modification alone significantly reduced emissions, the "bread-loaf" or groomed profile became the norm (Figure 1b). Other grooming/loading options included loading the coal flat, at or below the car sill level, loading lower than normal, and reshaping the top of the load into the "bread-loaf" shape. For clarification, the following definitions are given for surface treatments.

Normal profile: for the first sixteen field trials, cars that had a trapezoidal cross-section (Figure 1a); for the last fourteen field trials, cars that had an arcuate or " bread-loaf" cross-section (Figure 1b).

Groomed profile: any car that had an arcuate cross-section, or was modified to eliminate angular or trapezoidal cross-section.

Untreated cars: cars that may or may not be groomed, but received no additional water spray, surfactants, nor chemical binders.

Treated cars: cars that may or may not be groomed, but did receive additional water spray and/or surfactants, and/or chemical binders.

RESULTS

Laboratory Evaluations

Using the relative dusting index generated from the SARTDX experiments, coals were ranked according to their dusting potential. The final overall rankings were based on combining three dusting parameters: 1) wind speed threshold (WST), or the lowest wind speed at which emissions were detected; 2) maximum real-time aerosol monitor (RAM) readings; and, 3) total integrated emissions (IE), the calculated area under the entire emissions curve.

Interestingly, when the overall dustiness rankings based on the above three parameters were compared to what the rankings would have been based only on moisture content and fines content, the rankings were found to be discordant. While it is assumed that moisture content and size consist do play a role in a coals' dusting potential, it is clear that other factors (e.g., coal chemistry, moisture migration through the coal, and angle of repose) can play an equally important or even dominant role in dusting during transit.

For the 19 different coals tested in the SARTDX experiments, the inherent coal moisture contents ranged from 2.8 to 11.4%. In order to test all coal samples under the same conditions, it was necessary to dry all samples to approximately 1.5% moisture content (± 0.5%). It is fully recognized that such drying procedures do not reflect actual field conditions, as moisture contents vary significantly from mine to mine. However, the drying process allowed for marked and consistent delineations between the different coals' dusting potential, which was the objective of the SARTDX experiments. Figures 2 a and b, below, show SARTDX wind tunnel plots for two coals. Coal # 1, (Figure 2a) displays a moderate tendency to dust, while Coal # 2 (Figure 2b) shows a much greater propensity to dust during transport. This is displayed in the upper parts of the graphs, along the "Mini-Ram" axis.

Field Studies

Scale Weight Changes

During the field trials, 317 cars were weighed. For the earlier field experiments, a normal profile for a fully loaded coal hopper was trapezoidal in cross-section, had a smooth flat top-surface, and was stacked approximately eighteen to twenty-four inches above the car sill. After taking moisture changes into account, the normally loaded, untreated cars lost an average of 0.36 tons (± 0.1 tons), n = 52. The range for the scale-weight losses was from 0 to 0.6 tons, and some cars actually showed a weight gain--due to water uptake during transport. The greater losses occurred during the most severe (hottest and driest) conditions in the summer months, when wind and train speed averages were highest compared to other field trials.

Those cars that were loaded at or below the sill appeared to loose less coal in most cases, compared to normally loaded and untreated loads, but this difference was not statistically significant. Furthermore, these loading techniques reduced the load capacity for each car by 10 to 15%. Since loading at or below the sill gave mixed dust control results and reduced the load capacity, this dust suppression strategy was abandoned.

For the most recent field trials, the normal load-out procedure was changed to a "bread loaf" profile. The change in profile produced a measurable reduction in the weight losses for the untreated cars, with an average of approximately 0.20 tons (± 0.1), down from the 0.36 tons for ungroomed cars. While load profile changes produced significant decreases in weight losses, further reduction in material losses (95 to 99% from untreated cars, based on passive collection) was achieved by applying surfactants and/or binding agents to the groomed profiles.

RTEPS Data

The RTEPS instrument package offered an independent and corroborative perspective of material losses compared to the scale weight changes and passive collection. RTEPS was not designed to quantify material losses, but to record in real time the intensity and frequency of dusting "events." We emphasize that the emissions are a relative measure (relative to no emissions), and do not represent material losses. There is a strong positive correlation between frequent, intense dusting events during the course of a trip and its scale weight changes and passive collection. Furthermore, the higher the average coal surface temperatures, wind speeds and train speeds, the more frequent and intense the dusting events became (Fig. 3). While riding behind the coal trains in the research caboose, it was clear that dusting increased when coal cars passed through tunnels, over trestles, and close to topographic interfaces. RTEPS data also showed that emissions were most frequent during accelerations between fifteen and thirty miles per hour. The most frequent and intense emissions occurred when the study trains passed other trains moving in the opposite direction at track speeds.

Load-top Volume Changes

The original photographic method for estimating volume changes produced material loss estimates of 0.11 to 0.76 tons, with an average of 0.31 tons (n = 31). For these same cars, scale weight losses averaged 0.36 tons, thus providing some credence to the claim that the photographic method underestimates material losses. An example of "before" and "after" transects are shown in Figure 4. The photographic method also laid the foundation for an automated volume-change detection system such as CCLPS. As CCLPS becomes further developed, we hope to obtain more and more reliable results from our volume/mass-loss calculations.

Trip Stress Index (TSI)

In order to compare the stresses from trip to trip, an index was devised from information collected with RTEPS. Air temperature, coal surface temperature, and wind speed were combined to arrive at a Trip Stress Index (TSI), allowing direct comparison of the stresses from each trip. A relationship between passive collection and TSI was revealed through data analyses and is discussed below.

Passive Collection

Over the course of the thirty field trials, a total of 360 passive collector samples have been taken. The combination of profile modification and chemical sprays has resulted in a 95 to 99% reduction in coal losses compared to normal trapezoidal load profiles according to passive collection data. Statistical analyses of passive collection show that treated cars can be distinguished from untreated cars with a 99.9% confidence level. Table 1 depicts the average passive collection over all trips for untreated versus treated cars. The 153 passive collector samples not shown were either collected during "experimental" treatments, or there was no direct comparison available for treated versus untreated cars for a given experiment.

There appears to be no useful correlation between scale weight changes and passive collection on a car-by-car basis, likely due to the inherent scale inaccuracies and moisture content variations. This is another reason not to rely on the scale weight changes alone for material loss estimates, but instead, to apply independent loss estimates techniques. However, a clear relationship between passive collection and TSI is revealed in Figure 5. This relationship appears to be exponential. On the other hand, the data suggest that there is some threshold above which passive collection (i.e., fugitive emissions) significantly increases.

Surface Treatment Evaluations

As previously mentioned in the "Methodology, Surface treatments" section, a variety of surface treatments were tested during the study for their dust suppression capabilities. Using untreated cars as the reference for judging the success of treatments, results from RTEPS show that water-only treatments, whether sprayed on at the mines or en route, suppressed fugitive emissions for a maximum of only two to three hours under stressful conditions during a thirty-six to seventy-two hour trip. In fact, untreated surfaces actually emitted less dust than water-only treated cars under certain conditions (e.g. freezing temperatures). This was the case for both groomed and ungroomed cars. Grooming alone reduced passive collection and scale weight losses from an average of 0.36 tons to 0.20 tons during the most stressful trips. When profile grooming was combined with chemical treatments, even greater reduction in fugitive emissions was realized, up to 95% over untreated cars.

CONCLUSIONS

A total of thirty field trials have been conducted to date for the NSRES.

Analyses and stratification of a 360,000-car database yielded a standard deviation of about 6 tons in dump weights, masking any meaningful signal for weight losses for the NSRES.

Material losses based on scale weight changes for ungroomed, untreated cars averaged about 0.36 tons/car under high stress trip conditions.

Material losses based on scale weight changes for groomed, untreated averaged about 0.20 tons/car in the high stress trip conditions.

Intensity and frequency of emissions are greatest when the train is accelerating between 15 and 30 miles per hour, and when passing on-coming trains.

Increased fugitive emission events are associated with tunnels, trestles, and topographic interfaces.

The relationship between the Trip Stress Index and passive collection indicated that there is a stress threshold above which fugitive emissions significantly increase.

Based on passive collection, material losses from groomed, treated cars were reduced by up to 95% over untreated and ungroomed cars.

ACKNOWLEDGMENTS

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Table 1. **Passive Collection for Untreated Versus Treated Cars**

UNTREATED CARS AVERAGE (g)	TREATED CARS AVERAGE (g)
n = 113	n = 94
131	5

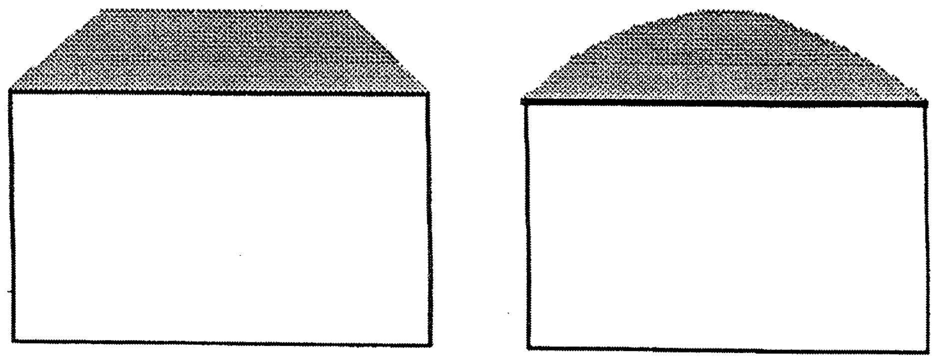

Figure 1a (left) and 1b (right). Cross Sections of Coal Hoppers with Trapezoidal Profiles (1a) and Rounded Profiles (1b)

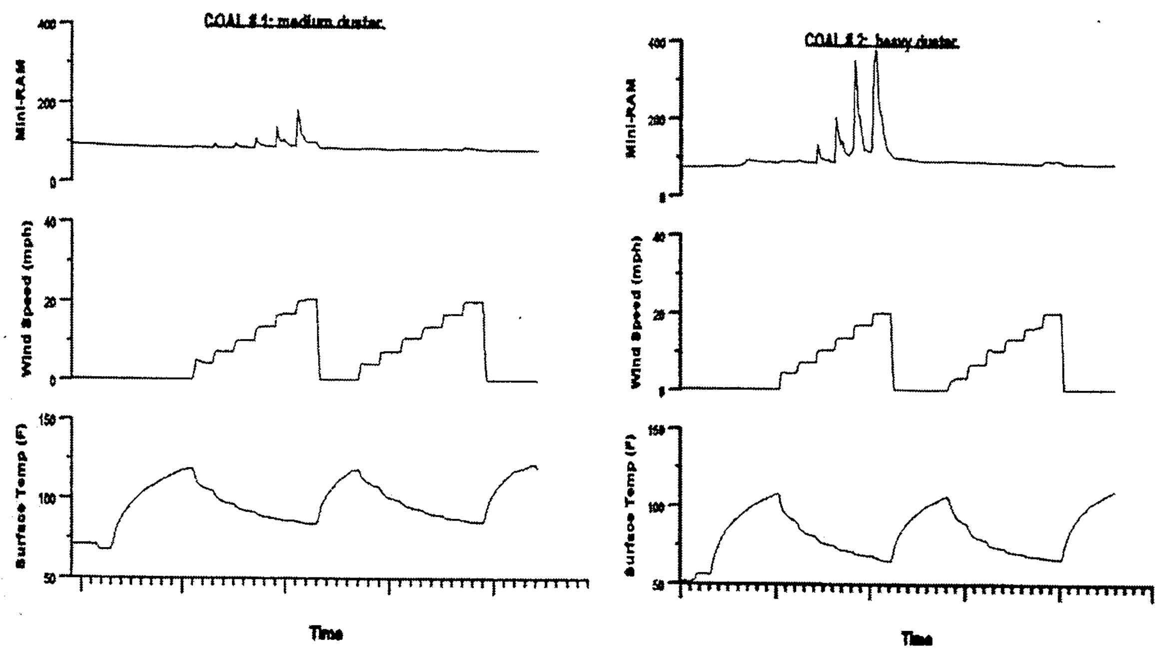

Figure 2a (left) and 2b (right). Graphical Difference Between "Medium" and "Heavy" Dusty Coals According to SARTDX Procedures

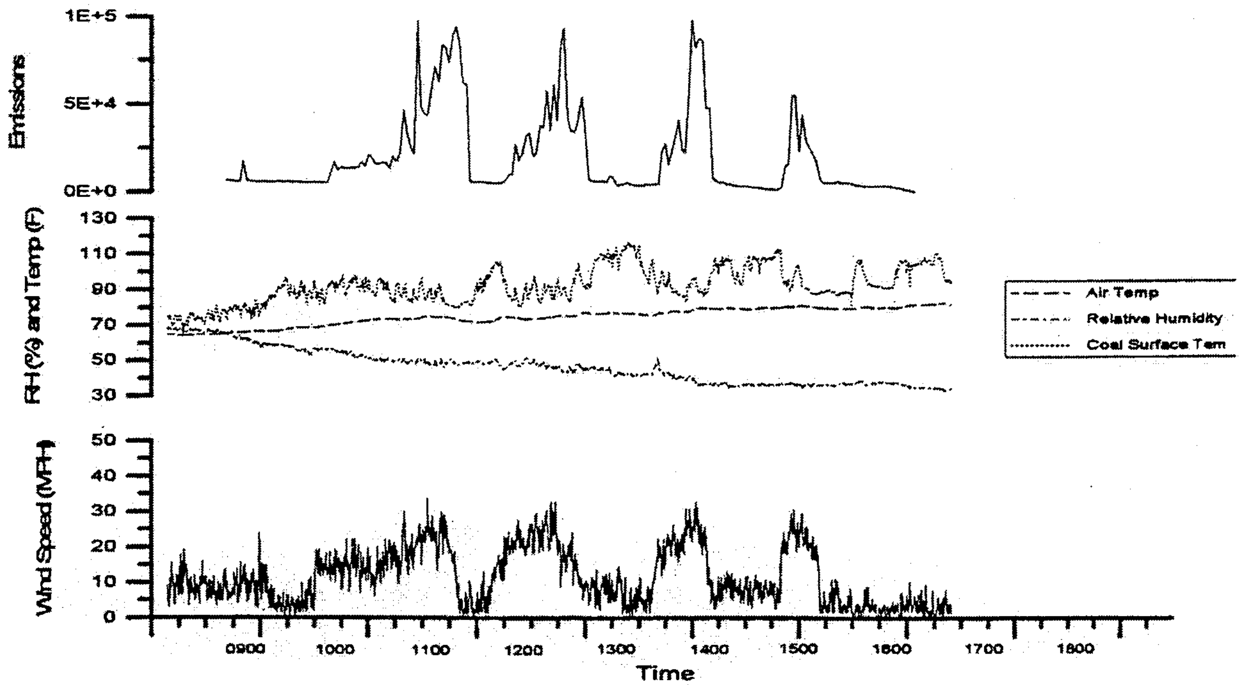

Figure 3. **A Typical RTEPS Trip Profile Showing the Correlation Among Emissions, Coal Surface Temperature, and Wind Speed**

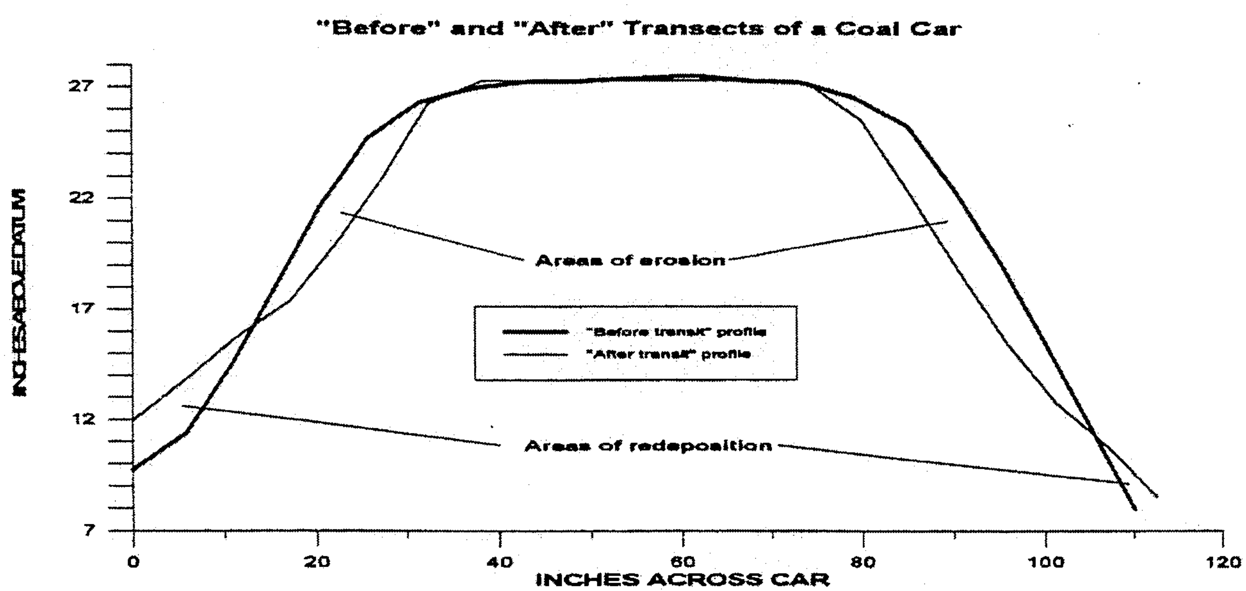

Figure 4. **An Example of a Photographic Transect Across an Untreated Car Showing Areas of Erosion and Deposition**

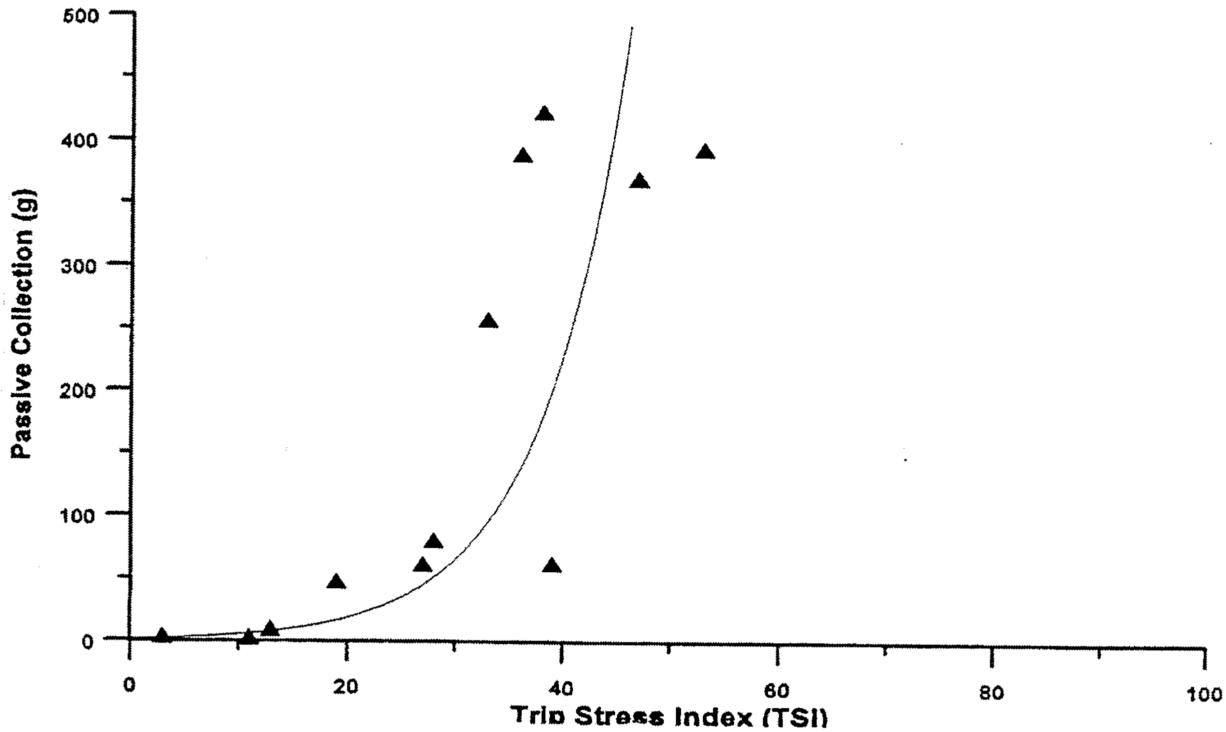

Figure 5. Trip Stress Index Versus Passive Collection

A Study of

Fugitive Coal Dust Emissions In Canada

November 2001

The Canadian Council of Ministers of the Environment (CCME)

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For:

The Canadian Council of Ministers of the Environment (CCME)

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A more complete list of all who contributed to this report is presented in Appendix C.

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EXECUTIVE SUMMARY

In Canada in 2000, coal was mined in five provinces, imported into seven, exported from three and consumed in nine. Coal was transported by barge, ship, truck and by rail. The coal came from mines in Alberta, British Columbia, Saskatchewan, New Brunswick, Nova Scotia, and the United States and was moved to ports and end-use facilities from Newfoundland to British Columbia.

As a result of the activities associated with the mining, shipping, importing, exporting and consuming of coal, coal dust may become airborne or become a *fugitive emission*. However, because of the dispersed and diverse nature of the various operations involved, fugitive coal dust emissions cannot be readily measured. Therefore federal, provincial and regional environment agencies must rely on estimates in order to compute overall emissions totals.

To estimate fugitive coal dust emissions for coal industry operations one requires data related to the following variables:

- quantity of coal mined, handled or shipped,
- the frequency of the activity or operation,
- the length of the activity (distance or time),
- the properties of the coal used,
- the efficiency of control measures, and
- local weather parameters at the time of the activity.

When possible, this information is then combined within an average emission factor (EF) for the particular operation or activity.

The purpose of this study is to attempt to estimate fugitive coal dust emissions for the various operations in the coal cycle from mine to end-use facility in Canada for 2000. However, because nuisance coal dust from trains has been an environmental issue for decades, particular emphasis is placed the emission factors and the emissions estimates from the transport of coal by rail.

Emissions for coal mining in Canada in 2000 were attempted using the latest production data that were available. An attempt was also made to estimate fugitive coal dust emissions at major Coal Terminals and from truck transport for 2000. While the Coal Terminal and truck transport estimates provide and indication as to the emissions from these two sectors, the uncertainties involved in the calculations were extremely high and they should only be considered rough estimates.

Fugitive dusting can also occur in relation to coal storage piles. Unfortunately, while some data in relation to coal storage piles were assembled for 2000, there was insufficient information available to allow fugitive dust estimates to be calculated. Fugitive dust emission from coal storage piles is an area where additional study is required.

In 2000, coal was transported by ship and barge in Canada. However, while some information on these activities has been presented, because of insufficient data, no fugitive dust emission estimates in relation to ship or barge transport were attempted.

As noted, a significant portion of this investigation focuses on fugitive coal dust emissions related to the transport of coal by rail in Canada in 2000. The accuracy of the present emission factors (EFs) for estimating fugitive coal dust from unit trains has been questioned. Therefore, an attempt was made to find new or revised emission factors for that sector. Coal rail transport databases were queried and contacts made in Canada, the United States and Australia.

It was discovered that coal dust emissions from trains are of concern in other countries, particularly in the state of Virginia in the USA. However, no emission factors for coal rail transport appear to have been created, since those developed in the early 1980s.

Regardless, while no new emission factors were discovered, the investigation revealed areas where changes to the present emission factors and their application could improve the accuracy of the rail generated fugitive coal dust estimates in emissions inventories.

For estimating fugitive coal dust emissions from rail transport on a national basis, it is recommended that a modified version the basic emission factor used for the estimates in Environment Canada's national *Criteria Air Contaminants (CAC) Inventory* be used. One modification is to accept that the basic emission factor is for the uncontrolled fugitive dust emissions and not for 75% control as presently assumed. Another modification is in regard to the use of that formula. It is felt that instead of the current practice of using the formula to produce new estimates for each provincial distance segment, an overall estimate for the entire rail journey should be produced. That overall estimate should then be prorated by distance segment. The BC Ministry of Environment Lands and Parks (MELP) currently uses the latter technique to prorate emissions for the Lower Fraser Valley.

For estimating fugitive coal dust emissions from rail, it is recommended that, the basic CAC EF be modified using:

- New PM_{10} and $PM_{2.5}$ scaling factors,
- A precipitation factor,
- An adjusted dust control factor of 99%, and
- A linear distance factor to prorate emissions.

In this study, all of the above factors were employed to estimate emissions for the rail transport sector of the coal industry in 2000.

New scaling ratios for the conversion of total particulate estimates to PM_{10} and $PM_{2.5}$ emissions are suggested. The results of this investigation suggest that the scaling factors presently used by both Environment Canada the BC MELP are too high or too great. Experiments conducted in the 1980s indicated that a fraction of the coal emitted by rail cars is likely greater in size than is allowed for by the present scaling factors.

Also, while using a dust control efficiency of 99% may appear excessive, it is the dust control efficiency currently assumed by Environment Canada for assessing national rail coal dust emissions. The use of an efficiency of 99% is also supported by the visible dusting evidence gathered in 2000 for coal trains in British Columbia. Only about 1% of the loaded coal trains, observed in Hope, BC in 2000, were assessed as 'heavy' emitters in terms of visible dust emissions.

In regard to inventories of fugitive coal dust, the present practice is for the federal and provincial agencies to estimate fugitive coal dust emissions only for coal mining and coal rail transportation. The fugitive dust emissions from truck transport, coal storage piles and large Coal Terminals are not estimated. However, many storage piles and Coal Terminals are located near populated areas. Therefore, it is recommended that emissions from these sources be included in future inventory estimates of fugitive coal dust.

The operations in relation to coal storage piles frequently produce fugitive dust emissions, and the activities involved with storage pile management are many and can vary from day to day. Consequently, the variables involved in estimating emissions are numerous. However, if data related to specific storage piles were available, there are emission factors that could be used for estimating emissions from these sources. It is suggested that regional, provincial and/or national agencies may wish to investigate the possibility of gathering the data required to estimate emissions from the coal storage piles that are located in or near large urban areas.

In addition to the issue of more accurate estimates for PM_{10}, $PM_{2.5}$ and total emissions of fugitive coal dust, there is the issue of nuisance soiling. Since the 1970s, nuisance soiling has been a problem in relation to coal blown from loaded railcars that travel from the Alberta and BC borders to Vancouver. Therefore, in Appendix B this report includes an updated overview of the issue of nuisance soiling from coal blown from railcars.

For unit coal trains, visible dusting incidents cannot be quantitatively linked to overall dust control efficiency. However, the number of visible dust events related to unit coal trains that were reported in 2000 confirm that the emissions control effectiveness of the dust suppressant systems used by certain mines that ship coal to Vancouver was less than 100% in that year.

ABBREVIATIONS

AP-42	-	US EPA Compilation of Air Pollutant Emission Factors
BC MELP	-	British Columbia Ministry of Environment Lands and Parks
CA	-	Coal Association of Canada
CAC	-	Criteria Air Contaminants (Inventory of Environment Canada)
CBDC	-	Cape Breton Development Corporation
CEPA	-	Canadian Environmental Protection Act
CCME	-	Canadian Council of Ministers of the Environment
CCMTA	-	Canadian Council of Motor Transport Administrators
CTA	-	Canadian Transportation Agency
EIA	-	U.S. Department of Energy, Energy Information Administration
EPA	-	U.S. Environmental Protection Agency
EPWG	-	Emissions and Projections Working Group (see NEIPTG)
LFV	-	Lower Fraser Valley – Hope to Vancouver British Columbia
MELP	-	British Columbia Ministry of Environment, Lands and Parks
NAICC	-	National Air Issues Co-ordinating Committee
NCACI	-	National Criteria Air Contaminant Inventory
NEIPTG	-	former name of the EPWG
PART	-	Total Particulate as used by Environment Canada CAC Inventory
PDB	-	Pollution Data Branch, Environment Canada
$PM_{2.5}$	-	Particulate Matter 2.5 micron and smaller
PM_{10}	-	Particulate Matter 10 micron and smaller
TSP	-	Total Suspended Particulate

Glossary of Terms

Emission Factor (EF) - An estimate or statistical average of the rate at which a contaminant is released to the atmosphere as a result of some activity divided by the level of that activity. The Emission Factor (EF), therefore, relates the average quantity of each contaminant emitted according to an appropriate base quantity. EFs are usually expressed as a weight of contaminant divided by a unit weight, volume, distance or duration of associated activity that emits the pollutant. EFs are usually obtained from data of varying degrees of accuracy and may be presented for either uncontrolled sources or facilities having air pollution control devices in place.

fine particulate matter - all particulate matter less than 10 microns in diameter includes both PM_{10} and $PM_{2.5}$ fractions

friable - easily crumbled

fugitive emissions - air pollution derived from human activities that do not emanate from a particular point, such as an exhaust pipe or stack. Coal dust from trains and roadway dust are examples of fugitive emissions.

opacity - the percentage of light transmitted from a source that is prevented from reaching a light detector

overburden - the rock and/or earth covering a seam of coal

Particulate Matter (PM) - any aerosol that is released to the atmosphere in either solid or liquid form. [Includes Particulates]

$PM_{2.5}$ - airborne particulate matter with a mass median diameter less than 2.5 µm

PM_{10} - airborne particulate matter with a mass median diameter less than 10 µm

parts per million (ppm) - a volumetric concentration measurement of contaminants

smoke (diesel) - all particles, including aerosols, suspended in the exhaust stream of a diesel engine that absorb, reflect, or refract light

Total Suspended Particulate (TSP) - airborne particulate matter with an upper size limit generally considered to be approximately 75 µm in aerodynamic equivalent diameter.

transmittance - the fraction of light transmitted from a source which reaches a light detector

unit train - a train with a similar consist of cars and that carries only one cargo. For the purposes of this report, that cargo is coal.

Fugitive Coal Dust Emissions In Canada

Chapter 1

Introduction

In Canada in 2000, coal was mined in five provinces, imported into seven, exported by three and consumed in nine.*

Table 1.1 Coal in Canada in 2000

Province	Mine	Import Coal	Consume Coal
British Columbia	Yes		Yes
Alberta	Yes	Yes	Yes
Saskatchewan	Yes		Yes
Manitoba		Yes	Yes
Ontario		Yes	Yes
Quebec		Yes	Yes
New Brunswick	Yes	Yes	Yes
Nova Scotia	Yes	Yes	Yes
PEI			
Newfoundland		Yes	Yes
All Territories			

* Data as reported by the Coal Association of Canada (CA 2001)

As a result of the activities associated with the mining, transportation, storing, transfer and consumption of coal, coal dust became airborne or became a *fugitive emission*. These airborne fugitive emissions are the subject of this investigation.

1.1 Estimating Fugitive Coal Dust Emissions

Fugitive coal dust emissions are of concern because of their possible adverse health affects, their tendency to soil or to be a nuisance pollutant, and the possibility of their causing cross-contamination of other bulk products.

While the implications of fugitive coal dust emissions on the health of workers in the coal industry (and related industries) are of major importance, they are beyond the scope of this investigation. The objective of this report is to attempt to determine the levels of fugitive coal dust emissions in Canada as they may relate to contributions to urban levels of particulate matter, PM_{10} and $PM_{2.5}$ and to nuisance soiling in 2000.

In general, because of the dispersed and diverse nature of the various operations involved in the extraction, processing, loading, storage, unloading and shipping of coal, fugitive coal dust emissions cannot be readily measured. Therefore federal and provincial environment agencies must rely on estimates. To estimate fugitive coal dust emissions for each coal industry operation one must gather data related to the following variables:

- The quantity of coal mined, handled or shipped,
- The frequency of the activity or operation,
- The length of the activity (distance or time),
- The properties of the coal used,
- The efficiency of control measures, and
- The local weather parameters at the time of the activity.

This information is then combined within an emission factor (EF) for the particular operation or activity.

One purpose of this study is to attempt to gather the emission factors, activity data and coal throughput for the various operations in the coal cycle from mine to end-use facility in 2000 and to estimate emissions of PM_{10}, $PM_{2.5}$ and total particulate. Particular attention is paid to the emissions of fugitive coal dust from unit trains.

An estimate can never be more than just that, an estimate of what is really happening. However, one way of improving the accuracy of estimates is by improving the emission factors used to produce the estimate. Fugitive coal dust from unit trains is one area where the current EFs used by federal, provincial and regional agencies to develop emission estimates require review.

An example as to why accurate fugitive coal dust emission estimates from unit trains are required is a statement from a recent report on the results of the BC program to test smoke emissions from on-road Heavy-Duty Vehicles. (Newhook 2000)

> *In the Vancouver area, despite representing only about 4% of the registered vehicle fleet, Heavy-Duty Diesel Vehicles are estimated to be significant sources of both NOx and PM, contributing 15% of total mobile source NOx and 16% of total mobile source-related PM. The contribution to overall PM would be greater except for a large amount of PM attributable to fugitive coal dust blown from trains, which accounts for 37% of the total mobile source PM inventory.*

In other words, if the emissions estimates for rail generated fugitive coal dust are inaccurate, they may mask the overall contribution of other sources of PM in an airshed.

1.2 Particulate Matter – PM_{10} $PM_{2.5}$ and Total

Particulate matter air pollution refers to a mixture of solid and liquid particles suspended in the air. The smaller particulates are sometimes described as an aerosol, which refers to a stable mixture of particles suspended in a gas. Airborne particulate matter is a mixture of chemical species and size fractions. Airborne particles usually range in diameter from 0.005 to 100 microns in size. *Total Suspended Particulate* (TSP) refers to particulate up to 75 microns in aerodynamic diameter. However, the particles of greatest concern, from a human health perspective, are those with an aerodynamic diameter of less than 10 microns, since they can penetrate the lung.

In Canada for ambient air assessment, fine particulates are currently divided into two distinct fractions. Particulates that are less than 2.5 microns in size ($PM_{2.5}$) and the coarser fraction particulates that are less than 10 microns in aerodynamic diameter (PM_{10}). Minute particulates in the ambient air may occur naturally or be man-made. At present there is a Canada-wide Standard for $PM_{2.5}$ and PM_{10} has been declared toxic under the new *Canadian Environmental Protection Act* (CEPA). (Canada Gazette Part II, 9 May 2001)

1.2.1 Nuisance Dusting

In addition to the issue of fugitive coal dust in regard to human health, and the estimation of those emissions for inventory purposes, there is the problem of nuisance dusting. In this study, an attempt has been made to separate these two issues. However, they are linked, and an overview of nuisance dusting problems, in particular nuisance dusting from unit trains, has been included for completeness. (See Appendix B)

Nuisance soiling or dusting is not specifically defined in the federal government's *Canadian Emissions Inventory of Criteria Air Contaminants*. (Deslauriers 1999) However, in regard to its investigations into fugitive coal dusting, the Australian Environment Department has developed to following definition: (AMEEF 2001)

> *Nuisance dust is a term generally used to describe dust that reduces environmental amenity without necessarily resulting in material environmental harm.*

While attempts to estimate the PM_{10} and $PM_{2.5}$ portions of total fugitive coal dust emissions are relatively new, complaints and investigations into nuisance pollution regarding fugitive coal dust emissions in Canada have a history in many areas of the country.

Table 1.2 General Areas of Nuisance Fugitive Coal Dust Complaints Registered in Canada 1980 to 2000

Province or Territory	Mines	Storage Piles	Trains	Trucks	Terminals and Loading to Ships
British Columbia		yes in 1980s	27 in 2000		yes in 2000
Alberta				road dust only	
Saskatchewan					
Manitoba		yes in 1980s			
Ontario		yes in 1990s			yes in 1980s
Quebec					yes in 1980s
New Brunswick					
Nova Scotia		yes in 1980s			yes in 1980s
PEI					
Newfoundland					
All Territories					

In Table 1.2, the intent is to show the areas where dusting is or has been a problem, and where, to the best that could determined during this short investigation, official complaints have been registered. It was not possible to list number of complaints received in certain areas; since some were community related and involved numerous complaints regarding the same incident.

Dusting from trains is the prime focus of this investigation. In 2000, complaints regarding nuisance dusting from 27 unit coal trains were registered in BC. (See Appendix B)

In British Columbia, nuisance dusting from coal trains has been a source of citizen complaint since 1974. More recently, according to officials with the Canadian Pacific Railway (CPR), there were incidents of dusting in 1994 and sporadically from 1994 to 2000. (CTA 2000)

> *The CPR typically received only a couple of sporadic complaints per year, usually in early summer and usually from residents in the Agassiz and Kent regions.*

Similar dust complaints from residents in the area of Flood, BC were received by Canadian National (CN) in the early to mid-1990s.

Fugitive dust complaints regarding coal emissions from storage piles, either at coal terminals or at end-use facilities, have been registered in at least four provinces since 1974. By the late 1980s, the complaints regarding nuisance dusting that had been received by Environment Canada in connections with coal storage piles included the following: (Cope 1988)

- The International Pier in Sydney, Nova Scotia,
- The storage piles on a pier at Port Stanley, Ontario, and
- The coal stored at the Nanticoke, Ontario power plant.

In 1987 there was an investigation by the Environment Canada and the provincial government regarding complaints from nearby residents of coal dusting from the storage pile and handling at the International Pier in Sydney, Nova Scotia. (Ternan 87)

In the 1980s there were a series of 'town hall' meetings in Port Stanley, Ontario regarding nuisance coal dust complaints in regard to the storage and handling of coal at the port. The coal was for the nearby Saint Mary's Cement plant. Complaints regarding coal dusting in Port Stanley were also received by Environment Canada in the 1990s.

In the 1980s, dusting complaints regarding storage piles and coal transfer operations at ports were registered in Quebec City and in connection with three of the coal terminals in British Columbia. (Cope 1988)

In British Columbia in 2000, the Greater Vancouver Regional District (GVRD) received one complaint regarding dusting from storage piles at the coal export facility at Roberts Bank. (GVRD 2001)

In Manitoba, in the past, nuisance-dusting complaints have been registered by private citizens who reside near Manitoba Hydro's Selkirk Generating Station. However, the possibility of future complaints is moot, since it is reported that over the next two years the Selkirk plant will be converted to natural gas to displace all coal use.

In Alberta, complaints have been received by government agencies regarding fugitive dust generated by coal trucks on haul roads from mine to power plants. These complaints were related to dust emissions from the coal cargo and from road dust.

All of these incidents related to public nuisance dusting from windblown coal illustrate that coal does become airborne and does cause problems in Canada.

Chapter 2

Coal in Canada in 2000

As noted in Chapter 1, in Canada in 2000, coal was mined in five provinces, imported into seven, exported by three and consumed in nine. In this Chapter, the data available at in the spring of 2001 for the coal industry in Canada in 2000 are presented. In many instances, data for 2000 were not available. Cautions have been added to the text, if the data used for emissions calculations were not for 2000.

2.1 Coal Mines

The coal mines operating in Canada in 2000 are illustrated in Table 2.1. While the production data for most of the mines was available for 2000, for a number, 1999 data were used. It was felt that for most cases the changes from 1999 to 2000 were minor.

In regard to fugitive dusting from coal trains, because of its nature and the distances it is shipped, the coal mined in Alberta and British Columbia is the main focus of this study.

The Lignite coal mined in Saskatchewan is by its nature less friable (therefore fewer fines) than most of the Alberta and BC coals. Also, the majority of the Saskatchewan coal is shipped only short distances by truck from mine to end-use facilities. Similarly, in New Brunswick, although the coal is closer to western coal in nature than is the Saskatchewan lignite; it is generally shipped shorter distances than the Alberta and BC coal.

In Nova Scotia, the majority of the province's production was from an underground mine in Cape Breton, and most of that coal was shipped only a short distance from the mine to a local power plant. However, that one remaining underground mine in Cape Breton, the Prince mine, closed in November 2001.

Some of the smaller mines in Nova Scotia ship coal by rail and truck over longer distances, but the quantities are small. There is no historical record of dusting complaints in regard to these shipments.

The majority of coal in Canada is mined in the open in operations that are referred to as open pit or strip mines. By their nature these operations generate dust from blasting, drilling, overburden removal, loading, hauling, unloading, processing, and final transport loading. These two mine types are as defined by their names. In general, an open pit operation takes place in a more concentrated area than does a strip mine. For open pit mines the coal seams may be in a deep pit that extends deep into the ground, or as a pit into the side of a hill or mountain. In some cases such as the Minto area of New Brunswick, coal that was once mined using underground mining techniques is now mined by removing hundreds of feet of rock and dirt, the *overburden*, to get at the coal deep in the ground. A large open pit is formed as a result of this overburden removal. A surface strip mine is a mining operation where, in general, the coal seam is not as deep under the ground than it is in an open pit operation. The coal is mined by stripping the overburden from the surface using devices such as draglines or bulldozers to reach the coal that is below.

Table 2.1 Canadian Coal Mines 2000

Mine	Prov.*	Type	Location	Marketable Coal Production 2000
				(10^6 Tonnes)
Bullmoose	BC	Open Pit	Tumber Ridge, NE **Closing 2003**	1.60
Coal Mountain	BC	Open Pit	SE	2.30
Elkview (Balmer)	BC	Open Pit	SE	3.00
Fording River	BC*	Open Pit	SE	8.30
Greenhills	BC*	Open Pit	SE	4.20
Line Creek	BC	Open Pit	SE	3.50
Quinsam	BC	Underground	Vancouver Island	0.24
Quintette	BC	Open Pit	Northeast – **Closed 2000**	1.00
Willow Creek	BC	Open Pit	Northeast - **open 2001?**	0.00
Coal Valley	**Alta**	Strip	Hinton, NW mid	1.00
Genesee	**Alta***	Strip	Warburg - Mid	3.60
Gregg River	**Alta**	Open Pit	NW mid – **Closed 2000**	2.10
Highvale	**Alta**	Strip	NW	13.00
Luscar	**Alta**	Open Pit	Hinton, NW mid	2.80
Obed	**Alta**	Open Pit	Hinton, NW mid	1.80
Paintearth (+Vesta)	**Alta**	Strip	Mid	3.50
Sheerness (+Montgomery)	**Alta**	Strip	Mid	4.00
Smoky River	**Alta***	Underground + Open Pit	Grande Cache, NW **Closed 2000?**	1.80
Whitewood	**Alta***	Strip	NW	2.30
Bienfait	Sask	Strip	Estevan, SE	2.00
Boundary Dam/Shand (Utility)	Sask	Strip	SE	6.50
Costello	Sask	Strip	Estevan, SE	?
Poplar River	Sask	Strip	SW	4.00
Minto	**NB***	Open Pit	SE - **Closing?**	0.24
Alder Point	NS*	Surface	Cape Breton	0.06
Coalburn	NS	Surface	Thorburn, Pictou County	0.03
Little Pond	NS*	Surface	Cape Breton	0.01
Prince (Phalen closed 00)	NS	Underground	Cape Breton - **Closed 2001**	0.98
Springhill Project	NS*	Surface	Springhill, Cumberland Cty	0.01
St. Rose	NS	Surface	Inverness County	0.03
Stellarton	NS	Surface	Stellarton, Pictou County	0.20

* production information is estimated from 1999 data

While underground mines once dominated the coal mining industry in Canada, in 2000 there were only three underground mines accounted for in the information available on coal mines. One underground mine is located in the interior of Vancouver Island near Comox and the other is the Prince mine in Cape Breton (now closed). Until the end of 2000 there was a combined underground and open pit mining operation in the Smoky River area of Alberta. Since this mine's equipment was listed for sale late in 2000, it was assumed that the mine was closed by the end of 2000. In the 1980s there was also an underground hydraulic coal mine in the area of Sparwood, BC, but this mine is now closed.

2.2 Imported Coal

In 1998 almost 19 million tonnes of coal were imported into Canada. While details related to all imports were not available, the total for 2000 was judged to be similar to the amount imported in 1998, Table 2.2.

For example, in 1998 coal was reported as imported into Alberta, Manitoba and Quebec. (CA 2001) However, information as to similar imports in 2000, and as to how that coal was shipped, was not available.

Fortunately, imported coal for the steel mills in southern Ontario in 2000 was reported. The coal for these mills is landed by ship at or near company facilities on Lake Ontario and Lake Erie. See Table 2.8. (Stelco 2001, Dofasco 2001)

A large quantity of coal is imported each year by *Ontario Power Generation* (OPG) Inc. (OPG is ex-Ontario Hydro). While it is thought that most of this coal arrives by ship and is unloaded at or near the company power plants, this could not be confirmed. Little new information was available regarding the coal imported by Ontario Power Generation Inc. in 2000. However, the total quantity that is imported by OPG annually will change by 2005 when the Lakeview coal generating station is slated to switch to natural gas. Larger cuts in OPG's imports could also occur if the company also switches the Nanticoke plant to natural gas.

The coal imported into New Brunswick arrives by ship at Belledune and is used at the nearby Belledune Power Plant. (NB 2001)

In 2000 Nova Scotia Power Corporation imported just over 2 million tonnes of coal. It arrived by ship at either the International Pier in Sydney or at Auld Cove in the Strait of Canso. With the recent announcement of the closure of the Prince mine in Cape Breton, the quantity of coal imported into Nova Scotia may increase in the near future.

In 2000, a small amount of coal was also imported by ship into Halifax for a private company near Brookfield. It is assumed that this coal was trucked from Halifax to Brookfield, Table 2.6. The coal that is imported into Newfoundland is landed at Sept. Iles, Quebec and shipped by train to Labrador City.

For the purposes of estimating fugitive coal dust emissions, it was assumed that most of the coal imported into Canada in 2000 was landed by ship. It was also assumed that most was landed at end-user port facilities or nearby and transferred by truck, or other wheeled movers, short distances to the end-user facilities.

During the last 20 years fugitive dusting incidents have been reported for coal handled or stored at a number of the receiving terminals and at end-user docks associated with imported coal.

Table 2.2 Coal Imported into Canada - 2000

	Destination	Landed at	Delivered by	Imports
				tonnes
Alberta	**Alberta Total =**			**6,324***
Manitoba	**Manitoba Total =**			**493,902***
Ontario	St. Mary's Cement	Port Stanley	ship	?
	Dofasco	Hamilton	ship	1,500,000
	Stelco	Hilton Works, Hamilton	ship	1,026,660
	Stelco	Lake Erie Works	ship	744,629
	Lambton Power Plant			3,421,680*
	Nanticoke Power Plant			7,236,809*
	Lakeview Power Plant			1,243,452*
	Ontario Total =			**15,173,231**
Quebec	**Quebec Total =**			**847,043***
NB	Belledune Power Plant	Belledune	ship	**1,022,070**
NFLD	Iron Ore Coy, Labrador City	Sept. Iles	ship	**49,471**
NS	NS Power Corp	International Pier, CB	ship	1,200,000
	NS Power Corp	Auld Cove, St. of Canso	ship	850,000
	Lafarge Canada, Brookfield	Halifax	ship	35,000
	NS Total =			**2,085,000**
			Total Canada =	19,677,041

* 1998 data

2.3 Exported Coal

In 2000, three coal terminals in British Columbia and one in Ontario exported Coal, Table 2.3

These four terminals are large operations that feature a circular loop of track for unloading mile long unit trains. Some of these terminals handle a variety of bulk products in addition to coal.

These four coal terminals feature rotary-dumpers for emptying their coal cars. These dumpers operate with cars that are fitted with special couplers that allow individual cars to be dumped without the necessity of decoupling.

The Neptune, Thunder Bay and Roberts Bank rotary-dumpers are located inside housings that limit dusting during the unloading operations.

In the 1990s, it is reported that the Quinsam mine on Vancouver Island exported coal via a small terminal facility on Texada Island in the Strait of Georgia. It was reported that this mine did not export coal in 2000.

Table 2.3 Canadian Coal Exports - 2000

Terminal	Name Location	Prov	tonnes	Mines that may have Supplied Export Coal in 2000
Westshore Terminals Ltd.	Roberts Bank Vancouver	BC	22,500,000	Coal Valley, Gregg River Luscar, Obed, Alta Coal Mountain, Elkview, Line Creek, Fording River, Greenhills, BC Powder River Basin, Montana Powder River Basin, Wyoming
Neptune Bulk Terminals (Canada) Ltd.	Vancouver Harbour Vancouver	BC	4,962,000	Coal Valley, Gregg River Luscar, Obed, Alta Smoky River, Alta
Texada Island	Texada Island Strait of Georgia	BC	0	Quinsam, BC
Ridley Terminals Inc.	Ridley Island Prince Rupert	BC	6,000,000*	Coal Valley, Gregg River Luscar, Obed, Alta Bullmoose, Quintette, BC
Thunder Bay Terminals Ltd.	McKellar Island Thunder Bay	Ont	1,830,000*	Coal Valley, Gregg River Luscar, Obed, Alta Coal Mountain, Line Creek, BC Bienfait, Sask Powder River Basin, USA
	Canada Exports	=	35,292,000	

* 1999 data from the Coal Association

2.4 Transportation – Rail, Truck and Vessels

Coal from Canadian mines is moved to market by rail, truck, barge or ship. As far as could be determined, in 2000, most of the coal imported into Canada arrived by ship and was unloaded near the facilities where it would be used.

2.4.1 Rail Transport

In Western Canada, unit trains are used to move coal from mines along the BC/Alberta border to terminals in Vancouver, Prince Rupert and Thunder Bay, Tables 2.5 and 2.6.

In Saskatchewan unit trains are used to move lignite coal from the Poplar River mine approximately 20 km to the Poplar River Power Plant. The Bienfait mine ships lignite coal by rail to Ontario for use at power plants near Thunder Bay. The rest of the lignite coal mined in Saskatchewan is moved by truck to nearby power plants.

In Western Canada, three rail companies haul domestic coal by unit train: (Table 2.4)

- Canadian Pacific (CP)
- Canadian National (CN)
- British Columbia Railway (BCR)

Table 2.4 Canadian Railway Coal Car Fleets in Western Canada

Railway Company	CP	CN**	BCR
1985			
Train Sets	19	12	9
Total Cars	2250	1379	889
2001			
Train Sets	?	12	2
Total Cars	3211*	1379	~200

* includes 625 new cars added in 2000 and an additional 625 that will be added in 2001. (CPR 2000)

** An information update for 2000 was not available

In 2000, the Canadian National reported that it transports metallurgical and thermal coal for the export market in a unit train configuration in rotary gondola cars. The length of the CN unit trains is 112 cars for their 53-foot cars (including new aluminum cars) and 102 cars for standard 58-foot steel car sets. CN also moves coal, metallurgical coke, and petroleum coke in small car blocks or single cars in other types of equipment, such as covered hoppers and bottom dump cars. (CN 2001)

CP added 625 new coal cars in 2000 and added 625 more new cars in 2001. (CP 2000) With the closing of one mine in Northeast BC, the BCR now operates fewer coal car sets than it did in the 1980s.

The movement of coal by rail in Atlantic Canada is on a much smaller scale than in the West. In the 1980s, some of the coal from the Minto mine in New Brunswick moved by rail to a power plant near the Quebec border. However, in 2000, it was reported that Minto coal was shipped by truck to the local power plant at Grand Lake and to the power plant at Belledune, NB. (NB 2001)

In Nova Scotia, details regarding all of the coal movements were not available. However, it is known that the majority of the coal from the Prince mine (the only large active mine in that Glace Bay group in 2000) was shipped by unit train approximately 8 km to the Lingan power plant.

While coal was shipped in other parts of Canada in 2000, it is felt that little of this coal is shipped by rail.

The Iron Ore Company of Canada imported a small quantity of coal for use at its facility near Labrador City. This coal was landed by ship in Sept. Iles, Quebec and taken by rail to Labrador.

In addition to imports, both the Roberts Bank and Thunder Bay terminals are reported to be experimenting with transshipping coal for export from the Powder River Basin in the USA via their terminals. This coal will enter and be transported through Canada in unit trains. The exact routes are not known at this time.

Unfortunately, as noted, during the short span of this investigation, information on the method of transporting most of the imported coal in Canada in 2000 was not available.

Table 2.5 Rail Shipment of Coal in Canada - 2000

Ship by Rail in 2000 from	From	To ⇒	Roberts Bank, BC	Neptune, BC	Ridley Island, BC	Thunder Bay, Ont	Other Destinations
Originating Mine	**Prov.**	**Transport Railway Coy.**					
Bullmoose	BC	BCR/CN			yes		
Coal Mountain	BC	CP	yes			yes	
Elkview (Balmer)	BC	CP	yes				
Fording River	BC	CP	yes				
Greenhills	BC	CP	yes				
Line Creek	BC	CP	yes			yes	
Quintette	BC	BCR/CN			yes		
Coal Valley *	**Alta**	CN	yes	yes	yes	yes	
Gregg River *	**Alta**	CP	yes	yes	yes	yes	
Luscar *	**Alta**	CN	yes	yes	yes	yes	
Obed *	**Alta**	CN	yes	yes	yes	yes	
Smoky River	**Alta**	CN		yes			
Bienfait	Sask	CN & CP				yes	Ont Power
Poplar River	Sask	Dedicated rail					Sask Local
Prince	**NS**	Dedicated rail					NS Local
Imported Coal							
For Iron Ore Company	Nfld	?					Que to Labrador
Transshipment							
Powder River Basin, Montana	**BC**		yes				
Powder River Basin, Wyoming	**BC**		yes				
Powder River Basin	Ont					yes	

* coal may not have been shipped to all four terminals in 2000. Breakdown not known.

Table 2.6 Quantity of Coal Shipped by Rail in Canada - 2000

Mine	Prov.	Status 2000	millions of tonnes
Bullmoose	**BC**	Closing 2003	1.60
Coal Mountain	**BC**	operating	2.30
Elkview (Balmer)	**BC**	operating	3.00
Fording River	**BC**	operating	8.30
Greenhills	**BC**	operating	4.20
Line Creek	**BC**	operating	3.50
Quintette	**BC**	closed in 2000	1.00
Coal Valley	Alta	operating	1.00
Gregg River	Alta	closed in 2000	2.10
Luscar	Alta	operating	2.80
Obed	Alta	operating	1.80
Smoky River	Alta	closed in 2000?	1.80
Bienfait	**Sask**	operating	2.00
Poplar River	**Sask**	local train	4.00
Prince (Phalen)	NS	operating	0.98
Imports by Rail			
For Iron Ore Cy	**Nfld**	via Que	0.05
Transshipment			
Powder River Basin, Montana	RB, BC	test only	?
Powder River Basin, Wyoming	RB, BC	test only	?
Powder River Basin	**TB, Ont**	test only	?

2.4.2 Truck Transport

In this report, for emissions calculation purposes, the transport of coal by truck refers only to the movement of marketable coal away from the property of the originating mine, Table 2.7. The information reported in Table 2.7 does not include the movement of coal from mine face to preparation facility or to mine load-out. For these operations, and the fugitive emissions associated with them, it was assumed that emissions related to these activities are included in, and accounted for, under 'mining' operations.

In Saskatchewan, trucks are used to move lignite coal from mine to market in all operations with the exception of those described in Section 2.4.1 for the Poplar River and the Bienfait mines. Most truck shipments in the province involve the movement of the lignite coal to nearby power plants.

As noted, in the 1980s, some of the coal from the Minto mine in New Brunswick moved by rail, however, in 2000 it was reported that all coal from the Minto mine was moved by truck to the nearby Grand Lake power plant or to the Belledune power plant. (NB 2001) For the future, NB Power has recently announced a plan to shut the Grand Lake facility in 2004. The fate of Minto coal and the mine is not known at this time.

Also, information was not available in regard to the movement of the coal imported by the Nova Scotia Power Corporation. For this report it was assumed that it was moved by truck. Similarly for a small amount of coal imported by ship to Halifax for a private company near Brookfield. It was assumed that the coal was trucked from Halifax.

In 2000 the Quinsam mine on Vancouver Island shipped coal by truck to port facilities in the Comox area where the coal was loaded on barges for shipment to end-use plants in the Lower Fraser Valley.

Also in British Columbia in 2000, the Bullmoose mine in the Northeast moved its coal by truck from the mine approximately 36 kilometers to the rail load-out.

2.4.3 Vessels, Ship and Barge, Transport

In 2000, all of the coal exported from Canada from the terminals listed in Section 2.3 was loaded into and transported by ship. Although it could not be confirmed at the time of writing, it was assumed that most of the coal imported into Canada in 2000 also arrived by ship, Section 2.2.

Other coal that is moved by water in Canada includes a quantity that is shipped by barge from Comox, BC. In the 1990s some of this coal was barged to Texada Island, BC for export. However, in 2000 the coal from Comox was reported as shipped by barge to local end-use facilities, likely cement plants, in the Lower Fraser Valley.

The coal from mines in BC and Alberta that arrives by rail at Thunder Bay is loaded into ships for transport to Ontario and to export.

Table 2.7 Coal Moved by Truck in Canada - 2000

Mine	Prov.	To	Distance km	millions of tonnes
Bullmoose	**BC**	Truck to Rail Load-out	36	1.60
Quinsam #	**BC**	Truck to Barge	50	0.24
Genesee *	Alta	Genesee Power Plant	10	3.60
Highvale **	Alta	Keephills Power Plant	10	3.63
Highvale **	Alta	Sundance Power Plant	10	9.37
Paintearth	Alta	Battle River Power Plant	5	3.50
Sheerness	Alta	Sheerness Power Plant	5	4.00
Whitewood *	Alta	Wabamun Power Plant	10	2.30
Boundary Dam/Shand **	**Sask**	Boundary Dam Power Plant	10	4.84
Boundary Dam/Shand **	**Sask**	Shand Power Plant	10	1.66
Bienfait #	**Sask**	Char Facility	5	0.20
Minto	NB	Grand Lake Power Plant	35	0.122
Minto#	NB	Belledune Power Plants	270	0.122
Alder Point #	**NS**	Domestic Coal Yard	40	0.06
Little Pond	**NS**	Lingan Power Plant	20	0.01
Springhill Project #	**NS**	Trenton Power Plant	100	0.01
St. Rose #	**NS**	Trenton Power Plant	200	0.03
Stellarton #	**NS**	Trenton Power Plant	10	0.20
Coalburn#	**NS**	Trenton Power Plant	20	0.03
Coal Imported by		**Landed at** / **For use by**		
NS Power Corp.#	NS	International Pier / Lingan & Pt Aconi	20	1.20
NS Power Corp.#	NS	Auld Cove / Trenton & P Tupper	100	0.85
Lafarge Canada#	NS	Halifax / Kilns at Brookfield	80	0.035
St. Mary's Cement#	**Ont**	Port Stanley, Ont. / St. Mary's Ont.	80	?

** prorated by Megawatts for Power Plant **# distances are approximations** *1999 data

The quantity of western coal shipped to Ontario Power Generation for use in their Power Plants was not available, but the quantities used by Dofasco and Stelco in their steel operations is shown in Table 2.8. (Selco 2001, Dofasco 2001)

Stelco received one trial shipment of coal from Western Canada in 2000. This coal arrived by ship from Thunder Bay. The company has planned for four such shipments, or approximately 94,000 tonnes, in 2001.

In 2000 Nova Scotia Power Corporation imported just over two million tonnes of coal. It arrived by ship at either the International Pier in Sydney or at Auld Cove in the Strait of Canso. (NS Power Corp, 2001) A small amount of coal was also imported by ship to Halifax for use by a private company near Brookfield. It was assumed that this coal was trucked from Halifax.

The data regarding the movement of coal by ship and barge in Canadian waters in 2000 was extremely limited. In regard to the emissions of fugitive coal dust, no information as to the nature of the shipments made by water was available. It was assumed that all coal shipped by powered vessels was in covered holds, therefore emissions while underway should be minimal. The only reported shipments by barge were from Vancouver Island to facilities in and around Vancouver. Whether the barges were covered or open was not reported. No attempt has been made to estimate emissions from ships or barges while underway.

Table 2.8 Coal Moved by Ship or Barge - 2000

Port Where Landed	Destination	Source	Port Shipped From	Quantity 2000 tonnes
Canadian Coal				
Hamilton, Ontario	Dofasco	Western Canada	Thunder Bay, Ont	200,000
Hamilton, Ontario	Stelco	Western Canada	Thunder Bay, Ont	94,000
Port Stanley, Ont	St. Mary's Cement	?	?	?
Ontario	?	Coal Mountain, BC	Thunder Bay, Ont	?
Ontario	?	Line Creek, BC	Thunder Bay, Ont	?
Texada, BC	by barge for export	Quinsam, BC	Comox, BC	0
Vancouver, BC	by barge	Quinsam, BC	Comox, BC	240,000
Imported Coal				
Internaional Pier, Sydney	Lingan & Point Aconi PPs	?	?	1,200,000
Auld Cove, S of Canso	Point Tupper & Trenton PPs	?	?	850000
Halifax, NS	Lafarge, Brookfield	?	?	35,000
Belledune, NB	Belledune PP	?	?	1,022,070
Sept. Isle, Quebec	Iron Ore Coy, Labrador City	?	?	49,471
Hamilton, Ontario	Dofasco	USA	?	1,500,000
Hamilton, Ontario	Stelco	USA	Toledo or Sandusky	1,026,660
Lake Erie, Ontario	Stelco	USA	Toledo or Sandusky	744,629
Sarnia, Ont	Ont Power Gen Lambton PP	USA	?	?
Nanticoke, Ont	Ont Power Gen Nanticoke PP	USA	?	?
Toronto, Ontario	Ont Power Gen Lakeview PP	USA	?	?

2.5 Storage Piles

At many junctures during the process that takes coal from mine face to end-use facility, coal will be stored. This storage may be long or short term. The coal may be stockpiled in the open or it may be housed in a containment structure.

In Western Canada it is not uncommon for mines to have rail load-out facilities that feature coal storage silos that can hold up to a full unit train load (over 10,000 tonnes of coal) or more. However, at end-use facilities and import/export terminals, because of the size of the operations, it is more common for coal to be stored in uncovered piles.

For this study, because of the limited data that were available, the discussion of dusting from storage piles in Canada must remain general. An attempt has been made to list the facilities in Canada in 2000 that were *likely* to have stored coal in piles (mines excluded), Table 2.9

Table 2.9 Major Coal Storage Sites in Canada – 2000

Port or End-Use Facility	Prov	Total Coal Throughput	Port or End-Use Facility	Prov	Total Coal Throughput
Terminals		**tonnes**	**Landed at For Power Plant**		
Westshore, Roberts Bank	BC	22,500,000	Sarnia Lambton PP	Ont*#	3,421,680
Neptune, Vancouver	BC	4,962,000	Nanticoke Power Plant	Ont*#	7,236,809
Texada Island	BC	0	Toronto Lakeview PP	Ont*#	1,243,452
Ridley, Prince Rupert	BC**	6,000,000	Belledune Power Plant	NB	1,143,570
Thunder Bay	Ont**	1,830,000	International Pier, CB	NS	1,200,000
Landed at For			NS Power Corp	NS	1,200,000
Hamilton Dofasco	Ont	1,500,000	Auld Cove	NS	850,000
Hamilton Stelco	Ont	1,026,660	NS Power Corp	NS	850,000
Lake Erie Stelco	Ont	744,629	**Other Power Plants**		**tonnes**
Port Stanley	Ont	?	Genesee Power Plant	Alta**	3,600,000
St. Mary's Cement	Ont	?	Sundance Power Plant	Alta#	9,368,344
Sept. Iles	Que	49,471	Keephills Power Plant	Alta#	3,631,656
Iron Ore Coy	Nfld	49,471	Battle River Power Plant	Alta	3,500,000
Montreal?	Que	731,000	Sheerness Power Plant	Alta	4,000,000
End Use for ?	Que**	731,000	Wabamun Power Plant	Alta**	2,300,000
Halifax	NS	35,000	Selkirk Power Plant	Man	276,483
Lafarge Brookfield	NS	35,000	Brandon Power Plant	Man	275,930
Comox	BC	240,000	Grand Lake Power Plant	NB	121,500
Cement Plants LFV	BC	240,000	Lingan Power Plant	NS	1,670,000
Other Facilities			Trenton Power Plant	NS	820,000
Char Facility	Sask#	200,000	Point Aconi Power Plant	NS	385,000
Domestic Coal Yard	NS	60,000	Point Tupper Power Plant	NS	425,000
			Thunder Bay Power Plant	Ont*#	624,197
			Atikokan Power Plant	Ont*#	423,861
			Boundary Dam Power Plant	Sask#	4,840,426
			Shand Power Plant	Sask#	1,659,574
			Poplar River Power Plant	Sask#	4,000,000

* 1998 data   ** 1999 data   # prorated by megawatts

2.6 End-Use Facilities

Many of the 'end-use' facilities for coal in Canada in 2000 are also as listed in Table 2.9. While there were more small users in each province, the facilities listed are those that account for the bulk of the coal consumed in Canada in 2000.

In 2000, fugitive coal dust emissions at end-use facilities were likely associated with the unloading and movement of coal to and from storage piles located at or near the facilities.

Chapter 3
Estimating Fugitive Coal Dust Emissions

As noted earlier, fugitive coal dust emissions cannot be readily measured and must be estimated. In general, because of the widespread nature of most coal operations, they are usually treated as *Area Sources* for the purpose of estimating emissions. Area Sources are defined as: *Activities or sources of emissions that are too numerous or too small to be accounted for on an individual basis*. (Deslauriers 1999) Therefore, federal and provincial environment agencies and the coal industry must rely on general emission estimates for evaluating the impact of windblown fugitive coal dust.

There are many variables that can affect fugitive coal dust emissions, and hence emission estimates. Since these parameters can vary from site to site and from case to case, it is difficult to accurately estimate fugitive emissions. In general, collective averages must be employed. Unfortunately, under most circumstances, combining generalized emission factors (EFs) with generalized activity data is the only method that is available for estimating fugitive coal dust emissions.

Historically, fugitive coal dust emissions for each coal industry sector or operation are estimated by combining the quantity of coal mined, handled or shipped with the frequency of the activity or operation. The general equation for estimating uncontrolled fugitive coal dust emissions is:

$$\textit{Uncontrolled Emissions} = \textit{EF} \times \textit{Quantity of Coal} \times \textit{Activity Factor} \quad (3.1)$$

Where:

EF = the emission factor for the activity in kg/tonne of coal
Quantity of Coal = the quantity in tonnes that is mined or moved
Activity Factor = the number of times (or duration or distance) the activity takes place in a year

To account for the impact of emissions controls modify equation 3.1 by applying a percentage related to control efficiency:

$$\textit{Controlled Emissions} = \textit{EF} \times \textit{Quantity of Coal} \times \textit{Activity Factor} \times (100 - \textit{Control Efficiency})/100 \quad (3.2)$$

Where:

Control Efficiency = the % efficacy of the control
i.e. if the Control Efficiency is 99% enter 99 in the formula.

3.1 Federal - Provincial Estimates for Fugitive Coal Dust Emissions

The Canadian Emissions Inventory of Criteria Air Contaminants (CAC Inventory) is published every five years by Environment Canada. (Deslauriers 1995, 1999) That inventory attempts to draw together data from across the country on the emissions of Particulate Matter, Sulphur Oxides, Oxides of Nitrogen, Carbon Monoxide and Volatile Organic Compounds. The CAC Inventory collects information from each province and territory to assemble its emissions estimates.

For particulate emissions until the 1990 inventory, only emissions of Total Particulate Matter (TPM) were reported. For the 1995 and future inventories, emissions of PM_{10} and $PM_{2.5}$ have been added to the TPM emission estimates.

The emission factors and formulas employed in the CAC Inventory to estimate fugitive coal dust emissions are described in the *1995 Criteria Contaminants Emissions Inventory Guidebook*, section 1.9.1 Industrial Sector: Coal Mining and Processing. (NEIPTG 1999)

For computing emission estimates PM_{10} and $PM_{2.5}$, Environment Canada, the provinces and the United States Environmental Protection Agency (EPA) apply scaling factors to the emission factors developed for estimating total particulate matter or PART. Emissions of PM_{10} and $PM_{2.5}$ are calculated by multiplying the appropriate scaling factor by either the EFs or the calculated emissions.

In general, the techniques used by Environment Canada, and the provinces to estimate fugitive coal dust emissions do not differ. The one exception is in British Columbia where officials used a different EF for estimating emissions for the rail transport of coal. Therefore, for the 1995 CAC Inventory, *coal dusting from unit trains* was the only sector where a province used a fugitive coal dust emission factor and technique that was different from the one used by Environment Canada. (See Chapter 5)

The techniques for estimating fugitive coal dust emissions for the coal industry from coal mine to end-user are discussed in the ensuing chapters. In general, unless it was discovered that there were problems in relation to the techniques employed for the *1995 CAC Inventory* estimates, those methods were used in this report. (Deslauriers 1999)

3.2 Parameters Affecting Emissions and Control

As noted, because of their fugitive or unconfined nature, it is difficult to predict or estimate the severity of coal dust emissions from any source. The factors that may affect fugitive coal dust emissions regardless of source include:

- type of coal
- coal fines content
- coal moisture content
- frequency of activity or frequency of disturbance of the coal
- surface area exposed
- ambient conditions: precipitation, wind speed, heat, freezing

3.2.1 Weather

As noted, one of the factors that will have an effect on fugitive coal dusting is the local ambient weather. The factors likely to have the most influence on fugitive dusting are precipitation, maximum temperature and wind speed and direction.

In general, most fugitive dusting complaints in regard to nuisance soiling, regardless of source, have been associated with periods of high temperature, high wind and little or no precipitation. For coal carried by rail over long distances in open rail cars in unit trains, it is not just the local weather at the time of emissions that can influence the severity of the dust emissions episodes. Hot and dry weather 'up route' of the emissions can influence the emissions at the point of observation. See discussion Section 5.2.3.1.

Chapter 4

Coal Mining - Fugitive Coal Dust Emission and Control

4.1 Coal Mining

The mining of coal comprises a number of activities depending upon mine type. In 2000 in Canada, there were three types of coal mines: underground, open pit and strip mines.

4.1.1 Underground Coal Mines

As noted in Chapter 2, in Canada in 2000 there were two underground coal-mining operations, accounted for in the information available on coal mines, plus a third that combined an underground mine with an open pit mine. (Table 2.1)

Underground mines by their nature will emit far less fugitive dust, above ground, into the local ambient environment than surface mines of a similar productivity. In this report, when estimating emissions for the two underground operations in 2000, dust emissions were only calculated for surface unloading activities.

4.1.2 Surface Coal Mines

As noted in Chapter 2, there were two general types of surface coal mine in operation in Canada in 2000, *Open Pit Mines* and *Strip Mines*. For surface and open pit mines, fugitive coal dust can be generated in connection with any one of the following operations:

- Overburden Removal and Replacement
- Drilling and Blasting
- Dragline or Bulldozer Operation
- Loading and Unloading
- Transfers Mine to and from Process Plant

The drilling and blasting may be associated with both the overburden removal operation or to the actual mining of the coal seam. The overburden, the earth or rock covering the coal seam must be broken up and moved to another site. This may be accomplished using bulldozers, shovels, mobile loaders and trucks and/or by a dragline.

Once the overburden has been removed, the coal must be moved from the mine face to the processing plant. This may be achieved by number of means that may include loaders, draglines, trucks, and/or conveyor systems. Coal dust will be become airborne and fugitive emissions will result as a result of any one of these repetitive operations.

For air pollution inventory purposes, it is virtually impossible to account for every one of these operations at every mine in each province. Therefore, the norm is for activities to be grouped together. An attempt is then made to present emission factors for each of the groups of activities in terms of the total coal mined each year, Section 4.2.

4.1.3 Process Plant Emissions

Most coal undergoes some level of processing after it is mined and before it is shipped to the end-user. The processing required may be a relatively simply operation that involves the crushing or breaking of the coal into a size that can be used by an end-user. However, many operations in Western Canada use more sophisticated processing. The processing of coal often involves a complex series of steps that may include sizing, washing, cleaning and sometimes drying operations. These operations usually take place in a coal cleaning or processing building. The extent to which different shipments of coal from the same mine are processed can also vary depending upon the requirements of the end-user or customer.

While coal dust may become wind borne as a result of coal-cleaning and processing operations, these emissions cannot truly be described as 'fugitive'. The processing operations at the majority of mines in western Canada normally take place in enclosed structures. These operations usually require emission controls that are covered under provincial permits and emissions will be regulated accordingly. This is particularly true for operations that require coal to be processed and thermally dried.

Emissions related to *Coal Processing* plants are not included in this report because:

1. They are "processing plants" and not an open wind-blown fugitive dust sources,
2. They are contained in structures with sophisticated emissions controls,
3. The emissions and their control should be known and covered by provincial permits,
4. Loading to and from the plants is covered under general mining fugitive emissions, and
5. Virtually all of their fugitive dust emissions are likely confined to mine property.

Not including possible fugitive emissions related to *Coal Processing* is supported by the control efficiencies listed in the *Air and Waste Management Association* (AWMA) manual. The manual lists the control efficiency for coal cleaning as 100%. Therefore, for most of the large coal mining operations in Western Canada, the fugitive dust emissions from Coal Processing would be close to zero. (AWMA 2000)

The dusting associated with coal loading and unloading from process plants is considered to be included under the loading and unloading operations associated with coal mining, Table 4.1. Other coal emissions associated with *Coal Processing* or coal-cleaning are considered beyond the scope of this report and have not been estimated.

4.2 Emission factors - Coal Mines

For emission inventory purposes, provincial and federal governments estimate fugitive dust emissions from mining operations, using the emission factors (EFs) shown in Table 4.1. The NEIPTG Guidebook states that these emission factors were "taken from section 11.9 of AP-42 5th edition (U.S. EPA 1995), and from factors used in previous Environment Canada inventories". (NEIPTG 1999)

The PM_{10} and $PM_{2.5}$ emission factors were derived using data from the EPA SPECIATE software. The scaling factors used for the CAC Inventory 1995 emissions estimates were:

$$PM_{10} = 0.545 \times PART$$
$$PM_{2.5} = 0.33 \times PART$$

Where: PART is the EF for total particulate matter (TPM).

Obviously, the emission factors in Table 4.1 are the generalized EFs that are used to estimate emissions for *Area Sources* in emissions inventories. Their strength is that they allow universal application to any coal mining operation for which yearly quantity of coal mined is know. They can be applied to individual mines or to total provincial production data.

The weakness of the emission factors shown in Table 4.1 is that, other than in a general way, they do not account for individual coal mining operations and the specific parameters at those mines that can influence fugitive coal dust emissions.

Table 4.1 CAC 1995 Inventory Coal Mining – Uncontrolled Emission Factors

Coal Mining Emission Factors	PART	PM_{10}	$PM_{2.5}$
	kg/tonne	kg/tonne	kg/tonne
Mining	0.0130	0.0071	0.0043
Raw Coal Loading – mine	0.0200	0.0109	0.0066
Raw Coal Unloading - mine	0.0330	0.0180	0.0109
Overburden Removal	0.0060	0.0033*	0.00198*
Pile Wind Erosion (t/ha)	0.85		

* Correction made for scaling factor PART = total particulate

The NEIPTG Guidebook (NEIPTG 1999) does not mention dust control techniques or efficiency of dust suppression methods in connection with the coal mining EFs. Therefore, it is assumed that the emission factors and the resulting estimates are for uncontrolled emissions.

As illustrated in Table 4.2, the information presented by the US EPA in the latest version of Table 11.9-2 of AP-42 contains more complicated EFs for coal mining than are currently employed for computing provincial and national emissions for the 1995 CAC Inventory. The EFs in Table 4.2 are clearly labeled by the EPA as uncontrolled emission factors. (EPA 2001-2) However, although these EFs may produce more accurate emission estimates for coal mining, they are intended for application to individual mines where the factors that may influence emissions are known for specific operations.

While data related to these parameters could be obtained for individual Canadian mines, such information is not readily available and is not public knowledge. Considerable resources would be required to assess and report on individual coal mining operations.

The influence of weather on coal mining emissions is also not included or accounted for by the EFs in either Table 4.1 or 4.2. Heavy precipitation and snow cover will likely limit fugitive dust emissions by inhibiting the wind entrainment of coal dust. Since weather conditions and their influence on coal dusting may vary on a day to day or week to week basis, detailed weather recording would be required at or near mine sites in order to judge the influence of local weather on fugitive dusting. A discussion of the potential influence of weather on fugitive coal dust emissions is presented in Section 5.2.3.1.

For this study, the EFs used to compile the 1995 CAC Inventory were used to compute fugitive coal dust emissions for coal mining, Section 4.4.

Table 4.2 US EPA AP-42 Table

(Table 11.9-2 EPA 2001-2)

EMISSION FACTOR EQUATIONS FOR UNCONTROLLED OPEN DUST SOURCES AT WESTERN SURFACE COAL MINES

		Emissions By Particle Size Range (Aerodynamic Diameter)[b,c]				
		Emission Factor Equations		Scaling Factors		
Operation	Material	TSP <30 µm	<15 µm	<10 µm[d]	<2.5 µm/TSP[e]	Units
Blasting f	Coal or Overburden	$0.00022(A)^{1.5}$	ND	0.52[e]	0.03	kg/blast
Truck loading	Coal	$0.580/(M)^{1.2}$	$0.0596/(M)^{0.9}$	0.75	0.019	kg/Mg
Bulldozing	Coal	$35.6\ (s)^{1.2}/(M)^{1.4}$	$8.44\ (s)^{1.5}/(M)^{1.4}$	0.75	0.022	kg/hr
	Overburden	$2.6\ (s)^{1.2}/(M)^{1.3}$	$0.45\ (s)^{1.5}/(M)^{1.4}$	0.75	0.105	kg/hr
Dragline	Overburden	$0.0046\ (d)^{1.1}/(M)^{0.3}$	$0.0029\ (d)^{0.7}/(M)^{0.3}$	0.75	0.017	kg/m 3
Vehicle traffic[g] Grading		$0.0034\ (S)^{2.5}$	$0.0056\ (S)^{2.0}$	0.6	0.031	kg/VKT
Active storage pile[h] (wind erosion and maintenance)	Coal	1.8 u	ND	ND	ND	kg/(hectare)(hr)

Note all symbols < should be < or equal to

VKT = vehicle kilometers traveled. ND = no data. b Particulate matter less than or equal to 30 µm in aerodynamic diameter is sometimes termed "suspendable particulate" and is often used as a surrogate for TSP (total suspended particulate). TSP denotes what is measured by a standard high volume sampler.

c Symbols for equations:

A = horizontal area (m^2), with blasting depth < 21 m. Not for vertical face of a bench.

M = material moisture content (%)

s = material silt content (%)

u = wind speed (m/sec)

d = drop height (m)

W = mean vehicle weight (Mg)

w = mean number of wheels

d Multiply the < 15-µm equation by this fraction to determine emissions, except as noted.

e Multiply the TSP predictive equation by this fraction to determine emissions.

f Blasting factor taken from a reexamination of field test data.

g To estimate emissions from traffic on unpaved surfaces by vehicles such as haul trucks, light-to-medium duty vehicles, or scrapers in the travel mode, see the unpaved road emission factor equation in AP-42 Section 13.2.2

4.3 Fugitive Dust Control - Coal Mines

In general, fugitive dust control at an underground coal mine is more of an occupational health issue for workers than it is an environmental issue. It is therefore beyond the scope of this investigation. However, for surface mining activities coal dust control may include one or more of the following (Note, rail transport fugitive dust control measures at coal mines are addressed separately in Chapter 5.):

- water sprays at appropriate locations
- water and sealant sprays on roads
- covered conveyor systems
- enclosed crushing, cleaning and processing operations
- cyclones and scrubbers at cleaning plants and transfer points
- enclosed or covered storage piles
- enclosed rail load-out facilities

As noted, the emission factors in the NEIPTG Guidebook (NEIPTG 1999) were used to compute fugitive coal dust emissions related to Canadian coal mining operations in 2000. Since no mention is made in that publication as to dust control techniques or efficiency of dust suppression methods, it is assumed that the emission factors and the resulting estimates are for uncontrolled emissions.

If the control efficiency of specific dust control features at specific mines is known, then the EFs could be modified as illustrated in equation 3.2, Chapter 3.

4.4 Emissions Estimates - Coal Mines

As noted, the CAC Inventory methodology as described in the NEIPTG Guidebook (NEIPTG 1999) was used to compute the fugitive coal dust emissions related to Canadian coal mining operations in 2000. As noted above, it is assumed that the emission factors from the NEIPTG Guidebook, Table 4.1, and the resulting estimates are for uncontrolled fugitive coal dust emissions.

The production data for most mines was available for 2000. However, for a number, 1999 data were used. It was felt that for most of these the changes from 1999 to 2000 were likely minor.

For this report, for the coal mining emissions estimates, the following changes were made to the CAC Inventory data and methodology:

- The Quinsam mine in BC is now an underground mine. Formerly it was an open pit surface mine.
- For the coal mining Emission Factors Table 1.9.1 in the Guidebook there appears to be an error in scaled EFs for PM_{10} and $PM_{2.5}$ in Overburden Removal. Using the $PM_{10} = 0.545$ x PART and .5 $PM_{2.5} = 0.33$ x PART the EF for PM_{10} should be 0.0033 not 0.0031 and $PM_{2.5}$ should be 0.00198 and not 0.0009. The changes were made and the EFs shown in Table 4.1 were used.

Only the 'unloading' segment of surface mining operations group of activities was used to make emissions calculations for the two underground mines in 2000. (Table 4.1)

The uncontrolled fugitive coal dust emissions estimates calculated for Canadian coal mines for 2000 are presented in Table 4.3. Because no data were available related to the size of the storage piles at individual mines, storage pile emissions at mines were not estimated. The sources used for the mine related data used in the calculations are listed in Appendix C.

4.5 Discussion – Fugitive Coal Dust from Coal Mining Operations

The EFs currently used to calculate fugitive coal dust emissions for coal mining operations are well suited for producing general provincial or national estimates. However, it must be recognized that they have their limitations in regard to accuracy in estimating emissions from individual mines. If an agency wishes to obtain more accurate estimates of emissions for a particular mine, it is suggested that the more detailed EFs that are contained in the EPA's AP-42 could be used. However, in order to apply these EFs individual day-to-day operations at a particular mine would have to be recorded for a significant period in order to develop acceptable average or mean values.

For example, to apply the EFs in Table 4.2, one would have to know details such as: the number of blasts per day, the hours that bulldozers were used, the dragline drop heights, the kilometers and trips made by trucks and graders plus the size of storage piles. This information would then be combined with the silt and moisture content of the coal.

Of importance for inventory consideration is the location of most mines in Canada. Most are situated in isolated areas away from populated urban centres. Therefore, it is suggested that for their inventories, agencies may wish to segregate PM_{10} and $PM_{2.5}$ emissions from coal mining from PM_{10} and $PM_{2.5}$ emissions estimates for the other sources that are located in and around urban population centres.

Cautionary notes regarding the emissions estimates in Table 4.3:

- The 'overburden' emissions estimates are likely to include non-coal dust.
- These annual emissions estimates do not account for the likely mitigating effect on fugitive emissions of localized precipitation.
- The emission factors that were used are general averages and therefore the uncertainties associated with the emissions estimates are likely to be high.

Table 4.3 Uncontrolled Fugitive Coal Dust Estimates for Coal Mining Operations for 2000 (Emissions in tonnes)

Use CAC EFs	Prov	Gross#	PART	PM_{10}	$PM_{2.5}$	PART	PM_{10}	$PM_{2.5}$	PART	PM_{10}	$PM_{2.5}$	PART	PM_{10}	$PM_{2.5}$	PART	PM_{10}	$PM_{2.5}$
Mines		**Mt**	**Mining**	**Mining**	**Mining**	Loading	Loading	Loading	**Unload**	**Unload**	**Unload**	OverB	OverB	OverB	**Total**	**Total**	**Total**
Bullmoose	**BC**	2.30	29.9	16.3	9.9	46.0	25.1	15.2	75.9	41.4	25.0	13.8	7.5	4.6	165.6	90.3	54.6
Coal Mountain	**BC**	3.37	43.9	23.9	14.5	67.5	36.8	22.3	111.3	60.7	36.7	20.2	11.0	6.7	242.9	132.4	80.2
Elkview (Balmer)	**BC**	5.14	66.9	36.4	22.1	102.9	56.1	33.9	169.7	92.5	56.0	30.9	16.8	10.2	370.3	201.8	122.2
Fording River	**BC***	12.93	168.0	91.6	55.5	258.5	140.9	85.3	426.6	232.5	140.8	77.6	42.3	25.6	930.7	507.2	307.1
Greenhills	**BC***	5.36	69.7	38.0	23.0	107.2	58.4	35.4	176.8	96.4	58.4	32.2	17.5	10.6	385.8	210.3	127.3
Line Creek	**BC**	4.90	63.7	34.7	21.0	98.0	53.4	32.3	161.7	88.1	53.4	29.4	16.0	9.7	352.8	192.3	116.4
Quintette	**BC**	2.09	27.1	14.8	9.0	41.7	22.7	13.8	68.9	37.5	22.7	12.5	6.8	4.1	150.3	81.9	49.6
Quinsam (UG mine)	**BC**	0.24	**			**			7.9	4.3	2.4	**			7.9	4.3	2.4
Coal Valley	**Alta**	1.84	23.9	13.1	7.9	36.8	20.1	12.2	60.8	33.1	20.1	11.1	6.0	3.6	132.6	72.3	43.8
Genesee	**Alta***	4.32	56.2	30.6	18.5	86.4	47.1	28.5	142.6	77.7	47.0	25.9	14.1	8.6	311.0	169.5	102.6
Gregg River	**Alta**	2.98	38.8	21.1	12.8	59.7	32.5	19.7	98.5	53.7	32.5	17.9	9.8	5.9	214.9	117.1	70.9
Luscar	**Alta**	3.41	44.3	24.2	14.6	68.2	37.2	22.5	112.5	61.3	37.1	20.5	11.1	6.7	245.4	133.8	81.0
Highvale	**Alta**	13.22	171.9	93.7	56.7	264.4	144.1	87.3	436.3	237.8	144.0	79.3	43.2	26.2	952.0	518.8	314.2
Obed	**Alta**	3.78	49.1	26.8	16.2	75.6	41.2	24.9	124.7	68.0	41.2	22.7	12.4	7.5	272.2	148.3	89.8
Paintearth (+Vesta)	**Alta**	3.50	45.5	24.8	15.0	70.0	38.2	23.1	115.5	62.9	38.1	21.0	11.4	6.9	252.0	137.3	83.2
Sheerness (+ Montgomery)	**Alta**	4.00	52.0	28.3	17.2	80.0	43.6	26.4	132.0	71.9	43.6	24.0	13.1	7.9	288.0	157.0	95.0
Smoky River (UG & OP mine)	**Alta***	1.97	25.6	14.0	8.5	39.4	21.5	13.0	65.0	35.4	21.5	11.8	6.4	3.9	141.8	77.3	46.8
Whitewood	**Alta***	2.39	31.0	16.9	10.2	47.7	26.0	15.7	78.7	42.9	26.0	14.3	7.8	4.7	171.7	93.6	56.7
Bienfait	**Sask**	2.00	26.0	14.2	8.6	40.0	21.8	13.2	66.0	36.0	21.8	12.0	6.5	4.0	144.0	78.5	47.5
Boundary Dam/Shand (Utility)	**Sask**	6.50	84.5	46.1	27.9	130.0	70.9	42.9	214.5	116.9	70.8	39.0	21.3	12.9	468.0	255.1	154.4
Costello	**Sask**	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Poplar River	**Sask**	4.00	52.0	28.3	17.2	80.0	43.6	26.4	132.0	71.9	43.6	24.0	13.1	7.9	288.0	157.0	95.0
Minto	**NB**	0.24	3.2	1.7	1.0	4.9	2.6	1.6	8.0	4.4	2.6	1.5	0.8	0.5	17.5	9.5	5.8
Prince (UG mine)	**NS**	1.15	**			**			38.0	20.7	12.5	**			38.0	20.7	12.5
Alder Point	**NS**	0.06	0.8	0.4	0.3	1.2	0.7	0.4	2.0	1.1	0.7	0.4	0.2	0.1	4.3	2.4	1.4
Coalburn	**NS**	0.03	0.3	0.2	0.1	0.5	0.3	0.2	0.9	0.5	0.3	0.2	0.1	0.1	1.9	1.0	0.6
Little Pond	**NS**	0.01	0.1	0.0	0.0	0.1	0.1	0.0	0.2	0.1	0.1	0.0	0.0	0.0	0.5	0.3	0.2
Springhill Rail Bed	**NS**	0.01	0.1	0.1	0.0	0.2	0.1	0.1	0.3	0.2	0.1	0.1	0.0	0.0	0.7	0.4	0.2
St. Rose	**NS**	0.03	0.4	0.2	0.1	0.7	0.4	0.2	1.1	0.6	0.4	0.2	0.1	0.1	2.4	1.3	0.8
Stellarton	**NS**	0.20	2.6	1.4	0.9	4.0	2.2	1.3	6.6	3.6	2.2	1.2	0.7	0.4	14.4	7.8	4.8
Total Canada		90.03	1152.3	628.0	380.2	1772.7	966.1	585.0	2970.9	1619.2	980.2	531.8	289.8	175.5	6427.8	3503.1	2120.9

* Used 1999 data   ** underground mine   #Gross mining production is prorated from marketable coal data   UG – Underground mine OP – Open Pit mine $Mt = 10^6$ tonnes

Chapter 5

Rail Transport
Fugitive Coal Dust Emission and Control

5.1 Rail Transport

As noted in Chapter 1, the shipment of coal by unit coal train in Canada can result in fugitive coal dust emissions en route. Portions of these emissions are likely to be in the PM_{10} and $PM_{2.5}$ range and may contribute to local airshed loadings in the population centres through which the trains transit.

The fugitive coal dust emissions from loaded coal cars can be controlled. The current practice at most of the mines in Alberta and British Columbia, that ship coal by rail over long distances, is to spray the surfaces of the coal load in each car with sealant spray to attempt to control fugitive dusting. (Appendix B)

Coal remaining in 'empty' cars can also contribute to coal dust emissions en route. Coal left in rail cars that are not fully dumped at the end terminals (or that is frozen in the bottom of cars) can be a source of coal dust on the route back to the mine. (Wituschek 86) In British Columbia in 2000, on more than one occasion, 'empty' rail cars in unit trains returning to mines were reported as being sources of heavy fugitive dusting.

5.2 Emission Factors – Rail Transport

As noted, one of the main objectives of this investigation is to attempt to improve fugitive coal dust emissions estimates for coal carried in unit coal trains. However, it is particularly difficult to estimate emissions from an open-top rail car. The additional variables that can effect the emission rate include: (Cope 1986)

Easily measured parameters

- rail car dimensions
- route length
- coal moisture content at start of journey
- coal surface coated at the start of the journey
- the sealant crust remaining at the end of the journey

Less easily measured parameters

- total surface area of coal load each car
- train speed at all points en route
- total surface covered each car en route
- jostling of load and crust on route
- ambient conditions on route: wind speed and direction, precipitation
- the proportion of coal lost at each stage of a journey

Regardless, even if available, it is difficult to incorporate these factors into a readily useable emission factor (EF). (See Section 5.2)

One focus of this study is to quantify fugitive coal dust blown from the unit coal trains that travel through British Columbia on their way to export terminals on the West Coast of Canada. One of the principal objectives was to search for new and/or improved emission factors (EFs) for the transport of coal by rail in Canada with particular emphasis on the EFs for the emissions of PM_{10} and $PM_{2.5}$.

> *Note that unless specific reference is made to 'empty' coal cars, the discussion of EFs related to rail in this report is in reference to 'loaded' rail cars. Empty cars are discussed briefly in Section 5.2.4.2.*

Investigations into fugitive coal dust EFs in the early 1980s found that several researchers had estimated *uncontrolled* emission factors for total particulate matter for coal shipped by unit train. The papers cited in the 1986 Environment Canada report were:

- *In Transit Control of Coal Dust from Unit Trains*, Fisheries and Environment Canada, Technology Development Report, Guarnaschelli, C., EPS-4-PR-&&-1, May 1977;
- *A Study of Coal Dust Contamination of Canadian Cellulose's Watson Island (Prince Rupert) Pulp Mill for the Operation of a Coal Terminal on Ridley Island and Coal Unit Train Access and Egress to the Proposed Terminal*, Beak Consultants, Hardy Associates (1978), Sandwell and Company, Swan Wooster Engineering Company, September 1980; and
- *In-transit Wind Erosion Losses of Coal and Method of Control*, Mining Engineering, USA publication, Nimerick, K.H., and Laflin, G.P., August 1979.

The data presented by these three research teams provided the best information available at the time regarding EFs for unit trains. The conclusion was that: (Cope 1986)

> *When no coal dust control measures were employed, the maximum potential coal losses (for a one way trip of approximately 1100 km over rough terrain during dry conditions through British Columbia to Vancouver) are estimated to be in a range from 0.5% and 3.0 % of the total coal load.*

The distance of 1100 km was chosen as the reference scenario, since it represents the approximate distance over which most mines on the BC/Alberta border must ship to reach coal terminals in Vancouver, Table 5.1.

In conjunction with the field studies in the early 1980s, by Environment Canada and the province of British Columbia, a series of controlled, wind tunnel experiments were funded in an attempt to derive an emission factor for coal train dusting. The data from those experiments revealed: (MH 1983)

> *A range of uncontrolled emission factors that falls within 0.008 kg/t-km to 0.016 kg/t-km (or 0.9% to 1.76% of the total coal load for a distance of 1 100 km) determined by wind tunnel studies in 1983.*

This range for experimental EFs falls within the 0.5% to 3.0% of load that were developed by the earlier researchers.

Since no measured emissions data are available, the provincial and federal governments use emission factors to estimate the total quantity of coal dust emitted by loaded rail cars in Canada. Environment Canada used the EF discussed in Section 5.2.1 to estimate fugitive dusting from coal trains for their last published, 1995, Criteria Air Contaminants (CAC) Inventory. (Deslauriers1999)

Of the provinces and territories, only British Columbia employed an EF that differed from the one used by Environment Canada, Section 5.2.2. A comparison of EFs used for estimating fugitive dust emissions is presented in Table 5.2.

Table 5.1 Approximate Rail Distances for Coal Transport in Canada

Province	Destination	Total Distance
Mines		km
British Columbia		
Bullmoose*	Ridley Island, BC	1180
Coal Mountain*	Thunder Bay, Ontario	2073
Coal Mountain*	Vancouver	1141
Elkview (Balmer)*	Vancouver	1055
Fording River*	Vancouver	1169
Greenhills*	Vancouver	989
Line Creek	Vancouver	1141
Line Creek	Thunder Bay, Ontario	2102
Quintette*	Ridley Island, BC	1250
Alberta		
Coal Valley	Vancouver	1093
Coal Valley	Ridley Island, BC	1381
Coal Valley	Thunder Bay, Ontario	2282
Gregg River	Vancouver	1114
Gregg River	Ridley Island, BC	1408
Gregg River	Thunder Bay, Ontario	2309
Luscar	Vancouver	1108
Luscar	Ridley Island, BC	1404
Luscar	Thunder Bay, Ontario	2305
Obed	Vancouver	958
Obed	Ridley Island, BC	1257
Obed	Thunder Bay, Ontario	2264
Smoky River*	Alberta	1180
Saskatchewan		
Bienfait*	Sask.	58
Bienfait*	Ridley Island, BC	1180
Poplar River*	Sask	20
Nova Scotia		
Prince*	NS	8
Import		
Nfld Import*	Labrador	350

* Indicates estimated distance, other distances from company supplied information.

5.2.1 CAC Inventory Emission Factors

The NEIPTG Guidebook contains a description of the method used by Environment Canada to compile rail coal dust emissions in the 1995 CAC Inventory: (NEIPTG 1999)

> *For coal transportation, emission factors were derived from the quantities of coal transported by rail, the distance traveled on the railroad and the type of containment of the coal (control, closed environment, covered wagon, etc.). Provincial average emission factors were based on the following formula:*
>
> $$EF = 0.1*(0.62*D)^{0.6} \qquad (5.1)$$
>
> *Where: EF = the emission factor in kg/tonne of coal transported and*
> *D = the distance travelled by rail cars (km).*

The original formula as published in 1991 was EF = $0.1*(\text{miles})^{0.6}$ kg/tonne. The 0.62 factor was added to allow the distance D to be entered in kilometres and not miles. Equation 5.1 represents a metric conversion of the original formula as published in the:

> *Methods Manual for Estimating Emissions of Common Air Contaminants in Canada*, ORTECH International for Environment Canada, May 1991.

The original formula was developed by SNC/GECO and ORF in 1981. It was designed to allow a distance factor to be incorporated into the basic emission loss equation of 0.1 kg/tonne. The reference is: *A Nationwide Inventory of Antropogenic Sources and Emissions of Primary Fine Particulate Matter*, SNC/GECO Canada Inc. and Ontario Research Foundation, Prepared for Environment Canada, 1981.

As noted in Section 5.2, from the findings of several researchers, the maximum uncontrolled emissions for coal carried at least 1100 km over rough terrain is 0.5% of the load of 100 tonnes or 500kg per car. This factor is the conservative end of the range of emission factors that was derived in three separate studies. Therefore, the 0.1 kg/tonne EF represents a control level of approximately 98%.

However, the Guidebook also claims that the EF in equation 5.1 is not the 'uncontrolled' EF for loaded cars: (NEIPTG 1999)

> *This formula was developed assuming a 75 % particulate control. Assuming that the formula is linear with respect to percent control of particulate and that the percent control in Canada is actually 99 % for rail transport of coal, the formula was adjusted to become:*
>
> $$\text{EF for total particulate PART} = 0.1*(0.62*D)^{0.6} * ((100-99)/(100-75)) \qquad (5.2)$$
>
> *The provincial average emission factors were calculated using the amount of coal transported by rail, the origin and destination of this coal and the distance of the specific rail destination.*

For over 20 years, for sprayed coal loads in trains, the total crust-retention on loaded rail cars at the end terminals, after a long journey, has been used as a measure of dust control. Therefore, although empirical evidence is limited, the references to the amount of dust control may relate to the quantity of sealant crust-retention at the end terminals. However, to date, such an assumption is not supported by measured data that can establish a one-to-one direct link between crust-retention and dust control percentage. (Section 5.3.2.1)

Therefore, 75% control in the formula may relate to 75% crust-retention at the end terminal. However, the accepted minimum level for dust control, since 1975, has been 85% crust-retention. Lacking empirical evidence to the contrary, the NEIPTG Guidebook may have erred on the side of caution and used a dust control effectiveness of 99%.

Reflecting upon the origins of the CAC EF, and the data behind its creation, it is felt that the following may apply in regard to dust control efficiency for unit coal trains:

- As illustrated in Table 5.2, the basic CAC EF, equation 5.1, appears to correlate to the basic uncontrolled EF of 0.5% of the coal load over a distance of 1100 km; and
- Therefore, contrary to what is stated in the Guidebook, the basic EF, equation 5.1, may be the *uncontrolled* EF for coal dust emission and not the EF at the 75% control point.

Support for accepting the basic CAC EF as the uncontrolled EF comes from recent emissions measurement work preformed for the Norfolk Southern railway. The group that performs the ongoing measurements for the Norfolk Southern considers a loaded coal car with a crust-retention of less than 80% to be an uncontrolled car in regard to its potential for fugitive dust emissions. Therefore, one could assume that an EF based on a 75% crust-retention would be the uncontrolled EF. (SWA 2001)

The contention that the CAC EF represents an uncontrolled EF of 0.5% of the load also seems to be supported by the EF comparison data presented in Table 5.2. For various assumed EFs, the calculations in Table 5.2 attempt to estimate coal dust emissions for a rail car carrying 100 tonnes of coal travelling 1100 km (≈ 700 miles) from a mine to a coal terminal. These are the same parameters that were used for illustration purposes in the 1986 Environment Canada background report on rail car dusting. (Cope 1986)

Scenario #1 in Table 5.2 illustrates the estimated emissions if the CAC EF is assumed to be the uncontrolled EF. The resulting emissions of 0.5015% of the load is strikingly similar to the 0.5% of the load, or the uncontrolled EF used by the BC MELP.

Scenario #4c in Table 5.2 illustrates the estimated emissions if the dust control efficiency is assumed to be 85%. The resulting EF of 0.0752% is again almost the same as the 0.075% employed to produce example calculations for the Environment Canada background report in 1986. Those calculations also assumed 85% control. (Cope 1986)

The difference between the simple 0.5% of the load EF and the EF produced by the CAC equation 5.1 appears to be the slight variation created by the non-linear function represented by equation 5.1.

Regardless, the basic formula used for the CAC inventory calculations is flawed in that it does not take into account the following:

- The moisture content of the coal;
- The wind and/or train speeds;
- The different between coal types with different fines content; and
- The dust control created by precipitation en route.

Moisture Content:

While moisture content is not factored into the equation, it may not vary significantly for a particular mine. If moisture content is felt to be critical, then it could be monitored by mine on yearly basis. The EFs used could then be adjusted by adjusting the overall emission control factor by mine.

Wind Speed:

The combined wind-over velocity that results from ambient wind and train speed is not used as a variable in equation 5.1. However, it may be sufficient to acknowledge that for most train journeys, the combined wind-over velocity is likely sufficient to create airborne dust. As noted in Section 5.2.3.1, over half the trains through the Lower Fraser Valley in January 2000 exceeded the threshold speed for dust entrainment. Therefore, it is likely that when combined with average winds in any particular area that the combined wind-over velocity which is sufficient to cause dust emissions. At present, there is insufficient data available for any in depth analysis of this parameter.

Fines Content:

For most Western Canadian coals, the fines content is likely sufficient to produce dusting. One mine claims that in 2000 their fines content was from 8 to 11 percent. In the 1980s, samples tested by the Alberta Research discovered that 7% of the coal was less than 200 mesh (75 micron). (Cope 86) Therefore, it appears that coal fine content has changed little in 20 years.

Precipitation:

Precipitation is a factor that should be accounted for in the rail coal dust EF. Precipitation is discussed in Section 5.2.3.1 and suggestions for changes to the current techniques for estimating emissions are presented.

Table 5.2 Rail Car Coal Dust Emission Factor Comparison

#	Scenarios 100 tonnes of coal carried in one open top car for 1100 km	The Emission Factor	Distance D	tonnes shipped (approx. 1 railcar)	EF	For Scenario TPM Emissions in tonnes	As a % of 100 tonne Load	or as a multiplication factor x tonnes carried
	CAC Inventory 1995 Basic Formula is 1	**CAC EF**			**kg/tonne**		**% load**	
1	EF in kg/tonne coal transported =	$0.1 \times (0.62 \times D)^{0.6}$	1100	100	5.015	0.5015	0.5015	0.00501
	where D = distance travelled in km							
2	If 1 assumes 75% control, uncontrolled EF =	$0.1 \times (0.62 \times D)^{0.6} \times (100-0)/(100-75)$	1100	100	20.060	2.0060	2.0060	0.02006
3	Based on 2 then the 99% control EF =	$0.1 \times (0.62 \times D)^{0.6} \times (100-99)/(100-75)$	1100	100	0.201	0.0201	0.0201	0.00020
4a	Assume Scenario 1 is really an uncontrolled EF. Then the 99% control EF =	$0.1 \times (0.62 \times D)^{0.6} \times (100-99)/100$	1100	100	0.050	0.0050	0.0050	0.00005
4b	Same as 4 but assume control is only 90%	$[0.1 \times (0.62 \times D)^{0.6} \times (100-90)/(100)]$	1100	100	0.501	0.0501	0.0501	0.00050
4c	Assume control is only 85%	$[0.1 \times (0.62 \times D)^{0.6} \times (100-85)/(100)]$	1100	100	0.752	0.0752	0.0752	0.00075
	Wind Tunnel EF Range in 1986	**Wind Tunnel Uncontrolled EFs**						
	Experiments found uncontrolled EFs range to be 0.9% to 1.76% of load	EF in % of total load over 1100 km			**t/tonne**			
5a	If uncontrolled EF is 0.9% of load	0.9/100 x tonnes carried	1100	100	0.009	0.9000	0.9000	0.00900
5b	If uncontrolled EF of 1.76% of load	1.76/100 x tonnes carried	1100	100	0.0176	1.7600	1.7600	0.01760
	Environment Canada in 1986	**Assumed Uncontrolled EF is 0.5 to 3% of total coal load**			**t/tonne**			
6	If uncontrolled EF of 0.5% of load	0.5/100 x tonnes carried	1100	100	0.005	0.5000	0.5000	0.00500
7	If uncontrolled EF of 1.0% of load	1.0/100 x tonnes carried	1100	100	0.01	1.0000	1.0000	0.01000
8	If uncontrolled EF of 3.0% of load	3.0/100 x tonnes carried	1100	100	0.03	3.0000	3.0000	0.03000
	BC MELP EF	**EF is 0.05% x total tonnes shipped x % track distance**			**t/tonne**			
9a	Generic uncontrolled EF= 0.5% of load	0.5/100 x tonnes carried	1100	100	0.005	0.5000	0.5000	0.00500
9b	BC used an EF that is the 90% controlled EF	0.05/100 x tonnes shipped x %D for %D=100%	1100	100	0.0005	0.0500	0.0500	0.00050
9c	If assume that there is 99% control	Example 9 x 0.01	1100	100	0.00005	0.0050	0.0050	0.00005
9d	If assume that there is 85% control	Example 9 x 0.15	1100	100	0.00075	0.0750	0.0750	0.00075

The effect of the non-linear CAC EF as presented in equation 5.1 is to produce lower emissions estimates for rail journeys over 1100 km that are produced using a prorated linear function with similar parameters. Also, for journeys of less than 1100 km the CAC EF produces emissions estimates that are higher than a prorated linear function, Table 5.3a.

Table 5.3a Linear versus Non-Linear Rail Dust Emission Factors

For the scenario of 100 tonnes of coal carried in one open top car for 1100 km

	Uncontrolled Emission Factor		Total Distance D (km)	tonnes shipped (approx. 1 rail car)	EF	Total Particulate Emissions in tonnes (PART)
A	**CAC EF** Note: the basic formula is used to estimate emissions for each distance segment				**kg/tonne**	
	EF in kg/tonne coal transported =	$0.1 \times (0.62 \times D)^{0.6}$	2000	100	7.17882	0.7179
	Where D = distance travelled in km		1500	100	6.04073	0.6041
			1100	100	5.01500	0.5015
			500	100	3.12476	0.3125
			250	100	2.06157	0.2062
			100	100	1.18969	0.1190
			72	100	0.97686	0.0977
			50	100	0.78490	0.0785
B	**Uncontrolled BC MELP EF is 0.5% x total tonnes shipped x % track distance**	The 1100 km emissions estimates are prorated by %Distance			**t/tonne**	
	EF = 0.5/100 x tonnes carried	181.8%	2000	100	0.00909	0.9091
		136.4%	1500	100	0.00682	0.6818
	The basic 1100 km scenario ⇒	100.0%	1100	100	0.00500	0.5000
		45.5%	500	100	0.00227	0.2273
		22.7%	250	100	0.00114	0.1136
		9.1%	100	100	0.00045	0.0455
		6.5%	72	100	0.00033	0.0327
		4.5%	50	100	0.00023	0.0227

Example A in Table 5.3a is as applied in the CAC Inventory. It assumes eight distinct rail journeys of the eight different distances shown. In other words, each distance represents a discrete application of the formula.

In the CAC Inventory, the distance segment in each province is used with the CAC formula to calculate an emission factor and emissions for that provincial segment. Those provincial totals would then be added to produce the emissions total for an entire journey. However, it is suggested that this may not be the way the CAC EF should be applied, since it assumes that the emissions in each segment follow the same non-linear pattern.

A different application, and the one forwarded as the recommended technique, would be to use the CAC EF formula to first produce an EF and an emission estimate for an entire journey. Then, instead of using the formula to calculate a separate EF for each segment of the journey, the total emissions for the 1100 km trip would be divided, or prorated, by distance in each province using the simple linear approach used by the BC MELP.

Table 5.3b presents an example chosen from the 1995 CAC Inventory. (Deslauriers 1999) It involves 1.49 million tonnes of coal from one mine shipped approximately 2073 km to Ontario. The difference between the two applications of the formula is subtle, but they produce very different emissions totals.

Table 5.3b Additional Linear vs Non-Linear Rail Dust Emission Factors

For an example scenario of 1.49 million tonnes of coal carried 2073 km

Coal shipped 1.49 Mt	Total	BC	ALTA	SASK	MAN	ONT
Distance (km)	2073	55	495	628	547	348
From CAC Inventory						
EF (kg/tonne)		0.033	0.124	0.143	0.132	0.101
Total Emissions (tonnes)	795	50	185	214	197	150
New Linear Method		**BC**	**ALTA**	**SASK**	**MAN**	**ONT**
Overall EF (kg/tonne)	0.293					
Total Emissions (tonnes)	437	12	104	133	115	73

A quick examination of the emission estimates produced by the two different approaches, Table 5.3b, shows that they produce significantly different emissions estimates. Not only are the estimates for each segment of the journey lower, but the estimated total emissions for the entire 2073 km trip are almost halved.

Other suggestions for revising the CAC EF, in light of these findings, are presented in Section 5.2.5.

The NEIPTG Guidebook offers the following in regard to estimating the emissions of PM_{10} and $PM_{2.5}$: (NEIPTG 1999)

> *The PM_{10} and $PM_{2.5}$ emission factors were derived from the particulate emission factor, using information from the PM CALCULATOR program from the U.S. EPA (SCC 30501101):*

$$PM_{10} = 1.0 \times PART$$
$$PM_{2.5} = 0.92 \times PART$$

However, it was found that the PM Calculator program does not contain a specific SCC for coal rail shipments. While the NEIPTG Guidebook states that the SCC used to ascertain the above fractions was 30501101, this SCC applies to the Cement Industry. The SCC in the PM Calculator for Coal Transfer is 30501011. It is not clear whether the manual contains an error, or that the Cement Industry SCC was used to obtain the PM fractions.

Regardless, both of these particulate fractions appear to be high in relation to the size of the coal particles that are likely to be emitted from coal rail cars in transit. The following is a general overview of the information available on the size characteristics of rail car generated coal dust samples taken in relation to fugitive dusting:

1] An *International Energy Agency* (IEA) report provides a comprehensive picture of coal properties, sources of coal dust emission from loading, unloading, stockpiles and transportation by trucks and trains, methods of coal dust control and coal dust monitoring methods. One conclusion reached was that the nuisance was caused mainly by coarse dust particles. (IEA 1994)

2] From the experiments conducted in connection with the Environment Canada investigations in the 1980s it was concluded that nearly 95% by weight of the particulate collected from loaded coal trains is reported to be larger than 20 microns. (Cope 1986)

Note, the data from the experiments conducted in the 1980s, should only be used as evidence to show a trend that larger particles than PM_{10} in size are emitted. The measurement equipment was used in a non-standard configuration to attempt to assess 'heavy visible' emissions. In general, most of the equipment, particularly the Hi-vol samplers, could not process sufficient sample in the short duration of a unit train event to collect sufficient sample for measurement. Also, since only one or two samplers were used per train, it is possible that smaller particulate could have blown over and been deposited away from the collection sites.

3] A number of Hi-vol and Lo-vol samples collected during a 1983 coal dust study were analyzed by computer controlled scanning electron microscope for size, shape and chemical composition of the particles. The results showed that the majority of particle mass for each sample was in the 5-30 microns size ranges. Similar analysis of metallurgical and thermal coal samples transported during the study period showed that about 20% (by weight) of the former type and less than 5% of the latter type of coal were comprised of particles having a physical diameter less than 2.5 microns. However, 52% of metallurgical coal particles and 68% of thermal coal particles were in the 10-30 microns range. (ESL 1985)

One of the samples collected during a day that featured visible coal dust emissions from trains passing the sampling equipment showed the following size distribution by weight: 20% less than 2.5microns, 41% between 2.5 and 15 microns, and 39% between 15 and 50 microns. (ESL 1985)

These data appear to support a decision to assume that approximately 50% of the emissions are greater than PM_{10} in size.

4] During a follow-up monitoring program in September-October 1984, a dichotomous sampler was used to estimate two size fractions of airborne particulate matter, namely coarse particles of sizes from 2.5 to 15 microns and fine particles of smaller than 2.5 microns in diameter. A Hi-vol sampler was also used to collect particles of less than about 50 microns in sizes. The collected samples were also analyzed for coal content by optical microscopy as well as X-ray fluorescence and flame ionization by two different laboratories. The results indicated that the coal content in the fine particles (< 2.5 microns) was 'minor and relatively insensitive to observed coal dust emissions'. However, the coal content in the coarse particles (2.5-15 microns) was 'high on all days with coal dust emissions regardless of the degree of dusting.' The analysis of Hi-vol samples showed that the coal content, particularly in the 15-50 microns particles, increased sharply for days when there were strong winds and heavy coal dust emissions. (ESL 1986)

The results of these studies should be viewed with caution. The data collected in the early 1980s were for brief track-side experiments that often featured non-standard sampling equipment. Regardless, the results appear to indicate that coarse coal particles, greater than 10 microns in diameter, are emitted from coal cars. Therefore, the scaling factors in the CAC Inventory used for PM_{10} and $PM_{2.5}$, 1.0 times and 0.92 times respectively, appear to be too high. Suggestions for new scaling factors are presented in Section 5.2.4.

5.2.2 British Columbia Emission Factors

As noted in Section 3.1, the British Columbia *Ministry of Environment, Lands and Parks* (MELP) was the only provincial agency to use a railcar dust emission EF different from the one used for the CAC Inventory to calculate emissions. Note: the local agency, the *Greater Vancouver Regional District* (GVRD), also used the BC MELP EFs for rail dusting in the GVRD.

The basic EF used by the province for the BC inventory was: (BCMELP 1999)

> *TSP = 0.05% x total coal shipped* or *0.0005 x total coal shipped (tonnes)* (5.3)
>
> Where: TSP = Total Suspended Particulate

The 1990 GVRD inventory states: (GVRD 1990)

> Remaining Lower Fraser Valley (LFV) sources and all other sources for the rest of the province, were inventoried as follows:
>
> > *Fugitive losses of coal dust were also estimated, based on the tonnage of coal transported by rail through both the Neptune and Roberts Bank Terminals. The percentage loss of load estimate for those fugitive losses was taken as the same (0.05%) as was assumed for the 1985 inventory. The emission factor for coal loss was derived from Environment Canada data (EAG, 1987) and is the same as used in the 1985 inventory at 0.05% of coal shipped.*

A distance factor was applied to the basic formula to develop an EF specific to the Lower Fraser Valley: (BCMELP 1999)

> For the emissions over a stretch of track such as the LFV the EF is:
>
> *TSP = 0.05% x total coal shipped x % of track* (5.4)

Documentation for the 1990 BC inventory for the Province outside the LFV indicates: (Levelton 1993) (GVRD 1994)

> *For coal shipped through the Port of Vancouver, the emission factor was adjusted for the length of track outside the LFV yielding the factor: 0.05 x (1-0.072) = 0.046%. This allows for 7.2% of the track length in the LFV. For the balance of the coal shipped in BC the emission factor used is 0.05%.*
>
> *To allow use of a single base quantity and, thus, simplify the calculation of coal dust emissions, and equivalent overall emission factor of 473-kg/1000 tonne coal shipped was calculated using the base quantities presented previously.*

However, at present, the basic EF used by the BC Government, equation 5.3, is flawed for the same reasons that the CAC EF is flawed. This EF also does not take into account the following:

- The moisture content of the coal.
- The wind and/or train speeds.
- Allowance for different coal types with different fines content.
- Allowance for the dust control created by precipitation en route.

The BC MELP claims that their EF takes into account the dust control provided by the sealants sprayed on the loaded cars by the mines: (Wakelin 2000)

> *This EF is based on the most conservative figure from the EPS report for uncontrolled cars (0.5%), and an assumed control efficiency of the latex sealer of 90%.*

Therefore, if one examines the emissions estimated by the uncontrolled CAC EF (scenario #1, Table 5.2) and the uncontrolled BC MELP EF (scenario 9a, Table 5.2) one will observe that they appear to produce approximately the same result. Similarly for the 90% control EF, scenarios 4b and 9b respectively. Additional discussion of the CAC and BC MELP EFs plus suggestions for improvements is presented in Section 5.2.5.

For their PM_{10} and $PM_{2.5}$ fractions of the total coal particulate emissions, the BC MELP used the following scaling factors: PM_{10} = TSP x 96% $PM_{2.5}$ = TSP x 92% (Wakelin 2000)

The BC MELP has submitted the following in relation to their use of the PM CALCULATOR: (Wakelin 2001)

> Some clarification appears to be required for the reference to the PM CALCULATOR. The U.S. EPA produced a file known as PSD4PM10. This file contains PM_{10} and $PM_{2.5}$ size fractions by SCC. The original publication that contained the basis for the file is:
>
> > *PM10 Emission Factor Listing Developed for Technology Transfer and Airs Source Classification Codes with Documentation*, by E.H. Pechan & Associates, Inc. Durham, NC 27707, EPA Contract No. 86-D0-0120, Revised June 1992.
>
> Application of the PSD4PM10 file to sources in BC originates with work done by SENES and the Air Resources Branch Co-op. SENES was contracted by the GVRD to produce the following report:
>
> > *Visibility and Fine Particulate Emissions Greater Vancouver Regional District and Lower Fraser Valley Summary Report*, by SENES Consultants Limited Vancouver, B.C. in association with Drs. Douw Steyn and Sara Pryor Department of Geography University of British Columbia, February 21, 1994.

For their PM_{10} and $PM_{2.5}$ calculations, the GVRD used the same scaling factor as employed in the CAC calculations, Section 5.2.1. (Sidi 2001) Regardless, the BC MELP and the GVRD scaling, as noted in Section 5.2.1, both appear to be too high. Suggestions for new scaling factors are presented in Section 5.2.4.

5.2.3 Recent Findings Regarding Coal Car Dusting EFs

A search of literature and the Internet was made in an attempt to discover any new information regarding emissions and EFs for moving coal trains. Unfortunately, little new information was discovered. In fact, it would appear that, at present, fugitive coal dusting from unit coal trains is only an issue in British Columbia and the state of Virginia, USA.

Since 1980, because of nuisance dust problems, the monitoring of wind-blown coal dust from coal trains has been attempted in several countries. However, it would appear that once dust-suppression measures were successfully applied and public complaints lessened, the monitoring program was discontinued.

The following sources were checked for references to coal train EFs (other contacts are listed in Appendix C):

> *I] "Revision of Emission factors for AP-42 Section 11.9 Western Surface Coal Mining, Revised Final Report. Prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emission Factor and Inventory Group, Research Triangle Park, NC 27711. Prepared by Midwest Research Institute under EPA Contract 68-D2-0159, September 1998."*
>
> > Although AP-42 covers various emission sources associated with coal mining, the shipment of coal by trains is not addressed as a source of dust emission. Also, as noted earlier, although the EPS has assigned

SCC codes to hundreds of industrial sectors, including several in the coal industry, it has not assigned one to the movement of coal by rail.

ii] "National Pollutant Inventory, Emission Estimation Technique Manual for Mining, Version 2.1, Environment Australia, October 11, 2000."

The sources covered in the manual include drilling, blasting, mine power generation (if any), excavators, bulldozers, scrapers, graders, front-end loaders, loading stockpiles, unloading from stockpiles, transfer points, wind erosion, mine transportation by trucks, and loading to trains, but not emissions from the trains.

iii] "Control of coal dust in transit and stockpiles", IEA Coal Research, IEAPER/15, December 1994."

The report provides a comprehensive picture of coal properties, sources of coal dust emission from loading, unloading, stockpiles and transportation by trucks and trains, methods of coal dust control and coal dust monitoring methods. It cites a study* that looked into the correlation between dust emission and nuisance it caused by simultaneous monitoring of dust levels and doing a survey of nearby residents. The conclusion reached was that the nuisance was caused mainly by coarse dust particles. However, no emission factor for coal dust emission is provided in this IEA report.

* "Nuisance from coarse dust", P. Hofschreuder and E. L. M. Vrins. Paper presented at European Aerosol Conference, Oxford, U. K., 1992.

iv] "Coal Particulate Emissions From Rail Cars", Noble, George, et al, Paper presented at A Specialty Conference on Fugitive Dust Issues in the Coal Use Cycle, held by Western Pennsylvania Section of Air Pollution Control Association at Pittsburgh, PA on April 11-13, 1983.

The study was undertaken to evaluate potential environmental impact of coal dust emission from rail cars on the ambient air quality. A Hi-vol sampler was used to collect ambient air samples at a location about 15 m (50 ft.) away from the rail tracks. A total of 12 trains, consisting of 7 exclusively coal cars, 4 trains of mixed coal and freight cars, and 1 with a number of empty coal cars, were samples. Train speeds varied from about 5-32 km/h. (No mention is made about the use of any dust suppressant on the coal cars.)

Statistical analysis was performed with the monitoring data to determine any relationship between variables such as number of coal cars, average train speed, wind speed, rainfall and source of coal. The results do not indicate any direct relationship between coal dust emission and any of the other variables; but it appears that a combination of factors influence the rate of dust emission. Other key findings are:

- the coal dust emission from coal trains ranged from 0.00004 to 0.00373 $\mu g/m^3$-day per coal car, and that from mixed coal and freight trains ranged from 0.00015 to 0.00159 $\mu g/m^3$-day for each car;
- the coal dust emission from 34 empty coal cars was 0.00093 $\mu g/m^3$-day. It appears that emissions from empty cars were nearly the same as that from loaded cars;
- the ambient coal particulate contribution was extremely low, irrespective of whether the train carried coal or not;

- particle size analysis indicated that on average 42% of the total coal particles were greater than 70 μm, and this fraction may represent up to 85%;
- the effect of rain shower on one occasion was observed on the significant reduction in the ambient concentration of coal particulates; and
- re-suspension of accumulated coal particles over time in the vicinity of the rail tracks may play some role in the observed dust emission during the passing of a coal train.

Unfortunately, this study did not produce an emission factor.

Since some of the conclusions reported for the investigation in #iv above seem to run counter to other observations, the following comments on those conclusions are offered:

1] A maximum train speed of 32 km/hr is barely within the emissions threshold for dusting discovered during wind tunnel experiments. More recent data indicate that excessive dusting only occurs at train speeds in excess of 50 km/hr. Were trains in the APCA study going at a speed that would generate sufficient dust for analysis?
2] The study results do not mention the separation diesel particulate from the coal dust collected on Hi-Vol samples? In the 1980s this separation was a major drawback in regard to the quantitative analyses of collected particulate samples. A method was not developed for this separation until 1994. (OAG 1994)
3] It is claimed that on the one day it rained, coal dust was down. However, they conclude that there was no direct link between precipitation and coal dust emissions?
4] Dust measurements were almost as high for non-coal trains? Again, did they separate coal dust from diesel particulate and other non-coal dust on the samples they collected?

Prior to this investigation, the BC MELP contacted agencies in Canada, the USA and internationally regarding new EFs for coal trains. These same agencies were contacted again as a part of this investigation. The BC MELP findings were confirmed. None of the groups contacted have developed an EF for coal trains. The contacts are listed in Appendix A.

The Midwest Research Institute (MRI) in the USA has been responsible for much of the research into fugitive coal dust emission factors for the US EPA. Unfortunately, neither the EPA nor the MRI has published EFs for coal train losses. When asked about EFs for coal trains the following response was received from a MRI researcher: (MRI 2001)

> *In regard to PM lost from coal trains, the wind erosion estimates in AP-42 Section 13.2 would be as applicable as anything because these were measured under steady, high air flows, just like the open surface in railcars. Furthermore, most of the AP-42 database involves coal erosion rather than any other material.*

In BC, several monitoring programs were initiated to address the problem of coal dust from trains carrying coal through the LFV to the Vancouver area. Various monitoring methods were employed to attempt to determine coal dust concentrations, and to a lesser extent the particle sizes of the coal samples. However, no EFs for coal dust were produced. The following contributed to the lack of success:

- the limitations of these monitoring methods;
- the different origins of the coal particles;
- weather conditions; and
- the complexity of apportioning collected particles to their sources.

Even less information is available on the particle size distribution of the coal dust in the collected samples.

Some of the most recent work on coal dust from trains involves the company, *Simpson Weather Associates* (SWA). SWA is working with the Norfolk Southern (NS) railway monitoring coal dust emissions from coal trains in Virginia.

SWA offers a number of systems and services in regard to rail car dusting: (SWA 2001)

- Rail Transport Emission Profiling System (RTEPS)
- Coal Car Load Profiling System (CCLPS)
- Portable LAser for Coal Emission Mapping (PLACEM)
- Evaluation of Chemical Dust Suppressants
- Autonomous control of wet dust suppression systems for coal storage piles (ProControl)
- Seasonally Adjusted Rail Transport Dusting Index (SARTDX)

SWA, for the Norfolk Southern Railway and its operations in Virginia, are involved in a series of coal dust measurement experiments and ongoing dust monitoring from rail cars. They have measured coal dust from rail cars using:

a] Passive Dust Collectors on the cars.
b] Car Weights before and after – buried moisture gauges were used.
c] Scanning Laser device to measure volume in the car.

Of the sources that were studied, the work of SWA with the Norfolk Southern Railway appears most likely to be capable of producing an EF for loaded rail cars. In fact, the data they have collected to date may have revealed EFs, but the data are proprietary and although contacted, neither company forwarded the measurement data that would have produced an EF.

In 1996 the Senate of the State of Virginia passed Joint Resolution # 257 that required the Norfolk Southern Railway to monitor dusting trains en route and to take measures to eliminate dusting. As a result, the Norfolk Southern installed two of *SWA's Track-Side Monitoring* (TSM) systems that automatically photographs dusting trains. Information is downloaded daily by SWA and once per week photos are graded by eye regarding dusting. SWA then informs the mine involved if their trains are dusting. (NS 2001) SWA were recently contacted by the CPR regarding a TSM system for possible installation at HOPE, BC. (SWA 2001)

Of note, SWA, when they monitor and report train dusting for the NS, consider a car with 20% crust loss (or 80% crust-retention) to be uncontrolled. They feel such a loaded coal car will be a *heavy duster* with emissions similar to those of an unsprayed car. (SWA 2001)

This conclusion appears to confirm the findings in Environment Canada's *1986 Recommended Practices*, that 85% crust retention is the *minimum standard* for dust control, and that a much higher level of crust retention is required to significantly reduce emissions. (Wituschek 1986)

5.2.3.1 Weather En Route - Analyses

For coal carried by rail over long distances in open rail cars in unit trains, it is logical to assume that weather conditions en route can influence coal dust emissions:

- High temperatures can contribute to the drying of exposed coal and surface sealant crusts;
- Freezing temperatures can influence the setting of sealant crusts or freeze coal in cars so that it does not all dump out at the end terminal;
- Ambient wind can add to train speed to produce a greater wind-over velocity for dust entrainment;
- Snow and ice may add a dust inhibiting layer to the surface of a coal load or cover loose coal in an empty car; and
- Precipitation as rain can inhibit dust emissions or breakdown and dilute sealant chemicals.

In regard to visible dusting incidents (and likely total emissions as well), it is not just the local weather at the potential emissions location that can influence the severity of the dust emissions episodes. The weather 'up route' of the emissions may also influence the emissions at the point of observation.

The nuisance dusting incidents reported in the spring, summer and fall of 2000 involved unit trains on the route through the Lower Fraser Valley. A total of 27 separate complaints regarding 'heavily' dusting trains were recorded in the area of Hope, BC from May to October 2000. In regard to specific dates, a Hope, BC resident registered one complaint on 12 July 2000 and another citizen in the same area reported on 21 July 2000 that "dusting was still a problem". (See Appendix B)

Weather data were obtained for 2000 from a number of Environment Canada weather stations along the rail route, from the mines near the Alberta/BC border to the port of Vancouver. Weather information from Kamloops (approximately 300 km closer to the coal mines than Hope), Hope and Abbotsford (approximately 80 km closer to Vancouver than Hope), British Columbia was analyzed. Note: these data have not yet undergone Quality Control assessment by Environment Canada. (Brewer 2001)

Maximum Temperature

For the three stations selected, a summary of the temperature data collected in 2000 is listed in Table 5.4.

Table 5.4 Maximum Temperature Readings (Tmax in °C) for 2000

	Kamloops	Max	Max	Tmax	**Hope**	Max	Max	Tmax	**Abbotsford**	Tmax	TMax	Tmax
Month	Average TMax	12-Jul	21-Jul	1 Day	Average TMax	12-Jul	21-Jul	1 Day	Average TMax	12-Jul	21-Jul	1 Day
Jan	-0.9			3.7	3.7			9.3	6.3			10
Feb	3.7			11.1	7.7			11.3	9.6			14.2
Mar	11.4			16.9	10.5			15.9	10.8			15.2
Apr	16.9			22.6	15.6			22.3	15.5			20.3
May	19.5			24.5	16.5			23.7	16.6			23.2
Jun	24.3			32.4	21.5			30.1	21.3			31.1
Jul	27.1	**30.7**	**34.3**	34.3	22.8	**24.7**	**29.7**	29.7	23.1	**24.8**	**30.7**	30.7
Aug	27.1			33.3	22.7			29.6	22.8			29.1
Sep	21.1			25.8	19.4			28.9	20.4			28.3
Oct	13.6			20.2	14.5			20.5	15.7			23.4
Nov	4.5			9.6	7.2			12.5	9.2			14
Dec	-1.0			8	3.3			8.7	5.6			10.3

The maximum temperature data from the three stations indicate that from May to September 2000 the maximum temperatures in all three cities ranged from warm to hot. In Kamloops, on the day of one reported dusting train, the temperature exceeded 30 degrees C. Single day maximums of greater than 30 degrees C were also recorded at each site in May, the month when the most visible dusting complaints were registered in 2000.

For loaded trains, an average temperature of below zero degrees Centigrade in Kamloops in January 2000 could have contributed to coal freezing in cars. On occasion, frozen coal in cars is not dumped at the end terminal. Subsequently on the return journey in the LFV in particular higher temperatures can cause that frozen coal to thaw. That unthawed coal can then be the source of dusting from 'empty' returning coal cars.

In regard to emissions estimates, no method was discovered for integrating the influence of maximum temperature into an emission factor. For nuisance dusting, what can be said is that in the spring and summer of 2000 there were many days in which the maximum temperatures were in a range that would have been conducive to nuisance dusting.

Wind Speed

Prevailing wind and the air movement created by train motion are critical to the coal dust emission rate for trains en route. Local wind plus train generated wind can combine to create complex air-flow patterns over the coal surface which can then entrain fine coal particles. Therefore, the coal surface in a train travelling at a relatively low velocity, may still be exposed to a wind of a much higher 'wind-over' velocity. The resultant wind-over the load will depend upon local wind velocity and direction plus train speed when the train transits a community en route to a coal terminal (or returning).

Episodes of 'heavy' dusting from trains have been recorded from fast trains on still days. Field observations have shown trains travelling in excess of 50 km/h (30 mph) in dry weather can emit significantly more dust than trains travelling at lower speeds in the same conditions. Conversely, field observations in the 1980s also indicated that trains dust at speeds lower than 50 km/hr. (Holmes 1982) (Cope 1986)

Laboratory wind tunnel experiments in the 1980s measured threshold-dusting velocities of 30 to 40 km/h (18 to 25 mph). (Cope 1986) More recent data, gathered by the EPA in regard to wind erosion, show threshold speeds for storage piles of approximately 18 km/hr. (EPA 2001-1).

A recent report appears to confirm that train speed is likely a factor in dusting. In January 2000, the average coal train speed in the LFV was reported as 35.8 km/hr. Therefore, one could conclude that for the communities in the LFV:

- On average, unit coal trains are travelling at a speed near the threshold wind velocity; and
- Over half the trains are travelling in excess of the threshold velocity.

For 2000, the hourly wind data for Hope, BC was averaged for each month. It would appear that the highest averages are in the winter months of January, February and December. In July, in Hope the average wind speed was 12 km/hr and from 12 to 21 July the local average wind speed was 13 km/hr, Table 5.5.

Table 5.5 Wind Measurement Averages - Hope, BC for 2000

2000			Wind	Average	in	km/hr					
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
16	15	10	12	11	13	12	12	10	11	10	19
					12-Jul	11					
					21-Jul	11					
				Average	12 –21 Jul	13					

The average measured wind in Hope in January 2000 was 16 km/hr in January. If in January 2000, the average coal train speed was 35.8 km/hr as reported, it is quite possible that on most days the two could combine and produce a resultant wind-over the coal load in each car that was in excess of the threshold speed for dust entrainment.

Since the average wind speed in Hope was 10 km/hr or greater from May to October, if one assumes that the average train speed in the spring, summer and fall of 2000 was also approximately 35.8 km/hr, then similar conclusions can be made for those periods. It would seem that on most days the combination of ambient wind and train speed should be capable of producing a wind-over velocity in each car in excess of the threshold speed for dust entrainment.

No emissions factor for rail car dusting that included a wind speed factor was discovered. However, the visible dusting incidents reported in 2000 in Hope, BC indicate that the combined wind-over velocity for those 27 coal trains was sufficient to produce dusting.

Precipitation

The rain, snow and total precipitation records for 2000 for these same three communities in BC were also analyzed. In July and August of 2000 each of the three communities had 20 or more days when the measured precipitation was zero, Table 5.6.

Less than one millimeter of rain fell in Kamloops each month from June to December of 2000. Less than 1.5 millimeters of rain fell in Hope in July and August of 2000. Conversely in May the average recorded rain was greater than 2.5 millimeters and yet more heavily dusting trains were recorded in that month than in any other month in 2000. As noted, Kamloops is approximately 300 km before Hope on the rail line to Vancouver. Therefore, in regard to precipitation, snow could cover or rain could wet the surface of the coal load prior to it reaching Hope.

Close to 2 millimeters of rain were recorded for Abbotsford in July, but on average, July and August were the two driest months in that community in 2000.

However, in 2000, from January to April inclusive, Kamloops had precipitation on eight or fewer days each month, on nine or fewer days for July, August and September and on only four days in November. Precipitation in Abbotsford, Hope and Kamloops on the 12th and 21st of July, 2000, the days when visible dusting was reported, was 0 mm of rain for all three communities.

Table 5.6 Recorded Precipitation - 2000

	Kamloops Rain Average mm	Days when Rain is 0	Days with Snow	Days with Precip	Hope Rain Average mm	Days when Rain is 0	Days with Snow	Days with Precip	Abbotsford Rain Average mm	Days when Rain is 0	Days with Snow	Days with Precip
Jan	0.39	29	8	8	1.01	26	21	21	4.24	7	2	25
Feb	0.21	18	2	8	1.44	18	7	14	3.94	13		16
Mar	1.18	24	1	7	2.26	13	7	20	4.79	12		18
Apr	0.92	24	1	6	1.87	14	6	18	3.65	15		15
May	1.09	17		14	2.57	9		22	5.81	10		20
Jun	0.84	19		11	2.21	14		16	4.31	14		15
Jul	0.96	22		9	1.39	19		12	1.72	24		7
Aug	0.76	25		6	1.23	21		10	1.11	27		4
Sep	0.26	20		9	3.15	15		15	3.81	16		14
Oct	0.32	21		10					4.28	16		15
Nov	0	26	1	4					3.46	19		11
Dec	0	27	15	17					3.58	14	3	17

In an analysis of emission methodology for unpaved road dust for British Columbia, the Emission Factor that was adopted was modified to account for 'precipitation days'.

> *Precipitation days* were defined as days when the rainfall exceeded three millimeters. Also, a snow day was one in which over one centimeter of snow lay on an unpaved road. (Levelton 1999)

With respect to dusting from coal trains, the difficulty with the application of such a factor will be variation in the number of precipitation and snow days in different areas along the 1100 km rail route through British Columbia.

For example, the data in Table 5.7 indicate that the average rain in Kamloops never exceeded three millimeters in any month in 2000 whereas, in Abbotsford the average exceeded three millimeters in every month but July and August or 2000. In Hope, for the nine months of data, the average only exceeded three millimeters in September.

Table 5.7 Precipitation Days and Snow Days in 2000

Abbotsford Rain		Abbotsford Snow		Hope Rain		Hope Snow		Kamloops Rain		Kamloops Snow	
M	Days > 3mm	M	Days > 1 cm	M	Days > 3mm	M	Days > 1 cm	M	Days > 3mm	M	Days > 1 cm
Jan	14	Jan	0	Jan	3	Jan	5	Jan	1	Jan	0
Feb	10	Feb	0	Feb	5	Feb	0	Feb	1	Feb	0
Mar	12	Mar	0	Mar	8	Mar	0	Mar	2	Mar	0
Apr	9	Apr	0	Apr	7	Apr	2	Apr	0	Apr	0
May	17	May	0	May	12	May	0	May	3	May	0
Jun	10	Jun	0	Jun	8	Jun	0	Jun	3	Jun	0
Jul	4	Jul	0	Jul	4	Jul	0	Jul	4	Jul	0
Aug	2	Aug	0	Aug	5	Aug	0	Aug	3	Aug	0
Sep	6	Sep	0	Sep	6	Sep	0	Sep	4	Sep	0
Oct	9	Oct	0					Oct	4	Oct	0
Nov	7	Nov	0					Nov	1	Nov	0
Dec	10	Dec	0					Dec	1	Dec	0
Total	110		0		58		7		27		0

Conclusions Regarding the Influence of Weather in 2000 Near Hope, BC
It would appear that for the section of the coal/rail route that passes through Kamloops, Hope and Abbotsford, British Columbia, that ambient weather conditions on many occasions in 2000 met the criteria that could be capable of producing heavily dusting trains.

There were extended periods of hot weather during the spring and summer months and all three communities experienced extended periods of little or no precipitation. The average wind in Hope, BC in the summer of 2000 did not. However, if the average monthly velocity of greater than 10 km/hr throughout the year were to combine with the train speed the combination could produce a wind-over velocity high enough to exceed the threshold speed for dust entrainment for any given train.

In regard to weather, the dusting conditions in the Hope, BC area during the period from 12 to 21 July, 2000 appear to have been ideal for the generation of dust from any untreated coal surfaces in unit train cars. For the three communities of Kamloops, Hope and Abbotsford, British Columbia, during the middle of July, the time of one specific dust complaint, only very light precipitation was recorded;

- Abbotsford recorded zero precipitation from 10 to 22 July;
- The Hope station recorded only 0.4 mm of rain on two days, 8 and 14 July, in a period from 5 to 21 July; and
- Kamloops only 0.2 mm on 20 July in a period from 9 to 21 July.

5.2.4 Recommended EFs for Rail Transportation of Coal
The literature and personal contact searches undertaken during the course of this study failed to identify any new EFs related to the loss of coal during shipment by train. Therefore it would seem appropriate to reiterate the findings of the 1980s: (MH 1983, Cope 1986)

> *The maximum potential coal losses, for one trip of approximately 1 100 km (700 mi.) over rough terrain during dry conditions, are in a range from 0.5 to 3% of the total coal load. This range for an uncontrolled emission factor is similar to the EF range determined by wind tunnel studies in 1983.*

As noted in Sections 5.2.1 and 5.2.2, if used to estimate emissions in relation to an 1100 km rail journey, the basic uncontrolled emission factors now used for the national CAC Inventory and the BC MELP Inventory are quite similar. Both are within the ranges noted above and appear to be based on the 0.5% of load uncontrolled EF that was discovered in early experiments. Where the two EFs differ is in how they incorporate distance and in what they consider to be the level of dust control achieved en route.

While the BC MELP EF is likely incorrect in the assumption that emissions are uniform over distance travelled, the CAC EF is also likely to be incorrect in the assumption that emissions always follow their non-linear relationship with distance travelled.

Data from the two Coal Terminals in Vancouver indicated that in 2000 approximately 27,462,000 tonnes of coal were exported through that port. Table 5.8 presents a comparison of the two EFs, if used to estimate dust emissions from rail cars for different hypothetical scenarios in relation to those exports. For the same dust control efficiency, the differences between the estimates produced by the two EFs are clearly illustrated. The two techniques produce estimates that are nearly identical for an 1000 km journey; they only differ by 4 tonnes. However, for a 100 km portion of the trip through the Lower Fraser Valley, the BC MELP EF produces a lower total than does the CAC EF, 125 tonnes versus 327 tonnes respectively (assuming that the CAC EF is employed to estimate emissions by distance segment).

However, as noted in Section 5.2.1, using the CAC EF in this manner is likely an incorrect application of the formula. It is suggested that, for the examples illustrated in Table 5.8, the CAC EF should first be used to produce an EF, and an emissions estimate, for the entire trip, in this example 1100 km. Then, it is suggested that those CAC EF generated emissions should be apportioned, or prorated, over the distance segments using the same linear technique as used by the BC MELP. Using the latter approach, since the EFs and emissions estimates for the 1100 km trip are almost identical, it also follows that the emissions apportioned to the 100 km segment would also be nearly identical, see B-Pro and G-LFV examples in Table 5.8.

However, the limitations of the BC MELP EF are also clearly illustrated in Table 5.8. The BC MELP EF, since it was derived in relation to a long rail journey, should only be used for estimating emissions from journeys in the range of 1100 kilometers. Those estimates can then be prorated for shorter segments such as the LFV, as is the present practice of the BC MELP.

However, since the BC MELP EF does not incorporate a distance factor, the application of their EF will produce the same total EF (for the same quantity of coal) regardless of the total distance travelled. Examples H and H-long in Table 5.8 illustrate this contention. While all of the coal shipped to Vancouver in 2000 did travel long distances, there were coal mines in Canada that did ship large quantities of coal by rail over short distances in 2000. When the BC MELP EF is applied for those scenarios, the estimated emissions for such short distances are questionably high. (See Section 5.4)

Conversely for longer distances, example G-long in Table 5.8. G-long illustrates a scenario where the BC MELP EF estimates, for an 1100 km trip, are prorated or extrapolated for a longer 1500 km journey. Used in this manner they produce higher emissions estimates than the CAC EF estimates using the same parameters, see C-long.

Therefore, for estimating emissions on a national basis, it is recommended that the basic CAC EF formula, equation 5.1, be used to represent the uncontrolled emissions for a rail coal journey. However, the use of that formula should be modified. Instead of the current practice of using the formula to produce new estimates for each provincial distance segment, the overall estimate for the total trip should instead be prorated by distance segment. The latter technique is used by the BC MELP to prorate emissions for the LFV.

Table 5.8 Comparison of Different EFs for LFV Emissions in 2000

Scenario	Description	D (km)	Coal Shipped through Vancouver in 2000 (tonnes)	EF	Emissions in tonnes (PART)
	Using the CAC EF			**kg/tonne**	
A	Uncontrolled CAC EF	1100	27,462,000	5.015	137,722
A-LFV	Using a Distance of 100 km for LFV	100	27,462,000	1.190	32,671
A-Pro	Prorate Using Distance of 100 km for LFV	100	27,462,000	0.456	12,520
B	As for 1995 inventory with 99% control	1100	27,462,000	0.201	5,509
B-LFV	Using Distance of 100 km for LFV	100	27,462,000	0.048	1,307
B-Pro	Prorate Using Distance of 100 km for LFV	100	27,462,000	0.018	501
C	99 % control applied to A	1100	27,462,000	0.050	1,377
C-LFV	Using Distance or 100 km for LFV	100	27,462,000	0.012	327
C-Pro	Prorate Using Distance of 100 km for LFV	100	27,462,000	0.005	125
C-long	For a distance of 1500 km	1500	27,462,000	0.060	1,659
	Using the BC MELP EF			**t/tonne**	
E	Generic uncontrolled EF= 0.5% of load	1100	27,462,000	0.005000	137,310
E-LFV	Prorate Using Distance of 100 km for LFV	100	27,462,000	0.000455	12,483
G	If assume that there is 99% control	1100	27,462,000	0.000050	1,373
G-LFV	Prorate Using Distance of 100 km for LFV	100	27,462,000	0.0000045	125
G-long	Prorate for a distance of 1500 km	1500	27,462,000	0.0000682	1,872
H	Use BC MELP EF for entire quantity of coal carried for a short trip of 100 km	100	27,462,000	0.0000500	1,373
H-long	Use BC MELP EF for entire quantity of coal carried for a long trip of 1500 km	1500	27,462,000	0.0000500	1,373

In conclusion, it is recommended that the basic CAC EF be modified using:

- New PM_{10} and $PM_{2.5}$ scaling factors,
- A precipitation factor,
- A linear distance factor to prorate emissions, and
- An adjusted dust control factor of 99%.

Particulate Sizing - PM_{10} and $PM_{2.5}$ Scaling Factors

The different sets of ratios for scaling TPM to PM_{10} and $PM_{2.5}$, as used by BC Environment and by the CAC Inventory, are felt to be too high. Therefore, as suggested by researchers at MRI, the scaling factors used in the Industrial Wind Erosion section 13.2.5.3 of the EPA AP-42 may be more appropriate. (MRI 2001)

AP-42 Chapter 13.2.5 on *Industrial Wind Erosion* lists particle size multipliers that vary with aerodynamic particle size: (EPA 2001-1)

Aerodynamic Particle Size Multipliers for EF equation:

30 µm	<15 µm	<10 µm	<2.5 µm
1.0	0.6	0.5	0.2

This distribution of particle size within the under 30 micrometer (µm) fraction is comparable to the distributions reported for other fugitive dust sources where wind speed is a factor. A comparison of the Scaling Factors used for comparable operations is presented in Table 5.9.

Recommended PM_{10} and $PM_{2.5}$ Scaling Factors
For this study, the recommended *Scaling Factors* to convert Total Particulate Matter emission estimates to PM_{10} and $PM_{2.5}$ emissions estimates are those assigned by the EPA for wind erosion of storage piles:

$$PM_{10}\ EF = PART\ or\ TSP\ EF \times 0.5 \qquad (5.5)$$
$$PM_{2.5}\ EF = PART\ or\ TSP\ EF \times 0.2 \qquad (5.6)$$

While the scaling factors for wind erosion from stockpiles have been selected for use with rail coal cars, the AP-42 EF for a stationary stockpile that is not subject to vibration is not felt to be appropriate since it does not adequately reflect rail car emissions.

Table 5.9 Comparison of Scaling Factors

Comparable Operation	Scaling factor x TSP		Reference
	PM_{10}	$PM_{2.5}$	
CAC Inventory - Train Dust	1.0	0.92	NEIPTG 1999
BC MELP - Train Dusting	0.96	0.92	BCMELP 1999
CAC Inventory Mining Coal Dust Emissions	0.545	0.33	NEIPTG 2001
Truck loading	0.75	0.019	US EPA[1]
Loading to trains	0.42		Env. Australia[2]
Wind erosion of stockpiles[3]	0.5	0.2	US EPA[4]
Wind erosion of stockpiles	0.5		Env. Australia[2]

1. "Revision of Emission Factors for AP-42 Section 11.9 Western Surface Coal Mining, September 1998, US Environmental Protection Agency."
2. "National Pollutant Inventory, Emission Estimation Technique Manual for Mining, Version 2.1, 11 October, 2000, Environment Australia."
3. Predictive emission factor equation.
4. "AP-42 Section 13.2.5 Miscellaneous Sources, January 1995, US Environmental Protection Agency."

Effect of Weather En Route – Precipitation Factor

It is not a new discovery that weather can influence particulate emissions. In regard to visible coal dusting from trains, the investigations in the 1980s revealed that incidents of 'heavily' dusting trains frequently occurred during periods of hot, dry weather. Conversely, heavy precipitation could act to limit dust emissions. The difficulty is in how to apply precipitation variables to dust emissions estimates? To date, it would appear that no agency has developed an EF for rail transportation that includes a weather qualifier. However, for this study an attempt is made to link the controlling effect of precipitation to dusting.

Recommended Precipitation Factor

Therefore, to account for rain en route, it is suggested that the basic EF be modified using the precipitation factor developed for unpaved road dust emission estimates: (Levelton 1999)

$$\textit{Final EF} = \textit{PART or TSP EF} \times (365-P)/365 \qquad (5.7)$$

Where P = number of precipitation days plus the number of snow days, see Section 5.2.3.1.

The difficulty with the application of this factor is that the number of precipitation days will vary with location over a long rail journey.

Coal Dust Distribution En Route – Distance Factor

In general, most of the EFs used for estimating fugitive dust emissions are meant for macro applications. They are best used to produce national, provincial or regional emissions estimates. By their nature they are general and meant to be used in a general context.

The CAC EF incorporates a rail distance variable. However, it is felt that it should not be used to estimate emissions for each segment of a longer rail journey, as is now the practice for the CAC Inventory. Instead it is suggested that the CAC EF equation should be used to produce an EF, and an emissions estimate, for the entire trip. Subsequently, the total trip EF (or the total emissions estimate) should be prorated for each trip segment using a simple linear function. This is the system that is now employed by the BC MELP to estimate emissions for the LFV. In other words a second distance factor is used related to the distance the coal travels in each segment.

Recommended Distance Factor

First, the Distance for the total trip, D, is used in the CAC uncontrolled EF formula, equation 5.1:

$$\textit{EF for Total Trip} = 0.1*(0.62*D)^{0.6} \qquad (5.1)$$

Where: EF = the emission factor in kg/tonne of coal transported and
D = the total distance travelled by rail cars (km).

Second, the EF is modified using the length of each segment:

$$\textit{Final EF each segment} = \textit{EF for Total Trip} \times (\textit{Segment Distance}/D) \qquad (5.8)$$

Where: Segment Distance = the distance the coal is shipped in km within the segment.

Emission Control Efficiency - Dust Control Factor

As noted in the general discussion of EFs in Chapter 3, one of the basic factors required to modify any uncontrolled emission factor is one that accounts for the efficiency of any emissions control system:

Recommended Dust Control Factor

$$\textit{Final Controlled EF} = EF \times (100 - \textit{Control Efficiency})/100 \quad (5.9)$$

Where: Control Efficiency = the % efficacy of the control i.e. if the Control Efficiency is 99% enter 99 in the formula.

Recommended Overall Rail Coal Dust EF

Therefore, the final EF formula recommended for estimating rail coal dust emissions is:

Rail Coal Dust EF (kg/tonne)

$$= 0.1*(0.62*D)^{0.6} \times (365-P)/365 \times (\textit{Segment Distance}/D) \times (100 - \textit{Control Efficiency})/100 \quad (5.10)$$

Where: D = total rail distance (km)
P = number of precipitation days
Segment Distance = distance travelled in a province or region
Control Efficiency = coal dust control efficiency

The PM_{10} and $PM_{2.5}$ PM emissions are then calculated using the scaling factors:

$$PM_{10}\ EF = \textit{Rail Coal Dust EF} \times 0.5 \quad (5.11)$$

$$PM_{2.5}\ EF = \textit{Rail Coal Dust EF} \times 0.2 \quad (5.12)$$

The BC MELP EF and the CAC EF were both used to illustrate emissions estimates for 2000, see Section 5.4.

5.2.4.1 Emission Factors for Dusting from Empty Trains

As noted in Section 1.3, from 1979 to 1984 of over 1600 *empty* unit trains observed in transit, approximately 2% were judged to be 'medium' to 'heavy' dusters in relation to visible coal dust emissions. While these trains are part of the nuisance dusting problem, their contribution to total train dusting on an annual basis is not known. No EFs in relation to total emissions from such trains were found as a result of this investigation.

It is suggested that while dusting from empty cars may create a number of visible, nuisance soiling dusting events during a year, the overall contribution to an annual emission inventory may also be minor. No EFs for empty rail cars are proposed, but the empty train issue deserves study as part of the continued nuisance soiling problems in communities in the Lower Fraser Valley.

5.3 Fugitive Dust Control – Rail Transport

In Western Canada, since 1975 the principal method for controlling fugitive coal dust emissions from rail cars has been to spray sealant chemicals on the surface of each car at the mine site prior to shipment. Other coal dust mitigation techniques that have been suggested, attempted or that are in use are listed in Table 5.10.

Table 5.10 Train Coal Dust Mitigation Techniques

	Technique	Comments
A	**Railway Companies**	
1	Reduce Train Speed	Claimed to be a railway policy in 2000
2	Uniform Design	Both CN and CP are adding new cars to their fleets
3	Group Coal Cars of Similar Design and Height	Car grouping suggested as a policy for railway companies
4	Ban Above Car Loading	Would reduce expose of coal load to high wind and may reduce dusting
5	Aerodynamic Modifications to Cars	May be difficult to retrofit and may not work with different loading systems
6	Buy Property or Homes Affected by Dust	Too many homes are affected for this technique to be practicable
7	Damage Compensation Payments- Yearly Stipend	Not a long term solution
B	**Coal Mining Companies**	
1	Flat Load-Profile	Effective load levelling systems are required at all mines
2	Chemical Sealant Application Systems	Effective sealant spray systems are required at all mines. In addition, backup or secondary sprays systems are also required at all mines
3	Switch Chemical Sealants	The most effective chemical sealants should be used
4	Increase Chemical Sealant Concentrations	If trains are dusting an increase in the sealant concentration may be required
5	Chemical or Water Sprays - En Route	Could be effective, but how, when, where and cost could present significant barriers to their use
6	Hinged Covers	While they could be effective in a new system, there retrofit to existing system is impractical
7	Lift-off Covers	Similar to above, but no functioning fast-load system currently available
8	Roll-Back Covers	Similar to above, but no functioning fast-load system currently available
9	Soft Once-Only Covers	Their retrofit into existing system is likely impractical and they would represent a source of pollution
10	Briquetting	Effectiveness and practicality is unknown at this time
11	Coarse Coal Topping	Attempted but found to be impractical and abandoned
C	**Coal Terminal Operators**	
1	Exterior Car Washing	Once in use at several terminals
2	Interior Car Washing	Suggested for empty car dusting problem
3	Thaw Sheds	In use at several terminals
4	Side Release Agents	Tested in the early 80s results unknown

5.3.1 Environment Canada's 1986 Recommended Practices

A series of studies into the problem of visible train dusting were conducted in the early 1980s. As part of those investigations, train loading and spraying practices were observed at several mines in Alberta and British Columbia from 1979 to 1984. The results of those observations indicated that the frequent occurrence of exposed (non-sealed) coal surfaces in rail cars, that had supposedly been sealed with chemicals, likely resulted from one of more of the following: (Cope 1986)

- Poorly designed spray apparatus;
- Inadequate maintenance procedures;
- Inappropriate sealant concentration;
- Incorrect spray chemicals;
- Inadequate loading, levelling and spray system operator training;
- Poorly functioning load levelling devices; and/or
- Weaknesses inherent in the sealant chemical spray technique.

To improve the control of fugitive coal dust from unit trains, all of the major coal mining companies in Western Canada in 1986 agreed to a number of *Recommended Practices*. The *Coal Dust Control, Recommended Practices for Loading, Unloading and Transporting Coal by Rail* were published by Environment Canada in 1986. (Wituschek 86) It was felt that following the application of these practices, illustrated in Appendix C, that consistent performance from the coal dust control systems could be achieved

5.3.2 Rail Car Dust Control at the Mines - 2000

While improvements have been reported in the coal dust control procedures at certain mines in Western Canada, an information update re the status of dust control equipment at mines was not available. Regardless, the visible dusting incidents reported in 2000 indicate that there are still equipment and procedural problems at certain mines that can lead to dusting trains.

Two examples of problems in relation to dust control were reported in 2000 and 2001:

- In 2001, one unconfirmed report indicated that at least one major coal mine in Western Canada, that shipped coal to Vancouver, was not spraying sealants on its loaded rail cars.
- In 2000 Transport Canada reported that they visited the Roberts Bank coal terminal to inspect the loaded coal cars on trains that had been judged to be *heavily* dusting. They observed nine cars in one train that had mid-load craters. (CTA 2000) Such craters are usually an indication that the level profile in a rail car has been disturbed after levelling and spraying in order to adjust the weight of over-loaded (weight) cars. These disturbed profiles are a known source of heavy fugitive emissions and the *Recommended Practice* for such actions was:

  When load adjustments are made at the mine, the load should be levelled and re-sprayed with sealant prior to departure from the mine site. (Wituschek 1986)

Tables 5.11 and 5.12 illustrate the information that would be required from each mine in order to adequately assess the dust control features and practices at each mine in Western Canada in relation to the *1986 Recommended Practices* for rail car dust control. Unfortunately, the mining companies contacted during the course of this investigation presented little or no information.

5.3.2.1 Crust-Retention at End of Journey

As noted in Section 5.2, since 1975, for sprayed coal loads in trains, the total crust remaining or retained on loaded rail cars at the End Terminals after a long journey has been used as a measure of dust control. The assessment of crust-retention is based upon the visual observation of exposed, non-crusted, coal surfaces when loaded trains arrive at the End Terminals. For the *1986 Recommended Practices*, the mines that ship coal to Vancouver, agreed that: (Wituschek 1986)

> *A minimum acceptable level of dust control is generally achieved under all conditions if the crust-retention of a train is at least 85%. The minimum objective for crust-retention is therefore 85% and should be calculated as a 'train average'.*

Unfortunately, crust-retention is only a crude gauge of dust control performance. One study in 1982 clearly stated that: (Holmes 1982)

> *The 85% crust-retention standard is inadequate since trains achieving a crust-retention level close to this value emit unacceptable levels of fugitive dust during periods of hot, dry weather.*

Also, as noted earlier, the company monitoring coal dusting from trains in Virginia consider that a car with 20% crust loss (or 80% crust-retention) is virtually uncontrolled in regard to dust emissions. (SWA 2001)

To date, a one-to-one link has not been established between crust-retention percentage at the end of a journey and the percentage dust control achieved en route. However, while crust-retention assessment may not provide a direct indication as to dust control efficiency, it can indicate when there are problems with the sealant spray and profile levelling systems at individual mines. Therefore, until another generally approved system is devised for dust control effectiveness assessment, crust-retention assessment is likely to be retained as a method for assessing dust control effectiveness.

5.3.3 Railcar Dust Control - The Railways

Table 5.13 lists the information that would be required from the railway companies in order to assess their current practices versus what was required by the *1986 Recommended Practices*. While little new information was available from the railway companies regarding their dust control procedures, the minutes of the public meeting in September 2000 in Hope, BC, indicated that the CPR stated that they had a *slow down* order in effect for dusting trains.

An industry-wide Action Committee on Coal Dust was formed in 2000. This committee comprises coal producers in BC and Alberta, CN, CP and the port facilities located in the Vancouver region. (Laing 2000) (See Appendix B)

A report of the Action Committee claims that: (Action 2000)

> *The railways reviewed operating procedures with train crews to ensure dusting trains are reported immediately and procedures for proper handling of dusting trains are followed.*

Table 5.11 Train Dust Control – Equipment 2001

Equipment		Sill Clean	Car Profile Load-Level Type	Compact	Adjust Load Backhoe	Re-level	Type of Sealant	Spray System Number or Spray Bars	Re-Spray Facility	Monitor Cones & Mixiing	Freeze Protection	Wind Protect
Mine	Prov.											

Table 5.12 Train Dust Control - Procedures - 2001

Equipment		Spray Systems Training Programs	Malfunction Procedures	Verification Procedures		Spray Cone &Volume	Inspect and Adjust During Car Spraying	Re-spray After Load Adjustment	Re-spray Cars if Required	Records of Spraying
Mine	Prov.			Equipment Function	Levelling					

Table 5.13 Railway - Train Dust Control Procedures

Railway Company	Group Cars of Similar Height	Speed Control Systems at Load-Out Facilities	Reduce Speed of Dusting Trains
CP			Claim a slow down order is in effect for dusting trains.
CN			
BCR			
Imports			
Rail to Vancouver			
Rail to Thunder Bay			

Table 5.14 Coal Terminals - Rail Car Dust Controls – Equipment & Procedures – 2001

Port	Prov	Empty Car Wash Exterior	Empty Car Wash Interior	Waste Water Collection & Treat	Empty Car Air Wash	Empty Car Sealant Spray	Treat Cars for Frozen Coal
Westshore	**BC**	yes	no	yes	no	no	freeze protection for car spray
Neptune	**BC**	no	no	yes	no	no	no
Texada	**BC**						
Ridley	**BC**						
Thunder Bay	**Ont**						
Procedures		**Training Programs**	**Equipment Malfunction Procedures**	**Standby Spray Truck for Malfunctions**	**Inspect all Empty Cars**	**Enclosed Rotary Dumper**	**Dump at Maximum Angle**
Westshore	**BC**					yes	yes
Neptune	**BC**	yes	yes	yes	no	yes	yes
Texada	**BC**						
Ridley	**BC**					no	
Thunder Bay	**Ont**						

5.3.4 Railcar Dust Control - Terminals

The *empty* railcar dust control procedures, as reported by two End Terminals for 2000, are illustrated in Table 5.14. The procedure of ensuring that their rotary-dumpers are turned to the maximum angle, was not in the *1986 Recommended Practices*. This technique was one of the actions reported by the industry *Action Committee on Coal Dust*. (Action 2000)

One terminal reported that it employs an external sill car wash to clean the rail cars after they are dumped. While this wash should eliminate one source of dust associated with empty cars, it would not remove coal that may be left inside of a car.

5.4 Coal Dust Emissions Estimates
Rail Transport – 2000

Estimates of the fugitive coal dust emissions for rail transport in Canada in 2000 were attempted for coal shipped by rail in 2000. Three sets of estimates have been prepared:

(While the production data for most mines were available for 2000, some 1999 data were used. It was felt that for most cases the changes from 1999 to 2000 were likely minor.)

1] Estimates were made using a CAC Inventory uncontrolled EF that was modified to include a dust control efficiency of 99%. However, the 99% efficiency control was applied differently than was the case for the 1995 CAC Inventory estimates. For this example, it was assumed the basic CAC EF is uncontrolled and not at the 75% level to start. This EF was used to estimate emissions for each provincial distance segment, Tables 5.15a and b.

2] Estimates were made using the CAC Inventory uncontrolled EF and the 99% control as in case 1] above to estimate total trip emissions. Then a linear distance function was used to apportion estimates by province, Tables 5.16a and b.

3] Estimates were made using the BC MELP EF of 0.5% of total throughput but assuming 99% control efficiency for those emissions, Tables 5.17a and b.

While a dust control of 99% may appear high, it is the dust control efficiency currently assumed by Environment Canada for assessing national rail coal dust emissions. It is also supported by the evidence that only just over 1% of the loaded coal trains observed in Hope, BC in 2000 were assessed as 'heavy' emitters in terms of visible dust emissions.

Of the four modifying factors noted in Section 5.2.4, three were used to make these estimates: PM_{10} and $PM_{2.5}$ scaling factors, distance factors and a dust control factor. The use of a precipitation factor is discussed in Section 5.4.1.

Also, for the CAC Inventory related emission calculations, the following changes, related to possible errors in regard to mines, were made:

- Quinsam mine in BC – the coal does not travel by rail, it travels by truck and barge.
- Highvale, Whitewood, Genesee mines in Alberta – coal travels by truck not train.
- Boundary Dam mine in Saskatchewan – coal travels by truck only.
- Poplar River mine in Saskatchewan – while coal does go by train to a power plant, the plant is only 20 km away not 192 km as now used.
- Bienfait mine in Saskatchewan – ships some coal by rail to Ontario for use at power plants near the Lakehead. Therefore there should be rail distances for Sask, Man and Ontario not just 58km for Sask.
- The Prince mine in NS (that closed in November 2001) – shipped to a nearby Power Plant.
- Trenton Power Plant in NS – do not think the coal goes by rail? This should be confirmed.
- Sheerness and Paintearth in Alta mines move coal only short distances by truck to local PPs.

Table 5.15a CAC EF Conventional Rail Dust Emissions Estimates – 2000 – Total Particulate

Coal by Rail

Total Particulate Emission factors – 99% control

(CAC 1995 EFs) **in kg/tonne**

	Prov	Coal	Dist	BC	ALTA	SASK	MAN	ONT	Que	NS	Nfld
Mines		Mt	km		PART	with	99%	control			
Bullmoose	**BC**	1.60	1180	0.052							
Coal Mountain	**BC**	2.00	2073	0.008	0.031	0.036	0.033	0.025			
Coal Mountain#	**BC**	0.30	1141	0.051							
Elkview (Balmer)	**BC**	3.00	1055	0.049							
Fording River*	**BC**	8.30	1169	0.052							
Greenhills*	**BC**	4.20	989	0.047							
Line Creek	**BC**	3.00	1141	0.051							
Line Creek#	**BC**	0.50	2102	0.011	0.031	0.036	0.033	0.025			
Quintette	**BC**	1.00	1250	0.054							
Coal Valley	Alta	0.70	1093	0.041	0.023						
Coal Valley#	Alta	0.20	1381	0.051	0.02						
Coal Valley#	Alta	0.10	2282		0.035	0.041	0.038	0.017			
Gregg River	Alta	1.50	1114	0.041	0.024						
Gregg River#	Alta	0.50	1408	0.052	0.02						
Gregg River#	Alta	0.10	2309		0.041	0.036	0.033	0.025			
Luscar	Alta	2.00	1108	0.041	0.024						
Luscar#	Alta	0.50	1404	0.051	0.021						
Luscar#	Alta	0.30	2305		0.036	0.041	0.038	0.017			
Obed	Alta	1.50	958	0.041	0.016						
Obed#	Alta	0.20	1257	0.051	0.013						
Obed#	Alta	0.10	2264		0.035	0.041	0.038	0.017			
Smoky River*	Alta	1.80	1180	0.043	0.025						
Bienfait	**Sask**	1.90	58			0.009					
Bienfait#	**Sask**	0.10	1086			0.022	0.033	0.025			
Poplar River	**Sask**	4.00	20			0.005					
Prince	NS	0.98	8							0.003	
Nfld Import via Que	**Imp**	0.05	350						0.018		0.015
Totals =											

Total Particulate Emissions Estimates –99% control

(Using CAC 1995 EFs) **Emissions in Tonnes for 2000**

Province	BC	ALTA	SASK	MAN	ONT	Que	NS	Nfld
Mines		PART	PART	PART	PART	PART	PART	PART
Bullmoose	83.69							
Coal Mountain	16.62	62.12	71.65	65.96	50.28			
Coal Mountain#	15.38							
Elkview (Balmer)	146.73							
Fording River*	431.72							
Greenhills*	197.61							
Line Creek	153.79							
Line Creek#	5.36	15.53	17.91	16.49	12.57			
Quintette	54.15							
Coal Valley	28.74	16.26						
Coal Valley#	10.28	3.96						
Coal Valley#		3.52	4.13	3.78	1.75			
Gregg River	61.58	36.26						
Gregg River#	26.15	9.75						
Gregg River#		4.10	3.58	3.30	2.51			
Luscar	82.11	47.81						
Luscar#	25.71	10.48						
Luscar#		10.79	12.38	11.35	5.25			
Obed	61.58	24.54						
Obed#	10.28	2.52						
Obed#		3.45	4.13	3.78	1.75			
Smoky River*	76.51	45.02						
Bienfait			16.30					
Bienfait#			2.23	3.30	2.51			
Poplar River			18.12					
Prince							2.55	
Nfld Import via Que						0.89		0.75
Canada = 2123.3	1487.99	296.12	150.44	107.96	76.62	0.89	2.55	0.75

* 1999 data # estimate quantity shipped in 2000 & subtract from total shipped to principal terminal

Table 5.15b CAC EF Conventional Rail Dust Emissions Estimates – 2000 - PM_{10} and $PM_{2.5}$

PM_{10} Emissions in tonnes
(PM_{10} = PART with 99% control x 0.5)

Province	Prov	BC	Alta	Sask	Man	Ont	Que	NS	Nfld
Mines			PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}
Bullmoose	BC	41.85							
Coal Mountain	BC	8.31	31.06	35.83	32.98	25.14			
Coal Mountain#	BC	7.69							
Elkview (Balmer)	BC	73.36							
Fording River*	BC	215.86							
Greenhills*	BC	98.80							
Line Creek	BC	76.89							
Line Creek#	BC	2.68	7.76	8.96	8.24	6.29			
Quintette	BC	27.07							
Coal Valley	Alta	14.37	8.13						
Coal Valley#	Alta	5.14	1.98						
Coal Valley#	Alta		1.76	2.06	1.89	0.87			
Gregg River	Alta	30.79	18.13						
Gregg River#	Alta	13.08	4.88						
Gregg River#	Alta		2.05	1.79	1.65	1.26			
Luscar	Alta	41.05	23.91						
Luscar#	Alta	12.86	5.24						
Luscar#	Alta		5.39	6.19	5.68	2.62			
Obed	Alta	30.79	12.27						
Obed#	Alta	5.14	1.26						
Obed#	Alta		1.73	2.06	1.89	0.87			
Smoky River*	Alta	38.26	22.51						
Bienfait	Sask			8.15					
Bienfait#	Sask			1.12	1.65	1.26			
Poplar River	Sask			9.06					
Prince	NS							1.27	
Nfld Import - Que	Imp						0.45		0.38
Totals =		744.00	148.06	75.22	53.98	38.31	0.45	1.27	0.38

$PM_{2.5}$ Emissions in tonnes
($PM_{2.5}$ = PART with 99% control x 0.2)

Province	BC	ALTA	SASK	MAN	ONT	Que	NS	Nfld
Mines		$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$
Bullmoose	16.74							
Coal Mountain	3.32	12.42	14.33	13.19	10.06			
Coal Mountain#	3.08							
Elkview (Balmer)	29.35							
Fording River*	86.34							
Greenhills*	39.52							
Line Creek	30.76							
Line Creek#	1.07	3.11	3.58	3.30	2.51			
Quintette	10.83							
Coal Valley	5.75	3.25						
Coal Valley#	2.06	0.79						
Coal Valley#		0.70	0.83	0.76	0.35			
Gregg River	12.32	7.25						
Gregg River#	5.23	1.95						
Gregg River#		0.82	0.72	0.66	0.50			
Luscar	16.42	9.56						
Luscar#	5.14	2.10						
Luscar#		2.16	2.48	2.27	1.05			
Obed	12.32	4.91						
Obed#	2.06	0.50						
Obed#		0.69	0.83	0.76	0.35			
Smoky River*	15.30	9.00						
Bienfait			3.26					
Bienfait#			0.45	0.66	0.50			
Poplar River			3.62					
Prince							0.51	
Nfld Import Que						0.18		0.15
Totals =	297.60	59.22	30.09	21.59	15.32	0.18	0.51	0.15

* 1999 data

\# estimate quantity shipped in 2000 & subtract from total shipped to principal terminal

Table 5.16a New CAC EF Rail Dust Emissions Estimates – 2000 – Total Particulate

Total Particulate Emissions Estimates - PART with 99% Control

Mine		Coal Mt	Total Distance km	New CAC EF Total Trip Kg/tonne	Emissions Total Trip tonnes	Mine	Emissions in Tonnes for 2000 BC	ALTA	SASK	MAN	ONT	Que	NS	Nfld
Bullmoose	BC	1.60	1180	0.052	83.69	Bullmoose	83.69							
Coal Mountain	BC	2.00	2073	0.073	146.70	Coal Mountain	3.89	35.03	44.44	38.71	24.63			
Coal Mountain#	BC	0.30	1141	0.051	15.38	Coal Mountain#	15.38							
Elkview (Balmer)	BC	3.00	1055	0.049	146.73	Elkview (Balmer)	146.73							
Fording River*	BC	8.30	1169	0.052	431.72	Fording River*	431.72							
Greenhills*	BC	4.20	989	0.047	197.61	Greenhills*	197.61							
Line Creek	BC	3.00	1141	0.051	153.79	Line Creek	153.79							
Line Creek#	BC	0.50	2102	0.074	36.98	Line Creek#	1.48	8.71	11.05	9.62	6.12			
Quintette	BC	1.00	1250	0.054	54.15	Quintette	54.15							
Coal Valley	Alta	0.70	1093	0.050	34.97	Coal Valley	25.21	9.76						
Coal Valley#	Alta	0.20	1381	0.057	11.50	Coal Valley#	9.55	1.95						
Coal Valley#	Alta	0.10	2282	0.078	7.77	Coal Valley#		2.07	2.71	2.34	0.65			
Gregg River	Alta	1.50	1114	0.051	75.80	Gregg River	53.62	22.18						
Gregg River#	Alta	0.50	1408	0.058	29.08	Gregg River#	24.37	4.71						
Gregg River#	Alta	0.10	2309	0.078	7.83	Gregg River#		2.66	2.13	1.85	1.18			
Luscar	Alta	2.00	1108	0.050	100.74	Luscar	71.64	29.09						
Luscar#	Alta	0.50	1404	0.058	29.03	Luscar#	23.71	5.31						
Luscar#	Alta	0.30	2305	0.078	23.45	Luscar#		6.43	8.09	7.00	1.93			
Obed	Alta	1.50	958	0.046	69.24	Obed	56.95	12.29						
Obed#	Alta	0.20	1257	0.054	10.87	Obed#	9.92	0.95						
Obed#	Alta	0.10	2264	0.077	7.73	Obed#		2.02	2.72	2.35	0.65			
Smoky River*		1.80	1180	0.052	94.15	Smoky River*	66.63	27.53						
Bienfait	Sask	1.90	58	0.009	16.30	Bienfait			16.30					
Bienfait#	Sask	0.10	1086	0.052	5.23	Bienfait#			1.26	2.42	1.54			
Poplar River	Sask	4.00	20	0.005	18.12	Poplar River			18.12					
Prince	NS	0.98	8	0.003	2.56	Prince							2.56	
Nfld Import via Que	Imp	0.05	350	0.025	1.25	Nfld Import - Que						0.71		0.53
				Totals =	1812.35	Totals =	1430.03	170.69	106.81	64.30	36.70	0.71	2.56	0.53

* 1999 data   # estimate quantity shipped in 2000 & subtract from total shipped to principal terminal

Table 5.16b New CAC EF Rail Dust Emissions Estimates – 2000 – PM_{10} and $PM_{2.5}$

PM_{10} = PART with 99% control x 0.5 scaling factor

Emissions in Tonnes for 2000

Mine		BC	ALTA	SASK	MAN	ONT	Que	NS	Nfld
Bullmoose	BC	41.85							
Coal Mountain	BC	1.95	17.51	22.22	19.35	12.31			
Coal Mountain#	BC	7.69							
Elkview (Balmer)	BC	73.36							
Fording River*	BC	215.86							
Greenhills*	BC	98.80							
Line Creek	BC	76.89							
Line Creek#	BC	0.74	4.35	5.52	4.81	3.06			
Quintette	BC	27.07							
Coal Valley	Alta	12.61	4.88						
Coal Valley#	Alta	4.77	0.97						
Coal Valley#	Alta		1.04	1.35	1.17	0.32			
Gregg River	Alta	26.81	11.09						
Gregg River#	Alta	12.18	2.35						
Gregg River#	Alta		1.33	1.06	0.93	0.59			
Luscar	Alta	35.82	14.55						
Luscar#	Alta	11.86	2.66						
Luscar#	Alta		3.21	4.04	3.50	0.97			
Obed	Alta	28.48	6.14						
Obed#	Alta	4.96	0.48						
Obed#	Alta		1.01	1.36	1.18	0.32			
Smoky River*		33.31	13.76						
Bienfait	Sask			8.15					
Bienfait#	Sask			0.63	1.21	0.77			
Poplar River	Sask			9.06					
Prince	NS							1.28	
Nfld Import -Que	Imp						0.36		0.27
Totals =		715.01	85.35	53.41	32.15	18.35	0.36	1.28	0.27

$PM_{2.5}$ = PART with 99% control x 0.2 scaling factor

Emissions in Tonnes for 2000

Mine	BC	ALTA	SASK	MAN	ONT	Que	NS	Nfld
Bullmoose	16.74							
Coal Mountain	0.78	7.01	8.89	7.74	4.93			
Coal Mountain#	3.08							
Elkview (Balmer)	29.35							
Fording River*	86.34							
Greenhills*	39.52							
Line Creek	30.76							
Line Creek#	0.30	1.74	2.21	1.92	1.22			
Quintette	10.83							
Coal Valley	5.04	1.95						
Coal Valley#	1.91	0.39						
Coal Valley#		0.41	0.54	0.47	0.13			
Gregg River	10.72	4.44						
Gregg River#	4.87	0.94						
Gregg River#		0.53	0.43	0.37	0.24			
Luscar	14.33	5.82						
Luscar#	4.74	1.06						
Luscar#		1.29	1.62	1.40	0.39			
Obed	11.39	2.46						
Obed#	1.98	0.19						
Obed#		0.40	0.54	0.47	0.13			
Smoky River*	13.33	5.51						
Bienfait			3.26					
Bienfait#			0.25	0.48	0.31			
Poplar River			3.62					
Prince							0.51	
Nfld Import Que						0.14		0.11
Totals =	286.01	34.14	21.36	12.86	7.34	0.14	0.51	0.11

* 1999 data # estimate quantity shipped in 2000 & subtract from total shipped to principal terminal

Table 5.17a New BC MELP EF Rail Dust Emissions Estimates – 2000 – Total Particulate

Total Particulate Emissions Estimates - PART with 99% Control

Mine		Coal Mt	Total Distance km	BC MELP EF Total Trip t/tonne	Emissions Total Trip tonnes	Mine	Emissions in Tonnes for 2000 BC	ALTA	SASK	MAN	ONT	Que	NS	Nfld
				.5/100*1/100										
Bullmoose	BC	1.60	1180	0.00005	80.00	Bullmoose	80.00							
Coal Mountain	BC	2.00	2073	0.00005	100.00	Coal Mountain	2.65	23.88	30.29	26.39	16.79			
Coal Mountain#	BC	0.30	1141	0.00005	15.00	Coal Mountain#	15.00							
Elkview (Balmer)	BC	3.00	1055	0.00005	150.00	Elkview (Balmer)	150.00							
Fording River*	BC	8.30	1169	0.00005	415.00	Fording River*	415.00							
Greenhills*	BC	4.20	989	0.00005	210.00	Greenhills*	210.00							
Line Creek	BC	3.00	1141	0.00005	150.00	Line Creek	150.00							
Line Creek#	BC	0.50	2102	0.00005	25.00	Line Creek#	1.00	5.89	7.47	6.51	4.14			
Quintette	BC	1.00	1250	0.00005	50.00	Quintette	50.00							
Coal Valley	Alta	0.70	1093	0.00005	35.00	Coal Valley	25.23	9.77						
Coal Valley#	Alta	0.20	1381	0.00005	10.00	Coal Valley#	8.31	1.69						
Coal Valley#	Alta	0.10	2282	0.00005	5.00	Coal Valley#		1.33	1.74	1.51	0.42			
Gregg River	Alta	1.50	1114	0.00005	75.00	Gregg River	53.05	21.95						
Gregg River#	Alta	0.50	1408	0.00005	25.00	Gregg River#	20.95	4.05						
Gregg River#	Alta	0.10	2309	0.00005	5.00	Gregg River#		1.70	1.36	1.18	0.75			
Luscar	Alta	2.00	1108	0.00005	100.00	Luscar	71.12	28.88						
Luscar#	Alta	0.50	1404	0.00005	25.00	Luscar#	20.42	4.58						
Luscar#	Alta	0.30	2305	0.00005	15.00	Luscar#		4.11	5.17	4.48	1.24			
Obed	Alta	1.50	958	0.00005	75.00	Obed	61.69	13.31						
Obed#	Alta	0.20	1257	0.00005	10.00	Obed#	9.12	0.88						
Obed#	Alta	0.10	2264	0.00005	5.00	Obed#		1.31	1.76	1.52	0.42			
Smoky River*		1.80	1180	0.00005	90.00	Smoky River*	63.69	26.31						
Bienfait	Sask	1.90	58	0.00005	95.00	Bienfait			95.00					
Bienfait#	Sask	0.10	1086	0.00005	5.00	Bienfait#			1.21	2.32	1.47			
Poplar River	Sask	4.00	20	0.00005	200.00	Poplar River			200.00					
Prince	NS	0.98	8	0.00005	49.00	Prince							49.00	
Nfld Import via Que	Imp	0.05	350	0.00005	2.47	Nfld Import Que						1.41		1.06
				Totals =	2021.47	Totals =	1407.24	149.63	344.00	43.90	25.23	1.41	49.00	1.06

* 1999 data   # estimate quantity shipped in 2000 & subtract from total shipped to principal terminal

Table 5.17b New BC MELP EF Rail Dust Emissions Estimates – 2000 – PM_{10} and $PM_{2.5}$

PM_{10} = PART with 99% control x 0.5 scaling factor

Emissions in Tonnes for 2000

Mine		BC	ALTA	SASK	MAN	ONT	Que	NS	Nfld
Bullmoose	BC	40.00							
Coal Mountain	BC	1.33	11.94	15.15	13.19	8.39			
Coal Mountain	BC	7.50							
Elkview (Balmer)	BC	75.00							
Fording River*	BC	207.50							
Greenhills*	BC	105.00							
Line Creek	BC	75.00							
Line Creek	BC	0.50	2.94	3.73	3.25	2.07			
Quintette	BC	25.00							
Coal Valley	Alta	12.62	4.88						
Coal Valley	Alta	4.15	0.85						
Coal Valley	Alta		0.67	0.87	0.75	0.21			
Gregg River	Alta	26.53	10.97						
Gregg River	Alta	10.48	2.02						
Gregg River	Alta		0.85	0.68	0.59	0.38			
Luscar	Alta	35.56	14.44						
Luscar	Alta	10.21	2.29						
Luscar	Alta		2.06	2.59	2.24	0.62			
Obed	Alta	30.85	6.65						
Obed	Alta	4.56	0.44						
Obed	Alta		0.65	0.88	0.76	0.21			
Smoky River*		31.84	13.16						
Bienfait	Sask			47.50					
Bienfait	Sask			0.60	1.16	0.74			
Poplar River	Sask			100.00					
Prince	NS							24.50	
Nfld Import	Imp						0.71		0.53
Totals =		703.62	74.82	172.00	21.95	12.61	0.71	24.50	0.53

$PM_{2.5}$ = PART with 99% control x 0.2 scaling factor

Emissions in Tonnes for 2000

Mine	BC	ALTA	SASK	MAN	ONT	Que	NS	Nfld
Bullmoose	16.00							
Coal Mountain	0.53	4.78	6.06	5.28	3.36			
Coal Mountain	3.00							
Elkview (Balmer)	30.00							
Fording River	83.00							
Greenhills	42.00							
Line Creek	30.00							
Line Creek	0.20	1.18	1.49	1.30	0.83			
Quintette	10.00							
Coal Valley	5.05	1.95						
Coal Valley	1.66	0.34						
Coal Valley		0.27	0.35	0.30	0.08			
Gregg River	10.61	4.39						
Gregg River	4.19	0.81						
Gregg River		0.34	0.27	0.24	0.15			
Luscar	14.22	5.78						
Luscar	4.08	0.92						
Luscar		0.82	1.03	0.90	0.25			
Obed	12.34	2.66						
Obed	1.82	0.18						
Obed		0.26	0.35	0.30	0.08			
Smoky River	12.74	5.26						
Bienfait			19.00					
			0.24	0.46	0.29			
Poplar River			40.00					
Prince							9.80	
Nfld Import						0.28		0.21
Totals =	281.45	29.93	68.80	8.78	5.05	0.28	9.80	0.21

* 1999 data

\# estimate quantity shipped in 2000 & subtract from total shipped to principal terminal

5.4.1 Application of a Precipitation Factor

As noted, the EFs used so far in Section 5.4 do not include a factor that accounts for the influence of weather, notably precipitation and snow, en route. It would be difficult to apply a weather factor that would apply year long to any single long distance rail route in Canada. However, as an example of the potential influence of weather, the Lower Fraser Valley example is used to illustrate the potential impact of applying a precipitation factor to the emission estimates, Table 5.18.

The number of rain and snow days for the three communities of Kamloops, Hope and Abbotsford on the coal rail route to Vancouver were estimated in Table 5.7. These data indicate the variation that is possible in relation to weather. The communities used in this example only span a portion of the route from the mines on the BC/Alberta border to Vancouver. In Abbotsford in 2000 the precipitation for almost one third of the year met the precipitation day criteria whereas in Kamloops that level of precipitation was only recorded on 27 days. In Hope, precipitation records were only available for nine months, but for those nine months the precipitation days were over twice the number recorded in Kamloops for the entire year.

Table 5.18 illustrates the impact on emission estimates of the application of a simple precipitation factor, as illustrated in equation 5.7, Section 5.2.4.

5.5 Discussion – Fugitive Coal Dust Emissions – Rail Transportation

The BC MELP EF for fugitive coal dust emissions employs a set percent emission per tonne carried. However, since it does not incorporate distance, there is a problem with its application to large amounts of coal carried short distances. The BC MELP EF is best suited for estimating emissions that are related to its derivation. That is, coal carried at least 1100 km. For that scenario, the BC MELP EF and the CAC EF provide approximately identical coal dust emissions estimates.

If the modified CAC EF emissions estimates are prorated by segment distance, the provincial or regional segments are similar to those produced by the BC MELP EF. Therefore, since the CAC EF provides what appear to be more reasonable estimates for the dust emissions for coal shipped over short distances, it is recommended.

However, the basic CAC EF, as recommended in this study, has been modified. Unlike the NEIPTG Guidebook recommendation, the basic CAC EF is considered to be the uncontrolled EF and not the 75% control EF.

In addition, as noted, for emission estimates this basic EF should be modified to account for distance, control efficiency, particulate size and precipitation.

Different PM_{10} and $PM_{2.5}$ scaling factors were employed for the estimates in this report. It was felt that the scaling factors currently employed by Environment Canada, GVRD, the BC MELP were too large and overestimated emissions in these two particulate ranges.

There are still no definitive data to directly link the dust control effectiveness of the systems currently employed to suppress rail car dust by the coal mines in Western Canada to a control efficiency percentage. Therefore, for the emissions calculations in this study it was decided to err on the side of caution and choose an efficiency of 99%. This is the same efficiency that is currently used by Environment Canada for their emissions calculations.

While a number of visible dusting events that lead to citizen complaint were registered in 2000, there is also no quantitative data to relate those visible dusting events to overall dust control efficiency. Suffice to say that these visible dusting events confirmed that for 2000 the emissions control effectiveness of the dust suppressant systems used by the mines that ship coal to Vancouver was less than 100%.

While temperature and wind en route can influence dust emissions, no method was discovered for quantifying the effect

Table 5.18 Precipitation Factor Example

Precipitation Factor Final EF = EF x (365-P)/365	Distance D	tonnes shipped through Vancouver in 2000	Basic EF t/tonne	Total Particulate Emissions in tonnes	Abbotsford Rain and Snow Days in 2000	Precipitation Adjusted Emissions Using Abbotsford tonnes	Kamloops Rain and Snow Days in 2000	Precipitation Adjusted Emissions Using Kamloops tonnes
Use BC MOE EF and assume 99% control								
	1100	27,462,000	0.000050	1,373	110	959	27	1272
Prorate Using a Distance of 100km LFV								
	100	27,462,000	0.0000045	125	110	87	27	116

Excerpt from Table 5.7 – Precipitation Days for 2000

12 months data | **9 months data** | **12 months data**

Abbotsford Rain		Abbotsford Snow		Hope Rain		Hope Snow		Kamloops Rain		Kamloops Snow	
Total	110		0		58		7		27		0

Chapter 6

Truck Transport of Coal Fugitive Dust Emission and Control

6.1 Truck Transport

As noted, fugitive coal dust emissions associated with coal by moved by trucks at mine sites and around other coal handling facilities are considered to be incorporated into the coal handling EFs and the estimates for coal mines and Coal Terminals, Chapter 4 and Chapter 8. The truck movements referred to in this Chapter are those associated with the shipment of coal from mine site, or from receiving terminal, to end-user facility by truck in Canada in 2000.

From the data available, it appears that most of the coal carried by trucks in Canada is from the large surface mines in Alberta and Saskatchewan to nearby electric power plants.

As noted in Section 5.4, the 1995 CAC Inventory has listed shipments of coal from several mines as being by train when they are actually shipped by truck. These corrections have been made for the estimates in Section 5.4 and in Table 6.1.

6.2 Emission Factors - Trucks

No provincial or federal agency is presently calculating coal dust emissions from truck transport. For estimates in this Chapter, the CAC EF that was employed for rail was also used for truck transport, Table 6.1 and 6.2. The PM_{10} and $PM_{2.5}$ scaling factors that were used for rail transport were also employed. No attempt was made to produce a precipitation factor.

6.3 Dust Controls - Trucks

The most readily available method for controlling dust from trucks carrying coal would be to cover the load in the truck. Information related to the use of truck covers in Canada for coal shipped in 2000 was not available. Therefore, as per the rail emissions calculations, a control efficiency of 99% was employed as were the same PM_{10} and $PM_{2.5}$ scaling factors.

6.4 Coal Dust Emissions Estimates - Trucks

For 2000, the emissions estimates for trucks carrying coal in each province in Canada are illustrated in Table 6.2. Please note that it was necessary to estimate many of the distances travelled using a map reference.

Because of the limited amount of information available regarding the transport of coal by truck in Canada in 2000, these estimates must be considered as only very rough indications of possible emissions.

Table 6.1 Coal Truck Transportation Emissions – 2000 – Total Particulate

					Distance by Truck in km						EFs Using CAC Rail EFs in kg/tonne (assume 99% control of PART)		
Mines		**Coal in 2000 Mt**	**Destination**	**Dist**	**BC**	**ALTA**	**SASK**	**ONT**	**NS**	**NB**	**EF = 0.1x(0.62xD)$^{0.6}$x(100-99)/100**	**CAC EF Total Trip kg/tonne**	**Emissions Total Trip tonnes**
Bullmoose	**BC**	1.6	Rail Loadout	36	36						Bullmoose	0.006	10.31
Quinsam #	**BC**	0.24	Comox	50	50						Quinsam	0.008	1.88
Genesee *	Alta	3.60	Local PP	10		10					Genesee	0.003	10.76
Highvale	Alta	13.00	Local PPs	10		10					Highvale	0.003	38.85
Paintearth	Alta	3.50	Local PP	5		5					Paintearth	0.002	6.90
Sheerness	Alta	4.00	Local PP	5		5					Sheerness	0.002	7.89
Whitewood *	Alta	2.30	Local PP	10		10					Whitewood	0.003	6.87
Bienfait #	**Sask**	0.20	Local Char	5			5				Bienfait	0.002	0.39
Boundary Dam/Shand	**Sask**	6.50	Local PPs	10			10				Boundary Dam/Shand	0.003	19.42
Minto to Grand Lake	NB	0.12	Grand Lake	35						35	Minto to Grand Lake	0.006	0.77
Minto to Belledune #	NB	0.12	Belledune	270						270	Minto to Belledune	0.022	2.62
Alder Point #	**NS**	0.06	Coal Yard	40					40		Alder Point	0.007	0.41
Coalburn #	**NS**	0.03	Local PP	20					20		Coalburn	0.005	0.12
Little Pond	**NS**	0.01	Local PP	50					50		Little Pond	0.008	0.05
Springhill Rail Bed #	**NS**	0.01	Local PP	100					100		Springhill Rail Bed	0.012	0.12
St. Rose #	**NS**	0.03	Local PP	200					200		St. Rose	0.018	0.60
Stellarton #	**NS**	0.20	Local PP	20					20		Stellarton	0.005	0.91
Imported Coal											**Imported Coal**		
NS Power Corp #	**NS**	1.2	Lingan PP	20					20		NS Power Corp	0.005	5.44
NS Power Corp #	**NS**	0.85	Trenton PP	100					100		NS Power Corp	0.012	10.11
Lafarge Canada, NS #	**NS**	0.035	Kilns	80					80		Lafarge Canada, NS	0.010	0.36
St. Mary's Cement #	Ont	?	Cement	80				80			St. Mary's Cement	0.010	?
											Totals =		124.79

*** 1999 data** **# distances are approximations**

Table 6.2 Emissions Estimates for Coal Transported by Truck – 2000

	PART in tonnes PART with 99% Control						PM_{10} in tonnes PM_{10} = PART with 99% control x 0.5						$PM_{2.5}$ in tonnes $PM_{2.5}$ = PART with 99% control x 0.2					
Originating Mines	**BC**	**Alta**	**Sask**	**Ont**	**NS**	**NB**	**BC**	**Alta**	**Sask**	**Ont**	**NS**	**NB**	**BC**	**Alta**	**Sask**	**Ont**	**NS**	**NB**
British Columbia																		
Bullmoose	10.31						5.2						2.1					
Quinsam	1.88						0.9						0.4					
Alberta																		
Genesee		10.8						5.4						2.2				
Highvale		38.8						19.4						7.8				
Paintearth		6.9						3.5						1.4				
Sheerness		7.9						3.9						1.6				
Whitewood		6.9						3.4						1.4				
Saskatchewan																		
Bienfait			0.4						0.2						0.1			
Boundary Dam/Shand			19.4						9.7						3.9			
New Brunswick																		
Minto to Grand Lake						0.8						0.4						0.2
Minto to Belledune						2.6						1.3						0.5
Nova Scotia												1.7						0.7
Alder Point					0.4						0.2						0.1	
Coalburn					0.1						0.1						0.0	
Little Pond					0.1						0.0						0.0	
Springhill Rail Bed					0.1						0.1						0.0	
St. Rose					0.6						0.3						0.1	
Stellarton					0.9						0.5						0.2	
Coal Imported by																		
Nova Scotia																		
NS Power Corp					5.4						2.7						1.1	
NS Power Corp					10.1						5.1						2.0	
Lafarge Canada, NS					0.4						0.2						0.1	
Ontario																		
St. Mary's Cement				?						?						?		
Totals =	12.20	71.27	19.82	0.00	18.12	3.39	6.10	35.63	9.91	0.00	9.06	3.39	2.44	14.25	3.96	0.00	3.62	1.36

6.5 Discussion – Fugitive Coal Dust – Truck Transportation

The CAC EF for rail emissions was used for providing a first approximation of the potential for fugitive coal dust emissions from coal transported by truck. However, since virtually no recent data was available in regard to transport of coal by truck in Canada, one should not harbour any illusions regarding the accuracy of these emissions estimates. They are rough approximations at best.

Given the origins of the railcar dusting EF, i.e. unit trains carrying coal over a thousand kilometres, it is likely that this EF is not representative of the EF for a single coal truck driven over a relatively short distance. In addition, no information was available regarding the emissions controls used by the various companies involved to limit dusting from their trucks in 2000.

As for coal mines, the large quantities of coal that are moved by truck in Alberta and Saskatchewan, and hence associated dusting, likely occur in areas remote from most large urban populations. Therefore the impact of the fugitive dust emissions from truck transport on those urban populations may be slight.

Chapter 7

Coal Storage Piles Fugitive Dust Emission and Control

7.1 Coal Storage Piles

In Canada in 2000, coal was likely stored in piles in a host of locations throughout the country. Every mine, transfer facility, Coal Terminal and end-use facility is likely to have at least one storage pile for coal. It is also likely that at each of these many sites, the quantity of coal stored varied throughout the year. An attempt to list the more likely sites for large storage piles in Canada in 2000 was attempted in Table 2.9.

This list did not include the coal mines. All coal mines are likely to store coal in piles at various locations on their mine property. For coal mines, fugitive dust emissions from the associated storage piles may be included in the fugitive coal dust emissions EFs that the EPA developed for coal mining, see Chapter 4.

Inherent in operations that use coal is the maintenance of outdoor storage piles. Because of the need for frequent material transfer into or out of storage, storage piles are often not covered. Dust emissions occur at several points in the storage cycle, such as material loading onto the pile, disturbances by strong wind currents while the coal is in storage and material load-out from the pile. The movement of trucks and loading equipment in the storage pile area is also a source of dust.

Since 1980 complaints regarding nuisance fugitive coal dusting from coal storage piles have been registered in Nova Scotia, Ontario, Manitoba and British Columbia. However, no agency in Canada appears to have made fugitive dust emissions estimates for the storage piles in their region or province.

Because of the many variable involved, and the lack of information regarding coal storage piles in Canada in 2000, emissions from storage piles were not attempted in this investigation.

7.2 Emission Factors - Storage Piles

Despite the paucity of information regarding coal storage in Canada, EFs for estimating fugitive dust emissions are available. The US EPA provides an emission factors for aggregate handling and storage piles in Section 13.2.4 of AP-42.

Aggregate Handling and Storage Piles (EPA 2001-3)

Emissions and Correction Parameters

The quantity of dust emissions from aggregate storage operations varies with the volume of aggregate passing through the storage cycle. Emissions also depend on 3 parameters of the condition of a particular storage pile: age of the pile, moisture content, and proportion of aggregate fines.

Predictive Emission Factor Equations

Total dust emissions from aggregate storage piles result from several distinct source activities within the storage cycle:

1. Loading of aggregate onto storage piles (batch or continuous drop operations).
2. Equipment traffic in storage area.
3. Wind erosion of pile surfaces and ground areas around piles.
4. Loadout of aggregate for shipment or for return to the process stream (batch or continuous drop operations).

Either adding aggregate material to a storage pile or removing it usually involves dropping the material onto a receiving surface. Truck dumping on the pile or loading out from the pile to a truck with a front-end loader are examples of batch drop operations. Adding material to the pile by a conveyor stacker is an example of a continuous drop operation.

The quantity of particulate emissions generated by either type of drop operation, per tonne of material transferred, may be estimated using the following empirical expression:

$$EF = k \times (0.0016) \times (U/2.2)^{1.3} / (M/2)^{1.4} \text{ (kg/megagram) (6.1)}$$

Where:
EF = emission factor
k = particle size multiplier (dimensionless)
U = mean wind speed, meters per second (m/s) (miles per hour [mph])
M = material moisture content (%)

The particle size multiplier in the equation, k, varies with aerodynamic particle size range, as follows:

Aerodynamic Particle Size Multiplier (k)

<30 µm	<15 µm	<10 µm	<5 µm	< 2.5 µm
0.74	0.48	0.35	0.20	0.11

The AP-42 reference on *Emission Factor Equations for Uncontrolled Open Dust Sources at Western Surface Coal Mines* Table 11.9-2 (Metric Units) has an active storage pile EF for wind erosion and maintenance: (EPA 2001-2)

EF for active coal storage pile $= 1.8\,u$ in kg/(hectare)(hr) (6.2)

Where u = wind speed (m/sec)

Unfortunately, the detail regarding the storage of coal in Canada at the various locations that would have allowed the application of even a simple formula, such as represented by equation 6.2, was not available. The application of equation 6.2 would require hourly wind readings plus dimensions for each coal pile in Canada in order to apply this factor with any accuracy.

7.3 Dust Control – Storage Piles

One of the best ways to control fugitive dusting from the storage of coal would be to enclose the pile. However, most coal storage piles in Canada are uncovered. The conventional methods for controlling dusting related to these uncovered piles include:

- fixed water spray towers
- water sprays on conveyors, stacker-reclaimers and other drop points
- sealant sprays for long term piles
- pile orientation with respect to wind
- limiting the angle of repose and height of piles
- mobile truck sprays,
- wind fences, and
- the cessation of all operations in high winds

The dust control equipment and practices at two of the large Coal Terminals in Vancouver are listed in Table 7.1. One coal end-use company, Stelco Inc., provided the following information in connection with the control of dust using coal storage pile management at their facilities: (See Table 7.1) (Stelco 2001)

> *Throughout the shipping season, coal received is both consumed in our ovens and stockpiled against the coming winter. The coals are moved to stock using "belly pan" earthmovers, which build low, compacted stockpiles. Lake Erie Steel maintains three stockpiles and Hilton Works maintains four. After the last coal has been received, these stockpiles are surface sealed. The piles are opened and reclaimed on the lee side of the prevailing winds. By early spring, we would have completely consumed all coal stockpiled the previous year. Throughout the season, coal received is both consumed and stockpiled against the coming winter.*

Table 7.1 lists possible dust control measures for storage piles at end-user facilities and terminals for operations other than for just coal trains. Unfortunately, information was only received from four facilities for 2000. A list of the information that would be required for a thorough assessment of fugitive dusting and control for storage piles is presented in Appendix B.

7.4 Coal Dust Emissions Estimates – Storage Piles

Lacking sufficient data regarding operating parameters, local weather conditions or quantities in regard to storage piles in Canada, no attempt was made to estimate emissions. An attempt was made to estimate emissions at Coal Terminals, for this one sector a crude attempt was made to estimate dusting in relation to the storage piles at those facilities, see Chapter 8.

7.5 Discussion – Fugitive Coal Dust Emissions – Storage Piles

The operations in relation to coal storage piles are many and varied and they frequently produce fugitive dust emissions. The variables involved in estimating those emissions are also numerous. Because of a lack of information, emissions from storage piles were not attempted in this study. However, if data related to specific storage piles were collected, there are emission factors available for estimating fugitive dust emissions.

At present, the various contaminant inventories in Canada estimate fugitive coal dust emissions for coal mining and coal rail transportation, but they do not include emissions from coal storage piles. However, most coal mining operations are remote from heavily populated areas, and although coal may be transported through heavily populated areas such as Vancouver, the bulk of the emissions from coal trains are likely to also be in more remote areas. In contrast, many coal storage piles are located near populated areas and yet emissions for these sources are not estimated.

It is suggested that regional, provincial and/or national agencies may wish to investigate the possibility of gathering the data that would be required to estimate emissions from the coal storage piles located in or near large urban areas. It is recommended that emissions from storage piles in or close to major urban centres be included in emissions inventories.

Table 7.1 Dust Control Storage Piles

Dust Control Storage Piles and Handling 2001

Control System Possible Storage Piles	Prov	# Piles	Max Pile Capacity	Water Spray Towers	Sealant Sprays	Pile Orientation	Pile Wind Fences	Water Truck	Stop Operations High Wind	Sprays on Conveyors	Sprays Stacker-Reclaimer	Other
Westshore	BC		2.5 Mt	119	roads/piles			fleet		yes	yes	integrated control system
Neptune	BC			yes		SW-NE		yes	yes			
Stelco, Hamilton	Ont	4			piles				work lee side			low compact piles
Stelco, Lake Erie	Ont	3			piles				work lee side			low compact piles

Chapter 8

Coal Terminals
Fugitive Dust Emission and Control

8.1 Coal Terminals

For this report, the term *Coal Terminals* is used in reference to the large coal handling facilities that receive coal (mostly Canadian coal) by rail and transship millions of tons of that coal each year, principally for export purposes. In 2000, there were four such *Coal Terminals* in operation in Canada:

- The *Thunder Bay Terminals Ltd.* facility in Thunder Bay, Ontario;
- The *Neptune Bulk Terminals (Canada) Ltd.* facility in the inner harbor, Vancouver, BC;
- The *Westshore Terminals Ltd.* facility at Roberts Bank near Vancouver, BC; and
- The *Ridley Terminals Inc.* facility in Prince Rupert, BC.

In 2000, a quantity of coal was moved through the *International Pier*, in Cape Breton, Nova Scotia, and millions of tons of coal were transshipped through port facilities in Ontario. Most of the latter coal was destined for the *Ontario Power Generation* power plants. However, these operations are considered to be coal received at *end-use* facilities and not coal terminal operations in the sense of the four noted above. Fugitive coal dust emissions estimates related to these port facilities are included in Table 8.2, but little is known about the details of these operations.

Coal Terminal Operations

Coal Terminals by their nature are active sources of fugitive dust. The Coal Terminals are designed to handle large quantities of coal every day. Many receive and unload coal from several, 100-car unit trains each day. The four Coal Terminals noted above all employ a rail loop that encircles most of the terminal and the storage piles. In 2000, each of the four Coal Terminals in Canada employed the rotary-dumping technique for unloading coal. This technique involves the near inversion of the car (while still coupled to the rest of the train) to release the coal.

In general, conveyor belts are used to move coal from the rotary-dumping facility to the storage pile, and at any one time a significant quantity of coal is usually in storage in a number of piles on the Coal Terminal property.

While in storage the coal in the pile may be disturbed as the pile is increased in size, rearranged, levelled, reconfigured, or decreased in size. The terminal may employ bulldozers or other 'earth moving' equipment to rearrange coal in the piles.

The Coal Terminals generally employ a *stacker-reclaimer* to do just that, stack coal on the pile after it is unloaded from rail cars (ships may also be loaded directly at some terminals) or reclaim the coal from storage piles for ship loading. Coal moves to and from the stacker-reclaimer via conveyor. At the ship-loading end, the coal is usually added to the ship using a large telescopic loading nozzle that can be lowered into the hold.

The activities or operations at a large *Coal Terminal* that can lead to the generation of fugitive coal dust include:

a] The rotary-dumping of the loaded coal cars,
b] Moving coal to and from the storage piles,
c] Loading to and reclaiming coal from storage piles
d] Pile handling operations - levelling and rearranging of storage piles,
e] Wind-blown dust from inactive storage piles, and
f] The loading of coal into vessels.

Coal dust may also be blown from loaded and empty unit trains while operating on the property, but this source is felt to be insignificant in comparison to the dusting potential of the other activities.

For 2000, the emissions from Coal Terminal operations are considered in regard to the operations noted above.

8.2 Emission Factors - Coal Terminals

Estimating emissions from Coal Terminals is difficult. The difficulty arises not because there is any particular mystery related to fugitive emissions from the activities at Coal Terminals, but because of the day-to-day variation in the activities and the parameters that may affect emissions, such as weather.

One approach to estimating emissions from a coal terminal would be to treat the facility as a 'black box' or a 'bubble'. Rather than focusing upon the individual operations at a coal terminal, one could measure airborne coal dust emissions at a number or points around the perimeter of the facility for a prolonged period during a variety of weather conditions. One could then attempt to generate an average EF for that coal terminal.

At various times over the last 20 years, government agencies in British Columbia have monitored coal dust emissions around the Coal Terminals in the province. However, it appears that no emission factors have resulted from that measurement activity.

Therefore, the alternative approach to estimating emissions from Coal Terminals is to attempt to isolate the various activities at the terminals and estimate emissions using average EFs for each of those activities. The average EFs for the various activities can then be combined with activity information in an attempt to estimate emissions.

Unfortunately, an investigation of the sources of fugitive coal dust EFs was unable to discover any average EFs that were specific to coal terminal operations.

Also, as noted, the activities and operations at a large Coal Terminal can vary significantly from day to day, therefore, the level of fugitive coal dust emissions can also vary significantly from day to day. The number of trains on a specific day, whether a vessel is being loaded, the alteration of storage piles, along with the weather conditions, are all important in relation to the magnitude of fugitive dust emissions.

To accurately estimate emissions, the detailed activity information related to the daily (or weekly or monthly) operations at the four Coal Terminals in Canada for 2000 would be required. Unfortunately these statistics were not readily available, and resources did not allow for their collection. While the representatives for the two major coal terminals in the Vancouver area did provide annual throughput data, they did not supply the detailed information that would be required for a thorough application of average EFs.

The *Air and Waste Management Association* (AWMA) produces an air pollution manual that contains fugitive dust emission factors for coal operations. While there is no section specific to Coal Terminals, the Coal Processing section has EFs that "are considered to include...coal-handling facilities". (AWMA 2000)

The AWMA EFs that could be applied to fugitive coal dust emissions at a Coal Terminal are illustrated in Table 8.1 along with the EFs used in this study to estimate emissions.

Table 8.1 Fugitive Dust Emission Factors - Coal Handling - Total Particulate

Activity	Uncontrolled AWMA EF*	Uncontrolled AWMA EF metric	Uncontrolled EF used in study	Controlled EF used in study
	lb/ton	kg/tonne	kg/tonne	kg/tonne
Unloading				
Truck	0.02	0.01		
Railcar rotary dumped	0.4	0.2	0.2	**dumper enclosed** 0.002 **dumper open** 0.1
Transfer and Conveying	0.2	0.1	0.1	0.001
Loading to pile	0.08	0.04	0.04	0.008
Vehicular traffic or levelling and rearranging of piles	0.16	0.08	0.04	0.008
Loading out or reclaiming	0.1	0.05	0.05	0.01
Storage Pile wind erosion	0.09	0.045		
Assume only 1/30 of coal is stored			0.0015	0.0003
Loading				
Truck	0.02	0.01		
Railcar	0.4	0.2		
Barge	0.4	0.2		
Ship			0.01	0.0025
Terminal Composite EF enclosed dumper			**uncontrolled** 0.4415	**controlled** 0.0318
Terminal Composite EF open dumper			**uncontrolled** 0.4415	**controlled** 0.1298

* EFs from the AWMA (AWMA 2000)

Unfortunately, while the AWMA EFs purport to apply to all coal-handling operations, their application to the operations at Coal Terminals is not entirely clear. The EFs for each of the activities at a Coal Terminal are discussed below.

a] The rotary-dumping of the loaded coal cars.
In 2000, the four Coal Terminals in Canada employed rotary-dumpers to unload unit trains. The Ridley Terminals Inc. facility in Prince Rupert, BC was the only one of the four Coal Terminals not to enclose its rotary-dumper. The enclosed rotary-dumper facilities usually employ bag-houses filtering systems to control coal dust emissions. It is assumed that the Ridley Island Coal Terminal does not enclose its rotary-dumper, because fugitive emissions are limited by the frequent precipitation in the area.

The emissions associated with an enclosed railcar dumper, where the coal dust emissions are controlled by a bag-house or similar device, are felt to be beyond the scope of this report, which is intended to focus on wind-blown fugitive emissions from exposed coal surfaces. Once enclosed and controlled, these emissions are no longer truly fugitive, and the emissions from such operations should be governed by regional or provincial permit. Regardless, for completeness, an attempt has been made to include potential dumping emissions in the overall EF for a Coal Terminal.

The AWMA lists a railcar unloading fugitive dust EF that is 20 times as great as that for unloading a truck, 0.2 kg/tonne for railcars as compared to 0.01 kg/tonne for trucks. It is unclear why the difference should be so great? Granted the railcar is inverted or nearly inverted when unloaded, but the load carrier in most dumping trucks is also raised to nearly 90 degrees to unload. Also, dumping trucks frequently bang, or otherwise agitate their load carriers, in order to release all of the coal. Therefore, it would seem that the truck unloading operations should generate a similar level of fugitive coal dust.

The AWMA manual does not provide details for selecting either of these unloading EFs. However, it may be that truck unloading is associated with raw coal and the railcar unloading with thermally dried coal. The latter has a higher fines content than the raw coal and is likely to have a greater dusting potential.

For this study, the AWMA EF for railcar unloading has been employed. A dust control efficiency of 99%, as recommended by the AWMA for an enclosed rotary-dumper equipped with a fabric filter has also been used.

The **uncontrolled** EF for **railcar dumping** used in this study: 0.2 kg/tonne
The **controlled** EF for **railcar dumping - enclosed dumper** used in this study:

0.2 kg/tonne x (100-99)/100 = 0.002 kg/tonne

Since they employ enclosed rotary-dumpers, this controlled EF is used to estimate emissions for the two Coal Terminals in Vancouver and the Thunder terminal.

However, for the Ridley Island Coal Terminal, the dumper is not enclosed. Regardless, the effect of the heavy precipitation in the area is assumed to be the same as the control efficiency from 'watering', 50%, as assigned in the AWMA manual.
Therefore, the **controlled** EF used for **railcar dumping - open dumper** is:

0.2 kg/tonne x (100-50)/100 = 0.1 kg/tonne

Since little is known of the coal unloading operations at other ports in Canada, the Ridley Island EF has been used to estimate emissions for these operations, Table 8.2.

b] The movement of coal to and from storage piles.
In general, the conveyor systems that move coal from the railcar unloading facilities to the storage piles, and from piles to ships are covered. The systems are covered to limit dust emissions. Most of the terminals also employ water sprays at the transfer points at the end of the conveyors to limit emissions as the coal is dumped onto the piles.

The AWMA provides an EF for transfer and conveying. This EF is subsequently modified for the control offered by covering the conveyors. However, it is not known if the various terminals enclose their transfer points and how they control dust at those transfer points. Some transfer points are enclosed and some employ water sprays. It is not known if they vent enclosures to fabric filter systems. However, what is known is that during extreme wind conditions some of the Coal Terminals cease operations.

Therefore, the AWMA uncontrolled EF for conveying is used, and to err on the side of caution, a control efficiency of 99% is employed. The AWMA manual assigns a 99% dust control efficiency to conveying with an enclosure vented to a bag filter.

The **uncontrolled** EF for **transfer and conveying** used in this study: 0.1 kg/tonne
The **controlled** EF for **transfer and conveying** used in this study:
0.1 kg/tonne x (100-99)/100 = 0.001 kg/tonne

c] Loading to and reclaiming coal from storage piles
As far as could be ascertained, all of the Coal Terminals employ bucket-wheel stacker-reclaimers to load coal onto their storage piles and to reclaim the coal for ship loading.

The AWMA manual provides separate EFs for loading and reclaiming. The manual also provides a control efficiency of 80% for a bucket-wheel reclaimer. However, since none of the controls noted for loading, in the AWMA manual, appear to apply directly to the Canadian Coal Terminals, the 80% control efficiency is used in this study for both loading and reclaiming,

The **uncontrolled** EF for **loading to piles** used in this study: 0.04 kg/tonne
The **controlled** EF for **loading to piles** used in this study:
0.04 kg/tonne x (100-80)/100 = 0.008 kg/tonne

The AWMA manual contains and EF for reclaiming that is slightly higher than the EF for loading. A control of 80% as listed in the manual for a bucket-wheel reclaimer has been used.

The **uncontrolled** EF for **reclaiming from piles** used in this study: 0.05 kg/tonne
The **controlled** EF for **reclaiming from piles** used in this study:
0.05 kg/tonne x (100-80)/100 = 0.01 kg/tonne

d] Pile handling operations - levelling and rearranging of storage piles
Operations on storage piles are a likely source of fugitive dust. After coal is loaded onto a pile, it may be subjected to a number of 'handling operations'. Depending upon the conditions at the time of handling, all of these are likely to generate emissions.

The only EF listed in the AWMA manual that may relate to these activities is titled *Vehicular Traffic*. While there may be some vehicular traffic near the piles at a Coal Terminal, they would likely be kept to a minimum. This is unlike the vehicular traffic associated with Coal Processing (the title of the chapter in the AWMA manual), since large trucks and coal movers will move coal to the Processing Plant, and the unwanted remnants away, on a near continuous basis. Therefore, the AWMA uncontrolled EF for vehicular traffic has been halved to err on the side of caution.

Also, the AWMA manual does not list controls specific to vehicular traffic or to storage pile handling operations. The large Coal Terminals all employ a considerable array of fixed and mobile water spray systems. These would likely be used to dampen any emissions from pile handling operations. Also, the operations are likely to be terminated in extreme wind conditions. Therefore, again to err on the side of caution, a control efficiency of 80% has been used for these operations.

The **uncontrolled** EF for **vehicular traffic and pile handling operations**
used in this study: 0.04 kg/tonne
The **controlled** EF for **vehicular traffic and pile handling operations**
used in this study: 0.04 kg/tonne x (100-80)/100 = 0.008 kg/tonne

e] Wind-blown dust from storage piles.
Coal storage piles are storage piles whether they are located at a mine, end-use facility or at a Coal Terminal. The wind-blown emissions from storage piles at Coal Terminals could not be estimated using the complex EFs listed in Chapter 7, because of the lack of information regarding those piles and the day-to-day weather conditions.

The storage pile wind erosion EF in the AWMA manual is simplistic and as such can only render an extremely crude estimate of storage pile emissions. However, in order to provide a more complete emissions estimate for Coal Terminals, estimates have been attempted using this EF.

The controlled EF for wind erosion from storage piles from the AWMA manual is used for this study. However, the AWMA manual does not supply a control efficiency for the most common dust control technique used for storage piles, wet suppression. Watering is only noted as a control technique in truck and railcar unloading. However, the crude application in the unloading situation is not comparable to the complex set of water tower sprays and mobile sprays that are used at most terminals.

Wet suppression with chemicals is noted, but this technique is generally only applied for long term, undisturbed storage. For example, Stelco Inc. indicated that they used sealant sprays on their long term piles.

The AWMA manual also does not provide factors for the control of dusting related to pile orientation, working only the lee side of the pile, stopping operations in high wind, and the restriction of pile height. All of these are used in connection with storage piles in Canada.

Therefore, in order to err on the side of caution, a dust control efficiency of 80% has been applied for wind erosion from storage piles.

However, not all of the coal throughput at a terminal in one year is in storage at any one time. Therefore, using the factor forwarded by the Greater Vancouver Regional District (GVRD), it has been assumed that 1/30th of the annual coal throughput is in storage at any one time. (Der 2001)

The **uncontrolled** EF for **wind erosion from storage piles** used in this study:

0.045 x 1/30 = 0.0015 kg/tonne

The **controlled** EF for **wind erosion from storage piles** used in this study:

0.0015 kg/tonne x (100-80)/100 = 0.0003 kg/tonne

f] The loading of coal into vessels.

As noted Coal Terminals generally employ a stacker-reclaimer to reclaim the coal for ship loading. Coal moves from the stacker-reclaimer to the ship via conveyor. In general, the conveyors are covered, the transfer point may be covered by a water spray and the loading nozzle for the vessel is telescopic and can extend into the hold.

While the AWMA manual provides an EF for barge loading, it does not provide one for ship loading. As far as could be determined, no barges were loaded at Canadian Coal Terminals in 2000.

No indication is given in the manual as to whether the barge considered for the EF is flat with a pile of coal on the deck or enclosed like a ship's hold. Also, the EF used by the AWMA for barge loading is the same as for railcar loading. This seems highly improbable. Most railcars are loaded under a silo, while the loading nozzle may extend into the railcar it is not the same as a ship loading nozzle that usually extends deep into the ships hold to load.

Therefore, to err on the side of caution, once again, the lower EF for truck loading has been applied for ship loading. For the controlled EF, the control efficiency of 75% for telescopic chutes from the AWMA manual is used.

The **uncontrolled** EF for **ship loading** used in this study: 0.01 kg/tonne

The **controlled** EF for **ship loading** used in this study:

0.01 kg/tonne x (100-75)/100 = 0.0025 kg/tonne

Composite EF Used for Emissions Estimates - Coal Terminals

A composite EF has been used to estimate emissions from Coal Terminals. It combines the EFs for rotary-dumping of the loaded coal cars, conveying coal to and from the storage piles, loading to and reclaiming coal from storage piles, pile handling operations, wind-blown dust from inactive storage piles, and the loading of coal into ships. The EFs from each of the operations have been added to produce the composite. This is felt justified, since the operations are largely independent.

The **overall** or **composite uncontrolled** EF for total particulate (PART) for
Coal Terminals used in this study: 0.4415 kg/tonne (8.1)

The **overall** or **composite controlled** EF for total particulate (PART) for
Coal Terminals, **dumper enclosed,** used in this study: 0.0318 kg/tonne (8.2)

The **overall** or **composite controlled** EF for total particulate (PART) for
Coal Terminals **dumper not enclosed,** used in this study: 0.1298 kg/tonne (8.3)

For the processed coal as received by the terminals, the same **scaling factors** for **PM_{10}** and **$PM_{2.5}$** that was used for rail transport were also employed for Coal Terminals:

PM_{10} Scaling factor is PART EF x 0.5

EF for PM_{10} = PART x 0.5 x terminal throughput per year in kg/tonne (8.4)

$PM_{2.5}$ Scaling factor is PART EF x 0.2

EF for $PM_{2.5}$ = PART x 0.2 x terminal throughput per year in kg/tonne (8.5)

Table 8.2 Emissions Estimates for Coal Terminal Operations - 2000

Coal Terminal	Location	Prov	2000 Throughput tonnes	Controlled Emissions PART tonnes	PM_{10} tonnes	$PM_{2.5}$ tonnes
Westshore	Roberts Bank**	BC	22,500,000	715.5	357.8	143.1
Neptune	Vancouver**	BC	4,962,000	157.8	78.9	31.6
Texada	Texada Island	BC	0	0.0	0.0	0.0
Ridley *	Prince Rupert***	BC	6,000,000	778.8	389.4	155.8
Thunder Bay *	Thunder Bay**	Ont	1,830,000	58.2	29.1	11.6
	Total Emissions =			**1710.3**	**855.1**	**342.1**
Transship Coal	**To**					
Comox	Vancouver***	BC	240,000	31.2	15.6	6.2
Vancouver	LFV***	BC	240,000	31.2	15.6	6.2
Import Terminals						
Ontario #	***	Ont	15,511,828	2013.4	1006.7	402.7
Quebec #	***	Que	847,043	109.9	55.0	22.0
NB	***	NB	1,022,070	132.7	66.3	26.5
NS	***	NS	2,085,000	270.6	135.3	54.1

* 1999 data # 1998 data ** used enclosed dumper EF ***used open dumper EF

8.3 Dust Controls - Coal Terminals

The dust controls employed at the four Coal Terminals in Canada in 2000 included:

- **Unloading Unit Trains**
    - Enclosed rotary-dumpers with dust control systems
- **Moving Coal to and from Storage Piles**
    - Covered conveyors
    - Water sprays at transfer points
- **Loading to and Reclaiming coal from Storage Piles**
    - Water spray towers
    - Water trucks with sprays
    - Stop operations in high winds
    - Use of stacker-reclaimers
    - Water sprays at transfer points
- **Levelling, Rearranging and Retrieving coal from Storage Piles**
    - Water spray towers
    - Water trucks with sprays
    - Stop operations in high winds
    - Pile orientation
- **Wind-blown Dust from Inactive Storage Piles**
    - Water spray towers
    - Chemical sealants
    - Pile orientation and configuration
    - Wind fences
    - Water trucks with sprays
    - Stop operations in high winds
- **The Loading of Vessels**
    - Telescopic ship loader
    - Water sprays at transfer points
    - Enclosed transfer points
    - Stop operations in high winds

Details as to all of the control systems used at the four Coal Terminals were not available. The two Coal Terminals in operation in the Vancouver area in 2000 forwarded the dust control systems that they employed at their terminal, see Table 7.1. Many of the dust controls at Coal Terminals are discussed in Section 7.3 for Storage Piles.

8.4 Emissions - Coal Terminals

For this study, rough estimates of the potential fugitive dust emissions related to the Coal Terminal have been made using the composite EFs presented in Section 8.2. These EFs were combined with the annual throughput data for each facility. The emissions estimates for Coal Terminal operations in Canada in 2000 are presented in Table 8.2.

8.5 Discussion – Fugitive Coal Dust – Coal Terminals

The emissions estimates listed in table 8.2 for Coal Terminals are only very rough estimates and are used to illustrate the potential for emissions.

Precipitation was used as a control factor to develop the open-dumper controlled EF. However, in general, weather has not been accounted for in these emission estimates. Most of the Coal Terminals are located in areas where the piles, the coal handling to and from the piles and the loading of ships will likely be exposed to high winds.

Chapter 9

Fugitive Coal Dust Emissions Trends 1985 to 2020

Fugitive coal dust emissions have been estimated for 2000, but what are the future trends? Projections are considered necessary in light of a study in the 1980s that predicted an almost explosive growth in the amount of coal that would be processed through the Port of Vancouver to year 2020.

The growth surrogate used was coal throughput at the *Port of Vancouver*. Data was obtained for 1985 and 1996 and extrapolated to the years 1997 to 2020. The projections that were originally used are: (Levelton 1999-2)

year	1000's tonnes
1985	20,163
1990	24,042
1995	26,500
2000	37,658
2005	49,568
2010	61,478
2015	73,388
2020	85,928

These predictions from the 1980s now seem very optimistic. For example, in 2000 the throughput for Westshore and Neptune terminals was 27,462,000. This total is similar to what was predicted for 1995 and over 10,000,000 tonnes short of the prediction for 2000.

The 1995 CAC Inventory listed the annual clean coal production in Canada for 1990 to 1995, Table 9.1. (Deslauriers 1999) These data reveal a decline in production in 1992 and a growth of slightly over 9.5% from 1990 to 1995.

Table 9.1 Clean Coal Production in Canada 1990 to 1995 (Deslauriers 1999)

Provinces and Territories	1990	1991	1992	1993	1994	1995
	10^6 tonnes	10^6 tonnes	10^6 tonnes	10^6 tonnes	10^6 tonnes	10^6 tonnes
Newfoundland	0	0	0	0	0	0
Prince Edward Island	0	0	0	0	0	0
Nova Scotia	3.416	4.138	4.486	3.647	3.509	2.444
New Brunswick	0.548	0.498	0.399	0.389	0.332	0.263
Quebec	0	0	0	0	0	0
Ontario	0	0	0	0	0	0
Manitoba	0	0	0	0	0	0
Saskatchewan	9.407	8.981	10.027	10.045	10.685	10.740
Alberta	30.405	32.554	33.528	34.319	35.675	37.119
British Columbia	24.556	24.962	16.922	20.629	22.608	24.350
Yukon	0	0	0	0	0	0
NWT	0	0	0	0	0	0
Canada	68.331	71.134	65.361	69.029	72.808	74.916

From 1995 CAC Inventory Calculations (Statistics Canada #45-002)

A more recent forecast of coal consumption in Canada until 2020 was obtained from by *Natural Resources Canada* (NRCan), Table 9.2. (NRCan 2001) These data show a decline in coal consumption in Canada from 2000 to 2020. Therefore, unless exports increase dramatically in the next 20 years, it would appear that the predictions for coal production from the 1980s were very high.

Table 9.2 Forecast of Coal Consumption in Canada*

Coal Consumption	1998	2000	2005	2010	2020
	10^6 tonnes	10^6 tonnes	10^6 tonnes	10^6 tonnes	10^6 tonnes
Ontario - Total Consumption including imports	17.2	13.7	13.8	11.6	2.7
Ontario - Import	15.7	12.4	12.5	10.4	2.1
Alberta	26.0	23.9	23.5	23.7	24.8
British Columbia	0.1	0.1	0.1	0.1	0.1
Saskatchewan	9.8	9.9	9.9	9.9	9.8
Quebec Import	0.7	1.0	1.1	1.1	1.2
New Brunswick - Total Consumption including imports	1.4	2.0	2.0	2.0	0.1
New Brunswick - Import	1.2	1.7	1.7	1.7	0.0
Nova Scotia	2.7	3.1	3.1	3.0	0.1
Manitoba	0.2	0.0	0.0	0.0	0.0
Canada - Total Consumption including imports	**58.1**	**53.8**	**53.5**	**51.3**	**38.7**
Canada - Total Import	**18.2**	**15.8**	**16.0**	**13.8**	**3.3**
Consumption Canadian Coal only	**40.0**	**38.0**	**37.6**	**37.5**	**35.5**

* (NRCan 2001)

Fugitive coal dust emissions projections for all coal in Canada were not attempted. However, to show the changes in emissions, estimates from dusting coal trains were attempted for the different quantity of coal shipped via Coal Terminals in Vancouver for 1985, 1990, 1995 and 2000, Table 9.3. Emissions were estimated using the CAC EF as recommended in Chapter 5 and the following coal throughput in tonnes:

1985	1990	1995	2000
19,624,000	24,042,000	26,500,000	27,462,000

Table 9.3 Coal Rail Fugitive Dust Emissions Estimates Lower Fraser Valley 1985 to 2000

	Total Trip km	LFV km	Coal Throughput tonnes	CAC EF Total Trip kg/tonne	Total Particulate Emissions Total Trip tonnes	Total Particulate Emissions LFV tonnes	Total Particulate Emissions LFV tonnes	PM_{10} Emissions LFV tonnes	$PM_{2.5}$ Emissions LFV tonnes
Year							Adjusted Precip *	Adjusted Precip *	Adjusted Precip *
1985	1100	100	19.624	0.0501	984.14	89.47	62.50	31.25	12.50
1990	1100	100	24.042	0.0501	1205.71	109.61	76.58	38.29	15.32
1995	1100	100	26.500	0.0501	1328.97	120.82	84.41	42.20	16.88
2000	1100	100	27.462	0.0501	1377.22	125.20	87.47	43.73	17.49

* The precipitation and snow days for Abbotsford were used

Chapter 10

Recommendations & Uncertainty

10.1 Coal Dusting Monitoring Program from Unit Trains for Establishing Emission Factors

A comprehensive en route dust-monitoring program is suggested in order to establish a more accurate dust emission profile and/or emission factor for coal trains that ship coal through ports in the Vancouver area. Besides other objectives, the program should be designed to monitor TSP, PM_{10} and $PM_{2.5}$ emission levels from coal trains, as well as wind speed, precipitation and temperature during monitoring.

It is suggested that this study also attempt to estimate how railway coal dust emissions disperse with distance along a prolonged rail journey, and how far different size particles are likely to spread from the rail line after being emitted from the rail cars.

In order to gather empirical data in regard to dust emissions control, detailed records of dust suppressants use at the mines plus the washing of coal cars at the terminals should also be maintained and coordinated with the train dust monitoring program plus any crust-retention measurement data. The data gathered should be used to assess whether there is a direct relationship between emissions control and crust-retention percentage. (See Appendix B)

10.2 Coal Dust Emissions from Trucks

The emission factors and emission estimates for dust blown from trucks, as presented in this report, can only be described as rough speculation. Very little information was available regarding the movement of coal by truck in Canada in 2000. In areas were emissions from coal trucks may be of concern, particularly in Alberta and Saskatchewan, agencies may wish to investigate and gather data related to those operations.

10.3 Coal Storage Piles and Coal Terminals

Agencies should attempt to gather the information that is needed to accurately estimate emissions for the coal storage piles in their areas of responsibility. Emission factors for storage piles are available, but they cannot be applied without detailed information regarding the storage piles and the activities related to them. Similarly for Coal Terminals, more detailed information related to their operations is required before accurate emissions estimates are possible.

Since many storage piles and Coal Terminal operations are located in or near large urban population centres, agencies may wish to concentrate their efforts regarding fugitive coal dust emissions estimates on these two areas. Unlike emissions related to coal mines, and most of the emissions related to coal trains, the dust emissions from storage piles and coal terminals may have a more immediate impact on urban populations.

10.4 Coal Mining Fugitive Dust Emissions

While fine particulate emissions at coal mines may have serious implications for employees at the mines, in general their impact on urban ambient air sheds is likely minor. Most coal mining operations in Canada are located in remote areas far from populated urban areas and much of the fugitive dust that is generated by mining operations is likely deposited on or near mining company property.

Therefore, there is the danger that fugitive particulate emission from coal mines, if added to provincial or national totals, may give a distorted view of the exposure of the majority of the population to those fine particulates. Therefore, those preparing inventories may wish to consider the listing of these emissions separate from other urban TPM, PM_{10} and $PM_{2.5}$ emissions totals.

10.5 The Influence of Weather on Fugitive Dust Emissions

There seems little doubt that heavy rain and snow will have an inhibiting effect on fugitive dust emissions. However, additional study is required to determine whether the rain and snow day assumptions for unpaved road dust, as assumed in this study, do apply to coal dust emissions or whether new criteria are required.

Wind speed is a factor in fugitive dust emissions regardless of source. However, while it is difficult to apply a wind speed factor to thousands of moving unit trains each year, wind speed can be applied to emissions from storage piles.

10.6 Uncertainties in Emission Factors

The emission factors and estimates of coal dust losses from trains have been based on investigations that range from theoretical estimates and wind tunnel experiments to actual field measurements at locations of nuisance dust complaints. Because of the combination of factors which influences coal dust emission from an open source moving over a long distance through different weather conditions, none of the EFs available to date appear to be able to yield coal dust particulate emission estimates with a high degree of certainty.

The uncontrolled emission factor used in this report for coal dust emission from trains is considered to be the best that can presently be derived from the information available. However, the inherent uncertainty in the emission estimates will remain high.

The emission factors for coal mine operations are the most established of the EFs used in this report. However, as noted, the EFs and emissions estimates for trucks and Coal Terminals are only intended to present a rough estimate of emissions for these two areas. The uncertainties for the truck and Coal Terminal emission estimates, presented in this report, are very high.

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NRCan, *Email from Analysis and Modeling Division*, Energy Policy Branch, Natural Resources Canada, hlabib@nrcan.gc.ca, 20 March, 2001
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Appendix A
Information Sources

Table A.1 Agencies Contacted Regarding Coal Train EFs

Agency	Contact Person	Comments
US EPA	Tom Pace (919) 541-5634 pace.tom@epa.gov	Doubts EPA will have anything.
US EPA	Bill Kuykendal (919) 541-5372 kuykendal.bill@epa.gov	No EF. EPA exposure profiling technique may be the closest to estimating dust from rail cars. Recommends Dr. Chat Cowherd of Midwest Research Institute (MRI). Check also with individual States to see if any local work done.
US EPA	Ron Myers (919) 541-5407 myers.ron@epa.gov	No EF. Recommends adapting coal pile EF. Adapt AP-42 EF.
MRI	Greg Muleski (819) 753-7600 Ext. 1596 Chat Cowherd (816) 753-7600 Ext. 1585	Suggest using AP-42, Sec. 11.9 Western Surface Coal Mining, Fugitive Dust EFs and modify for trains. Not aware of any jurisdiction quantifying coal train dust emission. Some work might have been done on wind erosion related to coal trains in South Africa.
CTA	Bill Aird (819) 953-9924	Only anecdotal evidence of train emissions.
Wisconsin DEQ	Mike Warren (307) 672-6457	No EF.
W. Virginia OAQ	Dave Porter (304) 926-3647	No EF.
Kentucky DAQ	Martin Luther (502) 573-3382	No EF.
Pennsylvania DEP, Bur. AQ	Dean Van Orden (717) 787-9495	No EF. Check with Penn. Coal Association.
Illinois EPA, Bur. Air	Don Sutton (217) 782-7326	No EF.
Ohio EPA	Tom Velalis (614) 644-4837	No EF.
Texas NRCC	Skip Clark (512) 239-1000	No EF.
Pennsylvania Coal Association	(717) 233-7909	No EF.
EP Authority, Victoria, Australia	Rhonda Boyle Rhonda.boyle@epa.vic.gov.au	No EF.
EP Authority, New South Wales, Australia	Elizabeth Davidson Davidson@epa.nsw.gov.au	No EF.

Table A.2 Sources of Year 2000 Detailed Information

Information Sources	Information Supplied	Contact
BC Mining Association - website	Links to various mines in BC	www.mining.bc.ca/relatedlinks.html
BC Mining Association - Grasley	Informed that the Association does not support this data gathering exercise	Lorne Grasley
Coal Association of Canada - website	Detailed mine production information for 1998 for CA mines	www.coal.ca
Coal Association HQ - Edmonton	Provided 1999 production data by CA registered mine	Marge Martin <martin@coal.ca>
Mines		
Fording Coal - website	Details regarding each mine - no production data	www.fording.ca
Luscar Coal - website	Details regarding each mine plus production data	www.luscar.com
Luscar Coal HQ	Contacted - to provide data	JOANNE_MILLER@LUSCAR.COM
Mines in NS - Government of NS	Production by mine in 2000	HENNICEW@gov.ns.ca
Mines in NB - NB Energy Dept.	Production, import and use in 2000 + Power Plant use	NB Energy Dept John.Griggs@gnb.ca
Mines in Alberta - Govt. of Alberta	1998 and 1999 coal production data	Khalid Jamil - Alberta Energy and Utilities Board
Smoky River Alta mine	Shipped Neptune 2000, Westshore backed out of buy, all equip for sale on net	Lederer, Neptune - intequip.com/news.asp

Table A.2 Sources of Year 2000 Detailed Information (continued)

Information Sources	Information Supplied	Contact
Railways		
BCR	Information on BCR train sets and cars in 2000	DermodyG@bcrail.com
CNR - website	Little information	www.cn.ca
CP - website	Little information	www.cp.ca/cp/e/index.htm
CP Ken McGuire	Supplied 2000 Annual Report with rail car fleet information	Ken_McGuire@cpr.ca
Norfolk Southern	Information on Coal Monitoring	Gibson Barbee
Terminals		
GVRD	Contacts at Neptune and Westshore	Kelly Der
Neptune Terminals	Sent total throughput in 2000 plus dust controls	Frid Lederer FLederer@NBTCL.bc.ca
Westshore Terminals - website	Operational details, equipment and dust controls	http://www.westshore.com/
Westshore Terminals	Sent total throughput in 2000 plus dust controls	David Crook DCROOK@Westshore.com
Ridley Terminals Inc. from CA	1999 data	Coal Association of Canada
Thunder Bay Terminals Ltd. from CA	1999 data	Coal Association of Canada
End-Users		
Stelco	Use data for 2 steel plants for 2000 plus storage pile control info	Paul Readyhough
Dofasco	Their coal use in 2000 import and Canadian	vasudha_seth@dofasco.ca
NS Power Corp	Coal use by plant in 2000 imports and Domestic	J.K. Keeping & tom.kumanan@nspower.ca
Ontario Power Generation website	Number of power plants and power generation	http://www.ontariopowergeneration.com/
Ontario Power Generation 1998 Progress Report	Total coal used in 1998, prorate from 1999 GWh each plant	www.opg.com/environmental/SEDrpt.pdf
Imports		
EC Newfoundland District Office	1998, 1999, 2000 coal to Iron Ore Company in Labrador	Charles MacLean charles.maclean@ec.gc.ca

Table A.3 Sources of General Year 2000 Information

General Information	Information Supplied	Contact
EIA on Canada re Energy	General information on Canadian Energy use	http://www.eia.doe.gov/cabs/canada.html
World Coal Institute	Links to some Canadian Mines	http://www.wci-coal.com/linkscoal.htm
Canadian Transportation Agency	Minutes meeting 20 Sep 2000	Bill Aird
Environment Canada (EC) PDB	Guidebook and 1995 EFs and Emissions Estimates	C. Vezina
EC Regions		
Pacific and BC	coal dust complaints for BC and recent history re dusting	D. Poon
Atlantic	General info mines in NB and NS	G. Teman &Andre.Gauthier@EC.GC.CA
Ontario	contacts with provincial government	S. Humphrey
Western	contacts with provincial government	D. Woo
Quebec	general info Quebec imports	A. Gosselin
Ontario Govt.	Can not respond - OPG contacts only	S. Wond
Provincial Governments		
BC Govt.	Contact data and BC estimates	Tony Wakelin
BC Govt.	General Mining History Information	Gordon.Ford@gems4.gov.bc.ca
Alberta Govt.	1998 and 1999 coal production data	Khalid Jamil of the Alberta Energy and Utilities Board
Alberta Govt. - Environment	contacts	Brian Hudson Energy- Randy M. Dobko Environment
Alberta Energy & Utilities Board website	power plant capacities in MW	http://www.eub.gov.ab.ca/
Saskatchewan Power Corp	Power plant capacities in MW	http://www.saskpower.com
Manitoba - Environment Department	coal use by plant in 2000	Manitoba Env Dept cmoche@env.gov.mb.ca
Statistics Canada	For Quebec - General total end use by industrial sector 1999	QRESD 1999
Statistics Canada	1998 import and consumption data	from Coal Association
States		
Virginia	Annual report on coal dusting from Norfolk Southern Railway	Tom Jennings, Dept. of Environmental Quality
Weather Data		
Environment Canada	Data for 2000 BC weather stations	Roxanne.Brewer@ec.gc.ca
Crust Monitoring		
Associate Research	Information on crust retention	Claudio Guarnaschelli
Coal Dust Complaints		
Alberta Govt.	No complaints to repor	Dave.Slubik@gov.ab.ca
District of Hope	Package of information	P. Taylor, Chief Admin. Officer
Coal Dust Monitoring		
Simpson Weather Associates, Inc. Virginia	Detailed information on train dust monitoring system May have data that would yield and EF but data are proprietary.	www.swa.com/coal/

Table A.4 Associations or Companies Contacted that did Not Supply Information

Company or Association	Status of Information	Contact
Mines		
BC Mining Association	Association does not support this data gathering exercise	Lorne Grasley
Fording Coal	No data supplied	dermot_lane@fording.ca
Luscar Coal		
Luscar - Manager Line Creek Mine	No data supplied	lloyd_metz@Luscar.com
Luscar - Line Creek mine.	No data supplied	John Van Den Broek
Luscar Obed Mine	Dust control info to be sent - none received	Ms. Saundra
Teck - website	Only general company information	www.teck.com
Teck Corp HQ Vancouver	Asked that I send request, but No data supplied	E. Evans for Mike Lipkewich Senior VP Mining, eevans@teckcorp.com
Teck - Bullmoose Mine	No response to Email	F. Duperreault
Teck - Quintette Mine	No response to Email	K. Sharman
Quinsam Coal - mine	Spoke to and sent Email request, No data supplied	Dave Selent dhs35@hotmail.com
Railways		
CNR	No response	Bryan Vaughan bryan.vaughan@cn.caSchoor schoor@cn.ca
End-Users		
Ontario Power Generation (Ontario Hydro)	Email to 3 contact persons – no response	lois.wallace@ontariopowergeneration.com
	Anne Douglas, Lois Wallace, Bill Perks	
Terminals		
Thunder Bay Terminals	Email to their contact person – no response	Paul Kennedy port@baynet.net
Ridley Island Terminals	Email to their contact person – no response	klindenberger@rti.ca

Appendix B
Nuisance Coal Dusting from Unit trains

B.1 Introduction

Nuisance soiling from windblown coal dust has been a particular problem in relation to coal blown from loaded rail cars that travel from the Alberta and BC border area to Vancouver. In 2000, federal and provincial agencies reopened investigations into the nuisance soiling problems related to fugitive dusting from unit coal trains. Once again various agencies had received complaints regarding nuisance soiling from coal dust associated with unit trains that transit through communities in the Lower Fraser Valley (LFV) of British Columbia from Hope to Vancouver.

While visible dusting incidents cannot be quantitatively linked to overall dust control efficiency, visible dust events confirm that in 2000 the emissions control effectiveness of the dust suppressant systems used by certain mines that ship coal to Vancouver was less than 100%.

This appendix provides an overview and an update of the situation in regard to nuisance soiling from coal blown from rail cars in Western Canada for 2000.

B.2 Unit Coal Train Nuisance Dusting Complaints in British Columbia

In British Columbia, nuisance dusting from coal trains has been a source of citizen complaint since 1974. More recently, according to officials with the Canadian Pacific Railway (CPR), there were incidents of dusting in 1994 and sporadically from 1994 to 2000. (CTA 2000)

> *The CPR typically received only a couple of sporadic complaints per year, usually in early summer and usually from residents in the Agassiz and Kent regions.*

Similar dust complaints from residents in the area of Flood, BC were received by Canadian National (CN) in the early to mid-1990s.

In 1999 Transport Canada officials attended a 'town hall' meeting in Yale, BC (north of Hope) to discuss coal dusting from unit trains with local citizens, and the Canadian Transportation Agency (CTA) reported that unit trains from mines in Alberta and BC were dusting in 2000 (CTA 2000)

Complaints regarding dusting trains in British Columbia returned in earnest during the spring and summer of 2000. From May to August 2000, a series of complaints were received regarding dusting from loaded and empty unit coal trains in the Flood-Hope/Kent areas in the Fraser Valley. From May to October 2000, 27 trains were reported as dusting in the Flood-Hope area of British Columbia. These complaints culminated in a meeting in Hope, BC on September 20, 2000 (See Section B.5) involving residents, mining companies, rail companies and concerned agencies from all levels of government. (MELP 2001) (Hope 2001)

B.3 General History

Coal Train Dusting in Western Canada

Wind blown fugitive coal dust can result in nuisance soiling complaints in connection with any one of the operations in the process that takes coal from mine to end-user. However, dusting from unit coal trains is a principle focus of this report.

In Canada, most coal is mined in Western Canada in Saskatchewan, Alberta and British Columbia. While the majority of Saskatchewan coal is consumed within the province, approximately one quarter of the coal mined in Alberta and virtually all of the coal mined in BC is exported. In order to reach the export terminals, three of the largest of which are on the West Coast, that export coal is shipped by rail.

Coal is shipped by rail in Western Canada in 'unit trains' of approximately 100 open top rail cars. This coal is highly friable and has a high percentage of fines, 20% less than 60 mesh (250 micron) plus 7% less than 200 mesh (75 micron) in some samples. (Cope 1986) The quantity of fine coal in bulk coal shipments is important because loose, exposed fine coal in an open-top rail car is susceptible to wind entrainment.

The rail corridors to Vancouver from coal fields in Northwest Alberta and the Southeast BC pass through many small communities. However, coal dust nuisance complaints appear to be concentrated in the section of that corridor from Hope to Vancouver in British Columbia.

The area from Hope to Vancouver appears particularly prone to fugitive dusting. This section of the trip is near the end of the long rail journey from mine to terminal. By this point in the trip, many of the surface coatings sealing the fine coal on the loaded rail cars may have fractured or broken as a result of atmospheric drying, vibration and shock on route. Much of the terrain along this section of the route is also flat and trains may travel at or near the maximum allowable tract speed of 80 km/hr. In addition, high ambient crosswinds combine with train generated wind to create high turbulent dust-entraining air currents over coal cars. (Cope 1986)

In the early 1970s, federal and provincial environment agencies received complaints regarding wind blown coal dust from unit trains from citizens residing in communities along the coal/rail corridor in the Lower Fraser Valley (LFV). Following initial investigations into those dusting complaints, all of the major coal producers in Western Canada recognized chemical sealants as the most practical method of controlling in transit dusting. In 1975, all of the coal producers that shipped coal by rail to Vancouver commenced spraying the coal loaded in their rail cars with sealants. (Cope 1986)

While the spraying achieved success initially, by 1979 unit train coal dust complaints in the LFV were sufficient to reopen investigations. From 1979 to 1984 over 2200 loaded coal trains were observed in transit near the town of Agassiz, BC. With respect to their visible dust emissions, these trains were graded using the purely subjective designations: heavy, medium and light. Of those trains, 359 or over 16% were judged to be emitting some level of visible dust. At the higher end of the range, 198 trains or approximately 9% were judged to be emitting either 'medium' or 'heavy' levels of visible dust. Trains with this level of dust emission in that community are know to give rise to nuisance soiling and citizen complaints. (Cope 1986)

Also, from 1979 to 1984 over 1600 unit trains returning to the mines, 'empty' trains, were monitored for visible coal dust emissions at the same site in Agassiz, BC. Of those empty trains, 66 were judged to have some level of visible dust and 35 of those, or approximately 2% were judged to be emitting either 'medium' or 'heavy' levels of visible dust.

From 1979 to 1984, standard high-volume sampler measurements of *Total Suspended Particulate* (TSP) from a provincial air monitoring station located 100 meters from the railway tracks in Agassiz, BC were below the annual maximum 'acceptable' standard of 70 $\mu gm/m^3$. However, occasional excursions of the measurement of TSP to the 24-hour maximum acceptable level of 120 $\mu gm/m^3$ were recorded. (Cope 1986) No measurements or assessment as to the emission of particulate in the PM_{10} and $PM_{2.5}$ range were made during those investigations.

In the early 1980s, the inconsistent performance of chemical spray systems at certain coal mines was considered the cause of the majority of the severely dusting trains. In 1984, a number of the coal mines that shipped coal via this route listed the following as reasons for inconsistent dust control performance for their sprayed trains: (Cope 1986)

- spray equipment malfunction,
- spray system freeze-up, and
- inexperienced personnel operating equipment at two new mines.

At that time, at least one West Coast coal terminal employed a water spray to clean coal from the outside of their cars once they had been dumped. The coal terminal cited the breakdown of the car wash as a possible reason for an increase in dusting 'empty' trains.

As a result of their investigations, Environment Canada in 1986 published a set of *Recommended Practices* for improving the control of fugitive coal dust from unit trains. These recommendations included suggestions for improvements in dust control practices at both the mines and end terminals. They also included recommendations for the railway companies. (Wituschek 86) (See Appendix C)

It was felt that the thorough application of these techniques and *Recommended Practices* would achieve more consistent performances from the various coal dust control measures.

During the 1990s, it appeared that the problems associated with nuisance coal dusting from unit trains had abated. As noted, the CPR reported incidents of dusting in 1994 and sporadically from 1994 to 2000. For the CPR it would appear that during the 1990s, nuisance dusting was confined to one or two complaints per year, usually in early summer and usually from residents in the Agassiz and Kent regions. (CPR 2000)

CN reported that during a two-year period in the mid-1990s dust complaints were received from residents in the area of Flood. CN conducted an investigation and they claim that the mining companies involved took remedial action to 'help contain coal particles'. (CPR 2000)

In 1999 Transport Canada officials attended a 'town hall' meeting in Yale, BC (north of Hope) to discuss coal dusting from unit trains with local citizens, and the Canadian Transportation Agency (CTA) reported that unit trains from mines in Alberta and BC were dusting in 2000. (CTA 2000) However, in the spring, summer and fall of 2000, the number of dusting coal trains transiting the Lower Fraser Valley appeared to increase dramatically. (See Section B.4)

One difficulty with finding a permanent solution to the rail coal dusting problem is the issue of jurisdiction. While the railways may come under federal jurisdiction, the mines that ship the coal are under provincial jurisdiction.

In connection with the most recent rail dust complaints in 2000, the Canadian Transportation Agency attempted to take control of the situation and assume responsibility for the control of rail car coal dusting. On 7 December 2000, a federal court ruled that the Canadian Transportation Agency did not have jurisdiction in the matter. The issue of jurisdiction remains unresolved.

B.4 Coal by Rail - The Nuisance Dusting Issue in 2000

As noted above, complaints regarding dusting from coal trains once again became an issue in British Columbia in 2000. The 27 dusting incidents reported in the Flood-Hope area in 2000 were reported from May through October, Table B.1. (Hope 2001)

Table B.1 Dusting Coal Trains Reported Flood-Hope Area - 2000

Month	May	June	July	August	September	October
# of Dusting Trains Reported	2	9	8	5	2	1

The number of incidents in the spring and summer of 2000 was considered significant enough for federal and provincial agencies to reopen investigations into fugitive dusting from unit coal trains.

The CPR felt that one possible reason for increased nuisance dusting in the Hope area in 2000 was because of a change of routing by the CPR: (CPR 2000)

> *In January 2000, CPR began operating trains westbound over the CN track west of Kamloops under an infrastructure sharing arrangement that also sees CN trains operate eastbound over the CPR track. Consequently, CPR trains are operating through the Flood area for the first time.*

At a 'town hall' meeting in Hope, BC in September 2000, federal agency, provincial environment department, coal mining, and railway officials attempted to address citizen concerns regarding unit train coal dust emissions. At that meeting a number of issues were raised in conjunction with the issue of coal dust from unit trains. (CTA 2000) Comments regarding those issues, in regard to the dusting experiences in BC during the early 1980s are presented in Section B.5.

However, the dusting incidents in 2000 should be put in context. The 27 reported incidents of dusting trains in the Flood-Hope area were only a fraction of the unit coal trains that would have transited the area in that year. As reported by the industry in August 2000, "six to seven trains per day are required to move the coal to export". (Action 2000) Assuming that this refers to full trains only, if returning empty trains are then included, presumably 12 to 14 coal related unit trains could have been in transit through the Flood-Hope area every day. (Action 2000)

While the precise number of trains that carried coal in through the Flood-Hope was not available, Table B.2 attempts to relate the dusting incidents to the loaded coal train activity during the spring, summer and fall months of 2000.

As noted, observations of loaded trains near Agassiz, BC from 1979 to 1984 revealed that approximately 9% were judged to be emitting either 'medium' or 'heavy' levels of visible dust. (Cope 1986)

No other visible dusting incidents were recorded or registered with government agencies in 2000. Therefore, if one were to assume an equal number of trains for the remaining six months of 2000, the percentage of dusting trains would drop to just over 1% for 2000.

Table B.2 Relating Dusting Trains to Total Loaded Trains

Month	Days	Loaded Trains per month*	Recorded Dusting Trains	% Dusting
May	31	186	2	1.1
June	30	180	9	5.0
July	31	186	8	4.3
August	31	186	5	2.7
September	30	180	2	1.1
October	31	186	1	0.5
		1104	27	2.4

* assume 6 loaded trains per day

Therefore, the data available for 2000 appear to indicate that the situation in regard trains judged as 'heavy' emitters of visible dust has improved since the early 1980s. During June 2000 when the reported incidents of heavily dusting trains was highest, the rate of dusting trains was only approximately half what it was 20 years earlier.

Unfortunately, while situation regarding heavily dusting loaded unit coal trains appears to have improved, sufficient nuisance dusting occurred in 2000 to generate complaints from the public.

B.4.1 Recent Actions - Government Agencies

As noted, one of the difficulties that government agencies have encountered in attempting to address the issue of citizen complaints regarding nuisance coal dusting is jurisdiction. In the 1980s Environment Canada took the lead in regard to the coal dust issue, but while recommendations for improving dust control were prepared, that agency did not have the power to enforce any of the changes or improvements listed in those recommendations.

With the renewed concern regarding the number of heavily dusting trains in 2000, complaints regarding dusting were filed with the Canadian Transportation Agency (CTA) by residents of the Flood-Hope area of BC. In response, the CTA convened the 'town hall' meeting in September of 2000 in Hope, BC that brought together most of the stakeholders. In October 2000 the CTA issued the official minutes of that meeting. (See Section B.5) However, in March of 2001 the CTA reported that:

> *The Agency lost jurisdiction to investigate and determine complaints such as noise, vibrations, pollution, etc. resulting from rail operations per a Federal Court Ruling dated December 7/2000.*

However, while the CTA lost jurisdictional rights, it does not appear that the federal court indicated which government agency did have jurisdiction in this matter.

This investigation into emissions for fugitive coal dust in Canada is funded by the Canadian Council of Ministers of the Environment (CCME). As such it would appear that all provinces have an interest in the issue of fugitive coal dusting and wish to determine the extent of the problem by improving their estimates of total emissions.

While the situation, both historic and at present, in respect to nuisance dusting from trains is described in this report, the principal objective is to provide an analysis of total dust emissions for 2000. A resolution of the nuisance dusting issue is beyond the scope of this investigation.

B.4.2 Recent Actions - Coal Mines, Railways and Terminals

In 2000 the coal mine, railway and coal terminal companies most directly involved in the transport of coal in the Lower Fraser Valley formed an *Action Committee on Coal Dusting*. This industry-wide committee comprises the coal producers in BC and Alberta, the CN and CP railways, and the coal terminals located in the Vancouver region. The Action Committee was formed to coordinate industry-wide efforts to control coal dust during rail transport. The Action Committee comprises two working groups: the *Technical Working Group* and the *Community Relations Working Group*. (Laing 2000)

The Action Committee on Coal Dust identified five major items that required their immediate attention: (Laing 2000)

Complaint Protocol

A toll-free complaint line was established and a process was put in place for quickly tracing reported trains to their source for immediate corrective measures and for root-cause analysis.

The Complaint Process links the complaint line directly to CPR Operations who then identify the train and relay the complaint to either the mine (for loaded trains) or the port (for empty trains). The mine or port then relays their analysis of the problem and corrective actions to the Community Relations Working Group who then contact the person making the complaint.

Accountability to the Public

The plan is for an independent external auditor to conduct an audit of coal-dust control practices across the coal transport chain in accordance with the Environment Canada Guidelines published in 1986. The results of this audit will be reported to the public.

Monitoring of Early Detection

The Action Committee is investigating available monitoring technology and, if feasible, will install and test and automated coal-dust monitoring system to record and report levels of dust generated by passing loaded and empty coal trains.

Mandatory check points for all coal train crews will be established along the route to visibly assess the level of dusting for both loaded and empty coal trains.

Performance Reporting

The Action Committee is developing a reporting process to evaluate the coal industry's performance in meeting its dust-control objectives. The Community Relations Working Group will work with community representative to develop a reporting format that meets the public's needs.

Stakeholder Involvement

The Action Committee plans to work with the public, local governments and government agencies on a regular consultative basis.

Committee Actions to Date

The Report of the industry Action Committee on Coal Dusting, issued on 30 August, 2000, claimed that since industry officials were made aware of increased coal dusting, the mines have undertaken the following steps: (Action 2000)

1. Each mine performed a complete spray system check to ensure all components were functioning properly. These checks have been and will continue to be completed on a daily basis by operating personnel. Issues identified during system checks are and will continue to be resolved before train loading commences.

2. Each mine reviewed operational practices and objectives with all crew supervisors. Supervisors conducted and will continue to conduct checks at the loadout and associated facilities during every train loading. Appropriate employees involved in loading trains reviewed their procedures and practices to ensure they are applied consistently. Operations management reaffirmed with appropriate personnel that the contents of all railcars must be properly coated with suppressant before trains are allowed to leave the mine site.

3. The railways reviewed operating procedures with train crews to ensure dusting trains are reported immediately and procedures for proper handling of dusting trains are followed.

The coal companies are also reported to have made adjustments to the concentration and/or amount of dust suppressant applied to railcars to improve dust suppression. In conjunction with these adjustments, the industry increased the frequency of crust-retention monitoring at the port to gather more detailed data on crust retention performance.

In summary, to combat the coal dust issue, the mines, railways and terminals have:

- Investigated the complaint,
- Thoroughly reviewed coal dust control guidelines, processes and procedures,
- Optimized (and will continue to optimize) the amount and concentration of suppressant used to reduce coal dust,
- Formed an Action Committee to coordinate industry efforts for immediate and long-term dust control,
- Established a communication process for complaints which ensures a prompt response, and
- Increased monitoring of crust retention now and into the future.

In their letter of 18 October 2000, the Action Committee also added that: (Laing 2000)

- The ports have already implemented changes to ensure that coal cars are being unloaded at the maximum angle of rotation to minimize the potential for coal carry-back in the empty cars.
- A third party will be retained to monitor empty trains for coal carry-back at Westshore Terminals, while Neptune Bulk Terminals will continue to monitor empty trains visually and by videotape.

B.5 Discussion Related to Public Meeting Hope, BC on 20 September, 2000

Based upon experience with the nuisance dusting issue from coal shipped by rail in British Columbia in the 1980s, the authors offer the following comments *in Italics* in regard to the issues raised and reported in the minutes of the 20 September 2000 meeting in Hope, BC. That meeting was attended by: provincial government and federal government agency representatives, coal mine personnel, railway company personnel, coal terminal officials and members of the general public. The Canadian Transportation Agency convened the meeting and published the minutes. (CTA 2000)

General Comments - Related to Canadian Transport Agency Minutes of 20 September 2000 Meeting in Hope, BC Related to Fugitive Dust from Coal Trains

> *Many at the meeting seemed to be viewing the coal dusting from trains in the region from Hope to Vancouver as a new issue that needs to be studied in depth before action can be taken. It is not a new issue. Heavily dusting trains were a problem in 1973. The mines began effective train spraying and agreed to the 85% crust retention standard in 1975. There were few or no complaints for 5 years until 1979 when heavily dusting trains once again became a problem. From 1979 to 1984 of over 2000 trains that were observed, approximately 10 percent were considered medium to heavy dusters and created nuisance pollution.* (Cope 1986)

Regarding Statements from Coal Mine Representatives

a] "Objective of the mines it to achieve 85% retention of crust...empirically that retention should prevent dusting"

> ***NO*** *– the Recommended Practices clearly state that 85% retention is the 'minimum acceptable level of dust control' – 85% retention will not 'eliminate' dusting. The original report clearly states that 85% crust- retention should 'eliminate' heavily dusting trains, not all dusting. Mining companies originally agreed to the 85% crust-retention standard in 1975.* (Wituschek 86)

b] "Mines only apply suppressant at the same rate based on the Environment Canada report findings."

> ***NO*** *– at no time do the reports or Recommended Practices issued in 1986 list rates or concentrations of suppressants.*

c] "Covers for cars are too expensive and technical difficulty due to loading and rotary dumping."

> ***NO*** *– whether they are too expensive when prorated over time remains to be proven, however, they may be too expensive to retrofit into and existing system. However, automated cover systems do work. In 1984, the near flawless operation of an automated cover system was witnessed including loading at a mine and the rotary dumping at a power plant in the Dakotas.* (Cope 1986)

d] "Since being made aware of the dusting issue, the mines have taken actions to prevent dusting"

> *They have been aware of dusting complaints since 1974? All of the measures recently listed by the mines should have been in place and in operation since 1975. The mines agreed to spray cars in 1974.*

Statements by Railway Companies

"Re-issued bulleting instructing crews to report dusting trains"

But did the railway companies re-issue the bulletin instructing the crews to slow down those trains as agreed to in the Recommended Practices?

Statements by Other Government Departmental Experiences

Transport Canada

"Note that dusting trains are limited to 25 mph speed limit to reduce continued dusting"

How often in 2000 did trains reduce speed and was it effective?

BC Environment Department

"Need to re-evaluate procedures in 1986 Federal DOE report as equipment and suppressants have changed since the report was issued"

While a review is needed, the question is did the mines change equipment to make dusting worse? Or, in other words, why and when did they change? If from 1986 to 2000 their dust suppressant systems worked (few complaints?) then why did they change? If new mines or owners are on then scene, why did they not incorporate the successful designs?

Canadian Transportation Agency

"Want a permanent solution not just resolution of dusting issue in summer 2000"

The truly permanent solution would be to add an automated cover system to every unit coal train operating in western Canada.

"Crew reporting of dusters has improved"

The question is improved from what and since when? Trains have been dusting heavily and there have been nuisance complaints since 1974.

"Slower speed for dusters can minimize dusting"

While this may be the case, the question remains, how frequently do trains slow down to prevent dusting and does it work? Since there were heavily dusting trains reported in 2000, either they did not slow down when dusting or slowing down did not work?

B.6 Recommendations

The following are suggested for improving estimates of fugitive coal dust emissions in Canada and for ameliorating the nuisance dusting problems for coal trains.

B.6.1 Recommendations Designed To Assist in Resolution of Nuisance Fugitive Dusting Problems

For British Columbia, in relation to the nuisance-dusting problem related to rail transport, a trackside monitoring system could be used in the communities most affected. This system could relate incidents of significant fugitive dusting to the mine of origin. The dust monitoring system could also be used to attempt to establish more accurate emissions factors and control efficiency data for rail coal movement in Western Canada.

Railcar dust control efficiency is difficult to assess. While crust-retention on railcars has been used for over 20 years to assess dust control on loaded rail cars, more conclusive empirical data to support a direct link between crust-retention percentage and dust control efficiency is still required.

Inter-linked Monitoring Programs

The current monitoring programs for crust-retention at coal terminals should also be inter-linked to the suggested en route system for monitoring dusting trains. It should also be combined with the public complaint feedback system established by the joint-industry Action Committee on Coal Dust. This system allows dusting train complaints to be linked to the mines of origin and any problems related to sealant spray systems.

This type of en route monitoring program is now in place in Virginia in the USA. Two automated Trackside Monitors are used to acquire information on dusting trains. (NS 2001-1)

It is important to note that this monitoring system should be designed to include coal imported into Canada from mines in the United States. As noted in Chapter 2, in 2000 at least one of the terminals in the Vancouver area experimented with the transshipment of export coal from mines in the Powder River Basin of the USA. While the future of these shipments is unknown, so is the nature of the rail car dust control measures that may or may not be used at the mines in the USA.

Comprehensive Survey of Fugitive Dust Control Techniques at Coal Mines

Considering the long history of fugitive dusting and related nuisance dusting complaints in regard to coal rail dusting, a comprehensive survey of the fugitive dust control techniques at each mine is required. This survey should be linked to the dust monitoring surveys noted above and an attempt should be made to discover why the nuisance dust problem has yet to be fully resolved.

An annual survey of the dust control equipment and procedures at each mine that ships coal by rail may be required in order to assess changes from year to year.

B.6.2 Information Requirements

Unfortunately, during the course of this investigation, most of the coal industry sources that were contacted for information did not respond, or did not supply the information requested. For a more accurate assessment of fugitive coal dusting, and the state of the dust control procedures used for controlling dust from unit trains, and storage piles in Canada in 2000, Tables B.3 to B.6 would have to be completed. While mines and associations were contacted during this investigation for this information, response was minimal.

Table B.3 Train Dust Control – Equipment 2001

Equipment		Sill Clean	Car Profile Load-Level Type	Compact	Adjust Load Backhoe	Re-level	Type of Sealant	Spray System Number or Spray Bars	Re-Spray Facility	Monitor Cones & Mixiing	Freeze Protection	Wind Protect
Mine	**Prov.**											
Bullmoose	BC											
Coal Mountain	BC											
Elkview (Balmer)	BC											
Fording River	BC											
Greenhills	BC											
Line Creek	BC											
Quintette – closed 2000	BC											
Coal Valley	**Alta**											
Gregg River – closed 2000	**Alta**											
Luscar	**Alta**											
Obed	**Alta**											
Smoky River – closed 2000?	**Alta**											
Bienfait	**Sask**											
Poplar River	**Sask**											
Prince	**NS**											
Nfld Import via Que	Que											
Transshipment												
Powder River Basin, Mon	**RB-BC**											
Powder River Basin, Wyo	**RB-BC**											
Powder River Basin	**TB-Ont**											

Table B.4 Train Dust Control - Procedures - 2001

Equipment		Spray Systems Training Programs	Malfunction Procedures	Verification Procedures		Spray Conc &Volume	Inspect and Adjust During Car Spraying	Re-spray After Load Adjustment	Re-spray Cars if Required	Records of Spraying
Mine	**Prov.**			**Equipment Function**	**Levelling**					
Bullmoose	BC									
Coal Mountain	BC									
Elkview (Balmer)	BC									
Fording River	BC									
Greenhills	BC									
Line Creek	BC									
Quintette – closed 2000	BC									
Coal Valley	**Alta**									
Gregg River – closed 2000	**Alta**									
Luscar	**Alta**									
Obed	**Alta**									
Smoky River – closed 2000?	**Alta**									
Bienfait	**Sask**									
Poplar River	**Sask**									
Minto	NB									
Prince	**NS**									
Nfld Import via Que	Que									
Transshipment										
Powder River Basin, Mon	**RB-BC**									
Powder River Basin, Wyo	**RB-BC**									
Powder River Basin	**TB-Ont**									

Table B.5 Dust Control Storage Piles

Dust Control Storage Piles and Handling 2001

Control System / Possible Storage Piles	Prov	# Piles	Max Pile Capacity	Water Spray Towers	Sealant Sprays	Pile Orientation	Pile Wind Fences	Water Truck	Stop Operations High Wind	Sprays on Conveyors	Sprays Stacker-Reclaimer	Other
Westshore	BC		2.5 Mt	119	roads/piles			fleet		yes	yes	integrated control system
Neptune	BC			yes		SW-NE		yes	yes			
Ridley, Prince Rupert	BC											
Cement Plants LFV	BC											
Comox	BC											
Texada Island	BC											
Battle River PP	Alta											
Genesee PP	Alta											
Keephills PP	Alta											
Sheerness PP	Alta											
Sundance PP	Alta											
Wabamun PP	Alta											
Brandon PP	Man											
Selkirk PP	Man											
Belledune PP	NB											
Grand Lake PP	NB											
Iron Ore Coy, Nfld	Nfld											
North Star Cement	Nfld											
Auld Cove, S of Canso	NS											
Domestic Coal Yard	NS											
Halifax, NS	NS											
International Pier, CB	NS											
Lafarge, Brookfield	NS											
Lingan PP	NS											
Point Aconi PP	NS											
Point Tupper PP	NS											
Trenton PP	NS											

Table B.5 Dust Control Storage Piles (continued)

Dust Control Storage Piles and Handling 2001

Control System / Possible Storage Piles	Prov	# Piles	Max Pile Capacity	Pile Water Sprays	Sealant Sprays	Pile Orientation	Pile Wind Fences	Water Truck	Stop Operations High Wind	Sprays on Conveyors	Sprays Stacker-Reclaimer	Other
St. Mary's Cement	Ont											
Atikokan PP	Ont											
Dofasco, Hamilton	Ont											
Lakeview Power Plant	Ont											
Lambton Power Plant	Ont											
Nanticoke Power Plant	Ont											
Port Stanley	Ont											
Sarnia	Ont											
Stelco, Hamilton	Ont	4			piles				work lee side			low compact piles
Stelco, Lake Erie	Ont	3			piles				work lee side			low compact piles
Thunder Bay	Ont											
Thunder Bay PP	Ont											
Sept. Iles for Nfld	Que											
Montreal	Que											
Bienfait Char	Sask											
Boundary Dam PP	Sask											
Poplar River PP	Sask											
Shand PP	Sask											

Table B.6 Railway - Train Dust Control Procedures

Railway Company	Group Cars of Similar Height	Speed Control Systems at Load-Out Facilities	Reduce Speed of Dusting Trains
CP			Claim a slow down order is in effect for dusting trains.
CN			
BCR			
Imports			
Rail to Vancouver			
Rail to Thunder Bay			

Appendix C

Coal Dust Control, Recommended Practices for Loading, Unloading and Transporting Coal by Rail (*Wituschek 1986*)

In general, the estimate of total dust released was not the issue. The Recommended Practices were intended to address nuisance dusting and their control, and not the estimation of total dust released by unit coal trains. These *Recommended Practices* underwent a page by page review and agreement by every major coal producer in Western Canada and the Coal Association prior to publication.

Table C-1 Recommended Design Practices – 1986

Design Recommendations for Load-Out Facilities

The optimum design criteria for loading, levelling and spraying systems are presented below. Some of these criteria may not apply where it is demonstrated that satisfactory control is being achieved. In general, each load out facility should be designed to:

- Achieve a uniform flat surface profile along the full length and width of all loaded rail cars, using either properly designed loading chutes or separate levelling devices;
- Provide a device to remove loose coal from the rail car sills using either sill sweeping devices incorporated as part of the load out station or a separate mechanism located before the chemical spraying station;
- Provide a chemical application spraying system consisting of primary and secondary spray units, each equipped with its own pumping unit, discharge piping, flow meter and spray header. The secondary spray unit should be located a sufficient distance from the primary unit to allow the identification of problem cars and to facilitate re-spraying. At facilities where only one spray header is used, trains should be backed up and re-sprayed if improperly sprayed the first time;
- Employ spray patterns that achieve complete and uniform coverage over all areas of the load surface within a car, regardless of the train speed through the load out;
- Provide freeze protection for effective operation during cold weather periods;
- Use spray nozzles compatible with the chemical requirements of the chemical solution and applied pressure;
- Provide wind screens to prevent spray pattern distortion at sites where high winds prevail;
- Provide a compressed air supply to clear blocked nozzles;
- Provide adequate mixing in the tanks where batch solutions are mixed;
- Provide a sufficient volume of mixed solution to spray a complete train when batch mixing systems are used;
- Provide automatic low level sensor and audible alarm on the solution storage tank for batch mixing systems or on the chemical storage tank for in-line mixing systems:
- Provide a flow metering device on the piping to the spray header to record flow rates and total volumes applied to each train; and
- Provide variable flow to the spray header in order to apply more solution volume to the end slopes in relation to the center flat section of the load profile.

Design Recommendations for Empty Rail Car Cleaning Facilities

Where there is a coal dust problem from empty trains, each terminal should provide an exterior rail car cleaning facility designed to remove loose coal deposited on the external car surfaces.

Water washing systems should have:

- Adequate system pressure and spray pattern to reach all exterior surfaces of the car;
- A self-draining system for the piping and spray headers to prevent freezing in cold weather operation;
- A wash water collection pad at the spray station to collect the wash water for recycling; and
- A wastewater treatment facility to meet local requirements-for suspended solid removal before discharging to the receiving environment.

Air cleaning systems should provide:

- Adequate system pressure and air jet pattern capable of reaching all exterior surfaces of the car;

- An enclosure for the rail car cleaning system. The enclosure should be equipped with an adequate air exhaust system; and
- A high efficiency emission control system on the air exhaust from the cleaning station capable of meeting the air pollution control requirements of local regulatory authorities.

Table C-2 Recommended Operating Practices – 1986

Load-Out Facilities

As a general requirement, the coal producers should plan and implement training programs for company employees assigned to the loading, levelling and spraying operations and emphasize the importance of proper system operations for achieving coal dust control. Training in environmental control could be integrated with other employee training programs such as technical and safety programs. Proper maintenance of load levelling equipment, sill cleaning devices and spraying equipment is essential. A comprehensive schedule of preventive maintenance of these systems should be implemented and an adequate supply of chemicals, spray nozzles and other essentials should be kept in stock. Each mine should develop a set of procedures to be followed in the event of equipment malfunction during the load out operation in order to avoid the possibility of poorly sprayed cars leaving the mine.

Operating procedures should include the following main features:

- Verify the proper operation of all equipment when loading the first cars, in particular the operations of the load-leveller or compactor, sill sweeper and chemical spray system;
- When load adjustments are made at the mine, the load should be levelled and re-sprayed with sealant prior to departure from the mine site;
- Verify the concentration and volume of the chemical solution before spraying a train for batch mix systems, and pump flow rates and settings for in-line mixing systems;
- Ensure that an appropriate volume of mixed solution is applied to each car;
- Inspect and adjust, if required, the operation of the system during the spraying of the first few cars;
- Re-spray any improperly sprayed cars; and
- Maintain records of solution concentration and volume for each train, including notes on system malfunctions, profile problems or other deficiencies.

While research and development are encouraged, proposed changes in chemical sealants should be first reviewed by the senior operating employees responsible for dust control operations and then approved for testing and/or routine use.

Coal Terminal - Empty Car Cleaning Facility

- Personnel involved with the operation and maintenance of the car cleaning system should be formally trained and advised on environmental requirements;
- Equipment malfunctions should be corrected immediately. Standby truck mounted spray systems, normally used at terminals to control fugitive coal pile emissions, should be used to used to wash rail cars in case of malfunctions in the car cleaning system; and
- Trains should be visually inspected and cleared by a designated employee prior to departing the terminal

Coal Train Operations

- Railway companies should provide coal train sets consisting of cars of uniform height when practical. Where cars of different height must be used within a train set, cars of similar height should be grouped together;
- Locomotive speed control systems at load out facilities should be maintained operational to ensure proper loading of coal; and
- In the event of heavy dust emissions from loaded or empty trains, train crews should be instructed to reduce the train speed to prevent dust emissions through communities where coal dust impacts are of concern.

FUGITIVE COAL DUST:

AN OLD PROBLEM DEMANDING NEW SOLUTIONS

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Abstract

Declining public tolerance of the nuisance aspects of fugitive coal dust together with the increasing dustiness of the coal products being marketed have presented operators of coal terminals with a situation that demands improved and/or new control measures. The response of railroads and port facilities in the Commonwealth of Virginia to increased pressure to be good corporate neighbors was to invest in the development of new dust control strategies and technologies. A discussion of these new initiatives is presented within the context of an integrated dust mitigation program.

1.0 Introduction

Swirling black clouds of coal dust lofted by the gust front of an approaching thunderstorm can ruin the day for the operator of a coal transshipment facility. Perhaps no air quality standards are exceeded, but the "blow-out" provides a visual suggestion to neighboring businesses and homeowners that, perhaps, some of their housekeeping costs should be underwritten by the offending coal terminal(s). As the air quality regulations for particulate shift away from TSP to PM-2.5 and/or PM-10, some of the nuisance aspects of fugitive dust emissions shift, in some jurisdictions, to remediation through the civil courts.

An increasingly fine grained coal product, the typically windy conditions of port facilities, and a rising intolerance of pollution trespass by neighboring property owners all combine to put increased pressure on coal handling facility owners to go beyond what it takes to just meet the regulated air quality standards. The coal mining and transportation businesses in the Commonwealth of Virginia have responded to regulatory and political pressure in ways that can serve as blueprints for others involved in similar situations. Several new operating practices and technologies have been developed that demonstrate the industry's willingness and capability to be good corporate neighbors.

As consultant to several major coal marketers and transporters, Simpson Weather Associates, Inc. (SWA) has been involved with developing innovative programs and technologies to meet air quality standards and to reduce the nuisance of fugitive coal dust and its impact on individuals and businesses located in close proximity to rail corridors, ground storage areas or shiploaders. By "nuisance" we mean, in general, emissions of odors, particulate, noise, light etc. that fall below the allowable thresholds set by regulatory agencies but are still considered to be sufficient to cause economic losses or inconveniences. In the case of fugitive coal dust emissions, nuisance usually denotes soiling as opposed to any health or biological insults.

The technologies and programs that are described in this article have been developed by SWA with funding from transportation partners including a railroad and two marine coal terminals (Dominion Terminal Associates and Pier IX of Newport News, Va.). These ideas include a Trackside Monitor (TSM), a Rail Transport Emissions Profiling System (RTEPS), a Coal Car Load Profiling System (CCLPS), ProControl, and a Portable Laser for Coal Emission Mapping (PLACEM).

2.0 Fugitive dusting from mine to ship

From the perspective of the port facility operations, their primary concerns are associated with fugitive emissions while the coal is in port. Emissions during loadout and rail transport are usually of secondary interest. However, the way in which the coal is handled and treated prior to its arrival in port can have effects on its "behavior" while being dumped, stored and reclaimed.

The following discussion of a suite of fugitive coal dust control programs and technologies is presented within the context of a common mine-to-ship scenario. The coal being marketed has gone through a processing plant where it is crushed, washed and thermally dried. The coal is loaded into railcars with a flood loader equipped with a spray bar and load profiling "plow". The train then travels 500 miles to port at speeds up to 50 mph. The rail corridor passes through many towns and cities that have experienced train traffic for many decades. The port facility is located in a generally industrial area but is in close proximity to residential and commercial dwellings, some of which were built long after the coal facility was in operation. The coal is unloaded using rotary dumpers and transferred to 60-80 foot high piles. After several days, the coal is reclaimed for loading into ships or barges for transport to its final destination.

The two properties of coal that we focus upon are its dustiness and its moisture content. Moisture content effects the handling characteristics, the BTU value and, for some coals, the potential for spontaneous combustion. A high bulk moisture content upon arrival in port may reduce the dustiness during stackout but may also set the piles up for sloughing or complete collapse after a lengthy period of rain. Low moisture content usually results in a dust problem through the entire transportation process. SWA's approach to all dust control projects joins the issues of moisture management and dust suppression.

3.0 Integrated approach to fugitive dust control

3.1 Selective treatment

Since dust control in port begins with dust control at the loadout facility near the mine, a program to spray the tops of loaded rail cars has been instituted. Not all coal products have the same potential to dust. In fact, the same coal's dusting potential may vary from season to season. Therefore the use of chemical dust control agents at the loadout facilities is based upon both laboratory and field evaluations of individual coals. In the laboratory, a wind tunnel is used to establish a dusting index called the Seasonally Adjusted Rail Transport Dusting Index (SARTDX). Each tested coal is ranked in terms of its dustiness relative to a reference coal. The reference coal is one that was the subject of an extensive series of experiments over a protracted period of time.

The laboratory classification of a coal is sometimes followed by a field test that involves the use of the Rail Transport Emission Profile System (RTEPS). RTEPS is a collection of active and passive instruments that are mounted on the rear of coal cars, providing one second data on all factors related to the stress (e.g. wind, rain, radiation, train speed) and the response (e.g. dusting, load redistribution, load settling) of the coal during transit. A railcar loaded with treated coal and equipped with the RTEPS is shown in Figure 1.

3.2 Providing timely feedback

As part of an agreement between the railroads and the State, monitors have been set up within the rail corridor to monitor the performance of the dust control prescriptions and the voluntary participation by the mines. A permanent TrackSide Monitor (TSM) was installed "uptrack" about 50 miles from port in a location where the trains tend to move at track speeds of 35-45 mph. A picture of the TSM is provided in Figure 2. The TSM includes a Realtime Aerosol Monitors (RAM), a weather station, a laser transmissometer, an Automatic Equipment Identification (AEI) transponder reader, and a video camera. Data from the TSM are uploaded to the consultant's main computers once per day, where the data is analyzed and reports on the performance of the treated and untreated loads passing that site are sent to the railroad for disposition.

In response to the clustering of some complaints on dust from railcars, a mobile version of the TSM was built and deployed. This version of the TSM not only provides very site specific dusting data but also visible evidence that the railroad is working on a local level to reduce the incidences of severe dusting events.

While the TSMs provide reliable evidence of dusting coal loads, they have an inherent limitation. The weather conditions and the speed of the train as it passes the TSM site must be conducive to dusting to consider the absence of a dusting signal as evidence of a non-dusting coal shipment. Also, the TSMs do not provide data for estimating the amount of coal lost to wind erosion during the entire rail trip. Thus, after extensive field studies to measure the tons ($$)/car loss of material during transit, a Coal Car Load Profiling System (CCLPS) was developed. CCLPS uses a scanning laser suspended over moving railcars to generate a 3-D mapping of the load top (Figure 3). Using an algorithm based on the field data, the volumetric changes to the load during transit can be estimated and the performance of the treatment applied at the mines evaluated. Currently the CCLPs resides in port for special diagnostic studies.

3.3 Fugitive dust control during stackout and reclaiming

If the treatment at the mine is successful, the coals then arrive in port resistant to dust emissions until they are unloaded in the rotary dumper. Given a treatment that addressed moisture uptake/loss as well as dust suppression, the coals should have also maintained moisture contents close to what they were during loadout. The case we are describing here is a port facility that employs the standard set of Best Available Control Technology (BACT) throughout the rotary dumping, belt transfer, stackout and pile forming. That is, the rotary dumper is enclosed, transfer belts are covered, scrappers are used to reduce "carryback", water sprays are used to wet down the working areas and water cannons are available for wetting down the storage piles. An example of the use of water cannons on storage piles is presented in Figure 4. The same BACT dust control measures apply to the reclaiming and shiploading activities.

In addition to the visual monitoring of yard activities, several RAMs have been installed to provide feedback to the operators of the stacker/reclaimers, bulldozers and maintenance vehicles. These RAMs can detect very low levels of particulate concentrations and, when combined with the wind data, not only provide the facility operators with an alert, but also suggest a likely cause of any higher than background dust signal. Monthly statistics derived from the log of alerts serve to focus enhanced dust prevention measures.

The in situ nature of the RAMs limits their usefulness to those times when the wind carries the dust plumes to them. Using a CO^2 laser, a prototype for a Portable Laser for Coal Emission Mapping

(PLACEM) was developed and demonstrated by Pier IX Terminals. The laser transmits a beam of infrared light which is then scattered by particles suspended in the air. A portion of the light is scattered back to a detector, which is co-located with the transmitter; the more particulate, the stronger the backscatter signal. .By scanning the entire coal facility several times per minute, the PLACEM builds a "climatology" of dust emission sites and activities. This then helps the facility owners to prioritize their investment in improvements to the dust control program. PLACEM is not yet in full operation.

3.4 Reducing emissions from storage piles

After the coal is in piles, the surface of the pile becomes the focus of dust suppression measures regardless of the internal (bulk) moisture content. The usual options for dust control of coal storage piles are topical treatments with a binder applied using a tanktruck or the use of water applied with an array of water cannons. The binders tend to be expensive and given the mean time between pile disturbances, are usually reserved for the problematic coals or extremely stressful situations. In Virginia, the scheduling of the cannons is the focal issue when both the effectiveness and the optimal use of water are considered. The State worked together with two coal terminals to develop a rational and objective basis for activating the water cannons. Antecedent weather, current weather and a 12-hour weather forecast were used to compute the wind erosion and drying stresses on the piles and prescribe a preventative application of water. The algorithm for scheduling the water cannons became known as the "K-factor".

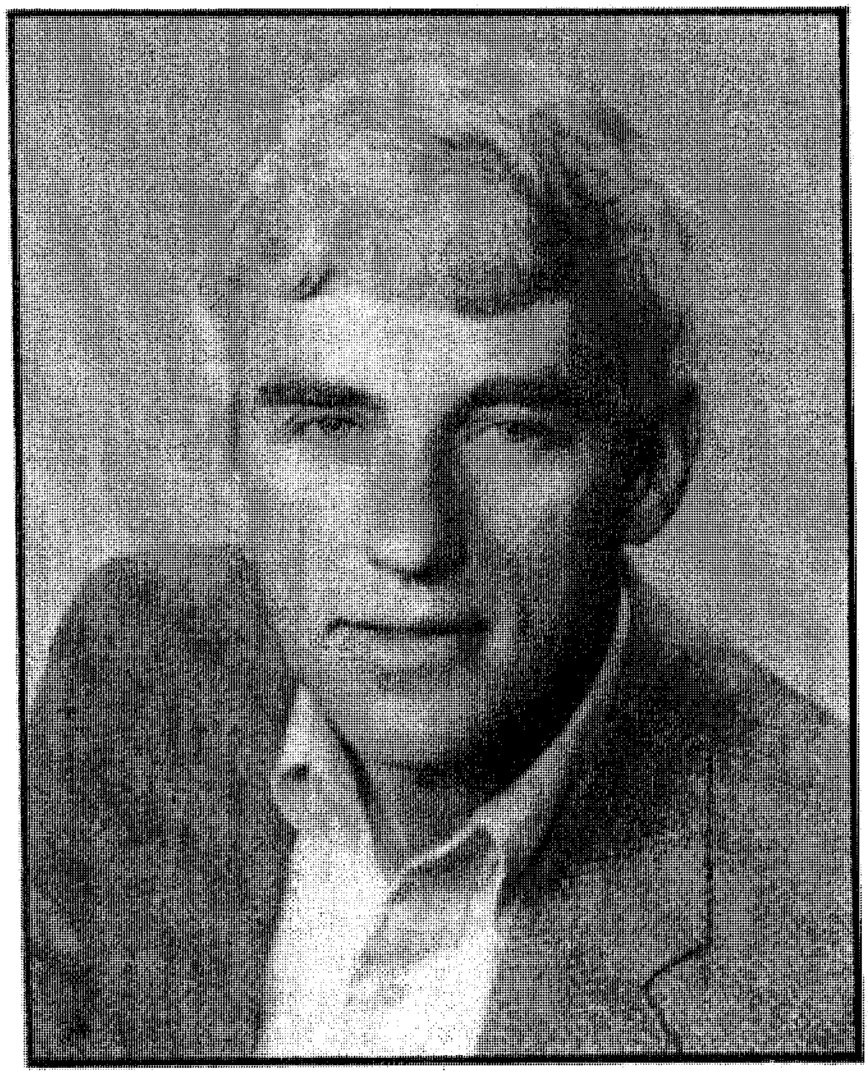
The logic of the "K-factor" has been combined into a more comprehensive package of software tools called ProControl. ProControl displays the weather data and dust monitor signals, schedules the cannons according to the "K-factor", and maintains records of interest to the State as well as the facility operators. Currently ProContol is being modified to include warnings of conditions favorable to the physical collapse of specific coal piles due to excessive moisture retention. Figure 5 provides an example of the weather and other advisory information displayed on the main screen of ProControl.

3.5 Documenting success and good faith effort

Having made significant investments in meeting imposed air quality standards and self-imposed "good neighbor" goals, the railroads and port terminals become involved in the dilemma of deciding whether or not to document the performance of their efforts. Usually there is the required TSP or PM-10 monitor with reports to the regulatory bodies. As Figure 6 shows, improvements can be seen in the long term statistics of many observations (180J is located just across a terminal's property line; Hampton is a regional monitoring site). Going beyond the conventional monitoring obligation raises the issue of recording emissions in ways that may be misinterpreted in adversarial situations. On the other hand, the data collected by RAMs or dustfall samplers can be used to show good faith effort, improved control, and identify specific targets for further investment that may be more cost effective than blind application of a control measure to the whole operation. The decision to collect data as part of a self-imposed dust control enhancement program must take into consideration many issues that will vary greatly from one terminal to another.

4 Conclusions

Taking extra steps beyond the required measures to meet air quality standards can involve significant costs and carries the risk of raising unreasonable expectations of the coal transportation industry. However, with the public's decreasing tolerance for the nuisances they associate with coal dust, there is political, legal and economic wisdom in demonstrating a good faith effort. Also, while not discussed above, there are some tangible benefits to the railroads and terminals. These cost savings may include reduced contamination of rail ballast with coal dust, reduced revenues due to loss of material, and reduced costs of cleanup of roadways and other work areas.



5 About the Author

Dr. George Emmitt is President and Senior Scientist with Simpson Weather Associates. His degrees are in Physics and Environmental/Atmospheric Sciences. His work with the coal transportation sector has been an opportunity to combine ongoing basic research in lasers for observing the earth's atmosphere and his experience with conventional observations and numerical models in solving practical problems.

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7 Captions

Figure 1: Railcar loaded with coal that has been groomed with a rake/plow and sprayed with a binder. The instruments attached to the rear sill of the coal car are part of the RTEPS.

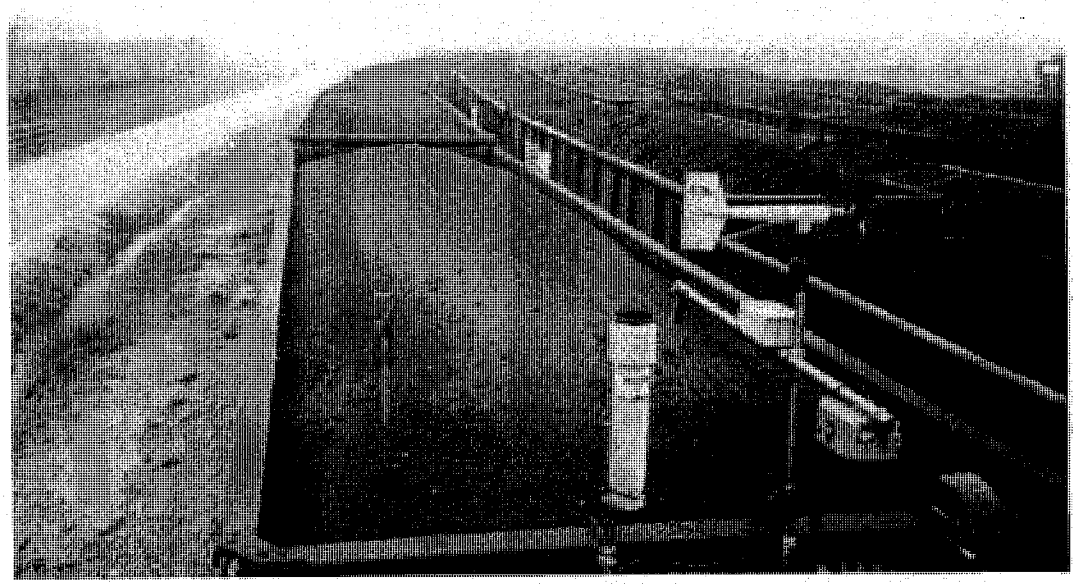
Figure 2: TSM site for monitoring the emissions from passing trains. The tower on the far right of the figure holds a laser that is focused on a detector mounted on the main tower (at left) and the intake for a RAM. All other instruments are located on the left side of the track.

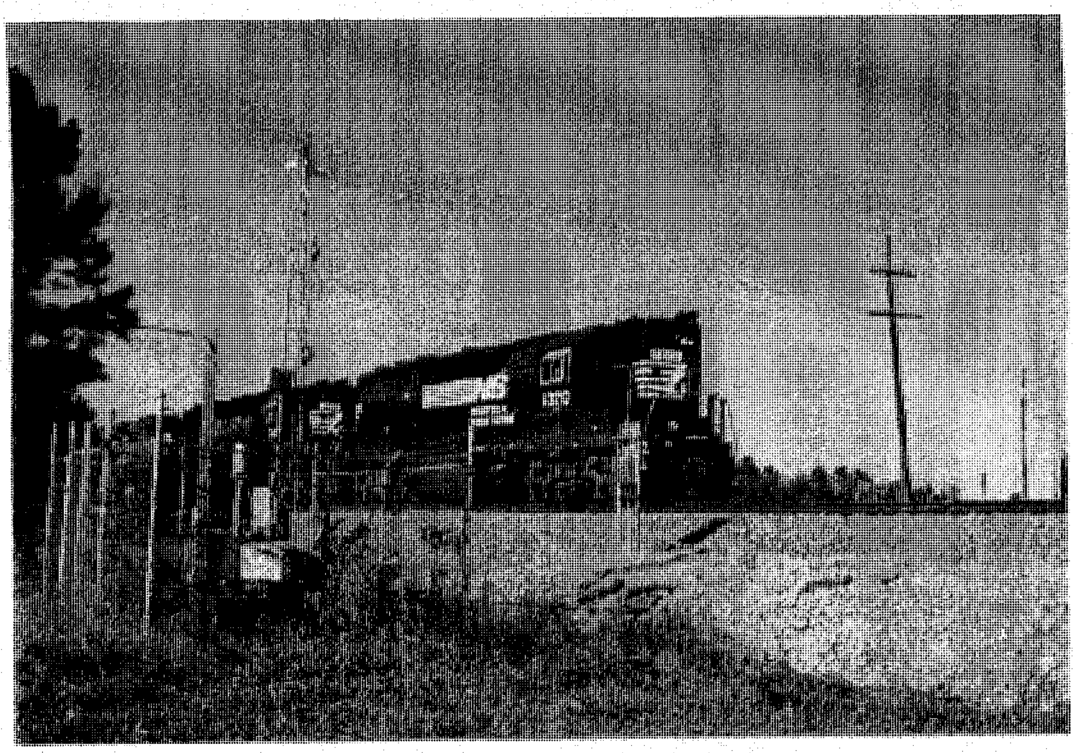
Figure 3: An example of a 3-D mapping using CCLPS of the top of a load of coal after it arrived in port. The white area denotes an area where the binder has been lost during transit.

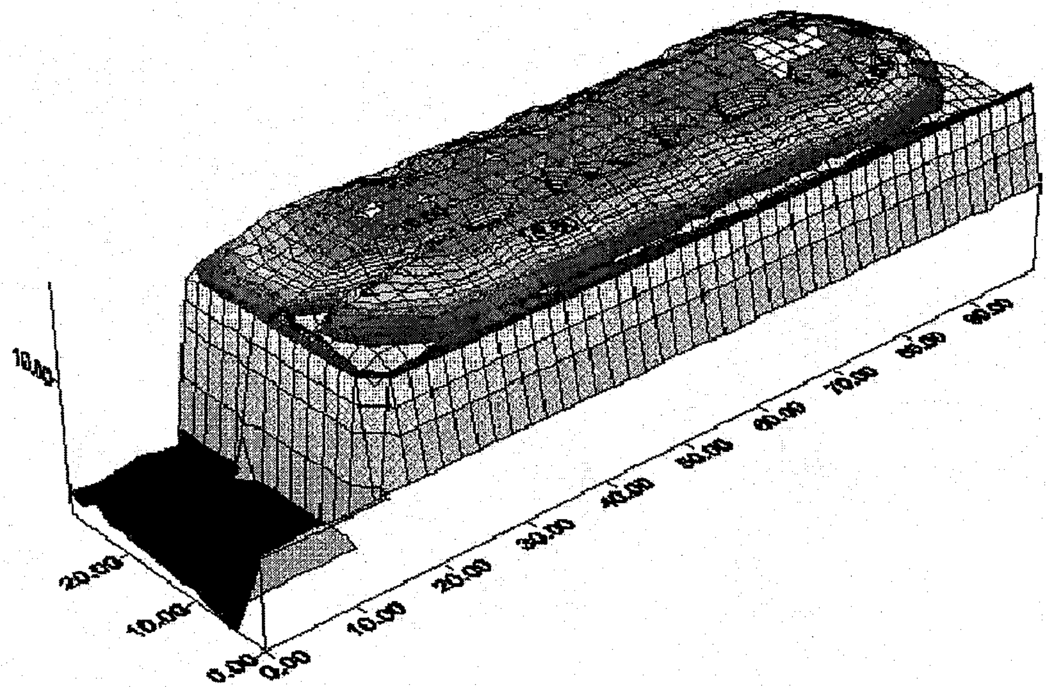
Figure 4: Water cannons being used to wet coal storage piles in Newport News, Virginia. ProControl schedules the activation of the cannons based upon the weather and coal type.

Figure 5: Example of the information presented on to the facility operators by the Pro Control system. The fan of lines focused on a point in the lower right of the image denote the suspected area containing the source of a detected dust event.

Figure 6: The decrease in the PM-10 concentrations after 199? Is coincident with steady improvement in the coal terminals' execution of their dust control programs. Note that the annual averages are well below the allowable limit of 50 micrograms/meter^3.



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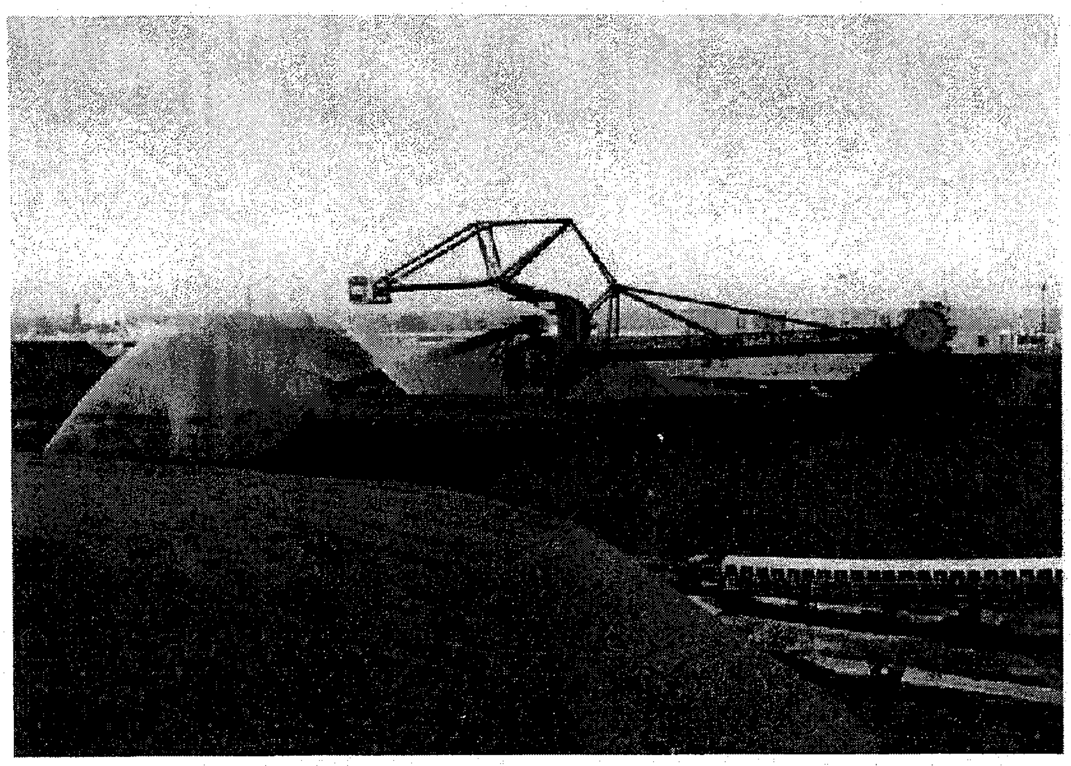
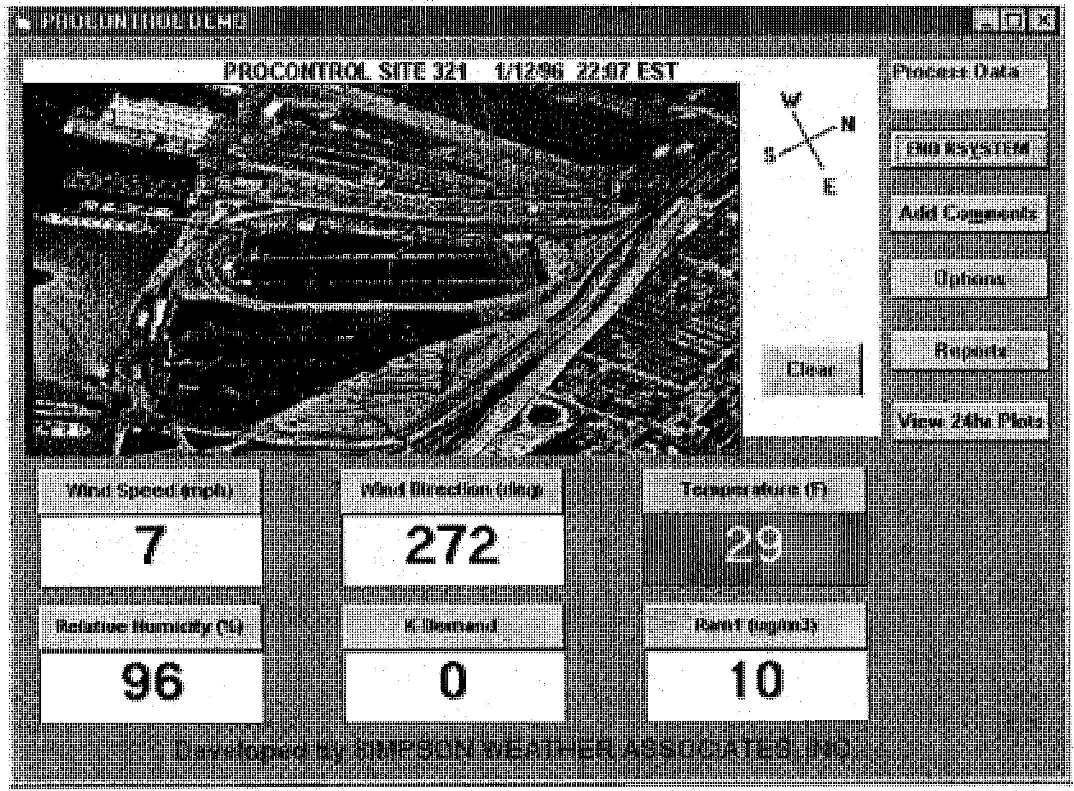
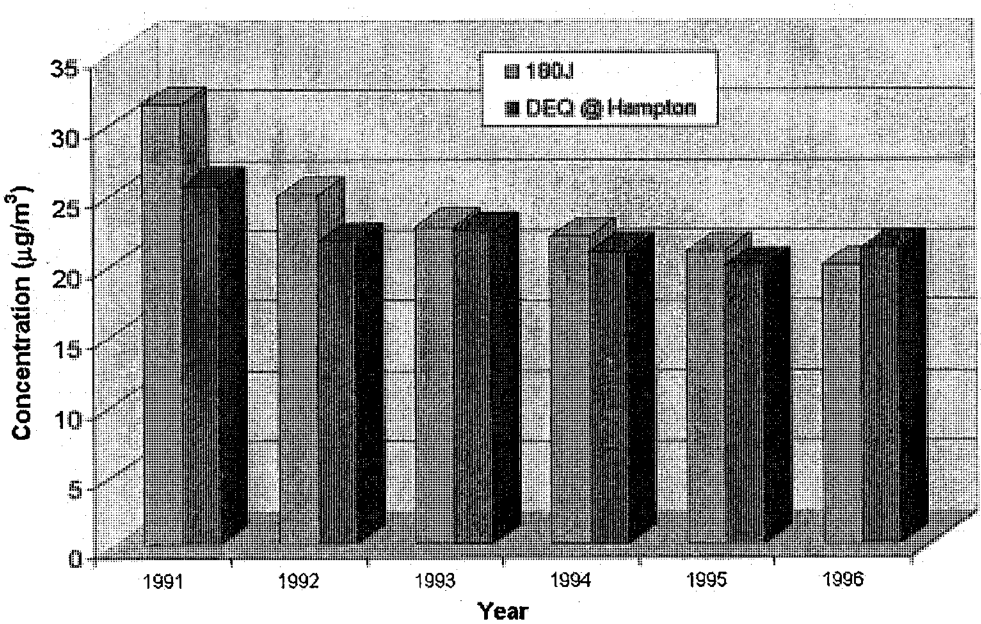




PM-10 Yearly Concentration Averages



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PROCEEDINGS
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A TWO-DAY CONFERENCE ON ENVIRONMENTAL MANAGEMENT AND POLLUTION PREVENTION

APRIL 11-12, 1996

Cameron Hall at Virginia Military Institute
Lexington, Virginia

Presented by
the Virginia Department of Environmental Quality
and VMI Research Laboratories, Inc.

PROCONTROL: AUTOMATED FUGITIVE DUST CONTROL SYSTEM

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Edward M. Calvin
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ABSTRACT

In the early 1980's, two new export coal terminals were built in Newport News, VA. Unlike the older terminals in the area which kept the coal in rail cars until ship loading, these newer facilities store the coal temporarily in 50-100,000 ton piles. Located on the north banks of the James River, the coal terminals are exposed to southerly winds, winds that blow from the river, across the coal storage area and into the adjacent community and business district. The terminals, working together with the Virginia Department of Environmental Quality (DEQ) and Simpson Weather Associates, developed a methodology and technology that has significantly reduced dust emissions. The 'K-factor' approach that resulted from this cooperative effort has now become one component of a more comprehensive dust control/monitoring system called PROCONTROL. A description of the basic system, its performance over the past few years and some recent enhancements will be presented using computer-generated demonstrations.

INTRODUCTION

A challenge facing many facilities that handle large quantities of coal (e.g., coal trans-shipment facilities, electric utilities, steel mills) is that of controlling fugitive coal dust emissions originating from coal piles, rail cars, rotary dumpers, conveyor belts, yard traffic, maintenance activities, etc.. Concerns associated with fugitive coal dust emissions issues fall into three broad categories: 1) compliance with regulatory emission standards; 2) public relations and corporate image; and 3) economics. Clearly, a facility must be in compliance with all Federal and State regulatory emission standards to conduct operations . Even when all emission standards are met, a facility may still receive complaints from the general public (residential and/or corporate) regarding "nuisance" dust. In these instances, the facility must weigh its options carefully and make crucial decisions which require balancing its desires to be a good neighbor against the economic realities of the marketplace.

As noted by Doll and Calvin (1994), 'Economic control of particulate emissions' can be defined as meeting the requirements of external factors such as air quality standards while also minimizing: 1) the capital and operating cost of the control system; and 2) the reduction of the value or loss of the material being handled. In most ground storage cases, the monetary value of the material leaving a site as fugitive dust is significantly less than the cost of preventing its loss. This is true because, although fugitive emissions can be controlled, they are by their nature difficult to conomically manage and control. With a wide range of designed to respond to changing weather, coal, and operating conditions.

Manually controlled spray systems have been used to combat fugitive dust emissions. This type of approach, however, is not an optimal solution to the fugitive dust problem. As an example, a water spray system operated only when dust is visible will not control nighttime emissions or fine-particle emissions which are not easily detected visually. Another typical method is to spray water just as strong winds arrive. This strategy usually results in much of the water being blown away from its target area. A third method is to run the water sprays at preset intervals which, in principle, will usually result in over-control, i.e., reduce the market value of the coal without an offsetting advantage.

The application of chemical binders and surfactants can also be used to control fugitive dust emissions. Although this type of chemical treatment is effective soon after an initial application, the chemicals often lose their effectiveness over time as a function of wet/dry and freeze/thaw cycles, physical handling, and chemical breakdown. The lifetime of a binder application to a coal storage pile may only be (depending on weather conditions and type of coal, among other factors) a matter of a day or so before reclaiming or further stackout necessitates retreatment.

Assuming the choice of water spray (instead of chemicals) for fugitive dust control, a facility must also consider the potential reduction in value of coal due to the higher moisture content resulting from over-spraying. As an example, assume that a dust control water spray system operated at a coal handling facility increased the moisture content of the treated coal piles by, on average, one percent. If there is a moisture penalty deduction from the sale price of the coal, there can be a significant loss of revenue. For a 1% moisture penalty deduction of $0.24 per ton, this would translate to an annual loss of $640,000 for a company which ships about two million tons of coal a year. This example points out the important and complex balance that must be reached between controlling dust emissions and the economic management of moisture/product quality.

THE K-SYSTEM

In 1984, the Commonwealth of Virginia's Department of Environmental Quality (DEQ), together with Simpson Weather Associates (SWA) and two Newport News, Virginia coal terminals, responded to public complaints of dust problems near the coal terminals. These complaints were registered despite initial efforts of the terminals to control dust emissions by using manually activated "rainbirds" to spray the coal piles. The manual efforts, however, were often taken after emissions had started, and frequently in wind conditions which rendered the spraying ineffective. Both the DEQ and the terminals recognized the need to develop autonomous control for the operation of water cannons to reduce fugitive dust emissions from coal storage piles. A product of this cooperative effort was the K-SYSTEM which is now considered the Best Available Control Technology (BACT) by the Commonwealth of Virginia and is required under terms of the terminals operating permits.

The K-SYSTEM is an autonomous scheduler used for activating arrays of water cannons to control fugitive dust emissions. The K-SYSTEM is based on an index called the K-factor which is used to determine when and how much water should be sprayed on coal piles to control fugitive dust emissions. The K-factor is an empirically derived quantity based on physical and statistical relationships between environmental conditions and the potential for wind generated dust emissions from coal piles. The K-factor is computed as follows:

$$K = (WS*T/RH)(p/u)$$

where WS, T, RH, p, and u represent hourly measurements of, respectively, wind speed (mph), temperature (degrees F), relative humidity (%), air density, and air viscosity of the air. The measurements of these variables are taken at a height (20-50 feet) above the top of nearby coal piles.

The K-SYSTEM coded logic incorporates equations representing the site's 'normal' uncontrolled emissions. 'Normal' uncontrolled conditions represent the mean day-to-day potential emissions uncomplicated by weather events such as precipitation, fog, frontal passages, etc. The K-system also involves the concept of a stable pile. A stable pile condition exists when one spray cycle reduces emissions in accordance with the percent reduction per cycle formulated into the program. Rain in excess of 0.025 inches is an example of a super stable condition. After a rain of this magnitude, the emission rate of the piles will return to stable conditions at a predetermined rate in accordance with the value of the K-factor and the elapsed hours. If water suppression is not activated, the piles are considered unstable and prone to emissions.

The K-SYSTEM software also contains logic that adjusts the K-factor for rain and freeze effects to define the need for water to be sprayed by the computer-controlled suppression system. Based on the K-factor (where higher values imply higher dusting potential), the computer-controlled K-SYSTEM will initiate one of the following actions:

1) no spraying required;
2) the spraying of a 'Demand cycle' to suppress the predicted dust emissions;
3) the spraying of one 'assurance cycle' at 0300, 0700, 1100 and 1300 if no other cycles have been run;
4) continuous spraying to recover from freeze events or in anticipation of high winds.

The suppression system used must have the capability to administer 0.025 inches of water per hour per site. The program uses three cycles when the K-factor is very high (high emissions)in order to reduce emissions and maintain stability. If this capability is not met, high K-factor values over time may cause the coal piles to slump and possibly blow out. In addition, the three cycle mode is necessary to administer the heavy pre-wetting needed to hold the piles before a pending freeze period (during which the water in the spraying system may freeze up and become unavailable for controlling emissions). At the end of such a freeze period, three cycles per hour is also needed to bring the level of pile stability back to a target value.

The K-SYSTEM can be implemented at almost any location. However, the primary hurdle to adapting this system to other sites lacking sufficient dust monitoring data is the formulation of equations to represent the new site's normal uncontrolled emission rate. This can be accomplished for sites other than the original coal terminals using the following necessary information:

1) standard modeling equations
2) configuration and area of coal storage area
3) one year of complete weather data

Once the system is in place, the accuracy of the modeling equations can be verified or modified with normal emission data.

PRO-CONTROL

The basic K-SYSTEM equations and instructions have been packaged by SWA into a computer program called PROCONTROL. This system was initially installed in the Newport News terminals in 1986. In addition to the basic K-factor logic described above, PROCONTROL provides the facility operators with information regarding the status of the weather instruments, water spray equipment, expected changes in the weather (e.g., freezes, thunderstorms, wind shifts, extended dry periods, etc.), status of coal handling equipment and dust crossing the fence line. The primary components of PROCONTROL are shown in Figure 1. The sensors included on the meteorological tower measure the following parameters: temperature, relative humidity, wind speed and direction, precipitation, and steel surface temperature.

The K-SYSTEM, as required in the State of Virginia, does not use any inputs from real-time dust monitoring equipment although the value of timely feedback on the performance of a dust control system is critical to the success of a low dust tolerance operation. However, PROCONTROL is designed to include the input of a recently developed monitoring strategy which uses Real-Time Aerosol Monitors (RAMs) to provide a reasonable check on the efficiency of dust control efforts. These data provide real-time and continuous evidence of the magnitude of the dusting within a selected area and help quantify the improvements achieved through the dust control program.

The PROCONTROL provides the following general functions:

1) Monitors the local weather and computes the drying potential (Figure 2) for the surface of coal piles.
2) Provides 12 hour weather forecast (Figure 3) to schedule special treatments such as manual application of chemical tarps, super-spraying prior to a freeze, or tiedown of equipment in anticipation of a major storm.
3) Automatically activates a network of water sprays for a prescribed period of time.
4) Issues visual and audible alarms for pre-set weather or real-time dust monitor conditions.
5) Performs end-of day calculations of estimated coal contribution to TSP at specified monitoring sites.
6) Archives data and operator comments for future reference and review by regulatory agencies.

SUMMARY

The K-SYSTEM has, in one form or another, been implemented at the Newport News, VA coal terminals since 1986, two years after operation began. Therefore, it is difficult to establish a statistically significant 'before' and 'after' comparison. However, the Virginia DEQ has judged the dust control effectiveness to be on the order of 90%. There are several observations that are consistent with this level of control:

1) There have been no violations (PM-10 concentrations) since 1987;
2) There has been a general decline in the annual average PM-10 concentrations at a nearby monitoring site (Figure 4); and
3) There has been a significant reduction in the number and intensity of visual dust events.

Additional benefits of using the K-SYSTEM include the reduction of potable water consumption, reduced manpower and equipment costs associated with 'last second' applications of surface binders to problem piles, and the redirection of personnel resources to handle exceptions not adequately covered by the automated decision system.

ACKNOWLEDGMENTS

The authors wish to acknowledge the input from Mr. John Stewart of the Virginia Department of Environmental Quality and personnel at both Dominion Terminal Associates and Pier IX terminals.

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1. Doll, E.R. and E.M. Calvin, 1994: PLACEM and PROCONTROL: New tools for fugitive dust control at coal handling facilities. Paper presented at the COAL PREP '94 Meeting, Lexington, KY, May.

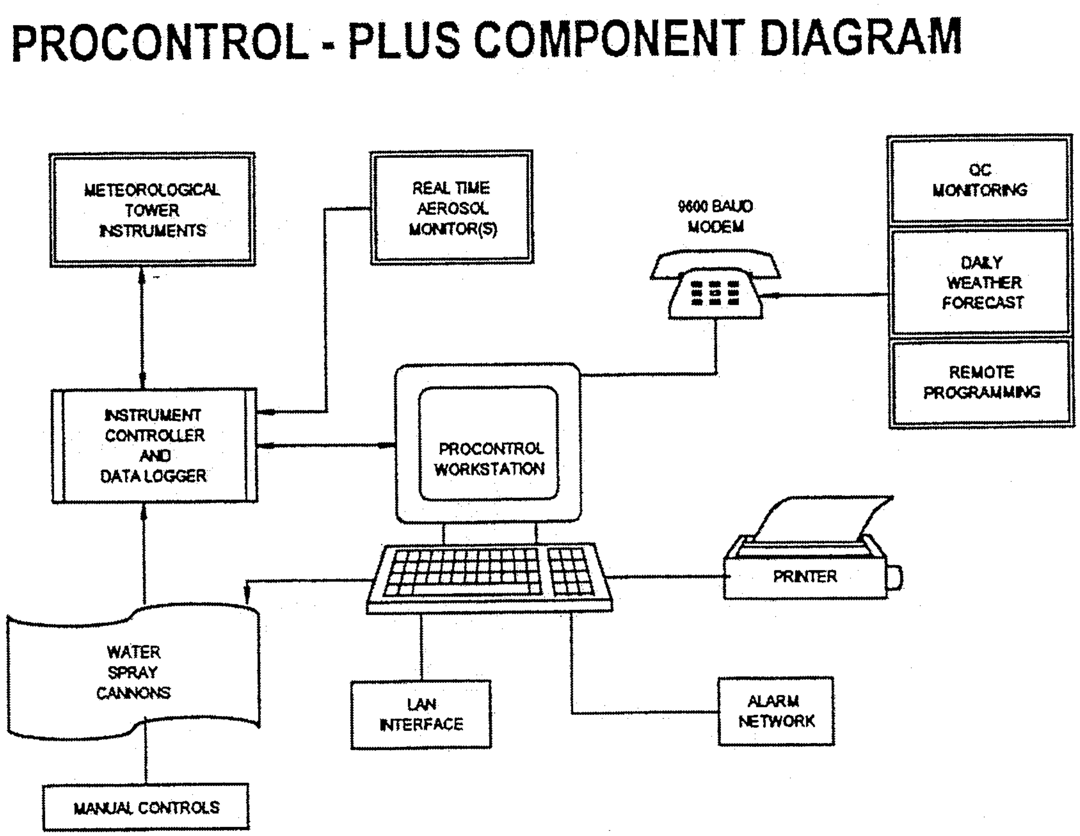

Figure 1. Component Diagram of PROCONTROL

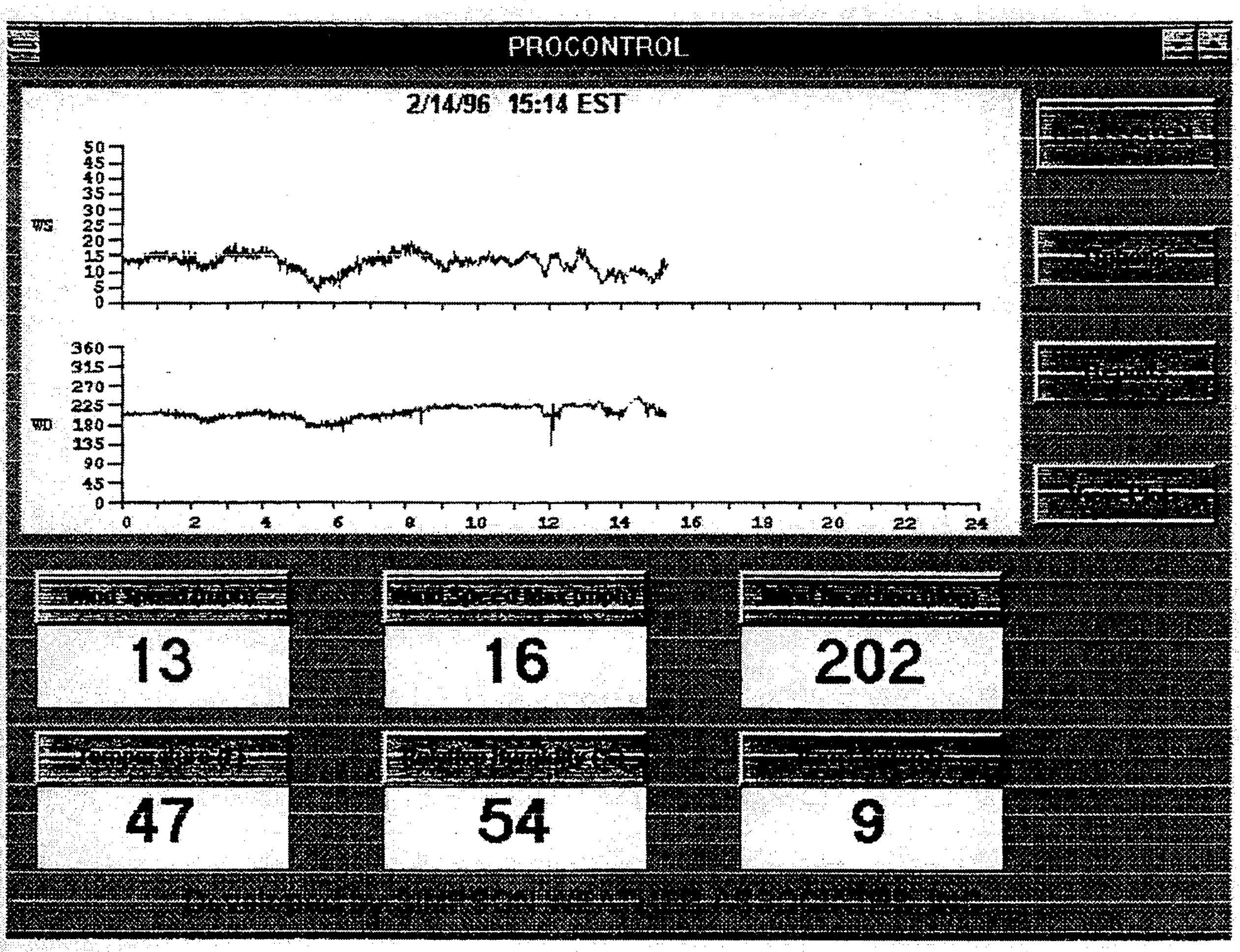

Figure 2. Main Panel for PROCONTROL Workstation Display

MESSAGE

Weather Advisory (Simpson Weather Associates) Forecaster: Dave Walker

W E D N E S D A Y 7:56 AM F E B R U A R Y 14

TIME (EDT)	WIND BLOWING FROM	MAX WIND SPEED	MAX WIND GUST	PROBABILITY OF : RAIN SHOWER	THUNDER STORM	FRONTAL PASSAGE	DRYING RATE EXPECTED	CRISIS INDEX
TODAY		MPH	MPH	%	%	%		
8 AM	N+NW	11	22	50	0	0	MED	*
2 PM	NW	13	25	35	5	0	MED	**
8 PM	NW	11	23	15	2	0	LOW	*
TOMORROW		MPH	MPH	%	%	%		
2 AM	W+NW	8	18	5	0	0	LOW	*
8 AM	W+NW	6	16	1	0	0	LOW	*
2 PM	WEST	10	20	0	0	0	MED	**

COMMENTS : Variably Cloudy, breezy and cool with occasional rain showers today. Cooler tonight. Breezy conditions should be with us for the next 2 days. Showers Monday? HIGHS : 55 THU 65 FRI LOWS : 42 FRI 47 SAT

CRISIS * PROBABLY SUFFICIENT TO RELY ON K-FACTOR CYCLES PROCEDURE

Figure 3. Sample of Twice Per Day Weather Forecast Coded for Interpretation of PROCONTROL Software

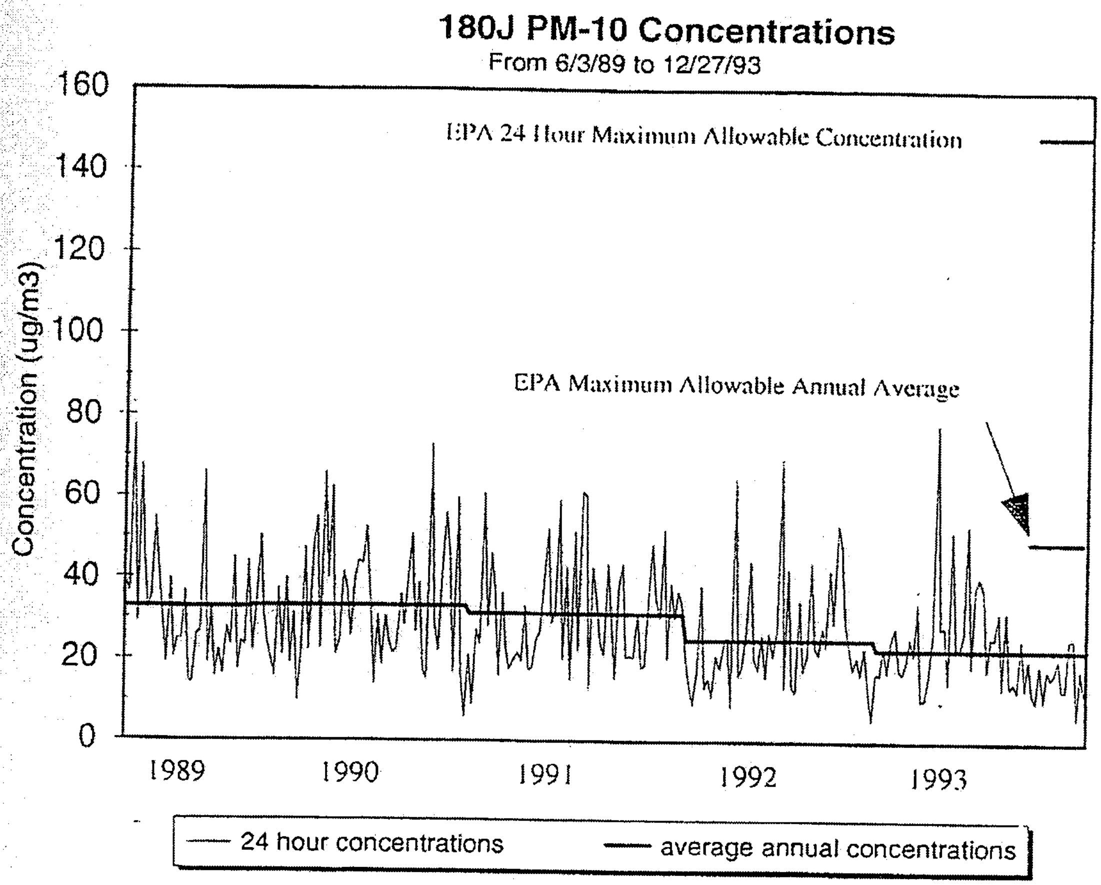

Figure 4. PM-10 Concentrations Within 300 Yards of Newport News Terminals Between 6/23/89 and 12/27/93

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MINIMIZING GROUNDWATER CONSUMPTION FOR REQUIRED FUGITIVE DUST CONTROL PROGRAMS

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Executive Vice President/Senior Scientist
Simpson Weather Associates, Inc.
Charlottesville, Virginia

ABSTRACT

Control of fugitive dust emissions from coal ground storage facilities, in most cases, involves the use of water, applied with fixed and/or mobile water spray cannons. Based upon experience at Virginia coal transshipment facilities, the Department of Environmental Quality (DEQ) has issued operating permits that require the use of ~ 8 gallons of water per throughput ton of coal. A facility, with throughput of 20-40 million tons puts a rather large demand on municipal water supplies or local aquifers. In either case, there are incentives to minimize the need for such water. Recycling of dust control water and the capture/storage of rainfall are two options available to reduce the demand on potable water supplies.

Simpson Weather Associates (SWA) has developed and applied a full Water Budget Model (WBM) for designing and operating a fugitive dust control system at a coal ground storage facility. The model uses 30 years of hourly weather data to simulate a model facility's impact on fugitive dust management, storm water management, water treatment, and water discharge. The model yields optimum settling pond size and water retention schemes to

1) minimize groundwater demand;
2) minimize discharge to streams during a 25+ year storm;
3) meet dust control permit requirements during extended droughts; and
4) minimize suspension of operations due to insufficient water supply or local flooding.

INTRODUCTION

A common strategy for suppressing fugitive dust emissions from an industrial complex is to use water sprays delivered by tank trucks, in situ spray bars or elevated water cannons. In the case of the ground storage of coal, the water required to maintain dust control can be significant, on the order of several 100 million gallons of water per year. Both existing and proposed ground storage facilities for coal in Virginia are required by the DEQ to employ water (plus surfactants in some cases) to assure compliance with air quality standards for particulates. The quantities of water needed to meet the permit requirements can represent a significant demand on potable water, whether it is supplied via municipality water mains or from dedicated wells.

In addition to reducing the annual consumption of potable water, facility operators are concerned with designing water holding/treatment ponds that will be adequate for dry period (low rainfall) operations as well as sufficient for the retention of major storm water runoffs. . A Water Budget Model (WBM) has been developed to provide the basis for sizing the water delivery, retention, treatment and discharge components of the dust control/storm water runoff system at a large coal ground storage facility.

THE WATER BUDGET MODEL

A general flow diagram of the Water Budget Model is illustrated in Figure 1. The primary assumptions made by the model are that water is needed for:

1) dust control during coal handling, in particular, at the rotary dumper, stacker/reclaimer and loadout silos;
2) dust control for piles;
3) the cleaning of storage pads, vehicles and roadways;

4) fire control; and
5) incidental human consumption, cleaning, etc.

It is further taken that:

1) saline water is not acceptable;
2) municipal or other public water is not available;
3) rainwater will be captured and stored;
4) a portion of the water used in dust control will be recycled; and
5) ground water will be the source of "make-up" water.

The following discussion of the WBM is based upon a hypothetical design of a facility with a ground storage capacity of 4 million tons, an average working storage of 2.5 million tons, and an annual throughput of 40 million tons.

The WBM was run using three different weather scenarios - a typical year, a design storm and a design drought. The "typical year" data was obtained from a meteorological tower located in Newport News, VA. The criteria for spraying the coal piles was taken to be the K-system required by the Virginia DEQ and described in Emmitt et al. (1996).

A second simulation was done using a design storm of 7.6 inches in 24-hours based upon climatological data from the official NOAA National Weather Service (NWS) station at Norfolk International Airport. This design storm has a return interval of 25 years.

A third water budget was run for a 90-day drought during the months of May, June and July. While there is no official engineering "design drought" for a coal handling facility, it is critical to design the water supply system to handle an extended dry period.

Water Demands

The primary demands for water include the spraying of the coal during its unloading and loading (inline dust control), the spraying of the piles of coal using the K-system (Emmitt et al., 1996), the wetting of roadways and the cleaning of equipment.

Inline Dust Control

It was assumed that water was used in the rotary dumpers to form a curtain spray to contain fugitive emissions during dumping. Based upon experience at Virginia terminals, a nominal water requirement is .75 gal/ton of coal handled. The curtain sprays are operated in a fashion to optimize capture and reuse of the spray water. It is estimated that at least 33% of the spray water can be captured and returned to the water supply pond.

In recognition that some of the incoming coal will require additional water (plus surfactant) to control emissions during stackout, inline sprays (.75 gal/ton) are provided at two more locations. In reclaiming the coal, additional wetting capability (.75 gal/ton) is provided at three selected transfer points.

Based upon a throughput of 40 million tons per year, the reprocessing* of 4 million tons per year and assuming the estimated annual maximum water requirement, the inline dust control, (INLINE) was computed to be 195 million gallons per year (MGY) (assuming all coal is treated with water at all six spray points).

The actual amount of water added to any given coal shipment may vary, depending upon several factors. First, real-time dust monitors at the dumper and other transfer points serve to identify coals that need water for dust control. Second, the amount of water needed to achieve a targeted level of dust control may depend upon the use and effectiveness of a wetting agent (surfactant). In the absence of sufficient data, a very conservative estimate was made: on the average only 50% of the inline spray capacity would used on the total coal processed.

A further reduction of the "inline" demand is realized when weather conditions are incorporated into the dust control system. Based upon weather data taken from Norfolk, VA, there are approximately 100-120 days per year with rainfalls greater than .10 inch. According to hourly data, it rains 6 out of 24 hours on days with rain and thus no spray water would be needed during that time.

Combining these reduction factors the expected inline water requirements for a typical year was calculated by the simulation model to be 71 MGY.

Coal Pile Dust Control

Control of fugitive dust emissions from the coal piles represents the largest demand for water. Sizing the water supply/delivery system depends primarily upon the estimated water requirements for fugitive dust control during extended dry periods.

In estimating the average annual water demand for dust control from coal piles we have made several assumptions:

- the objective of the pile spray system is to deliver an average of .02" of water in one spray cycle to the surface area of each pile and the surrounding pad area. The value of .02" is based upon amounts found acceptable by the DEQ for coal storage facilities in the Norfolk area,
- except for very extreme (crisis) cases each pile will be sprayed, at most, once per hour, and
- a minimum of 4 spray cycles will be used each day except when it is raining, the temperature is below freezing, or it is foggy.

While we recognize that it may be possible to reduce the water demand by discriminating between coals of different dust potential or between used and unused portions of the storage pad, a maximum treatment is computed and used as a "reference". The amount of water required for a reference spray cycle (assuming no overlapping in coverage) is 84,025 gals/cycle.

To estimate the spray water required during a typical year we have considered the following factors:

- number of hours in a year during which its is raining, below freezing, foggy or snow covered; and
- the number of cycles that would be required under a current DEQ permit. Thirty year's worth of hourly meteorological data obtained locally are used.

To determine the number of water spray cycles that are required for dust control, one cannot use average climate statistics. Instead, hourly weather data must be used to simulate the sequence of demand for dust control. Based upon 30 years of recorded hourly data, the K-system operations were simulated and the average water required to treat the piles was estimated to be 160 MGY.

Road Sprays

The pile spraying system was assumed to cover the primary yard traffic routes and thus no additional water was needed for road surfaces. It was further assumed that any frequently used road not wetted by the coal pile spray system would be paved and cleaned periodically with a spray truck.

Wash Water

A value of 6% (based upon experience) of pile spray water required was used to estimate the amount of water needed per day to clean roadways, vehicles, and other equipment. It was further assumed that with the exception of the roadways, this cleaning would take place where the water would be recaptured for recycling. A recycle factor of 75% was assumed as a best guess.

Water Supplies

Groundwater should not be the primary source for meeting the demands of a coal storage facility. The annual average and daily maximum amounts of required ground water are the net results of a water budget study and are therefore discussed in Section 3. It is advantageous to find alternative water supplies and ways of increasing the efficiency of water usage.

Rainfall

Rainfall represents a significant source of water if properly captured and stored. Not only can rainfall be stored but it also negates the need for other water usage during and immediately after rain events.

Our estimates of rainwater available for capture are based upon the following:

48.5" (4.0') of rain per year

capture areas
- pad - 6.8×10^6 ft^2
- inbound loop (includes pad) - 19.3×10^6 ft^2
- outbound loop - $10.3 \times 10^6 \times$ ft^2

runoff factor (% of incident water)
- bare ground - 25%
- pad - 95%
- coal piles - 73%

The total amount of rain water runoff potential (gals):

loop area (w/o pad)	171.3 MGY
pad (30% open)	57.5 MGY
coal piles	103.0 MGY
Total	331.8 MGY

While the amount of rain water potentially available for dust control exceeds the estimated water demands, not all of that water survives evaporation or can be stored. In our simulation we have made the conservative assumption that only if it rains more than 0.25 inches within a 24-hour period will there be any runoff from the pad and piles that is actually available for capture. In other words, 0.25 inches of rain is lost to pooling on tops of piles, inhibited flow in drainage ditches and evaporation.

The model facility has perimeter ditches. These ditches carry water from the non-pad areas into the storage ponds. However, only under very heavy rain conditions should there be significant return from those ditches. The amount of water from these ditches that can actually be captured for use in the dust control system will depend upon the antecedent conditions of the soil and the pond levels at the time of the rainfall event. This potential water supply is not incorporated into the WBM at this time.

Coal Pile Flow Through

This is the most difficult term in the water budget to assess. It also has the potential of being a significant source of water. By "coal water yield" we include any water that exits the pile from the bottom. This water could be coal moisture that was imported with the coal or it could be some of the rain or spray water that infiltrated and flowed through the pile.

Using soil analogies (sand/silt) we can only make a very rough estimate of what this term might be. If the coal looses 1% weight due to gravitational drainage, then there is ~100 MGY available for retention. Based upon laboratory experiments, we estimate that the infiltration water (from rain) is released by the pile within 24 hours.

There is significant uncertainty in these estimates. There is the likelihood that much of the drainage would occur during non-rainy periods and would therefore evaporate before getting to the retention pond. We have assumed that 75% of the leachate will evaporate before being captured. The total flow through is reported primarily for water chemistry computations.

Recycled Water

Not all of the water sprayed on or toward the coal is absorbed. This is particularly true for the in-line dust control at the rotary dumper and loadout silos. Some of this water can be captured and recycled. The exact amount depends on the design of the dust control system. For the model facility we have assumed that 33% of the rotary dumper water and 75% of the water used to clean pads and vehicles can be recycled. All other inline spraying should be absorbed by the coal and effect the desired dust control.

WATER BUDGET RESULTS

All of the factors and budget components discussed in the preceding sections have been incorporated into the Water Budget Model. Thirty individual years of operation were simulated producing time series such as the one for 1974 shown in Figure 2. The model was also run for 2 design situations, the results for which follow.

Typical Year

A plot of the daily water demand during a 'typical year' for dust control and the groundwater requirements to maintain pond levels is provided in Figure 3. A summary of the water budget for this typical year follows:

Kilogallons of water associated with:	
Inline dust control	71099
Pile dust control (2668 cycles)	26491
Wash water	13589
Total water demand	311179
Captured rain water	113108
Recycled control water	14885
Pile flow through water	121440
Evaporation	99962
Total surface supply	149470
Groundwater required	161581
Total water supply	311051
Discharge required	819
Total rainfall (inches)	48.47

From this simulation we see that with a facility designed to use storm runoff, pile drainage and recycling of dust suppression water can meet nearly 48% of its water needs without use of fresh water from the ground supply. Given the limited capacity for storage of storm runoff, approximately ~1 MGY must be discharged. However, even this amount of "lost" water can be reduced by using the storage pads (with a berm) as a surge pond during heavy rains.

A Year With a 90-day Drought

In this simulation (Figure 4) we have used the same data used in the typical year case but have zeroed the rain for 90 consecutive days and have kept the minimum number of pile spray cycles per day at 4.

Kilogallons of water associated with:

Inline dust control	72205
Pile dust control (2813 cycles)	238807
Wash water	14328
Total water demand	325340
Captured rain water	77804
Recycled control water	15512
Pile flow through water	115088
Evaporation	95119
Total surface supply	113205
Groundwater required	211187
Total water supply	324392
Discharge required	0
Total rainfall (inches)	33.72

It is clear from the table above that the demand for water only increased 14 MG for the year (section 4.1) but the groundwater requirement increased by nearly 50 MG, due to the extended absence of rainfall.

SUMMARY

A water budget model has been developed and applied to a 'model' coal ground storage facility to provide the basis for designing the dust control water supply system and predicting the discharge of treated water. A properly designed facility can provide nearly 50% of its water requirements through the capture of rainwater, and the recycling of dust control water, combined with adequate sizing of retention and treatment ponds.

ACKNOWLEDGMENT

A portion of the development of the WBM was made possible through support from the Norfolk Southern Corporation.

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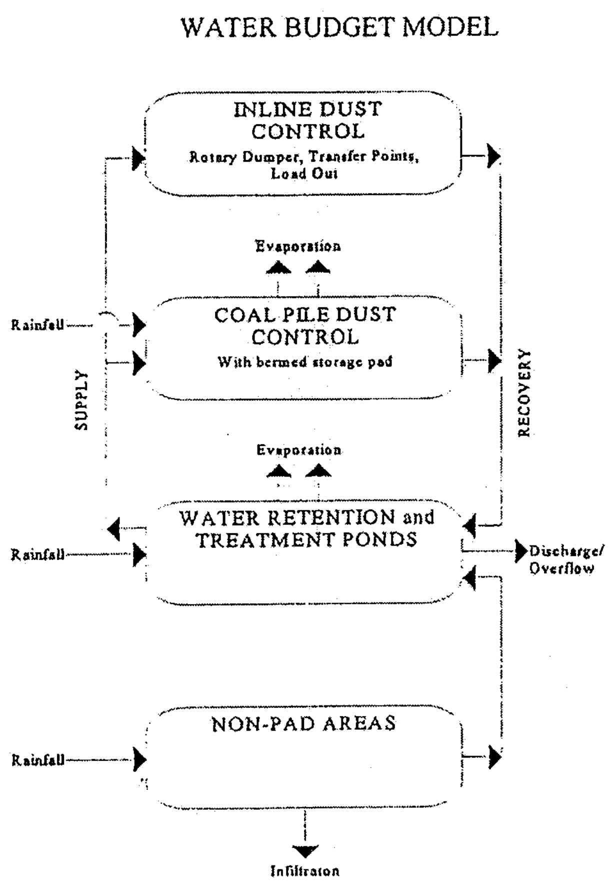

Figure 1. Flow Diagram for Water Model Budget

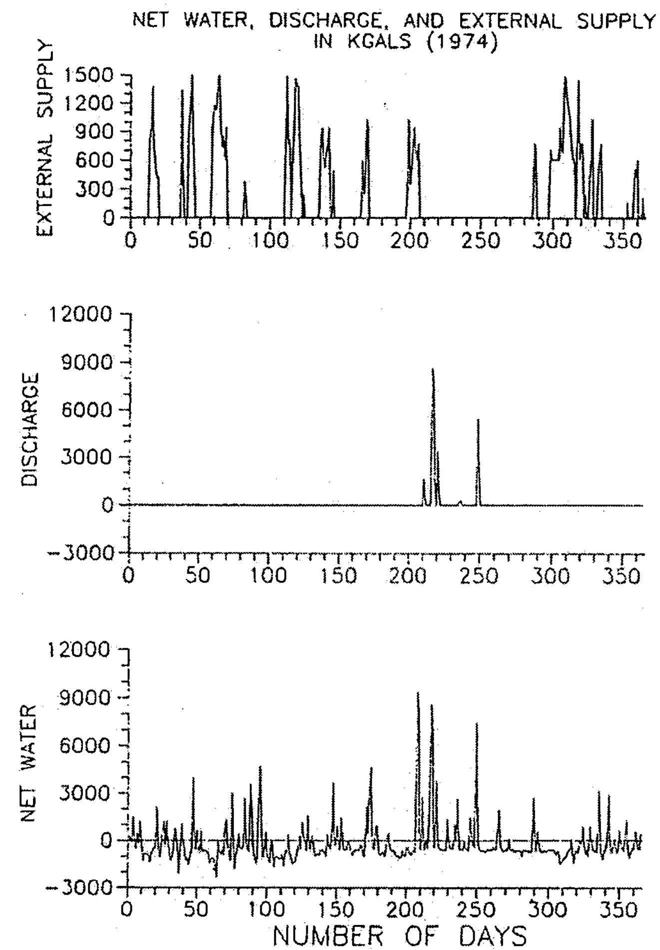

Figure 2. Example of One Year's WBM Simulation of the Model Coal Handling Facility

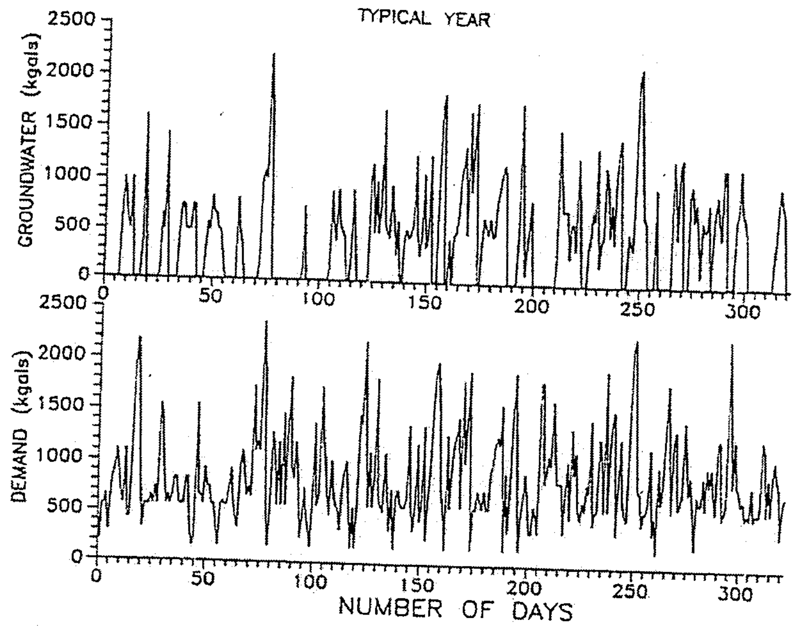

Figure 3. DEMAND (Dust Control) and GROUNDWATER (Municipal Supply)

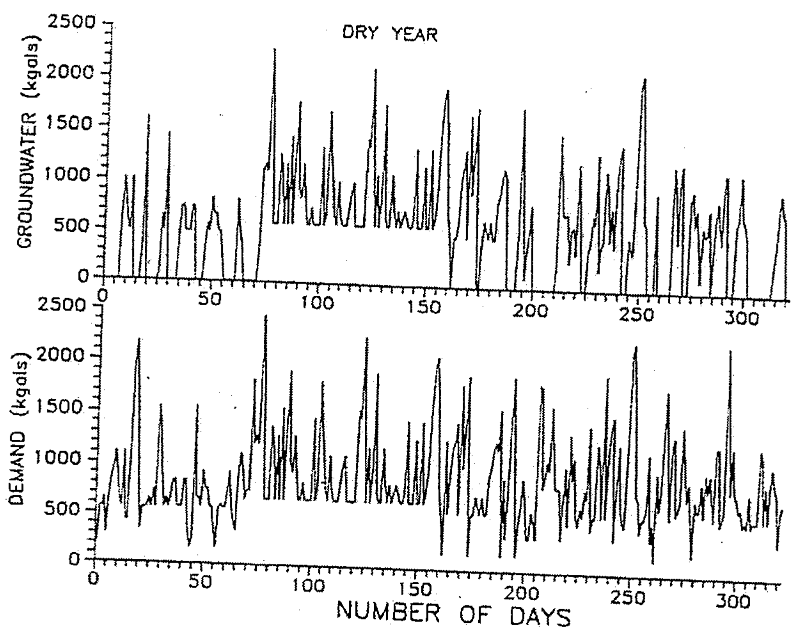

Figure 4. Same as Figure 3 Except a 90-Day Dry Period is Included

IN-TRANSIT CONTROL OF COAL DUST

FROM UNIT TRAINS

by

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Environmental Protection Service

Fisheries and Environment Canada

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ABSTRACT

Effectiveness of chemical binders in controlling coal dust emanating from unit trains was investigated and monitored during 1974 and 1975. The parameters investigated included loading profile, type of chemical binder and spraying technique. A flat loading profile provided maximum retention of binder crust and simplicity of spray application. Oil products were the most effective binders. Almost equally effective were the oil and asphalt emulsions. Latex type chemicals formed brittle crusts that were easily fractured by torsional movement of the cars. A combination of simultaneous flooding and spraying was the most effective technique applied during the study. Coal trains from four mines were monitored for crust retention by measuring the percentage of crust cover remaining over the total car surface when the unit trains reached the terminals. Coverages of up to 95% were obtained; however, the crust coverages which most frequently occurred varied from 86% to 90%, 76% to 80%, 81% to 85% and 61% to 65%, depending on loading profile, type and concentration of chemical binder.

RÉSUMÉ

En 1974 et 1975, on a étudié et contrôlé l'efficacité de certains liants chimiques à éliminer la poussière de charbon se dégageant des trains intégraux. Les paramètres examinés comprenaient le profil de charge, le type de liant chimique et la technique d'arrosage. Le profil plat donnait à la croûte de liant une résistance maximale en même temps qu'il simplifiait l'application. Les produits huileux se sont révélés les liants les plus efficaces et les émulsions d'asphalte ont donné des résultats presque aussi valables. Les produits chimiques à base de latex formaient une croûte cassante que le mouvement de torsion des wagons brisait facilement. C'est le procédé combinant un jet de saturation et l'arrosage superficiel qui s'est révélé le plus efficace. En contrôlant les trains provenant de quatre mines, les techniciens ont mesuré l'adhésion de la croûte qui s'exprime en pourcentage de celle-ci demeurée intacte lorsque le train arrive à destination. Ils ont ainsi mesuré des couches protectrices intactes atteignant 95 p. 100 de la surface. Toutefois, les croûtes superficielles le plus souvent observées ont varié de 86 à 90 p. 100, de 76 à 80 p. 100, de 81 à 85 p. 100 et de 61 à 65 p. 100 en fonction du profil de la charge ainsi que du type et de la concentration du liant chimique.

ACKNOWLEDGEMENTS

The author of this report wishes to express his appreciation for the considerable assistance received from the members of the project committee: Mr. L.J. Cherene, Manager of Environmental Services, Kaiser Resources Ltd.; Mr. D.J. di Biasio, Staff Assistant, Fording Coal Limited; and Mr. W. Mummery, Assistant Superintendent, Canadian Pacific Rail.

Recognition is also given to B.H. Levelton and Associates Ltd. for their assistance during the monitoring program, and to numerous staff of the mining companies who provided invaluable technical advice.

Specialized technical assistance was also freely given by staff of other Federal agencies, particularly Mr. Sam Payne of the Canadian Transport Commission for his monitoring work, and by my colleagues in the Environmental Protection Service.

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IN-TRANSIT CONTROL OF COAL DUST FROM UNIT TRAINS

1 CONCLUSIONS

(a) Results of the field studies proved that some chemical binders offered an immediate and satisfactory solution to controlling coal dust emanation from en route unit trains.

(b) Coal Spray 100 and Reclamation Oil were the most effective products used to control dust, principally because their regenerative properties were capable of sustaining a cohesive crustal cover which overcame surface cracks caused by torsional stresses of moving rail cars.

(c) Oil emulsion (DS200) and asphalt emulsions (DS100) produced 85% crustal coverage, which met acceptable government and operating mining company criteria.

(d) Properly formulated latex binders used on horizontal surfaces were as effective as oil emulsions, but on sloped surfaces they were less efficient.

(e) The Study Committee had postulated that crustal deficiencies on irregular coal surface profiles may be overcome if increased spraying on sloped surfaces was applied by an improved spraying method. The field test and observed results did not substantiate this theory, particularly in the case of latex products. These compounds are brittle after the curing period and do not re-polymerize on the surface of the coal cars.

(f) Complete dust control depends on a spraying technique which provides complete and controllable spreading of the binder, adequate quantities and concentrations of applied chemical (gallons/car), the use of acceptable and readily available chemicals to the mining industry, and loading techniques which form flat loading profiles.

(g) Extensive monitoring confirmed that when latex products are used, crustal retentions of 85% can be readily achieved if the coal surface configuration is a central horizontal plane bounded by limited sloped ends. Crustal retention can be increased to 95%, if the front-end slope is made level with the horizontal central portion.

2 INTRODUCTION

2.1 Objectives

The study was designed to evaluate chemical methods of eliminating or minimizing wind dispersion of coal dust from open-top rail cars during transportation of coal from mine sites to terminal storage areas. Dust control techniques were to be tested and developed which would be economically acceptable and readily adaptable by mining and railway companies. In addition, the establishment of sound, proven control technology would become available to legislators as guidelines in formulating any necessary environmental control regulations.

2.2 Environmental Concerns

The clouds of wind-blown dust that emanate from moving trains are receiving considerable attention as an environmental issue in many countries. In Canada, concern about the air-borne transport and deposition of coal dust has been expressed by the public as numerous complaints to railway companies, operating mines, municipalities, Members of Parliament and government agencies. Supportive evidence in newspaper articles has also highlighted the pollution aspects.

Figure 1 illustrates the geographical range and monthly frequency distribution of complaints in the study area of British Columbia during 1972 - 1973. The peak of complaints during March to May, possibly reflects the public's tendency to object prior to the onset of the summer outdoor season, a time when their awareness of air-borne dust becomes more acute. Also, moisture deficient coal transported during dry months has lower compaction rates and is more susceptible to wind dispersion than during the wetter months of fall and winter. Evidence of this was observed following compaction tests* on a unit train where only 58% of total compaction had occurred after transportation of 180 miles.

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*Kaiser Resources, Internal Report

Physically, coal is black, nontransparent and relatively lightweight. In populated areas its black colour soils houses, swimming pools, terraces and clothing. The nontransparency creates highway hazards by reducing visibility, while its lower density makes it readily airborne and capable of being carried further than common silicate dust.

From a chemical viewpoint, coal mined in Western Canada has not been demonstrated to be acutely toxic to salmonids. Bioassays conducted by B.C. Research proved that liquid extracts from East Kootenay coal are acutely nontoxic to fish.[(1)]

Pollution by coal dust, then appears to be confined to some aesthetic values and to physical hindrance where excessive quantities of coal are deposited.

2.3 Coal Transportation in the Study Area

Coal is transported to British Columbia terminals by Canadian National Railways (CNR) and by Canadian Pacific Rail (CPR). CNR moves coal from two major mines located in Alberta (McIntyre Mines Limited and Cardinal River Coal) to Neptune Terminals Ltd. in North Vancouver. CPR transports coal from the East Kootenay (Kaiser Resources Ltd. and Fording Coal Ltd.) to Westshore Terminal, the superport at Roberts Bank in the Municipality of Delta.

Figure 1 shows the major coal mine locations and railway routes to the Vancouver terminals. During 1973, 11,303,539 short tons of coal were transported over the railway system, 8.3 million tons by CPR and approximately 3 million by CNR. Table 1 details the coal movements to British Columbia terminals during 1973. Future coal industry development will greatly increase the tonnages transported, particularly from the northeastern area of British Columbia. Such development will emphasize the need for effective en route coal dust control.

3 THE STUDY PROGRAMME

In February 1974, a committee of representatives from Kaiser Resources Ltd., Fording Coal Ltd., Canadian Pacific Rail and the Federal Government formulated a study and test programme to determine the relative effectiveness of available chemical binders as an immediate solution to the problem of coal dust control on moving unit trains.

3.1 Phase I - Planning and Preliminary Field Investigations (During 1974)

(a) Planning involved technical and logistic considerations to determine the following:

- The most economical and effective location to apply chemical spraying.
- The minimum number of rail cars per train required to obtain a conclusive test programme.
- The number and types of tests to be conducted to obtain base data for Phase II.
- Allocation of test sites, based on in-transit settling characteristics, where tests would be carried out.
- What test evaluation procedures and criteria would yield reliable data.
- Preliminary screening and assessment of available chemical products to be used in the field test work.

(b) Field Work

Initially, spraying locations other than the mine sites at Fort Steele, were considered to evaluate the possible advantages of spraying after coal compaction had taken place. Eventually all trains were sprayed at the mine sites (Kaiser and Fording) to avoid all pollution problems.

Each chemical product was tested on a maximum of five cars, with each car selected on the basis of representative profile and location at, or near, the head-end of the train, to avoid possible accumulation of coal dust escaping from other cars. Binding performance at the departure point, at Kamloops, and at the Vancouver terminal was recorded by each committee member on a Visual Observation Form (see Table 2). The final rating for each series of tests reflecting the opinion of the total group was recorded on Tables 3 to 10.

3.2 Phase II - Extension of Field Investigations to Complete Unit Trains

In order to confirm the test results and analyses obtained in the limited (five cars per train) Phase I work, B.H. Levelton and Associates Ltd. were contracted by Environment Canada to carry out control tests on complete unit trains during the period August 28th to September 30th, 1975. A synopsis of Levelton's report entitled, "Measurement of Crust Remaining on the Surface of Coal Cars on Arrival at Dumping Terminals - Results of Monitoring 30 Trains", is presented in Sections 9 and 10 of this report.

4 COAL LOSSES BY WIND FROM UNTREATED CARS

Early in the study it became evident that the loading profile, that is, the geometrical configuration of the exposed surface of the coal, had a large influence on the coal lost in transit (Plate 1). Beshketo[2] reported heavy losses of coal at high train speeds. According to his data, the best "hood" height, based on car capacity and winds losses, is 200 mm (8") above the sill of the coal cars (Figure 2). He observed that 6 mm of coal was lost at 60 km/h (40 mph) and 13 mm (1/2") lost at 100 km/h (approx 60 mph). A parallel study on dust losses from mineral concentrates was carried out by Schwartz.[5] He observed that losses from concentrates were up to 2.1% for speeds up to 60 mph.

Screen analyses of the various coals transported to British Columbia terminals are presented in Figure 3. Even though the coal from Alberta is somewhat coarser than the coal from British Columbia, both types readily become airborne at low speeds.

Exact measurements of coal losses during transportation were difficult to determine with a high degree of confidence. Some problems experienced during the study included: inconsistencies in weigh scale calibration, variations of existing moisture content of the coal, addition of flying debris deposited in cars en route, and the inclusions of rain and/or snow. Thus calculations of coal lost en route as a measurable difference between car weight at the departure point and its weight at the terminal were somewhat unreliable.

Previous studies[2 and 3] suggest losses in the order of 1.5 tons/car or 1.5% for a 100-ton car capacity. Even if we assume that losses of western coal are only 0.5% or 1/2 ton/car per 700 mile journey, it is relatively easy to justify a reasonable expenditure to keep coal in the cars and, at the same time, reduce public concern over pollution.

In economic terms, prevention of the assumed Western Canada coal losses represent a saying, based on $60/ton of $30/car or over <u>$3 million annually</u>.

5 LOADING PROFILE

5.1 <u>Effects on Crust Retention During Transit</u>

Loading profiles had a profound influence on crust retention (Plates 1, 2). A surface particle is affected by the vertical force of gravity and by horizontal forces of linear and centrifugal acceleration and/or deceleration. The magnitude of each component depends on whether the particle rests on a horizontal surface or on an inclined plane and on the resistance to shear offered by the substrate. Furthermore, if the independent particle is chemically bound to other surface particles, the strength of the chemical bond is an additional force that increases the particle's resistance to sliding.

During the field tests it was soon realized that a totally flat surface would produce the most desirable profile (Plates 3, 4). Coverage of the flat portion of the car never presented a serious problem, suggesting that the effects of acceleration and deceleration of the train were negligible compared to the resistance offered by the substrate. The only evidence of failure was the appearance of surface cracks induced by torsional and vibrational stresses to which the cars were subjected during transportation.

5.2 Influence of Loading Method

In practice, the operation of a single loading chute always produced a sloped end at each end of the car (Plates 5, 6). On these slopes, the larger the horizontal component of the opposing force the more stable the system became. At the natural angle of repose where all forces were in balance, any minor disturbance due to acceleration or deceleration of the cars was sufficient to cause failure. To increase crust stability the angle of repose would be decreased at least by the expected maximum acceleration or deceleration of the cars. If this cannot be achieved, then, the strength of the chemical bond within the binder must accommodate the impact of these accelerations plus any torsional or vibrational components.

6. CHEMICAL BINDERS EVALUATED IN PHASE I

A chemical spray is more effective if it shows an affinity for the material on which it is sprayed and if the product (eg. coal) does not slump after the application (Plate 10). Coal readily absorbs oils without any prior surface treatment (lipophilic property) but repels water (hydrophobic property). In the case of emulsions, where water is the continuous phase, wetting of the surface can occur only if the surface has been pretreated with a solution containing a surface-active agent, or if there are sufficient quantities of a fast acting surfactant within the formulation.

Papic and McIntyre[4] tested 83 surfactants to evaluate their ability to improve the wetting of coal by water. Their findings showed that nonionic surfactants of the alkyl-phenylpolyethoxy ether type were the best wetting agents.

During the study the following chemical binding products, with or without the addition of specific surfactants, were tested:

(a) Dowel M167, a latex product by Dowell of Canada.

(b) Alchem 63026, a latex product by Alchem Limited.

(c) Dust Suppressant 100, an asphalt emulsion produced and marketed by Pounder Emulsions Limited.

(d) Dust Suppressant 200, an emulsified petroleum residue produced and marketed by Pounder Emulsions Limited.

(e) Acquatain, a product marketed by Whitlock Construction.

(f) Lignin Derivatives, an experimental product by Cominco.

(g) Coal Spray 100, an oil preparation by Imperial Oil Limited.

(h) Reclamation Oil, a product tested by Cominco.

6.1 Oil and Emulsion Test Results and Comments

Oil sprays and emulsions were the most effective binders (Plates 7, 8, 9). The success of the binders was attributed to the production of a flexible crust, high viscosity and an inherent ability to regenerate their surface. In other words, the stability of the product prevented the formation of a rigid crust by reacting neither with the coal particles nor with the atmosphere. The cohesive forces of the oil phase were enhanced by the lipophilic character of the coal which facilitated spreading of the oil on the coal surface. In this case the oil-coated particles adhered to each other forming a porous and oozy top layer. The same mechanism was operative in regenerating the top layer of the crust whenever a surface crack was produced by vibrational and/or torsional movement of the cars or by settling of the coal. The oils and emulsions were the only products to display this regenerative property.

Some of the disadvantages of using oils included the adverse effects on rubber conveyor belts and the possibility of washing residual oil and/or additives into adjacent water bodies.

Tables 3, 4, 5 and 6 present a summary of the detailed analysis and results of oil and emulsion tests obtained by each participant and previously recorded on Visual Observation Forms - Phase I (See Table 2).

Table 3 shows results for Coal Spray 100; Table 4, Reclamation Oil; Table 5, Dust Suppressant 100; and Table 6, Dust Suppressant 200.

Table 11 is an overall summary based on the best tests from the above tables, and includes the rating and the degree of acceptability of all the products.

6.2 Other Binding Products, Test Results and Comments

The main disadvantage of latex is its brittle crust. Vibrational and torsional movements cracked the surface polymer and patches of polymerized latex were easily removed or displaced by wind (Plate 2). Adherence of the crust to the substrate was minimal, and therefore, the best retention occurred on horizontal surfaces (Plates 10, 11, 12). Because the well polymerized and chemically stable crust of latex products is not water soluble, leaching is unlikely to take place, and therefore, pollution of adjacent water bodies will not occur.

Lignin derivatives, which are strong wetting agents, formed a thick crust which will dissolve readily in water. Following excess rainfall, the lignin derivatives were transported into the bulk of the coal in the cars, and the remaining washed unconsolidated coal behaved as untreated coal in that coal dust became airborne.

Tables 7, 8, 9 and 10 present a summary of the detailed analysis and results of latex and Lignin Derivatives products obtained by each participant and previously recorded on Visual Observation Forms - Phase I (see Table 2). Table 7 shows results for Dowell M167; Table 8, Lignin Derivatives; Table 9, Aquatain; and Table 10, Alchem 63026. Table 11 is a summary based on the best tests from the above tables, and includes the rating and the degree of acceptability of all the products.

7 SPRAYING METHODS

The difficulties of retaining a crust on the surface slopes necessitated an investigation of spraying techniques. Two mechanical techniques were tried: (a) preferential spraying, and (b) a combination of flooding and spraying.

Preferential spraying is the uneven application of chemical binders to different parts of the exposed surface (Plates 13, 14, 15). The slopes were sprayed more than the horizontal surfaces. This technique has been used with moderate success and will continue to be applied when fast and complete wetting can be achieved without binder run-off.

To increase binder retention on slopes, Fording Coal Ltd. devised a penetration-spray system designed to achieve not only maximum penetration and thickness but also an adequate surface coverage (Plates 17, 18). The system employs an oscillating spray bar equipped with nozzles capable of open-orifice discharge and fan spraying. The open-orifice discharges are designed to prevent run-off of the emulsion and the formation of a thick crust by increasing binder penetration. The fan sprays are designed to provide a more uniform and adequate coverage of the surface layer. Using this system, Fording Coal Ltd. demonstrated that undesirable slopes could be stabilized almost entirely (Plates 19, 20).

8 SPRAYING REQUIREMENTS

The major coal companies operating in Western Canada, in direct response to public concern about the coal dust pollution problem and their agreement with the findings of this report, volunteered to apply reasonable measures to control the coal dust emanating from moving trains. As of July 1, 1974, all major mining companies sprayed every train leaving their property.

Unfortunately, not all of the chemical binders offered adequate protection. Industrial and Federal representatives agreed that the single parameter that best describes the effectiveness of the various chemical binders is the residual surface coverage measured at the terminals. Assuming that coal dust originates uniformly from every part of the exposed surface, then effective surface coverage is the only parameter that is directly proportional to the coal dust generated in transit.

The mining companies agreed with the standards presented in Phase I of this report that a minimum of 85% of the surface would be covered immediately and furthermore, that a 90% coverage should be achieved by October 1975.

9 PHASE II FIELD MONITORING

Sections 9 and 10 present a synopsis of the B.H. Levelton and Associates' study. The spraying techniques and methods of crust retention observation and recording were founded on the basis of the Phase I work. In the Levelton study, the range of tests were extended to include complete unit train protection and to assess the coverage resulting from mine optimization of chemical binder required to produce an 85% cover. Table 12 shows the number of trains and cars monitored.

9.1 Coal Shipments

All unit trains originating from western mines consist of open-top rail cars, but the size of cars varies not only between the two major railway companies but also within the same company.

The most common car size used by CP Rail is 48-ft long, 12-ft high and 10-ft wide. Cars from CN Railway are 50-ft long, 10-ft high and 10-ft wide.

Unit trains from Alberta to Vancouver cover a distance of approximately 700 miles at a maximum speed of 45 mph. Coal trains from British Columbia cover approximately the same distance but are allowed to travel at 50 mph.

9.2 Loading Profiles

The total surface profile of the coal cars comprized three distinct sections: a front slope, a central flat area and a rear slope. Typical longitudinal profiles showing slope lengths, slope angles, flat lengths and cross-sectional profiles are shown in Figure 4. The total exposed area, therefore, is comprised of the area along the two slopes plus the flat area.

9.3 Measurements of Surface Coverage

Initially, the areas of both front and rear slopes and the levelled area in the centre were measured in several cars from each of four mining companies. Later, a "trained observer" was exposed repeatedly to measured and observed sections of the cars in order to eliminate unnecessary measurements and costly slow-down procedures at the terminals. Measured and estimated percentages of the front slope, middle surface and rear slope were recorded on a pre-printed "Coal Car Coating Inspection" form (See Figure 5). From these individual area measurements, the extent of crustal cover remaining intact at the Vancouver terminal was calculated as a percentage of the total original coal surface. At the same time, a summary sheet was prepared. This summary included data on:

- Terminal
- Coal origin
- Train number
- Times train left origin and arrived at terminal
- Binder used
- Weather during treatment, during transit and during observation
- Number and location (in train) of cars inspected
- Nature of crust cracks, crust loss and crust character
- Abnormalities in profile
- Special observations
- Percent coverage
- Percent coverage on total coal surface.

In addition, colour photographs were taken of about 220 coal cars. See Plates 21 to 24 for typical photographic recordings.

10 PHASE II MONITORING RESULTS

10.1 Crust Retention Calculations

The number of cars and their respective coverage expressed in percent of total surface area have been tabulated for each mine in Tables 13, 14, 15 and 16. These data have been rearranged below to show the frequency distribution for total cover remaining as a percentage of coal cars inspected.

COVER REMAINING (%)	MINE B (%)	MINE C (%)	MINE A (%)	COVER REMAINING (%)	MINE D (%)
0-50	2.6	6.6	0	0-40	5.0
51-55	0.5	0.9	0	41-45	7.5
56-60	1.0	1.0	1.2	46-50	7.5
61-65	2.1	2.4	0	51-55	22.5
66-70	1.0	9.0	2.5	56-60	25.0
71-75	10.0	14.2	9.9	61-65	25.0
76-80	11.6	18.4	14.8	66-71	7.5
81-85	21.6	16.5	30.9		
86-90	26.3	17.0	21.0		
91-95	17.9	10.4	19.8		
95-100	5.3	3.3	0		

The frequency distribution of total cover remaining is shown graphically in Figure 6. The most frequently occurring coverage within a 5% interval is 86-90% for Mine B, 76-80% for Mine C, 81-85% for Mine A and 61-65% for Mine D.

10.2 Crust Retention on Front and Rear Surface Slopes

The percentage of cover remaining on front and rear slopes for coal shipped from Mines A, B, C and D and is tabulated in Table 17. This frequency distribution has been plotted for 10% intervals in Figures 7, 8, and 9. The most effective coverage observed resulted from levelling the front slope of the cars at the loading site of Mine B. Levelling increased surface crust retention by an average of 40% when compared to Mines A and C.

11 NEW LOADING TECHNIQUES AND CHEMICAL PRODUCTS FOR COAL DUST CONTROL

Since September 1976 all coal mines shipping to British Columbia terminals have adopted a modified method of loading and spraying unit trains.

New and more capable loading (eg. Plate 16) chutes have improved the loading profile, increased dust control and have reduced considerably the total loading time for the unit train. In addition, the operator can more effectively control the total tonnage carried by each car thus fewer variations in the total carrying capacity occur when cars are loaded to the allowable limit. The net result is a substantial saving of time and money.

Encouraged by the potential savings in coal losses and by required environmental controls, many companies in the U.S.A. and Canada are developing new chemical products to equal or better the performance of the products tested in this report.

Coverages approaching 100% can be expected by the end of the 1970's.

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TABLE 1

MOVEMENT OF COAL TO BRITISH COLUMBIA TERMINALS DURING 1973

SHIPPER*	FROM	TO	COAL TRANSPORTED (Short Tons)
CPR	Elkview	Delta	4,847,530
CPR	Fording	Delta	2,464,740
CPR	Coleman	Port Moody	867,497
CPR	Canmore	Port Moody	200,249
CNR	Winniandy	Vancouver	1,658,251
CNR	Luscar	Vancouver	1,265,272

* CPR - Canadian Pacific Railway
CNR - Canadian National Railway

TABLE 2

VISUAL OBSERVATION FORM - PHASE I

Participant ____________________ Spraying date ____________________

Product tested ____________________ Spraying location ____________________

Test No. ____________________ Type of coal ____________________

Train No. ____________________ Test rated by ____________________

Car No. \ Parameter		Weather	General Crust Appearance	Crust	Binder Penetration (inches)		Condition of Fines		Remarks
					Top	Sides	Crust	Cracks	
______	origin								
conc. ____	en route								
vol. ____	terminal								
______	origin								
conc. ____	en route								
vol. ____	terminal								
______	origin								
conc. ____	en route								
vol. ____	terminal								
______	origin								
conc. ____	en route								
vol. ____	terminal								
______	origin								
conc. ____	en route								
vol. ____	terminal								

LEGEND:

(H) homogeneous
(C) crushed
(P) patchy
(N) nodulized

(F) friable
(B) brittle
(T) tough

(U) unconsolidated
(C) consolidated

TABLE 3

TEST RESULTS AND SUMMARY: COAL SPRAY 100

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Kaiser	20	100	Good coverage up to 30 gal/car. Excellent coverage above 45 gal/car.
	30	100	
	45	100	
	60	100	
	70	100	
Fording	40	100	Very homogeneous coverage. Some evidence of blowing. Good results.
	50	100	
	60	100	
	70	100	
	80	100	

TABLE 4

TEST RESULTS AND SUMMARY: RECLAMATION OIL

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Fording	25	100	Good coverage on slopes.
Fording	50	100	Very good. Minor exposure of ends.
Fording	30	100	Soft crust. Good ends.
Fording	30	100	Good coverage. Minor exposure of ends.

TABLE 5

Powder Em

TEST RESULTS AND SUMMARY: DUST SUPPRESSANT 100

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Ft. Steele	70	30	Good crust. Fair results.
Ft. Steele	75	15	Tough crust. Poor spraying. Good results.
Ft. Steele	45	25	Good crust. Good results.
Ft. Steele	70	10	Brittle to tough crust. Evidence of blowing.
Kaiser	50	5	Homogeneous, brittle to tough. Good coverage.
Kaiser	120	15	Fair to good. Evidence of blowing.
Kaiser	50	25	Good crust. Excellent results.
Fording	50	15	Homogeneous crust. Ends blown. Poor to fair results.
Fording	50	15	Homogeneous crust. Ends blown. Poor to fair results.
Fording	108	10	Homogeneous, poor slopes.
Fording	62	15	Consolidated crust. Slopes partly exposed.

TABLE 6 Dust Sup. 200

TEST RESULTS AND SUMMARY: DUST SUPPRESSANT 200

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Fording	90	15	Homogeneous crust. Exposed ends.
Fording	60	15	Soft crust. Minor exposure of ends.
Fording	50	15	Good coverage on improved profiles.

TABLE 7

TEST RESULTS AND SUMMARY: DOWELL M167

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Ft. Steele	24	9.0	Friable to brittle crust. Fair.
Ft. Steele	60	10.0	End erosion by wind. Fair.
Ft. Steele	25	5.0	Friable crust. Poor penetration.
Ft. Steele	42	5.0	Thicker crust. Fair to good.
Ft. Steele	43	5.0	Patchy. Wind erosion. Poor.
Kaiser	65	7.5	Good coverage. Fair to good results.
Kaiser	40	7.5	Good appearance. Good results.
Kaiser	40	10.0	Brittle to tough crust. Fair.
Fording	40	7.5	Rain had detrimental effect. Poor.
Fording	55	7.5	Brittle crust. Fair results.
Fording	60	5.0	Friable crust. Wind erosion. Poor.

TABLE 8

Cmin

TEST RESULTS AND SUMMARY: LIGNIN DERIVATIVES

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Fording	50	8	Crust thickness up to 3".
Fording	60	8	Evidence of blowing at both
Fording	70	8	ends. Fair results.
Fording	80	8	
Fording	72	8	Brittle crust. Poor ends.
Fording	80	8	Fair coverage on slopes.
Fording	60	8	Excessive exposure on poor profile.

TABLE 9

TEST RESULTS AND SUMMARY: AQUATAIN

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Ft. Steele	32	12.5	Weak, friable crust. Slopes exposed.
Ft. Steele	45	14.2	Friable crust. Wind erosion. Poor.
Ft. Steele	18	20.0	Patchy, friable crust. Poor.
Ft. Steele	40	14.3	Patchy crust. Ends eroded.
Ft. Steele	40	33.0	Evidence of blowing. Poor.
Kaiser	32	Not reported	Thin, friable. Poor results.
Kaiser	36		Improved crust. Poor to fair.
Kaiser	23		Friable crust. Poor to fair.
Fording	73	6.6	Homogeneous thin crust. Fair.
Fording	60	6.6	Sides blown. Poor results.
Fording	60	6.6	Thin and friable crust. Ends eroded.

TABLE 10

TEST RESULTS AND SUMMARY: ALCHEM 63026

SPRAYING LOCATION (Mine Site)	VOLUME (Gal.)	CONCENTRATION (%)	REMARKS
Ft. Steele	27	7.2	Friable, inadequate coverage. Poor.
Ft. Steele	27	5.4	Thin crust, excessive wind erosion. Poor.
Ft. Steele	26	3.8	Extremely poor. Little or no crust.
Ft. Steele	27	3.0	Much evidence of blowing. Poor.
Ft. Steele	30	1.6	Poor results on poor profiles.
Kaiser	27	3.8	Thin, friable crust. Much blowing.
Kaiser	27	11.0	Improved crust. Still unacceptable.
Fording	30	4.0	Patchy, friable crust. Poor.
Fording	40	10.0	Slight improvement. Still very patchy.
Fording	26	6.2	Thin and friable. Poor.

TABLE 11

RATING AND ACCEPTABILITY OF CHEMICAL BINDERS
BASED ON COMPARISON TESTS OF BEST PERFORMANCES

(Derived from Tables 3 to 10)

BINDER	VOLUME (Gal.)	CONCENTRATION (%)	GALS/CAR	RATING	ACCEPTABILITY
Coal Spray 100	45	100.0	45.0	1	Best performance on all profiles.
Reclamation Oil	50	100.0	50.0	2	
DS 100	50	25.0	12.5	3	Effective on flat profiles and slopes.
DS 200	50	15.0	7.5	4	
Dowell M167	65	7.5	4.9	5	Effective on flat profiles.
Lignin Derivative	60	8.0	4.8	6	
Acquatain	73	6.6	4.8	7	Unacceptable.
Alchem 63026	40	10.0	4.0	8	

TABLE 12

NUMBER OF TRAINS AND CARS MONITORED DURING PHASE II FIELD WORK

SOURCE	NO. OF TRAINS	TOTAL CARS	CARS/TRAIN (Average)	LOCATION IN TRAIN
Kaiser	12	211	17.6	Front 3 trains Centre 4 Rear 4 All cars 1
Fording	10	215	21.5	Front 6 trains Centre 1 Rear 2 All cars 1
Luscar	4	79	19.7	Front 1 train Centre 1 Rear 2
McIntyre	4	42	20.0 (2 trains) 1.0 (2 trains)	

TABLE 13

MINE B

COVER REMAINING ON COAL ON ARRIVAL AT TERMINAL (PERCENT OF TOTAL SURFACE)

TRAIN	432	434	436	444**	446**	448**	450	457	460	463	468	TOTAL
DATE	Aug 31	SEP 3	4	7	9	10	11	15	17	18	19	
NO CARS	10	18	20	20	13	28	20	20	20	20	2	211
LOCATION	R	C	C	C	R	All	F	C	F	F	R	
WEATHER	El	OW	SW	SW	SW	SW	SW	R	SW	SW	SW	
COAL							WET	WET	WET			
PERCENT												
98		5[a]										5
97												
96		5										5
95		5							4			9
94										2		2
93								2	3	1		6
92		1						1		4		6
91		1		1					1	8		11
90			1	3		3	2		5	1		15
89			1	2				1	1			5
88			5	1	1		1	1	1	2		12
87						2		4				6
86			3	2	1		2	2	1	1		12
85			2	4		1	2	3	1		2	15
84			3	1	1		1					6
83					1	2		1				4
82			1		1	3	2	1				8
81			1		2	1	2	2				8
80				1		2			2	1		7
79					2							2
78					1	1	1					3
77						1	2					3
76	1			1	2		3					7
75				1		4	1		1			7
74	1					4	1					
73												
72			2			2						4
71	1					1						2
70					1							1
69												
68				1								1
	(63) 1	(50) 1	(65) 1	(65) 1		(63) 1	(63) 1					
	(59) 1						(60) 1					
	(54) 1											
	(39) 1											
	(38) 1											
	(36) 1											
	(23) 1											

**Binder is "modified" latex.

Footnote: a. The number of cars with percentage cover as shown.

TABLE 14

MINE C

COVER REMAINING ON COAL ON ARRIVAL AT TERMINAL (PERCENT OF TOTAL SURFACE)

TRAIN	821249	821254	821257	821261	821262	821263	821269	821270	821271	821273	Total
DATE	Aug 29	Sept 1	Sept 5	Sept 8	Sept 9	Sept 9	Sep 16	Sep 16	Sep 17	Sep 19	
NO. CARS	44	24	22	20		22	22	24	25	12	
LOCATION	All	F	F	F*	F	F*	F*	R	R	C	
WEATHER	SW	OW	SW	SW	SW	SW	OW	OW	SW	SW	
COAL PERCENT											
97	1				PART INSPECTED WAS NOT COATED						1
96	1		2						2		5
95									1		1
94	6								1		7
93	4								2		6
92	1								2		3
91	3							1	1		5
90	1		1					1	1		4
89	3		1	1					1		6
88	3						1	1	4		9
87	2					2		2	3		9
86	1			1		1		2	2	1	8
85	1		1	1		3	1	1		1	9
84	2						1	2			5
83	1	1	2				1	2	1	1	9
82			1			2		1			4
81			1	2		2	1	1	1		8
80				2		3		1			6
79	2	1	2	1				2		1	9
78	3	2	1	1		2	1			1	11
77	1		1	2			1				5
76	2	1				2				3	8
75						1	2		1	2	6
74	2			1			1	1		1	6
73	2		2	2		1	1				8
72		1		1		1	1	1			5
71			1			1	1	1		1	5
70			1			1	1				3
69		1	1	1			1				4
68		2	1				4				7
67		3					1				4

*Night train

SW = Sunny and warm; OW = Overcast and warm; Cl = Cloudy
R = Rain. F = Front; R = Rear; C = Centre.

TABLE 14 (CONTINUED)

MINE C

COVER REMAINING ON COAL ON ARRIVAL AT TERMINAL (PERCENT OF TOTAL SURFACE)

TRAIN	821249	821254	821257	821261	821262	821263	821269	821270	821271	821273	Total
DATE	Aug 29	Sept 1	Sept 5	Sept 8	Sept 9	Sept 9	Sep 16	Sep 16	Sep 17	Sep 19	
NO. CARS	44	24	22	20		22	22	24	25	12	
LOCATION	All	F	F	F*	F	F*	F*	R	R	C	
WEATHER	SW	OW	SW	SW	SW	SW	OW	OW	SW	SW	
COAL											
				(66) 1			(65) 1	(65) 1			
							(64) 1				
								(63) 1			
				(62) 1							
		(60) 1	(60) 1								
	(59) 1										
		(57) 1									
		(55) 1									
		(53) 1									
								(48) 1			
		(43) 1									
		(39) 1									
									(38) 1		
			(36) 1	(36) 1							
				(35) 1							
		(29) 1									
		(23) 1									
								(21) 1			
		(20) 1	(20) 1								
		(0) 2									

*Night Train.

TABLE 15

MINE A

COVER REMAINING ON COAL ON ARRIVAL AT TERMINAL (PERCENT OF TOTAL SURFACE)

TRAIN	L151*	L154	L158	L160	TOTAL
DATE	Aug 28	Sept 3	Sep 14	Sep 16	
NO. CARS	19	20	20	20	
LOCATION		C	R	R	
WEATHER	R	SW	SW	SW	
COAL					
PERCENT					
94				1	1
93	1	1	1	3	6
92				4	4
91			1	3	4
90		1		3	4
89	1			4	5
88					
87	1	1			2
86	2	1	3		6
85	2			1	3
84		4	3	1	8
83		3			3
82	3	1	5		9
81	1	1			2
80			1		1
79	1				1
78	1	2	2		5
77	1		1		2
76		1	2		3
75	1	2			3
74					
73		1			1
72	3	1			4
71					
70					
69					
			1		1

*Night train.

TABLE 16

MINE D

COVER REMAINING ON COAL ON ARRIVAL AT TERMINAL (PERCENT OF TOTAL SURFACE)

TRAIN	M380	M381*	M388	M389	TOTAL
DATE	Sep 9	Sep 10	Sep 22	Sep 23	
NO. CARS	18	22	1	1	
LOCATION	F	F-W			
WEATHER	SW	SW			
COAL					
PERCENT					
71	1				1
70		1			1
69		1			1
68					
67					
66					
65					
64	1	1			2
63	3	1			4
62	1				1
61	1	1			2
60				1	1
59	1	2			3
58		2			2
57	2	1			3
56	2				2
55		1			1
54	1				1
53	2	1			3
52	1	1			2
51		2			2
50		1			1
49	1		1		2
48					
47	1				1
46					
45		1			1
44					
43		1			1
42		1			1
30		1			1
0					1

*Night train

TABLE 17

FREQUENCY OF COVERAGE ON FRONT AND REAR SLOPES

Percent Cover	Kaiser		Luscar		Fording	
	Front	Rear	Front	Rear	Front	Rear
0	1	16	1	13	9	10
5	-	2	-	-	1	-
10	2	14	1	4	19	3
15	-	-	-	1	1	-
20	2	10	1	5	13	6
25	-	5	3	-	3	-
30	-	9	10	4	15	14
35	1	6	1	1	2	-
40	-	18	6	10	23	23
45	-	1	1	1	-	1
50	8	14	16	21	20	32
55	-	1	2	-	-	2
60	5	14	14	14	34	31
65	-	1	2	3	-	3
70	4	11	12	1	27	11
75	1	7	3	2	5	10
80	13	18	4	2	16	18
85	9	9	-	-	2	10
90	42	15	1	1	10	13
95	14	9	-	-	6	15
95+	6	3	-	-	-	9
100	22	8	-	-	-	2

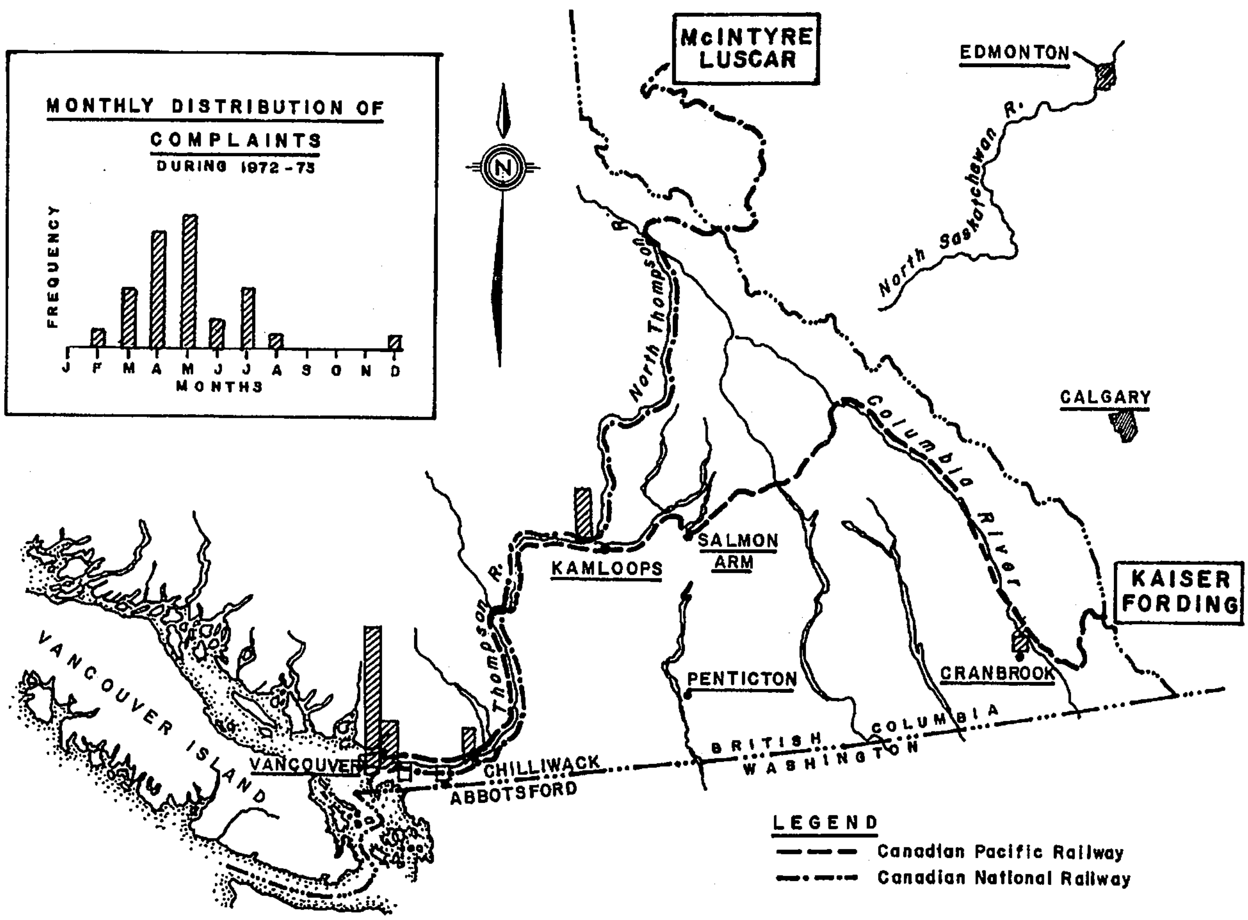


FIGURE I REGIONAL DISTRIBUTION OF COMPLAINTS DURING 1972 - 1973

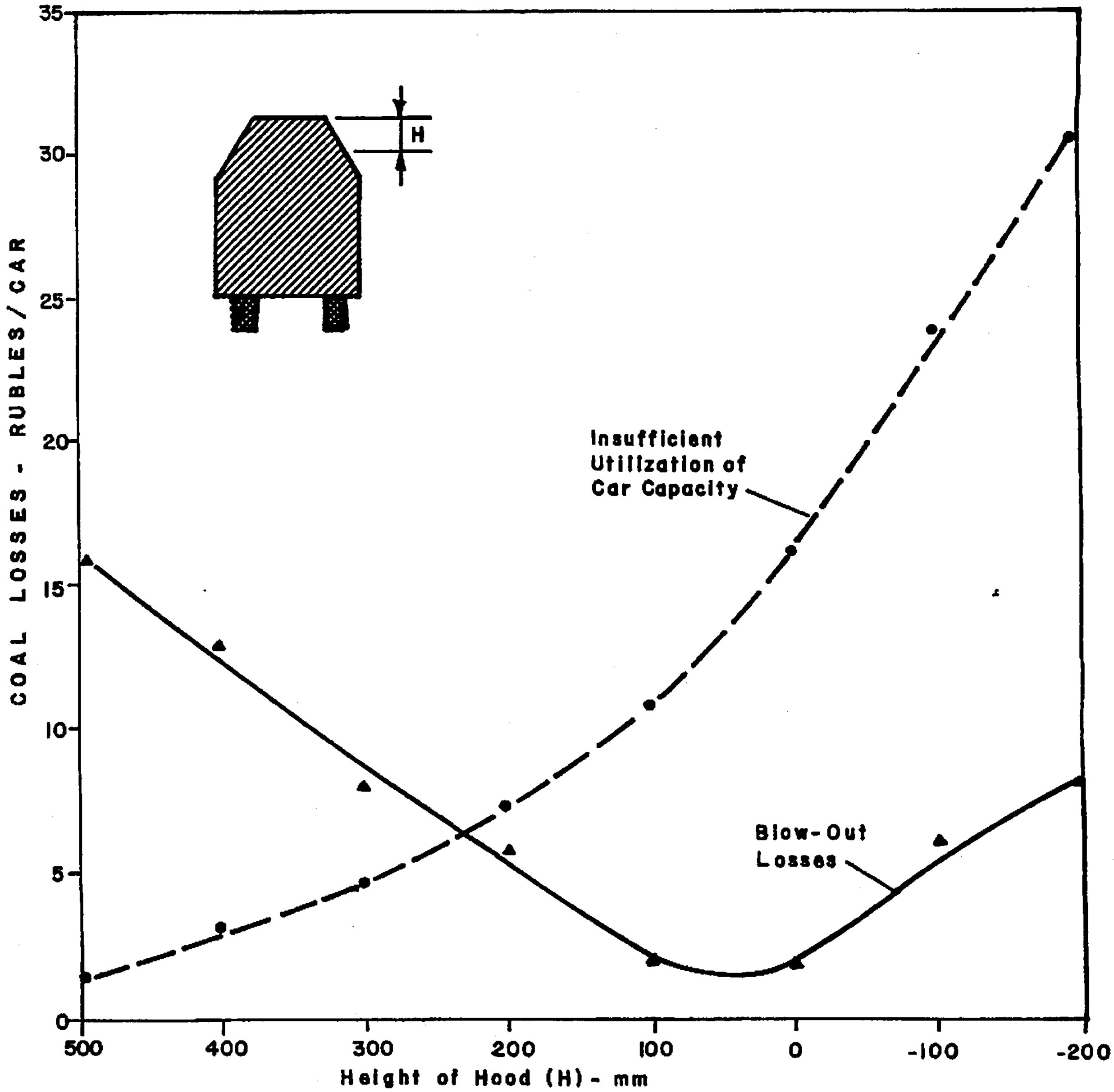


FIGURE 2 COAL LOSSES OF HIGH SPEEDS
(After V.K. Beshketo)

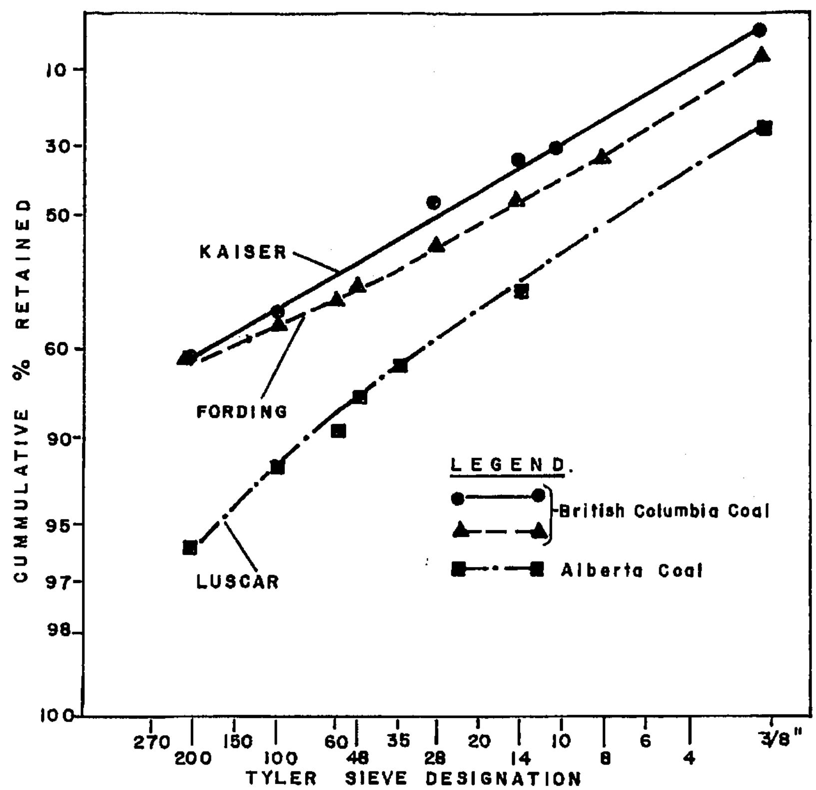


FIGURE 3 COMPARATIVE SCREEN ANALYSIS OF BRITISH COLUMBIA AND ALBERTA COALS

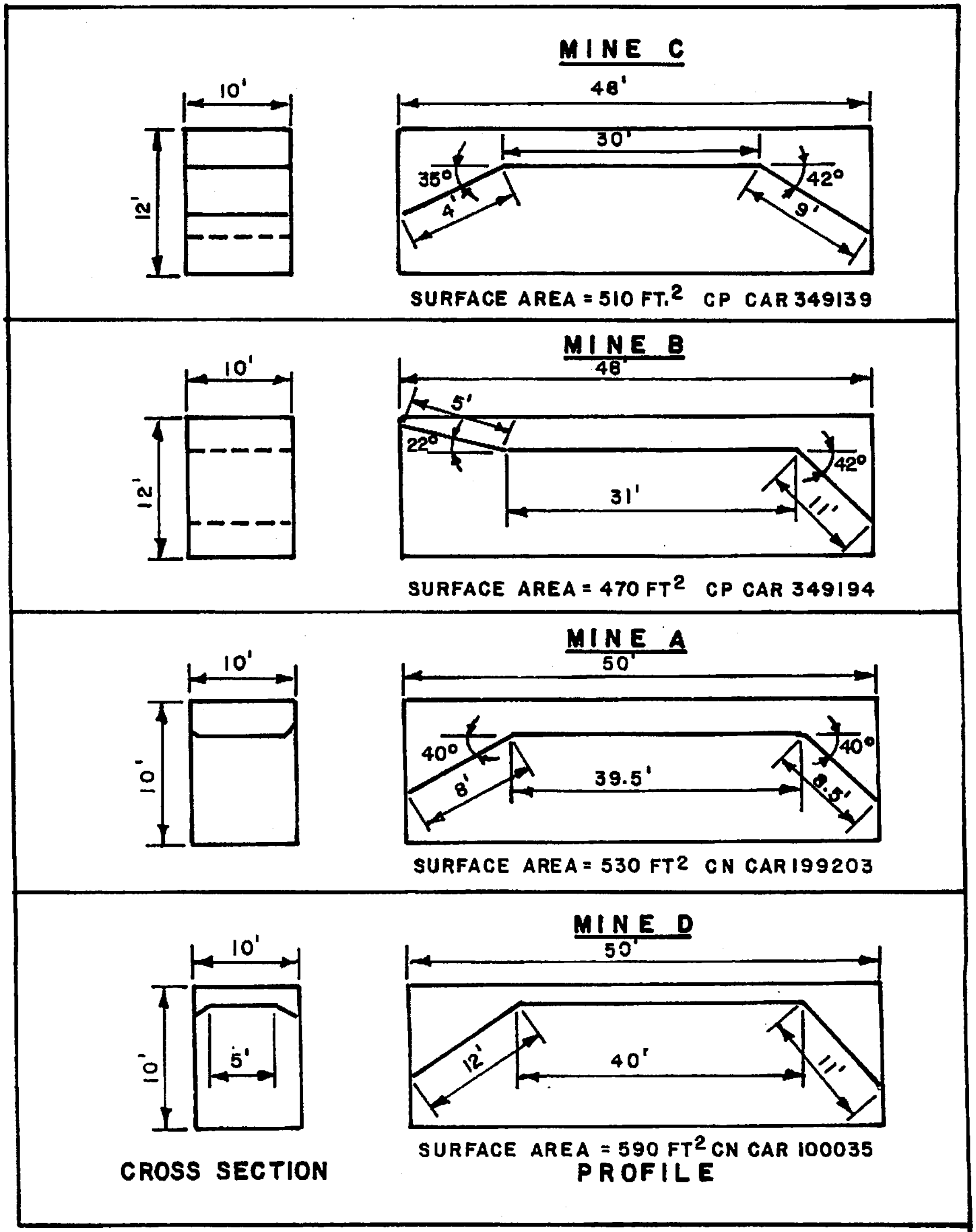


FIGURE 4 TYPICAL COAL CAR SURFACE DIMENSIONS
(From Levelton & Associates Ltd.)

B. H. LEVELTON & ASSOCIATES LTD. 1755 WEST 4TH., VANCOUVER, B.C. V6J 1M2 PHONE 736-6516

COAL CAR COATING INSPECTION

Terminal ________ Date Treated ________ Origin ________

Photo No. ________ CP/CN Train No. ________

Inspector ________ Date Examined ________ Car No. ________

Time ________ Binder ________

Weather - During Treatment ________ During Trip ________ On Arrival ________

	FRONT	FLAT	REAR	TOTAL
% Coverage				
Condition				
Du-t Escapement Evidence				
Crust Flexibility				
Crust Thickness				
Crust Failure Nature and Prevalence				
Incomplete Coverage				

Terminal ________ Date Treated ________ Origin ________

Photo No. ________ CP/CN Train No. ________

Inspector ________ Date Examined ________ Car No. ________

Time ________ Binder ________

Weather - During Treatment ________ During Trip ________ On Arrival ________

	FRONT	FLAT	REAR	TOTAL
% Coverage				
Condition				
Dust Escapement Evidence				
Crust Flexibility				
Crust Thickness				
Crust Failure Nature and Prevalence				
Incomplete Coverage				

FIGURE 5

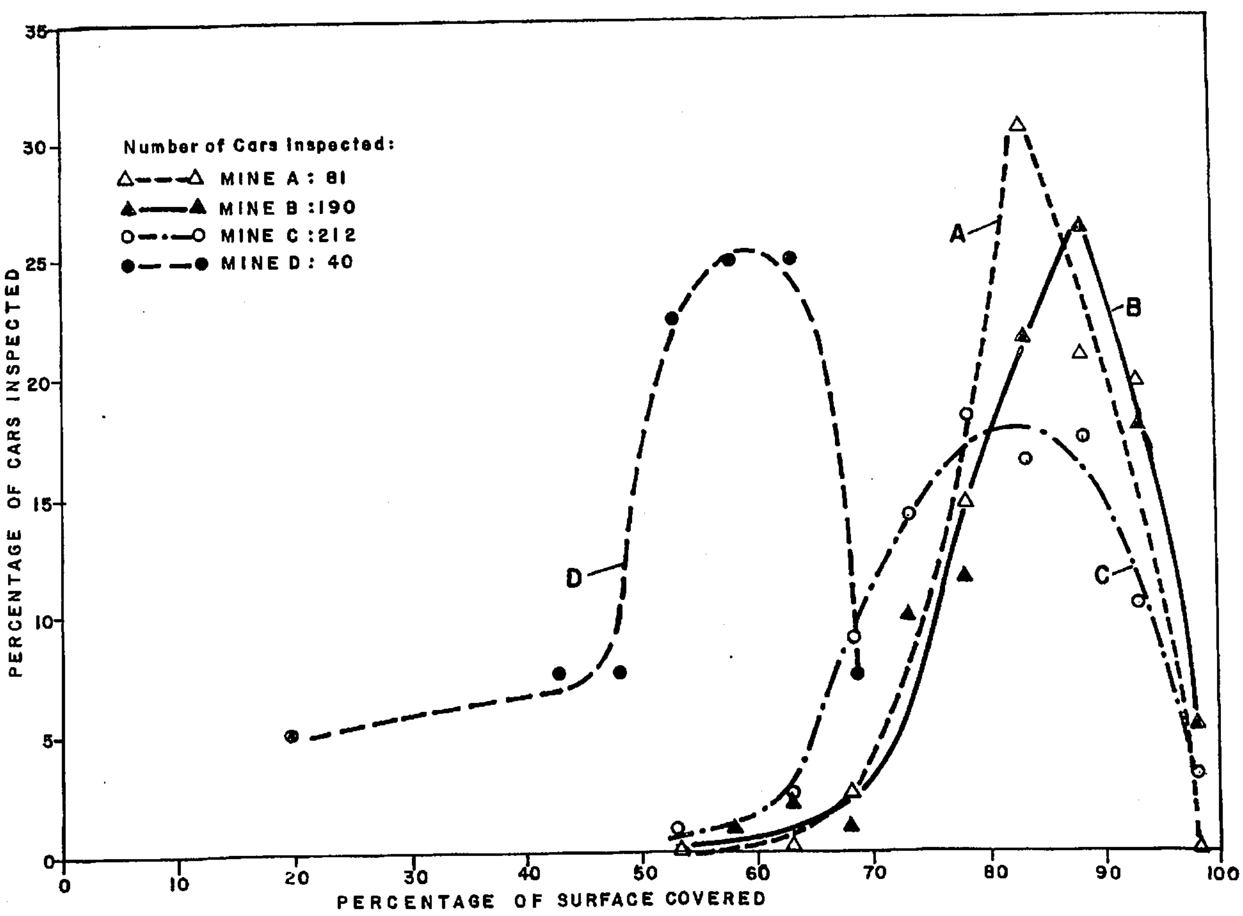


FIGURE 6 DISTRIBUTION OF COVER REMAINING ON TOTAL SURFACE OF COAL CARS

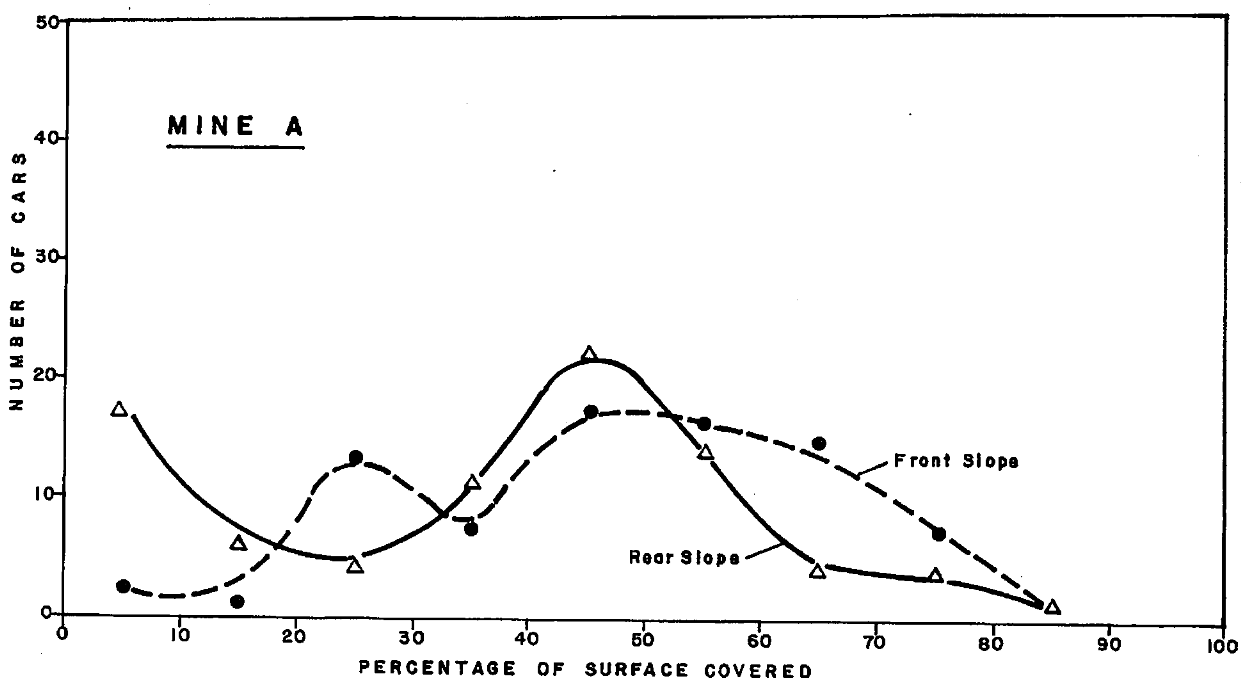


FIGURE 7 DISTRIBUTION OF COVER REMAINING ON FRONT AND REAR SLOPES

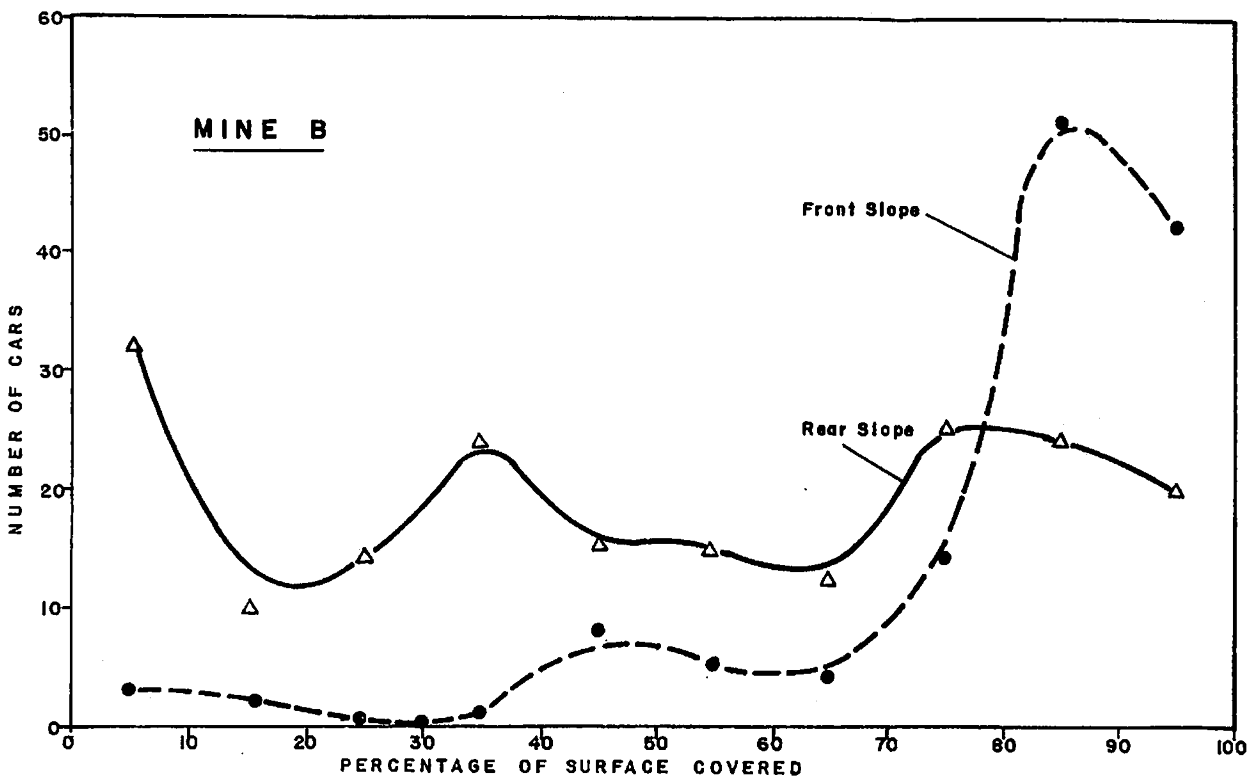


FIGURE 8 DISTRIBUTION OF COVER REMAINING ON FRONT AND REAR SLOPES

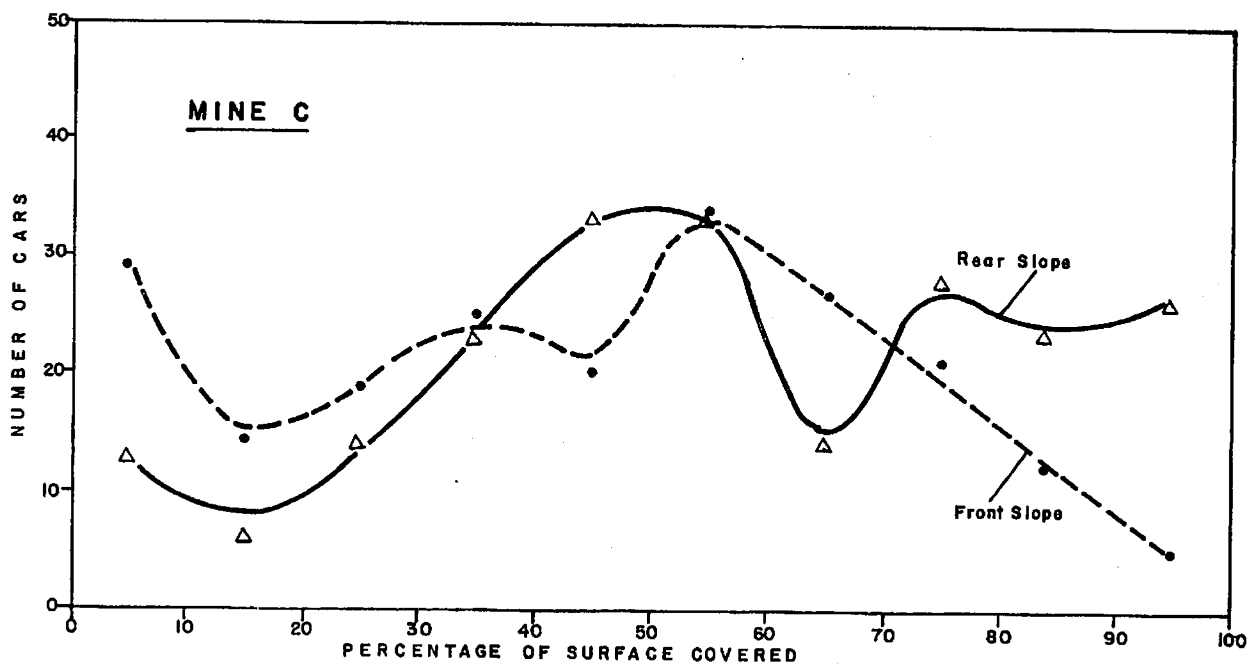


FIGURE 9 DISTRIBUTION OF COVER REMAINING ON FRONT AND REAR SLOPES

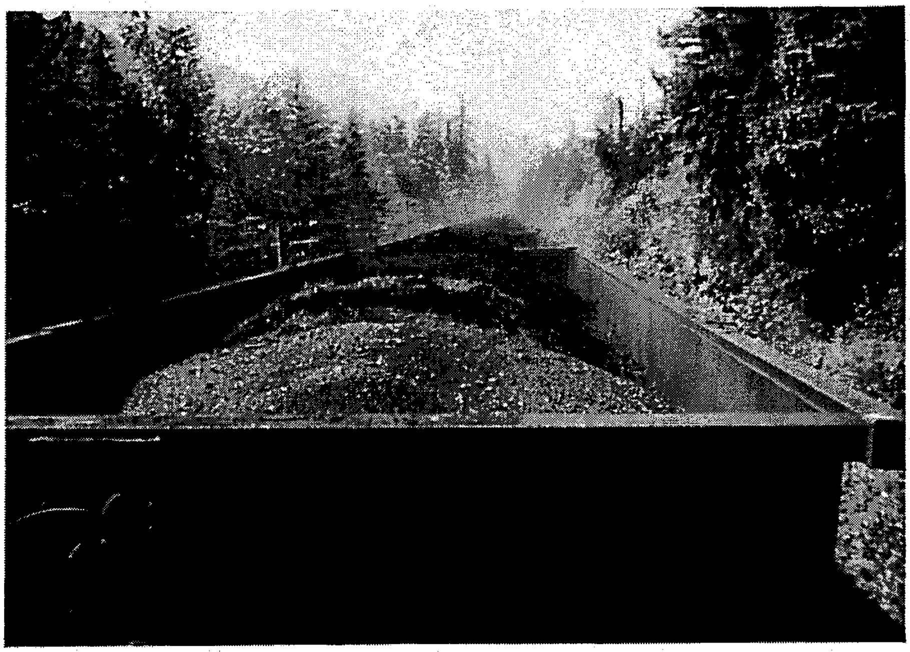


PLATE NO. 1: COAL LOSSES IN TRANSIT

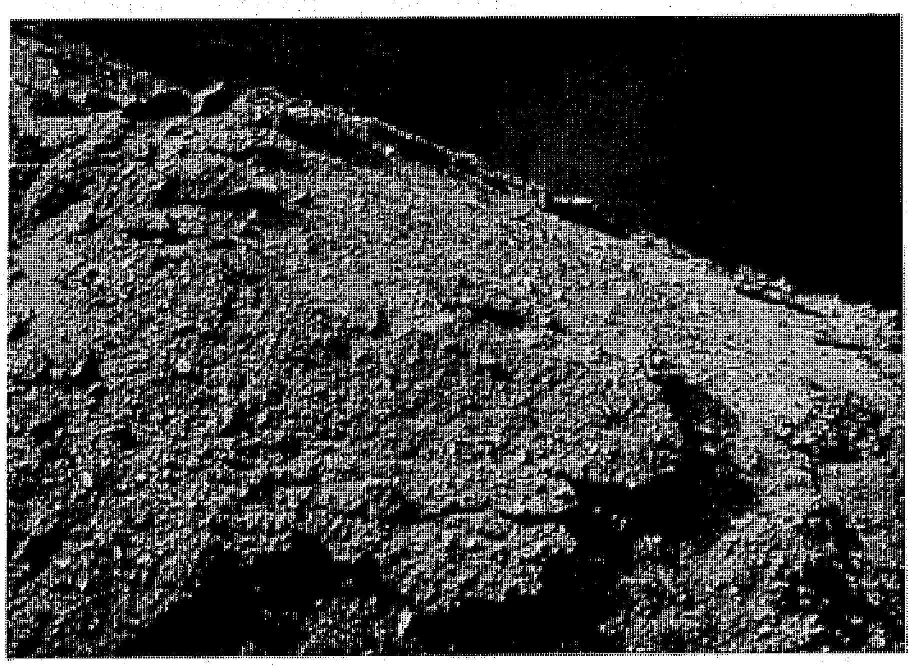
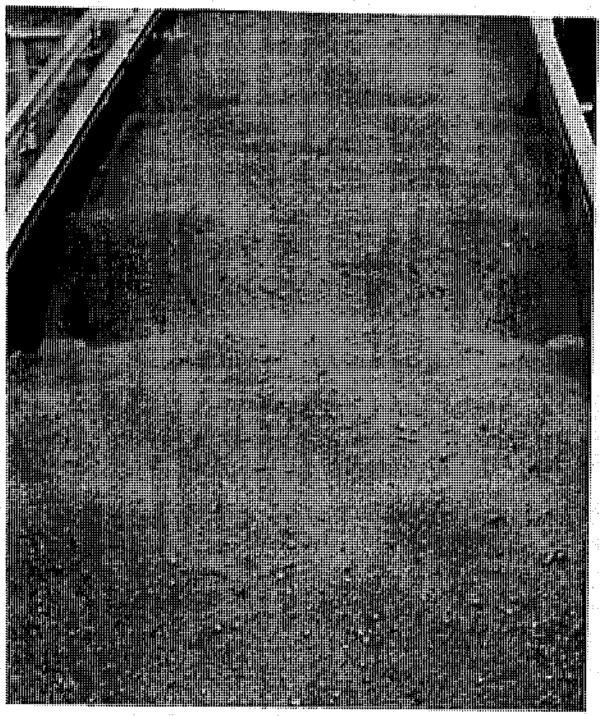


PLATE NO. 2: INCOMPLETE COVERAGE OF SLOPES



❮ PLATE NO.3: UNTREATED CAR SHOWING POOLS OF WATER AND COARSE COAL

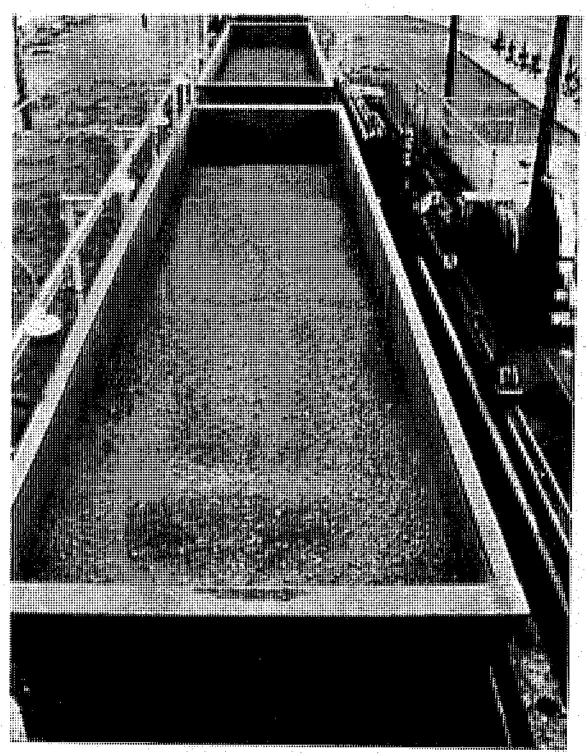


PLATE NO.4: PREFERENTIAL WIND EROSION OF UNTREATED CAR ❯

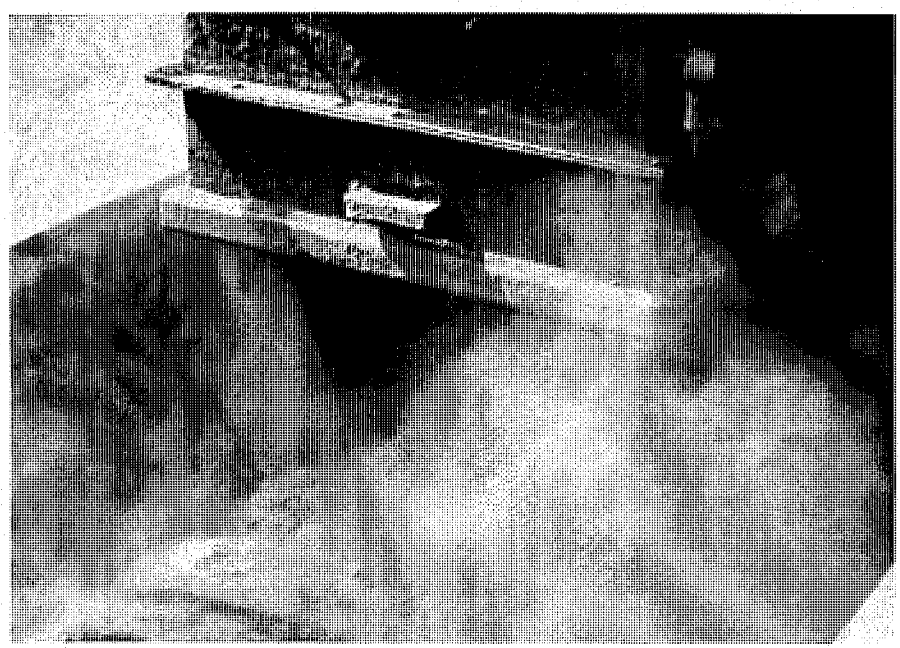


PLATE NO.5: ORIGINAL LOADING METHOD

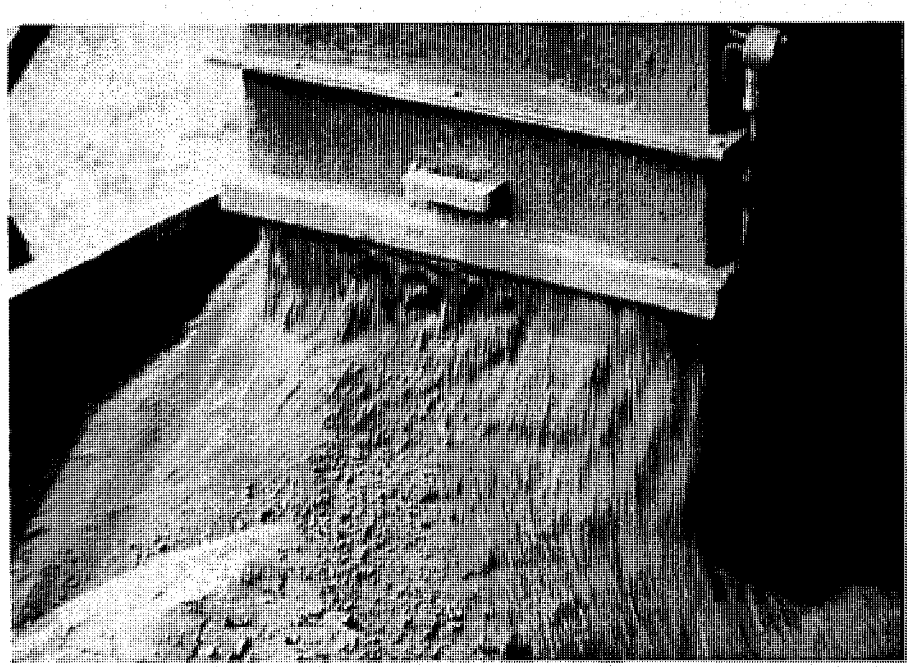


PLATE NO.6: FORMATION OF UNDESIRABLE SLOPES

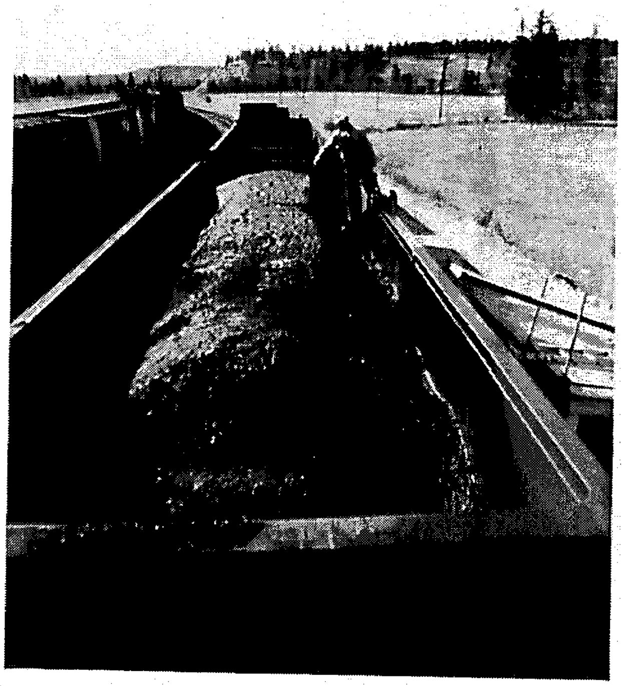
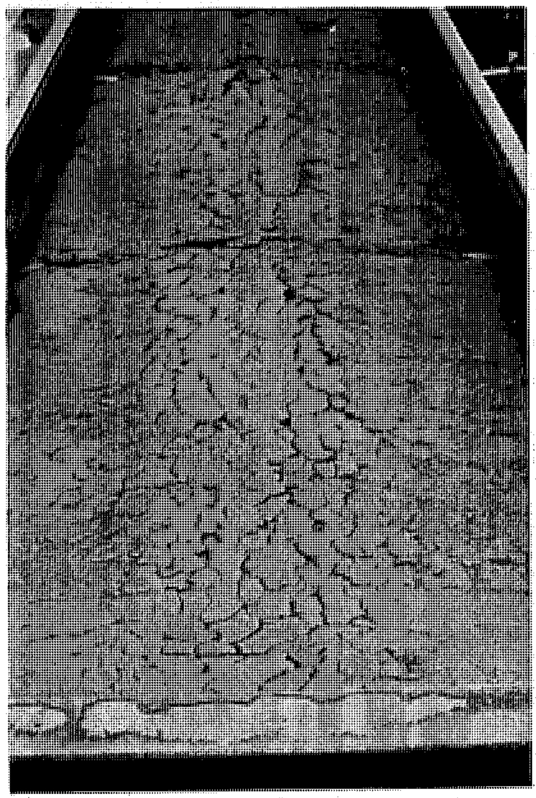


PLATE NO.7: HAND APPLICATION OF ASPHALT EMULSION

PLATE NO.8: CAR IN PLATE 7 AT KAMLOOPS

PLATE NO.9: CAR IN PLATE 7 AT WESTSHORE TERMINALS



❬ PLATE NO.10: UNIFORM SURFACE COVER

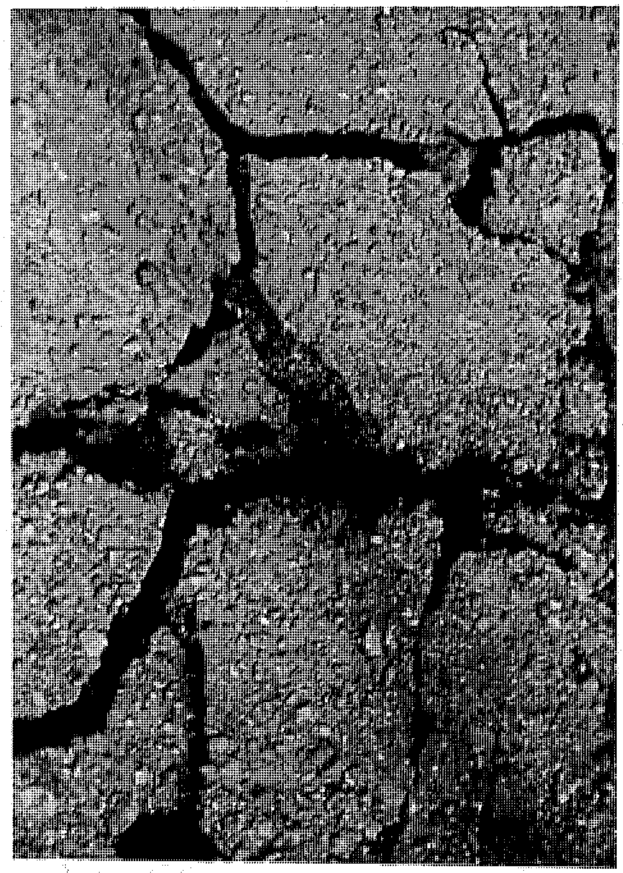
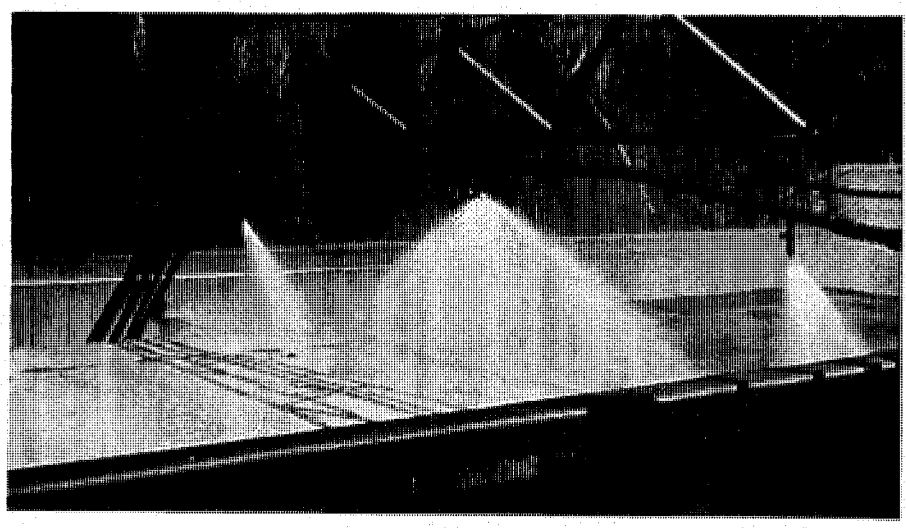


PLATE NO.11: CLOSE-UP SHOWING PENETRATION OF BINDER ❭

❬ PLATE NO.12: WELL PROTECTED FRONT-END SURFACE



❮ PLATE NO.13: PREFERENTIAL SPRAYING PATTERN OF A WELL PREPARED SURFACE

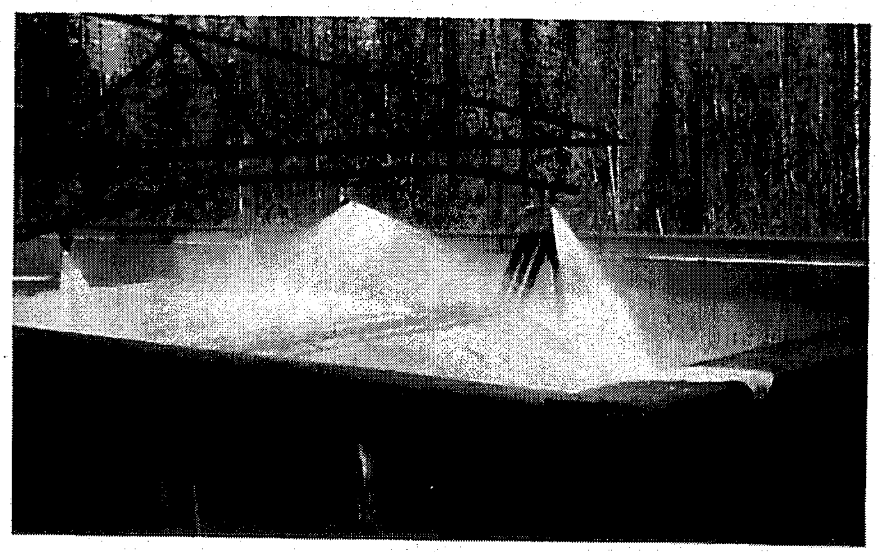
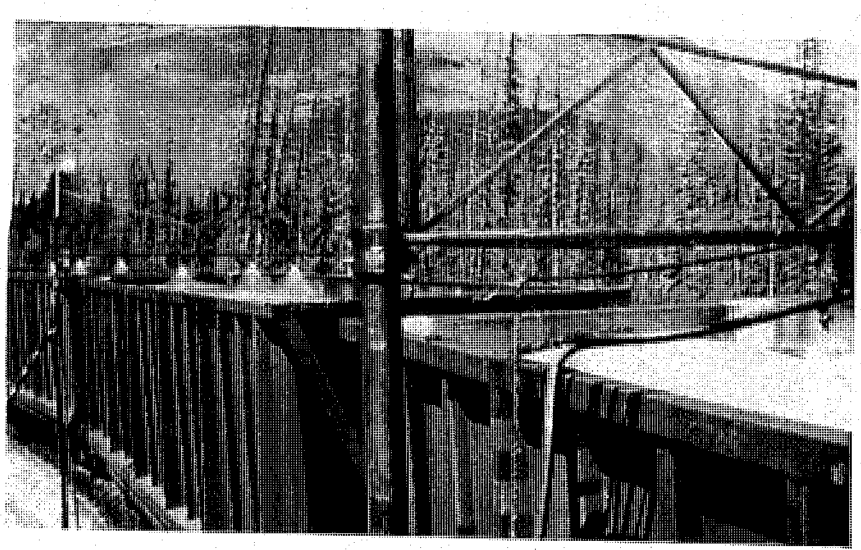
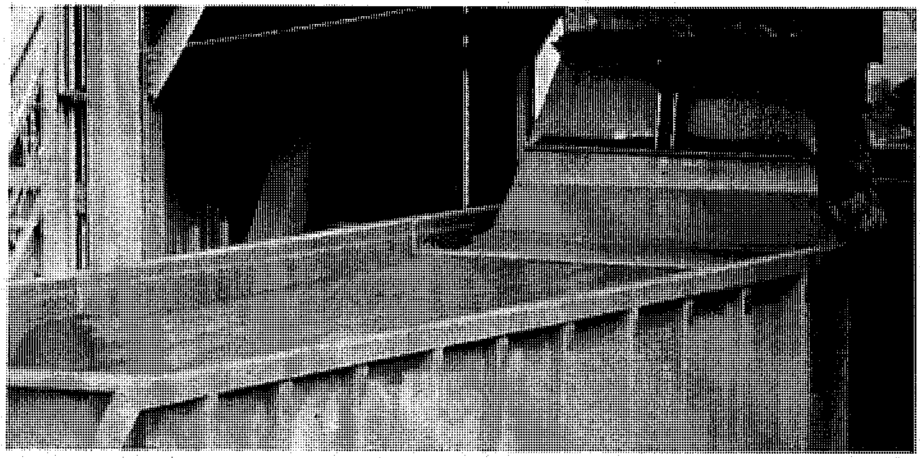


PLATE NO.14:
END SPRAYING ❯

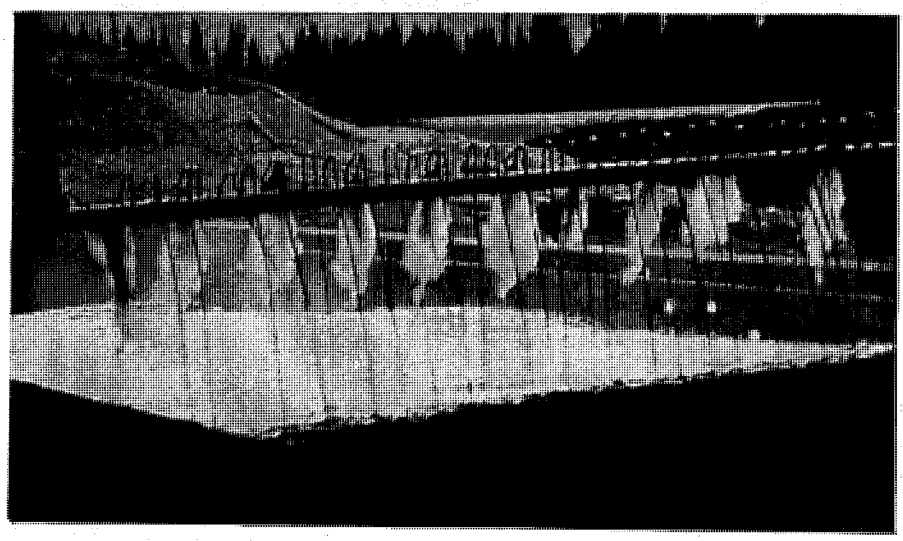


❮ PLATE NO.15: ADDITIONAL WATER SPRAYS TO INCREASE PENETRATION OF BINDER

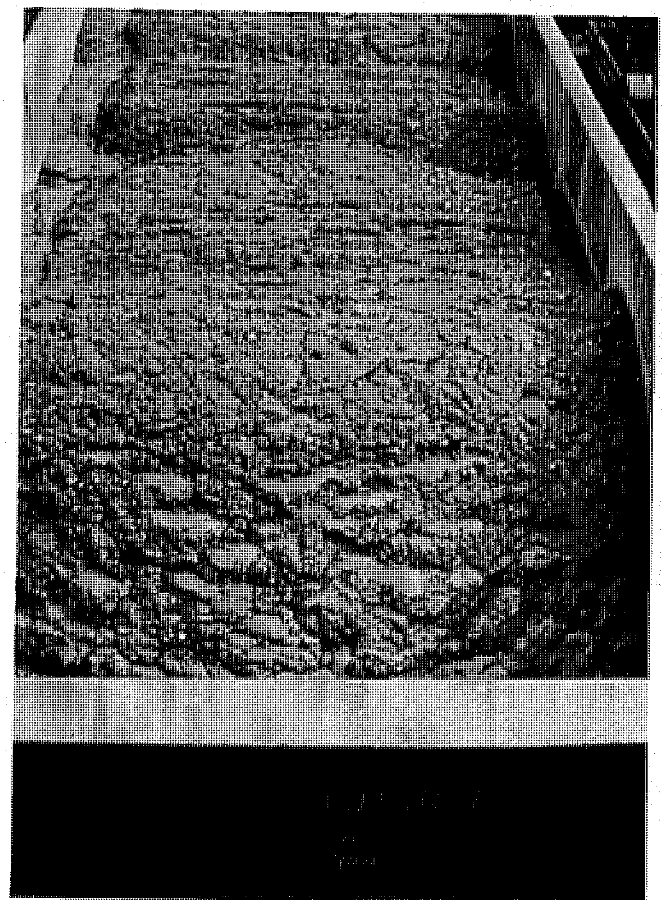


❮ PLATE NO. 16:
MODIFIED LOADING
METHOD

PLATE NO. 17:
COMBINATION OF
FLOODING AND
SPRAYING ❯



❮ PLATE NO. 18:
PROPERLY LOADED AND
SPRAYED SURFACE



❮ PLATE NO. 19: EFFECTIVE SPRAYING ON AN UNEVEN PROFILE

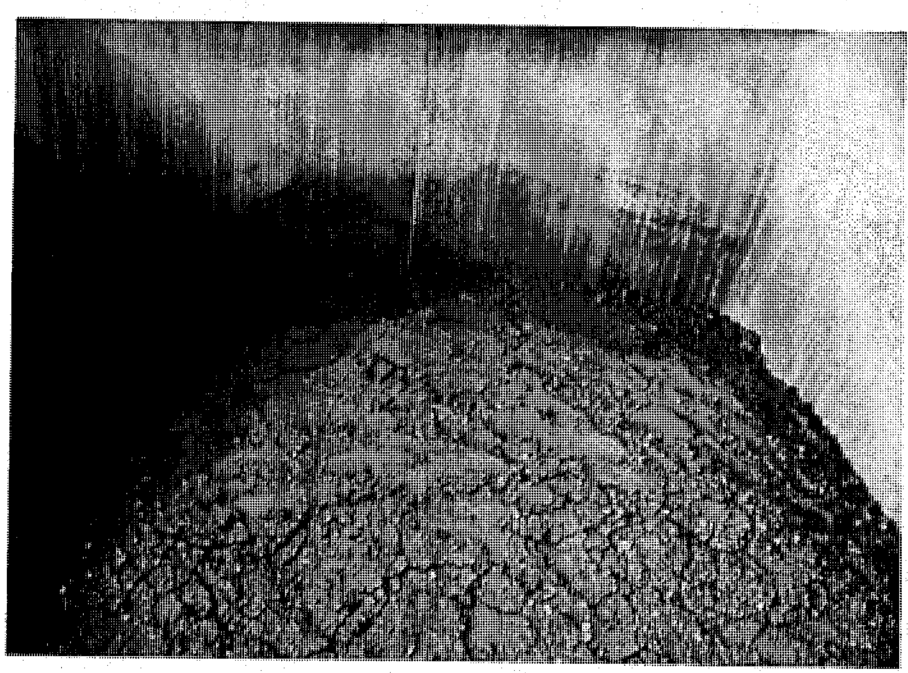


PLATE NO. 20: LIMITED CRUST FAILURE OF SLOPED AREA IN CAR IN PLATE 19

PLATE 21: SLIDE 434-2
MINE B
CAR 349498
DATE SEPT. 3, 1975
COVERAGE 95%

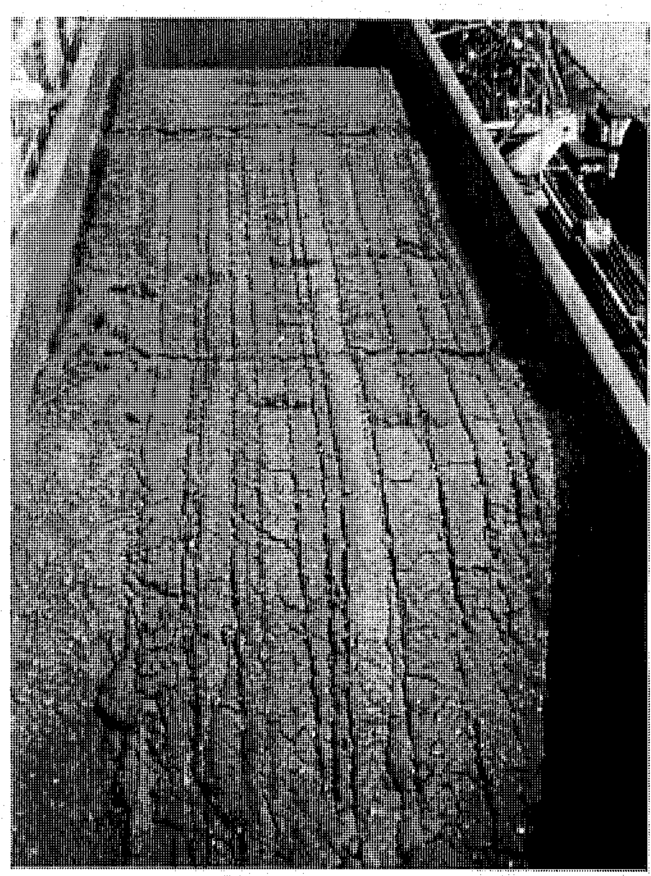
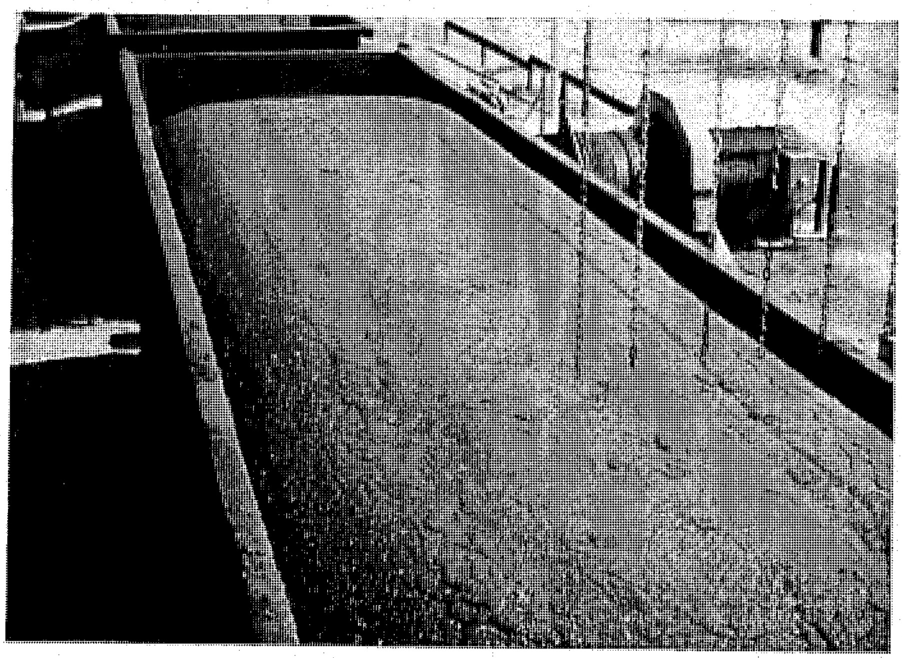


PLATE 22: SLIDE 254-1
MINE C
CAR 351620
DATE Sept. 2, 1975
COVERAGE 70%



❮ PLATE 23:
SLIDE L154-1
MINE A
CAR 199013
DATE SEPT. 3, 1975
COVERAGE 95%

PLATE 24:
SLIDE M280-10
MINE D
CAR 100945
DATE SEPT. 9,1975
COVEERAGE 80% ❯

CERTIFICATE OF SERVICE

I hereby certify that on this 5th day of August, 2010, I caused a copy of the foregoing to be served on the following Parties of Record by first class mail, postage prepaid:

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