HAT CREEK PROJECT

MINING FEASIBILITY REPORT

APPENDIX C

FUGITIVE MINE-DUST STUDY

Prepared for

British Columbia Hydro and Power Authority

by

Cominco-Monenco Joint Project

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APPENDIX C

FUGITIVE MINE-DUST STUDY

TABLE OF CONTENTS

PREFACE

In October of 1978 the Cominco-Monenco Joint Venture was commissioned to conduct an evaluation of potential fugitive dust levels in the region of the proposed Hat Creek open pit coal mining operation. The study, as outlined in a letter from Mr. D.P. Mahoney to Mr. J.J. Fitzpatrick of B.C. Hydro dated 12 October 1978, was to be based on an assessment of dust levels near existing coal mining operations in the Northwestern United States and Western Canada. In conjunction with this survey, visits were made to regulatory officials in Wyoming, Montana and British Columbia, and to mining operations in British Columbia and Montana. Time did not allow site inspection of coal mines in Wyoming.

Because the survey identified coal stockpile areas as one of the largest potential sources of dust generation and because of the large stockpile/blending area proposed for Hat Creek, a separate survey was made of large coal stockpile areas to identify specific dust control measures. Approval to proceed with the study was given by Mr. J.J. Fitzpatrick in a letter to Mr. K.F. Randall dated 3 November, 1978.

The study formed an extension to the previous work done by Environmental Research and Technology, Inc., (ERT) in estimating potential fugitive dust levels resulting from the operation of the Hat Creek facilities using theoretical emission factors and computer modelling techniques. These theoretical evaluations predicted significant violations of the B.C. Pollution Control Branch's (PCB) total suspended particulate (TSP) objectives and presented B.C. Hydro with some cause for concern.

It should be recognized that this report was completed after submission of the "Hat Creek Mine Feasibility Study" and as such was intended to investigate only the technical and logistic problems associated with fugitive dust.

Part One of this report is an introduction to the study and to the Pollution Control Branch's present and proposed TSP objectives. Part Two presents a state-of-the-art summary of emission factors and fugitive dust modelling as well as a summary of the ERT study and TSP predictions. The results of the study surveys are presented in Part Three of the report. Part Four presents a summary of the Hat Creek mining plan, of the results of the background studies conducted in conjunction with the bulk sample program, and recommendations made to control dust resulting from the Hat Creek development to meet the objectives within the mine boundaries.

SUMMARY OF CONCLUSIONS

1. From the results obtained from the survey of operating mines conducted it was determined that:

   - coal load-out and storage areas were greater contributors to fugitive dust levels than the mining operations;

   - measured particulate levels do not appear to be a function of mine size;

   - TSP levels decreased with distance from the operations and were less than B.C. PCB objectives within a few kilometers from the development in most cases and within about 1 km in a few cases.

2. From the results of the survey of selected stockpile areas, it was determined that:

   - the stockpile operations with the greatest potential for dust generation are coal load-out and vehicle movement on the pile;

   - a number of large stockpile sites did not require dust control measures because of the high moisture content in the coal (between 25-35%);

   - fugitive dust episodes can be eliminated through specific control measures and design features;

   - dust at certain stockpile sites has been controlled to prevent fugitive dust complaints within less than 1 km from the site.

3. During the pre-production period, the major source of fugitive dust will be the topsoil stripping operation. Year -3 is of particular concern in this regard because over 75% of the topsoil removed during the pre-production is stripped during Year -3.

4. The most significant source of fugitive dust during the production period is determined to be the blending area coal piles.

5. Dust control measures recommended during the pre-production period include:

   - leaving the trees as much as possible to act as wind breaks;

   - the use of minimum advance clearing and minimum advance stripping operations to reduce the area exposed to wind erosion in advance of these operations;

- the use of water spraying during the frost free period in conjunction with stripping as required as well as on haul and service roads;

- spraying of surface binding agents on surfaces that will remain exposed for long periods of time such as the edges of areas stripped, or temporary vegetation.

6. Dust control measures recommended for the production period include:

   - developing the blending area into the face of the hill and protecting it from winds from the critical direction (see Section Four) by means of a dike;

   - spraying surfaces exposed to the wind with surface binding agents;

   - orientating the coal piles in a NW-SE direction to help prevent high dust levels in the maintenance area;

   - spraying haul roads with water or waste oil as required depending on the time of year;

   - using a telescopic chute and water spray on the boom of the stacker;

   - spraying water on the coal piles during the frost free period by means of automatically controlled, stand-mounted spray system;

   - contouring the high grade coal piles in the blending area since these will have a longer turnover time than the regular piles;

   - leaving as many trees as possible around the region of the blending area and pit and plant vegetation to aid in wind protection in places such as on the blending area protection dike.

7. The critical wind direction is sector SE to W.

8. The critical wind speed is determined to be 11 km/hr. The percentage of time winds greater than this speed blow from the critical wind direction is 2.6 percent of the time (5 days per year) during the frost period and 4.1 percent of the time (about 8 days per year) during the frost free period.

9. During the pre-production period, B.C. TSP objectives are expected to be met within about 0.25 km of the stripping operation except perhaps for high wind velocity episodes which are estimated to occur for less than 1% of the time.

10. For the production period, B.C. TSP objectives are expected to be met at a distance of 0.5 km from the blending area and at a distance somewhat less than this for the open-pit mine except for low probability, high wind conditions.

SECTION ONE

INTRODUCTION

SECTION ONE

INTRODUCTION

CONTENTS

Page

1.1 BACKGROUND

In 1976, ERT was commissioned by B.C. Hydro to evaluate the air quality and climatological effects of the proposed Hat Creek Project. This study included an evaluation of potential fugitive dust levels resulting from the operation of the Hat Creek mine based on theoretical modelling into which available emission factors for dust generating activities were inputed (ERT, 1978). This study predicted significant violations of the province of British Columbia's total suspended particulate objectives. Of particular concern in this regard was an Indian Reservation which is less than a kilometer to the north of the mine property line. The ERT study considered the situation that would develop after about 35 years of mine operation. An evaluation of the design features and a development of specific recommendations to control dust emissions from those areas of operation identified as being potentially dusty were beyond the scope of the ERT study.

The present evaluation is an extension of the ERT study and examines the potential for fugitive dust emissions during the pre-production and production stages of the Hat Creek mine development based on a survey of several operating coal mines and coal handling terminals and on the results of background studies including the bulk sample program. The latter field program provided specific information about the nature of the materials at Hat Creek, the potential for reclamation of waste materials, etc., which was not available for use by ERT. The high-volume data obtained from the survey of operating mines gives some perspective of potential fugitive dust levels at Hat Creek. The review of several large coal stockpile and storage areas provided a basis to evaluate specific control practices of stockpile wind erosion.

Based on the inputs identified above, the major fugitive dust sources are identified and a number of recommendations are made to control dust emissions during the pre-production and the production years of mine operation. An analysis is made of the probability of violation of regulated TSP levels based on an analysis of the distribution of critical wind direction and speeds.

1.2 REGULATORY OBJECTIVES

Fugitive dust concentrations at mining operations in British Columbia are required to meet the Pollution Control Objectives for the Mining, Mine-Milling, and Smelting Industries of British Columbia. Emission control at new developments must be sufficient to meet level A objectives. These are outlined below along with the revisions of the existing objectives that are presently being considered by the Provincial Government. The latter proposed changes are indicated below within brackets.

A. <u>Desirable Levels of Ambient Air Quality</u>

.1 Total Suspended Particulate Matter:

Annual geometric mean - $\mu g/m^3$ 60 (60 to 70)
Maximum 24 hours - $\mu g/m^3$ 150 (150 to 200)

.2 Dustfall:

$mg/cm^2/mo$ 0.875
$(mg/(dm^2.d)$ (1.7 to 4.1)
$tons/mi^2/mo$ 25 (15 to 35)

B. <u>Control Objectives for Gaseous and Particulate Emissions for Mining</u>

.1 Total Suspended Particulate Matter including background:

Annual geometric mean - $\mu g/m^3$ 60
Maximum 24 hours - $\mu g/m^3$ 150

.2 Maximum allowable above background

Annual geometric mean - $\mu g/m^3$ 15
Monitoring: collection on a 0.3 μm fibre filter by high volume sampler operated for one 24 hour period once per week. Gravimetric analysis.

For the purpose of this study it is assumed that the Hat Creek mine would be required to meet the low end of the new objectives, i.e. the same as the existing level A.

SECTION TWO

STUDIES TO DATE

SECTION TWO

STUDIES TO DATE

CONTENTS

LIST OF TABLES

LIST OF FIGURES

2.1 INTRODUCTION

This part of the report presents a brief summary of the present status of characterizing dust emissions from various operations associated with a coal mine by means of emission factors and the status of theoretical models to predict suspended particulate levels based on emission factors and mine parameters. A summary of the fugitive dust evaluation made by ERT for the Hat Creek project is also presented in this part of the report.

2.2 FUGITIVE DUST MODELLING - GENERAL DISCUSSION

In order to predict suspended particulate levels resulting from a mining operation, it is necessary to identify the operations that produce dust, characterize the rate of dust emission, and develop a dispersion model to be used in conjunction with the assumed emission factors. To accomplish this in a manner that is applicable to different mining operations and areas is a difficult task. The quantity of dust generated by a given operation is a function of a number of parameters, including: the nature and layout of the mine and facilities, the specific operations and equipment involved in the mining scheme, the quantity and nature of the materials handled (mechanical properties, percentage of fines, free moisture content, etc.), the meteorological conditions (particularly wind intensity), the amount of precipitation, and the success of measures instituted to control dust.

211 EMISSION FACTORS

A considerable amount of work has been carried out in developing emission parameters for fugitive dust sources associated with coal mining operations. Besides the information sources ERT used to generate the emission factors on which their calculations are based (see Section 2.3), two recent works published subsequent to ERT's study are of note. PEDCo Environmental Inc., published a report entitled "Survey of Fugitive Dust from Coal Mines" in February of 1978. This work represents the first comprehensive sampling program at coal mines with the specific purpose of determining particulate emission rates. High-volume samplers were used in the study. The studies were carried out in a total of 5 mines located in Colorado (1), Wyoming (2), Montana (1) and North Dakota (1). The emission factors generated, shown in Table 2-1, were developed for use with a fallout function within the dispersion model. The results indicate a large variability between mines.

Criticism of the sampling methods used by PEDCo in their field studies have been made by environmental/regulatory officials from the states of Wyoming (Collins, 1978) and Montana (Maughan, 1978). One of the main criticisms was that the samplers were located too close to the

TABLE 2-1

Emission Factors Estimated for Individual Coal Mining Operations at Each of the Five Mines Surveyed

Operation	Units	Mine A N.W. Colo.	Mine B S.W. Wyom.	Mine C S.E. Mont.	Mine D Cent. N.D.	Mine E N.E. Wyom.
Dragline	lb/yd^3	.0056	.053	.003[b]	.021	
Haul roads	lb/veh-mi[a]					
w/watering		6.8	13.6	3.3[b]		4.3
no watering			17.0		11.2	
Shovel/Truck loading	lb/ton					
coal		.014	.007	.002[b]		.0035
overburden						.037[b]
Blasting	lb/blast					
coal				25.1	78.1	72.4
overburden		1690[b]		14.2		85.3
Truck dump	lb/ton					
bottom dump		.014	.020	.005	.027	
end dump						.007
overburden						.002[b]
Storage Pile	lb/acre-hr		1.6 u*			
Drilling	lb/hole					
coal						.22
overburden				1.5		
Fly-ash dump	lb/hr	3.9				
Train loading	lb/ton			.0002		
Topsoil removal	lb/yd^3					
scraping					.35	
dumping					.03	
Front-end loader	lb/ton				.12	

* u is in m/sec

[a] Only veh-mi by haul trucks; travel by other vehicles on haul roads (pickup trucks, ANFO trucks) is incorporated into these values.

[b] These values were all noted to be somehow a typical and should not be used without first determining the limitations to their applicability described in this report.

SOURCE: PEDCO-Environmental, Inc. (1978)

dust source and hence some heavy particles were collected that would otherwise settle near the source. The short sampling period of 1 hour (high-volume samplers normally are operated for a 24-hour period) also increases the chance of non-representative results. The State of Montana Officials (see appended letter from David Maughan, Air Quality, State of Montana to PEDCo) in their review of the PEDCo report concluded that a great deal of refinement of the emission factors proposed by PEDCo would be necessary before the factors would be useful to the State of Montana.

The Department of Environmental Quality of the State of Wyoming's Air Quality Division, reviewed published emission factors and recommended values to be used for calculation purposes based on their analysis. These findings were circulated for review in November 1978 (see appended letter from Randolph Wood, Air Quality Division, State of Wyoming). The main purpose of the evaluation was to provide some guidance in the area of emission factors and their use in dispersion modelling for applicants wishing to develop and operate coal (or uranium) mining operations within Wyoming. The state requires proponents to estimate dust levels for the purposes of environmental impact analyses. Table 2-2 presents the factors recommended by the Wyoming State Government. As noted by Table 2-2 the factors recommended for use attempt to relate to the physical parameters of a mining area (e.g. % of silt in haul road surface materials is part of the equation for determining the dust emissions for haul roads) and provides a correction for the number of wet days. This compilation represents a comprehensive up-to-date evaluation of existing emission factors. The significant differences between these factors and those available for use by ERT emphasize that the development of emission factors is at an early stage.

Others have expressed concern over the lack of reliable emission data. Southerland and Masser (1977) in their paper entitled "The Role of Fugitive Emissions Factors in Meeting National Ambient Air Quality Objectives", concluded from their literature search on fugitive dust emissions and emission factors that there was a lack of adequate test data to develop comprehensive and defensible emission factors for fugitive dust sources. Cowherd, 1977, in a paper entitled "Measurement of Fugitive Particulates", states that for the most part proven methods for quantifying fugitive emissions have not been developed to date.

Based on the above summary, one can conclude that further refinement and field verification of emission factors are needed. Despite these concerns, however, emission factors can be used to point up potentially dusty areas for which control measures may be required.

212 MODELLING

The modelling of fugitive dust and the prediction of TSP levels resulting from mining operations are also at an early stage of development. PEDCo, 1978, suggests that current dispersion models are

TABLE 2-2

State of Wyoming
Division of Air Quality
Guidelines for Fugitive Dust Emission Factors
for Mining Activities
(To be used in conjunction with a fallout function)

Mining Activity	Operation	Emission Factor
1. Overburden	Dragline	0.053 lb/yd^3(1)
	Truck/Shovel	0.037 lb/ton(1)
	Scraper	[1] 32 lbs/hr(2)
2. Haul Roads		[2] $E = 0.81s(S/30)\ \left(\frac{365-W}{365}\right)$ lb/VTM*(3)
Access Roads		[2] $E = 0.81s(S/30)\ \left(\frac{365-W}{365}\right)$ lb/VTM(3)
3. Haul Road Repair and Construction	Graders	[1] 32 lbs/hr(2)
	Scrapers	[1] 32 lbs/hr(2)
4. Wind Erosion		[4] E = AIKCL'V' ton/acre/yr(4)
5. Product Removal	Coal-Truck/Shovel	0.007 lb/ton(1)
	Coal-Frontend Loader	[5] 0.007 lb/ton
	Uranium-Frontend Loader	[6] 0.007 lb/ton
6. Product Dumping	Coal-Truck Dump	[7] 0.02 lb/ton(1)
	Uranium	[7] 0.02 lb/ton
7. Stockpiles (wind erosion)	Coal	[8] 1.6 u lb/acre/hr
	Uranium	[9] E = 0.05(s/1.5) (d/235) (f/15) (D/90) lbs/ton(5)
8. Blasting	Overburden	90 lb/blast(1)
	Coal	80 lb/blast(1)

* Vehicle Travelled Miles

NOTES:

1. If applicant's estimate of grader and scraper hours includes wet days, then reduce emissions by the factor 365-W where W = no. of days where rain or snow precipitation is 0.01" or greater.

2. From Reference (3) $E = 0.81s(S/30)\ \left(\frac{365-W}{365}\right)$ lbs/VMT

Continued

TABLE 2-2 (Cont'd)

State of Wyoming
Division of Air Quality
Guidelines for Fugitive Dust Emission Factors
for Mining Activities
(To be used in conjunction with a fallout function)

Notes: Cont'd)

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where s = silt content of road surface material (%)
S = vehicle speed in mph
W = no. of days with 0.01" precipitation or more
S/30 factor should be squared for speeds less then 30 mph
Apply correction for number or width of tires compared to light vehicles

3. Frequency and rate of application as per manufacturer's recommendation or as justified by applicant for site, specific road materials and experience.

4. From Reference (4) E = AIKCL'V' ton/acre/yr

   where A = portion of losses which become suspended
   I = soil erodibility
   K = surface roughness factor
   C = climatic factor
   L' = unsheltered field width factor
   V' = vegetative cover factor

   A & I are related to soil types.

5. It was felt that given the similarity of operation of a frontend loader to a shovel that measured emissions from Reference (1) of 10 to 20 times more (loader vs. shovel) were not reasonable, thus the selection of 0.007 lbs/ton.

6. Given the usual wetness of observed uranium ore in surface mines this factor is probably conservative. Factor estimate only - not measured.

7. Estimate only - not measured.

8. 1.6 u lb/acre/hr where u is wind speed in m/sec. Factor includes some equipment activity around and on piles. Total emission should include truck dumping, etc.

9. From Reference (5) E = 0.05(s/1.5)(d/235)(f/15)(D/90) lbs/ton throughput through pile

   where s = silt content of material (%)
   d = no. of dry days/yr
   f = percentage of time wind speed exceeds 12 mph
   D = duration of material in storage (days)

Continued

TABLE 2-2 (Cont'd)

State of Wyoming
Division of Air Quality
Guidline for Fugitive Dust Emission Factors
for Mining Activities
(To be used in conjunction with a fallout function)

Notes: Cont'd

Factors to be used in conjunction with a fallout function of the form:

$$Q_x/Q_o = \exp\left(\frac{-aV_d\ x^b}{u}\right)$$

where,

a & b = constants (function of atmospheric stability class)

V_d = settling velocity

u = wind speed

Q_o = initial emission rate

x = downwind distance

References:

(1) EPA-908/1-78/003, "Survey of fugitive Dust from Coal Mines", by PEDCo Environmental, Inc., February, 1978.

(2) EPA-908/1-76/008, "Wyoming Air Quality Maintenance Area Analysis", by PEDCo Environmental, Inc., May, 1976.

(3) AP-42 "Compilation of Air Pollutant Emission Factors (Supplements 1-8)", May, 1978.

(4) PEDCo 1976, "Evaluation of Fugitive Dust Emissions from Mining", by PEDCo Environmental, Inc., April, 1976.

(5) Cowherd, C. and R.V. Hendriks, "Development of Fugitive Dust Emission Factors for Industrial Sources", Paper No. 78-55.4, Annual Meeting Air Pollution Control Association, Houston Texas. June, 1978.

inadequate because they do not accommodate features usually associated with mines such as effect of terrain on dispersion of suspended dust, sources in pits and at ground-level, wind speed related emission rates, wind channeling and poorly defined source locations.

The National Coal Policy Project in their report "Where We Agree" (Murray, 1978) concluded in regard to fugitive dust that "air quality models and emission factors for different phases of mine operations that are used in existing models are not capable of accurately assessing the impacts of mining on air quality".

It must be concluded that further development work and model refinement is required along with field verification before the difficult problem of accurately predicting TSP levels resulting from mining operations is resolved. Despite the early stage of development, however, existing models can be used to identify potential problem areas (i.e. areas of potentially high TSP levels) resulting from the development and operation of a mine.

2.3 HAT CREEK FUGITIVE DUST MODELLING

Presented in this Section of the report is a summary of the fugitive dust evaluation conducted by ERT. The details of this evaluation are contained in the ERT report entitled "Air Quality and Climatic Effects of the Proposed Hat Creek Project" dated April 1978.

231 BASIS OF ERT STUDY

Figure 2-1 outlines the mine plan on which ERT based their calculations. The open pit mine would be developed by means of a truck/shovel/ conveyor combination mining method. Excavated waste material and coal would be loaded onto trucks for transfer to in-pit conveyor transfer points, from where all materials would be transported out of the pit via an inclined conveyor system. The coal would be conveyed to the blending/stockpile area and the waste to one of two waste dump areas as shown on Figure 2-1. Surficial materials removed by scraper before the start of production would be stored in the North Valley dump. A separate dump would be maintained for low grade coal.

The mining operations determined to be important in terms of suspended particulate generation were: surficial material removal, overburden removal, coal removal, haul road traffic and repair, and coal stockpiling.

The fugitive dust evaluations made by ERT were based on operations during the year 2017-2018 which are typical of maximum production and activity.

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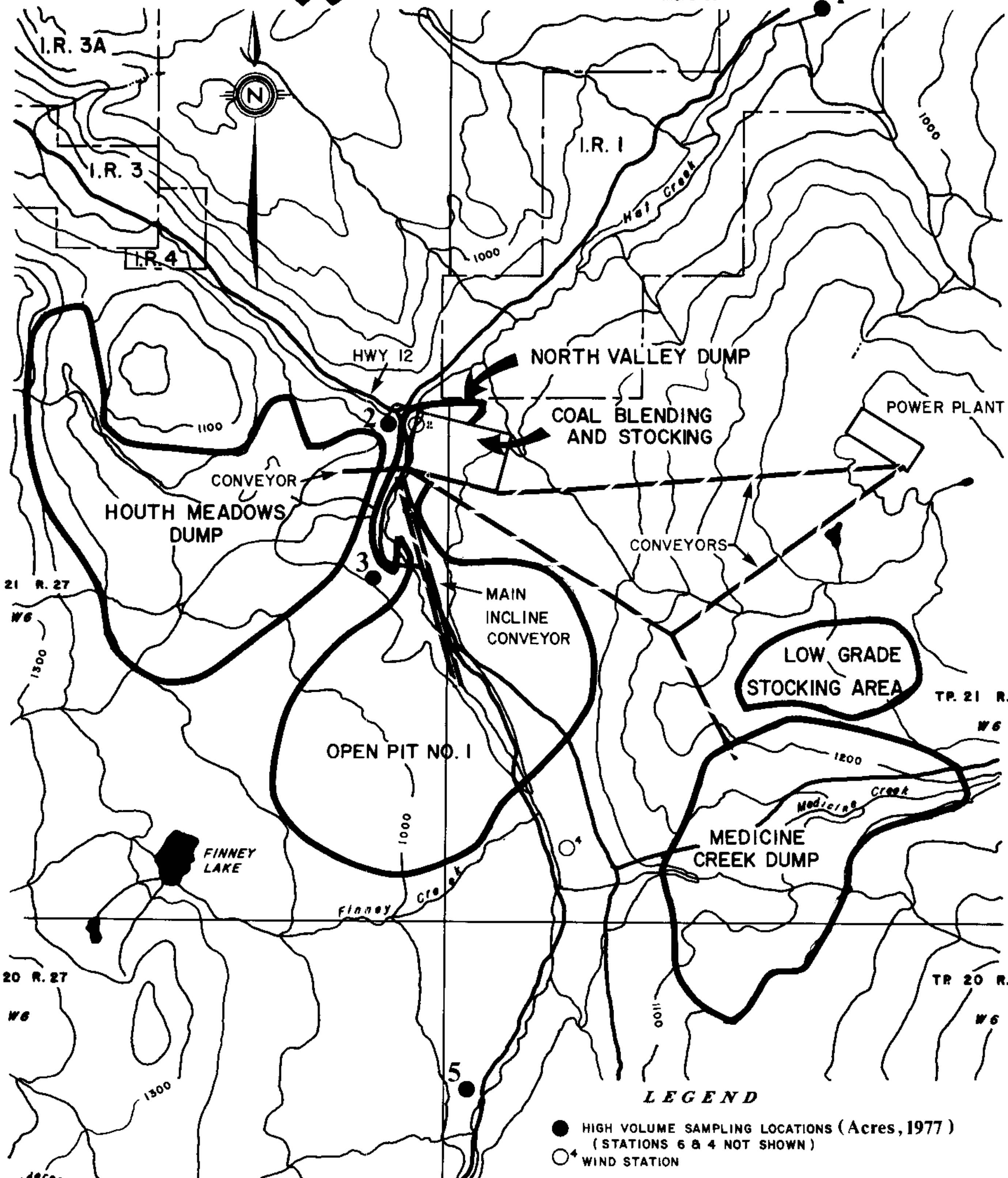

FIGURE 2-1
BRITISH COLUMBIA HYDRO
AND POWER AUTHORITY
HAT CREEK FUGITIVE
DUST EVALUATION
MINE PLAN ON WHICH E.R.T. BASED
THEIR FUGITIVE DUST EVALUATION

231.1 Emission Factors and Dust Emission Rates

Table 2-3 presents the results of the ERT calculations of fugitive dust emissions along with emission factors and source operating units (ERT 1978). These results include the effects of dust control measures.

As indicated by Table 2-3, wind erosion was identified as the major dust source for the Hat Creek mine. After wind erosion, the major sources of fugitive dust were determined to be haul road traffic, overburden removal and surficial material removal.

231.2 Assumptions and Models

ERT made a number of simplifying and conservative assumptions in their modelling of fugitive dust at Hat Creek. The major assumptions include the following:

- all dust sources for the Hat Creek mine are emitted at ground-level. The model did not account for the fact that many of the emissions will occur within the open pit below groundlevel;
- topographical influences were not accounted for in the model;
- reclamation of the waste dumps lags a number of years behind dumping;
- only that fraction of disturbed material small enough to remain suspended beyond the mine area was considered in the evaluation. Because of this assumption a fallout function was not used in the dispersion model;
- emissions are assumed to be mixed uniformly through an initial 10 m depth.

The ERT approach was to take estimated emission rates for point, area and line sources and uses a Gaussian dispersion model to predict TSP concentrations resulting from the mining operations. Point sources include activities such as dumping of coal and waste material at the out-of-pit transfer points; vehicle movement on haul roads is an example of a line source; and area sources include activities such as scraping and coal removal. Predictions were made of annual average particulate concentrations and worse-case 24-hour values due to fugitive dust emissions at the Hat Creek mine. The calculations were performed for several stability classes.

231.3 Model Predictions

Of the nine meteorological situations investigated, the maximum 24 hour average TSP value, above background, of more than 400 $\mu g/m^3$ was determined on the eastern side of Upper Valley for a stable atmosphere and a wind from the SSW at 0.77 m/s (0.2 km/h). Concentrations in excess of 200 $\mu g/m^3$ were predicted for the same conditions on the southern section of Indian Reserve I (see Plate 2-1) with the 150 $\mu g/m^3$ contour extending to the northern boundary of the reserve. For the most "typical" meteorological situations in the Upper Valley, incremental TSP concentrations above 150 $\mu g/m^3$ were within the mine site. As noted in Part One, the present PCB 24-hour objective is 150 $\mu g/m^3$, while that under consideration is a range of 150 - 200 $\mu g/m^3$.

TABLE 2-3

Estimates of Particulate Emissions for the Hat Creek Project Coal Mine
(Based on a Maximum Level of Activity for the Year 2017-2018)

Source/Type	Emission Factor	Source Operating Units [1]	Emissions (kg/yr)
Surficial removal (scrapers)	7.26 kg/scraper-hr[2]	26,250 scraper-hours/years[2]	191,000
Overburden removal (truck/shovel)	7.26 kg/shovel-hr[2]	27,000 shovel-hours/year	196,000
Coal removal (truck/shovel)	0.01 gm/kg coal removed[2]	9.98×10^9 kg/year in-situ coal	99,800
Blasting	0.005 gm/kg coal blasted[3]	9.98×10^9 kg/year in-situ coal	49,900
Coal haul road	0.31 kg/vehicle-km traveled[2,4]	4.96×10^5 vehicle-km/yr	154,000
Overburden haul road	0.31 kg/vehicle-km traveled[2,4]	1.23×10^6 vehicle-km/yr	381,000
Truck hopper dump	0.01 gm/kg coal dumped	9.98×10^9 kg/year in-situ coal	99,800
Conveyors	-		-
Coal Stockpiles	0.122 gm/kg coal stored[2,5,6,7]	9.07×10^8 kg coal stored	111,000
Haul road repair	7.26 kg/grader-hr[2]	9000 grader-hours/year	65,300
Wind Erosion	0.056 kg/m^2/yr[5,6,7]	1.68×10^7 m^2	941,000
		TOTAL	2,288,800

[1] Ebasco/Integ Mine Plan (Reference 1)

[2] PEDCo (Reference 4)

[3] Gulf Oil/Standard Oil (Reference 5)

[4] U.S. EPA (Reference 6)

[5] Woodruff and Siddaway (Reference 3)

[6] PEDCo (Reference 7)

[7] Thornthwaite (Reference 8)

SOURCE: ERT (1978)

Annual average predicted TSP levels greater than 100 $\mu g/m^3$ above background were confined to the immediate vicinity of the mine pit. Annual concentrations beyond the mine boundary generally range from 25 to 50 $\mu g/m^3$ with peak values of 60 $\mu g/m^3$ above background predicted on IR 1. The ERT model could only present these values in terms of an annual arithmetic mean whereas the objectives specify an annual geometric mean of 60 $\mu g/m^3$ with the range 60-70 $\mu g/m^3$ under consideration. The geometric mean can never be greater than the arithmetic mean and it is generally smaller adding a further margin of conservation to the results.

Despite the conservative nature of the ERT predictions, the model results point up the fact that a potential fugitive dust problem exists as a result of the operation of the Hat Creek mine and hence suggests that specific fugitive dust controls need to be evaluated.

SECTION THREE

STUDY SURVEYS

SECTION THREE

STUDY SURVEYS

CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

3.1 INTRODUCTION

In order to gain an appreciation for the potential fugitive dust levels resulting from the operation of the Hat Creek mine, a survey was conducted of a number of large coal mining facilities in Western Canada and Northwestern United States from which total suspended particulate level measurements (high volume data) were available. A total of eight mines were surveyed. Three were in Montana (M1, M2 and M3), three were in Wyoming (W1, W2 and W3) and two were in British Columbia (BC1 and BC2).

Visits were made to the three mines in Montana and to the two mines surveyed in British Columbia. The designated mines in Wyoming were not visited because of time constraints. Data for the Wyoming mines was received through telephone conversations with mine personnel and Wyoming State Government officials. Visits were also made to the Air Quality Branches of the Wyoming and Montana State Governments and to the Provincial Government of British Columbia.

In order to present the data obtained through the survey in proper perspective, a brief summary of the local climate and of the operations is given for each mine as available. A more detailed description of the local environmment in the region of each mine and of the mining operation is given in the appendices.

In this study, it was recognized that the evaluation must encompass all aspects of the fugitive dust question at Hat Creek from the pre-production phase when the mine is first opened up to the period of full production which the above data reflects. As indicated in Section Four of this report, two areas that are anticipated to be potentially dusty are the topsoil stripping operation and the coal blending facilities. The blending area is of particular concern because it would be located close to (1km from) an Indian Reservation (see Figure 2-1). As a result of this concern, a specific evaluation was made of measures to control dust from several coal stockpile areas. At two of the coal stockpile sites surveyed, specific studies were conducted and measures taken which successfully eliminated a fugitive coal dust problem. Monitoring results were available for only one of the stockpile areas surveyed.

3.2 FUGITIVE DUST SURVEY

The results of the evaluation of the eight coal mining operations surveyed for overall fugitive dust levels are presented in this section of the report. Reference is also made to other mines surveyed for which TSP data was not available.

321 MONTANA MINES SURVEYED

The regulated standards for TSP levels in Montana are an annual geometric mean of 74 $\mu g/m^3$ and a 24-hour arithmetic mean of 200 $\mu g/m^3$ which is not to be exceeded more than 1% of the time (about 4 days per year). Comparisons in the discussions below are made with the proposed B.C. objectives given in Part One of this report.

321.1 Mine M1

This mine is situated in a relatively dry area in which the relief is gently rolling to flat, with mountains about 80 km to the west. Vegetation in the mine area is sparce with the prevailing cover being native grasses with isolated conifers occuring on north facing slopes. The major use of the land is for cattle and sheep grazing. The bedrock consists of horizontal sedimentary strata underlying a thin glacial till cover.

321.11 Local Climate This area receives a yearly total precipitation of 372 mm while the average wind speed is about 12.5 km/hr. The prevailing winds blow from the west - northwest. The local mean annual daily temperature and relative humidity are 5°C and 56% respectively.

321.12 Mine Data Table 3-1 presents a summary of the M1 strip mining operation and indicates that the annual production rate is about 9 million tonnes of sub-bituminous coal. Approximately 2.3 million tonnes per year of coal are fired in a utility plant located about one mile from the present mining area; the remainder is exported. Overburden is removed by shovels and draglines and the coal is extracted with coal loaders and loaded onto haul trucks for transfer to the thermal plant or to an export stockpile area. The outdoor stockpile area covers about 0.4 ha and contains about 90 000 tonnes of coal. The coal is loaded out by a boom stacker and reclaimed in an underground system for loading onto unit trains by means of one or two tipples. The only fugitive dust control measures practiced at this site are the use of water sprays at the conveyor transfer points and the final load-out, and the watering of haul roads. Measures for stockpile dust control are not considered necessary at the site.

321.13 Monitoring Results Figure 3-1 presents a map of the M1 mining operation showing the location of the high volume samplers. At the present time atmospheric particulate levels are being measured at 10 locations. The length of time over which monitoring has been conducted at each location is given in Table 3-2 along with the monitoring results.

The results given in Table 3-2 are presented both in terms of monthly arithmetic means and annual geometric means for each station. The only stations with consistently high readings are 3 and 6. An annual geometric mean of 60 $\mu g/m^3$ is exceeded at only stations 3 and 7. A monthly arithmetic mean of 150 $\mu g/m^3$ is exceeded at station 7 for most months measured and for several months at station 3. The latter value is exceeded in only a few other occasions for the eight other remaining stations.

TABLE 3-1

Mine M1 Data Sheet
(Site Visited Nov. 15, 1978)

Operational Details

Type of Mining: Sub-bituminous coal 8600 Btu/lb

Method of Mining: Strip

Production: 8.2 million tonnes/year 365 days/year

Strip Ratio: 4 overburden:1 coal

Use of Coal: 2.3 million tonnes/year to mine mouth thermal plant
5.9 million tonnes/year to other markets

Equipment Used

	Size	Number	Cycle
Overburden Removal			
Draglines	46 m^3	2	
Stripping Shovel	19 m^3	1	
Drills		3	
Overburden drill		3	
Coal Extraction			
Coal Loader	13 m^3	3	
Hauling (to plant and to export stock pile)			
Trucks	92 tonne	9	
	90 tonne	4	
Export Coal Loading			
Tipple	3628 tonnes/hr	1	2 trains/day
	1134 tonnes/hr		

Blasting: Information not available.
Haulroad: Overburden surface, length 1 mile pit to plant width 90 ft.
Storage: Outside stockpiles, no wind breaks.
Waste: Ash to lagoons, no waste dump.
Associated Development: Thermal Power Plant at mine.

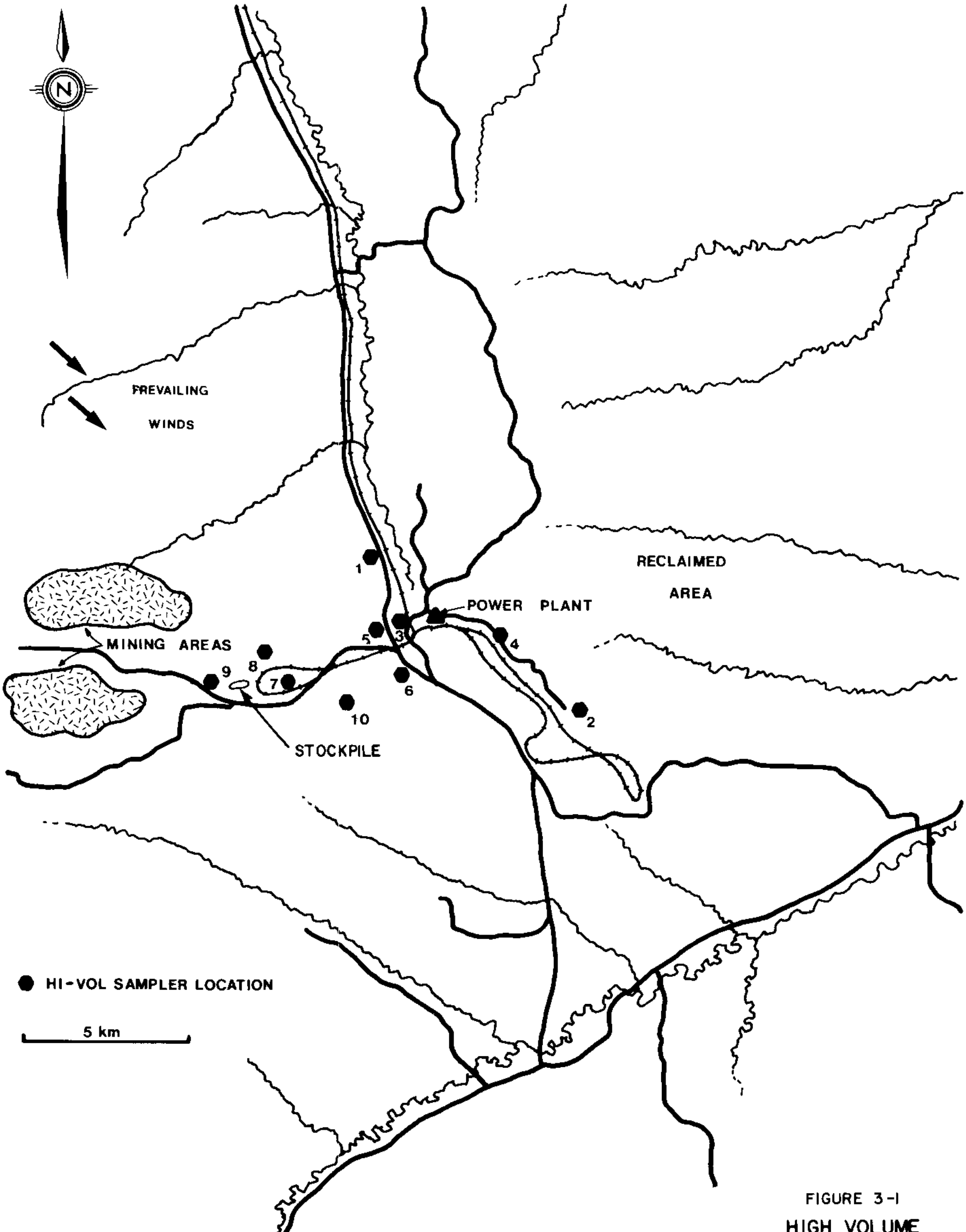

FIGURE 3-1
HIGH VOLUME
SAMPLING LOCATIONS
MINE M1

TABLE 3-2

Coal Mine High Volume Sample Data Summary - Mine M1

Monthly Arithmetic Means and Annual Geometric Means

$\mu g/m^3$

Station No.	OCT (1976)	NOV	DEC	JAN (1977)	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	Annual	No. of Samples
1			53	15	60	32	37	28	-	33	23	24	34	19	21	51
2			18	9	17	27	23	18	-	21	15	16	16	7	14	51
3			161	58	181	180	156	86	-	104	68	81	90	77	94	52
4*	-	-	-	-	-	-	-	-	-	-	42	42	39	15	28	20
5	156	164	102	32	22	60	140	114	67	-	-	89	47		52	54
6	84	73	70	52	32	64	68	129	48	-	-	89	47		52	54
7	388	364	358	106	122	339	217	262	261	-	-	115	118		170	51
8	122	52	118	26	67	48	188	150	76	-	-	37	77		54	54
9**	-	-	-	-	-	-	119	91	51	-	-	29	25		57	54
10	101	57	167	48	64	83	68	150	63	-	-	35	57		57	54

* Was commissioned in August 1977

** Was commissioned in April 1977

(-) Indicated data missing or not collected

Station 3 is located in a residential area near which there are some construction activities which generate dust in addition to local traffic. The high levels measured at station 3 result from the local activity in the residential area and is probably not influenced by the mining operations to any measurable degree. Station 7 is located fairly close to the coal loading area and as shown on Figure 3-1 the prevailing winds blow from the train loading area to the station 7. Station 8 is located close to but upwind of the coal loading area as is indicated by the considerably lower TSP levels compared with station 7. The results measured at station 10 compared to those at station 7 suggest that for the conditions at mine M1 a significant reduction in particulate levels occurs within a few kilometers of the mine. The results measured at stations 1 and 2 (annual geometric mean of 21 and 14 $\mu g/m^3$) reflect essentially background levels.

The placement of the hi-vol stations in general suggests that less concern in regard to TSP levels is shown for the mine area compared to the export coal loading area and coal hauling to the thermal plant.

321.2 Mine M2

This mine is situated approximately 12 km southwest of mine M1 and hence has basically the same regional characteristics. Section 321 gives a brief description of this region and its climate. Rainfall measured locally at M2 in 1977 was 278 mm which is somewhat lower than that measured at mine M1.

321.21 Mine Data As indicated in the summary, Table 3-3, Mine M2 produces about 2.3 million tonnes/year of sub-bituminous coal for export from the area. Overburden is removed by draglines. The coal, after ripping, is extracted, by shovels and front end loaders and loaded onto trucks for transport to a cathedral type storage building. From the storage building the coal is relcaimed in an underground system and fed to a tipple for loading onto unit trains. As shown on Figure 3-2, the present mine area is the second area to be mined. The previously mined area, part of which has been relcaimed, is located just south of the active mine.

Dust control measures are limited to the watering of haul roads as required, the use of water sprays at all conveyor transfer points and the enclosed storage of coal.

321.22 Monitoring Results The location of the four monitoring sites near the M2 mining operation are given in Figure 3-2 while the particulate levels measured at each location are given in Table 3-4. The length of time for which monitoring has been conducted at each station is also shown on Table 3-4.

TABLE 3-3

Mine M2 Data Sheet
(Site Visited Nov. 16, 1978)

Operational Details

Type of Mining: Sub-bituminous coal

Method of Mining: Strip, operations start-up 1969

Production: 2.3 million tonnes/year

Strip Ratio: 8:1

Equipment Used

	Size	Number	Cycle
Overburden Removal			
Scrapers		5	topsoil-periodic
Draglines	7800, 7400	3	
Drills	50R, 30R	2	
Coal Extraction			
Shovels		3	
Front End Loader		1	
Dozers (ripping)		5	
Hauling			
Dirt Trucks (converted)		5	2 loading shifts/day
Coal Loading (for Export)			
Tipple (enclosed)		-	

Blasting

2 blasts/week, size and quantity material produced - information not available.

Haulroad: surficial material length and width information not available.

Storage: Covered storage - no outside storage.

Waste: No waste dump.

Associated Development: None.

cominco-monenco joint venture

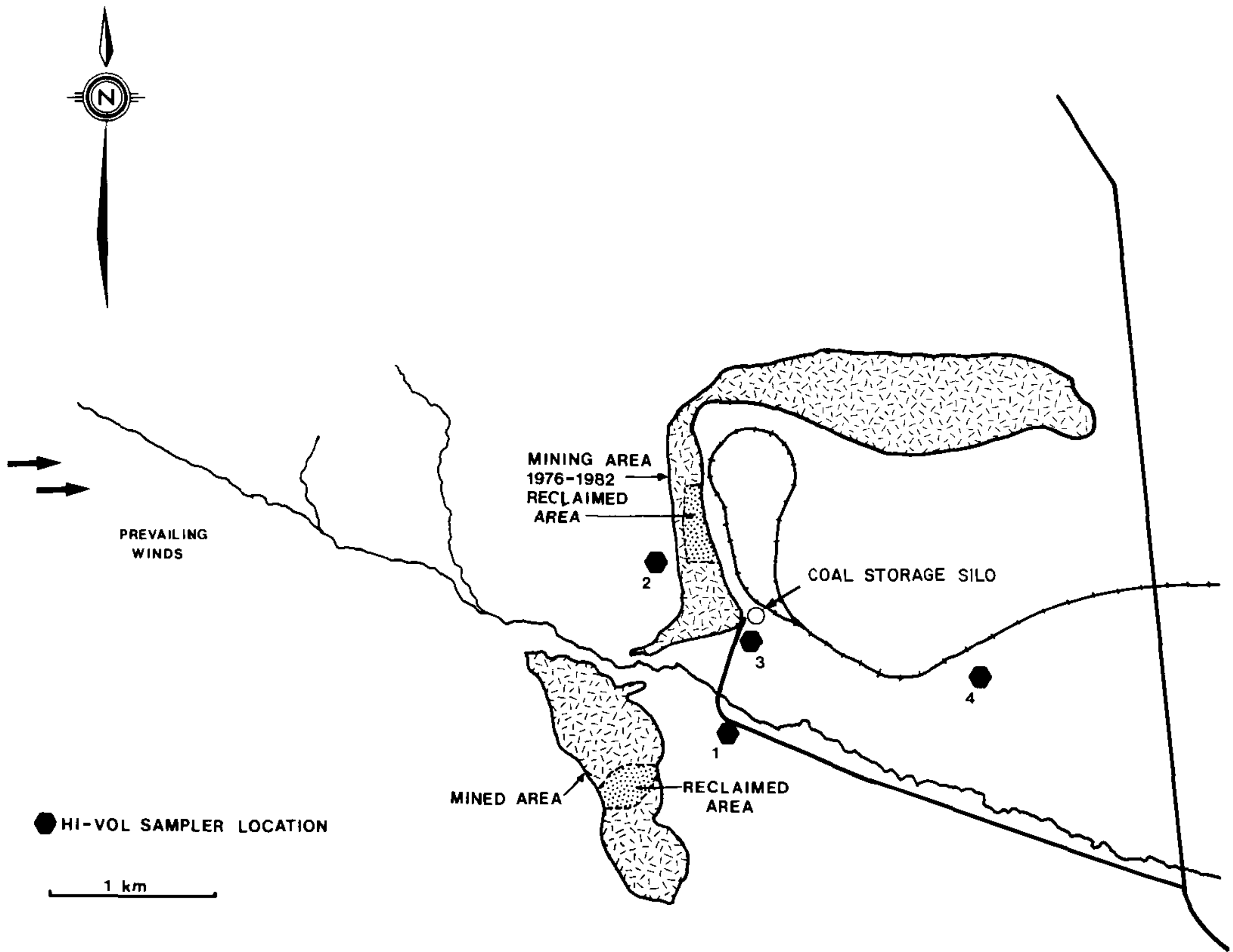

FIGURE 3-2
HIGH VOLUME
SAMPLING LOCATIONS
MINE M2

TABLE 3-4

Coal Mine High Volume Sample Data Summary - Mine <u>M2</u>

Monthly Arithmetic Means and Annual Geometric Means

$\mu g/m^3$

Station No.	OCT (1975)	NOV	DEC	JAN (1976)	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	Annual	No. of Samples
1	36	18	8	48	70	47	111	77	84	176	245	244	50	60
2	78	11	9	20	38	29	81	125	60	70	53	123	33	60
3	41	59	12	49	132	87	73	183	92	140	183	184	65	62
	(1976)			(1977)										
1	46	31	33	14	21	81	84	86	57	108	75	49	42	50
2	20	14	18	8	12	39	25	51	49	37	36	18	21	52
3	77	92	144	17	61	102	122	105	69	95	140	118	68	54
4*					9	45	22	30	27	33	23	30	26	30

* Was commissioned in February 1977

The only location that has yielded results greater than an annual geometric mean of 60 μg/m^3, although only slightly so, is station 3 which is located close to the mine office and load-out area. The levels measured at the other stations over the two year period for which data was collected are less than an annual geometric mean of 60 μg/m^3. In terms of monthly arithmetic means, most of the values are less than 150 μg/m^3 with noticeable exceptions for dryer periods (July-September) in 1976.

The regulatory standards are outlined in Section 321.

321.3 Mine M3

This mine is situated on a gently rolling plain covered with glacial till overlying sedimentary strata. Vegetation cover is native grasses with scattered conifer stands. The land in the area is used mainly for cattle grazing.

321.31 Climate The precipitation measured in 1977 was about 407 mm and the average wind speed was 6.9 km/hr. The mean annual temperature for the region is 5.4°C.

321.32 Mine Data As indicated in Table 3-5, the M3 strip mining operation produces about 9.4 million tonnes of sub-bituminous coal from a seam averaging about 15 m in depth. Two draglines are used to remove the overburden. Coal is extracted in a 2-lift operation using front end loaders or a loading shovel and is loaded onto trucks for transport to a load-out area from where it is loaded into enclosed storage silos. Coal from the silos is loaded onto 100-car unit trains by means of a tipple. In the event that the silos are filled, coal is stored outside in an area capable of storing about 70 000 tonnes. The outdoor coal is truck dumped and reclaimed by front end loaders.

As indicated in Figure 3-3, the active mining area, the West mine, is west of the rail spur. An area east of the rail spur, the East mine, is presently being developed. The coal in the East mine will be removed by open pit mining techniques. Waste materials from the pit will be piled in a waste dump to the south of the East mine. Overburden has already been dumped in the waste pile. The East mine will be a shovel/truck operation.

The dust control measures practiced at M3 include the watering of haul roads (essentially continuous during the frost free period), the wetting of outdoor coal storage piles as required and the daily washing out of the coal load-out/tipple area. The filled train cars are sprayed with oil to help bind the exposed coal surfaces.

321.33 Monitoring Results Figure 3-3 is a schematic of the M3 mining operations showing the approximate location of the monitoring stations relative to the mining operations.

TABLE 3-5

Mine M3 Data Sheet
(Site Visited Nov. 16, 1978)

Operational Details

Type of Mining: Sub-bituminous coal - 15.8 m seam

Method of Mining: Strip - 2 lift operation

Production: 9.4 million tonne/year 365 days/year

Strip Ratio: Not available

Equipment Used

	Size	Number	Cycle
Overburden Removal			
Dragline	32 m^3	1	
Dragline	54 m^3	1	
Coal Extraction			
Loading Shovel	12 m^3	1	
or			
Front End Loader	18 m^3	1	
Hauling			
Wabco Trucks	136 tonne/load	10	146 loads/day

Coal Loading

Tipple - Characteristics not available

Blasting

100 sq. ft. bench - drill 12 x 15 - down to 50 ft. ammonium nitrate, fired by primacord.

Haulroad: By observation they are extensive. No data available.

Storage: 2 silos 12,245 tonne each
63,490 tonne outside stockpile

Waste: No waste dump.

Associated Development: A second nearby mine began development in 1978. It utilizes stripping shovels to remove overburden and haul trucks to dump overburden at waste dumps.

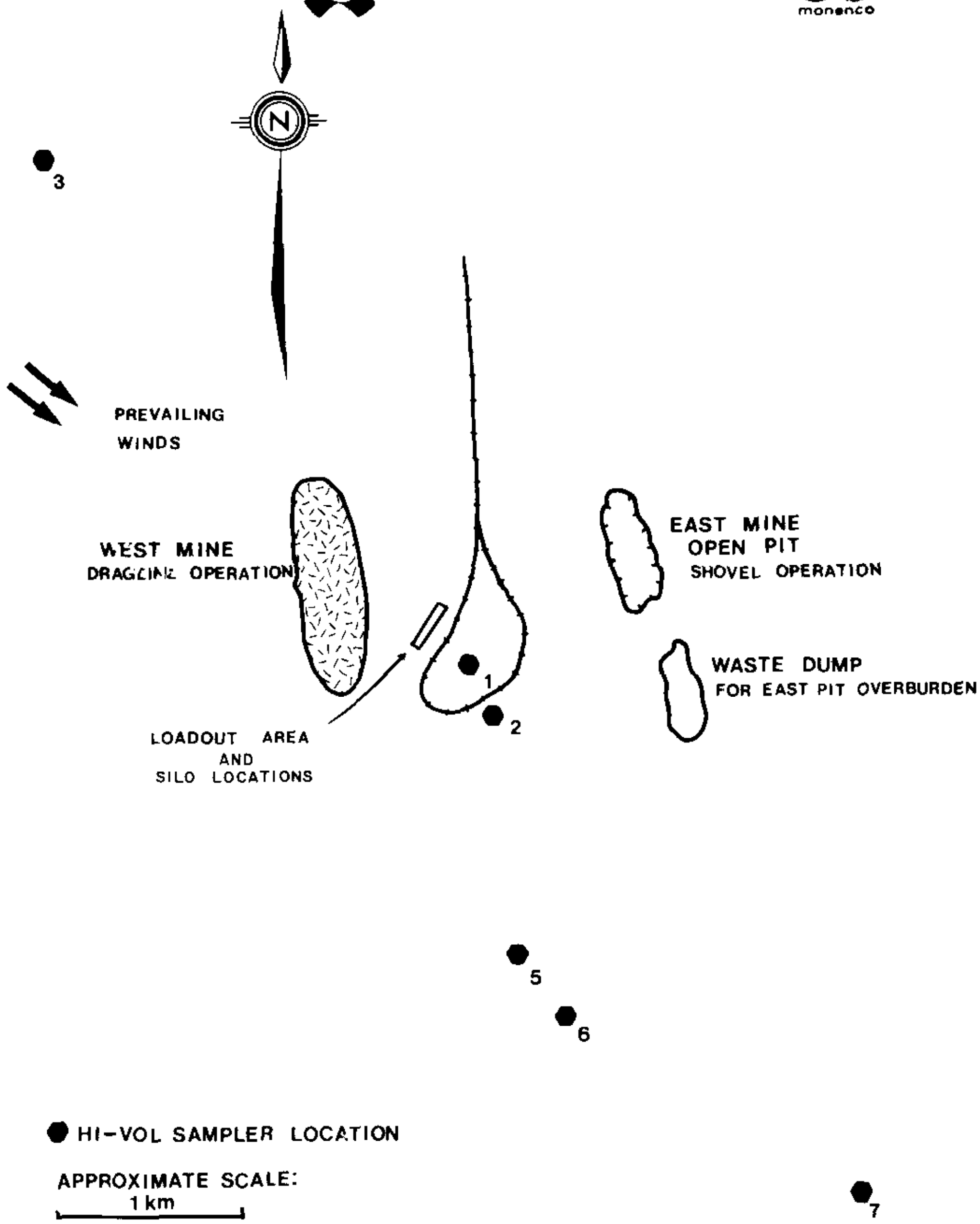

FIGURE 3-3
APPROXIMATE SAMPLING LOCATIONS
MINE M3
SCHEMATIC

The results of the atmospheric particulate monitoring program are shown in Table 3-6. The monthly arithmetic means and the annual geometric means are less than 150 μg/m^3 and 60 μg/m^3 in all cases. The personnel at Mine M3 feel that the low particulate levels around their operation are a result of a conscientious dust control program. The clean nature of this mine was evident in the visit made. The regulatory requirements are outlined in Section 321.

322 WYOMING MINES SURVEYED

Since none of the mines in Wyoming surveyed were visited, the detailed mine visit data sheets appended could not be filled to the same level of detail as for the mines visited nor was a specific regional and climate summary prepared for each mine. Data and information for each mine were obtained from the Wyoming State Government officials and through telephone conversations with mine officials.

In general, the Wyoming region in which the mines surveyed were located is characterized by a terrain that is rolling to steeply rolling. The region is dry with a mean annual precipitation of about 254 mm. The average annual temperature is about 8°C with January the coldest month (temperatures ranging from -10 to 0°C) and July is the warmest month (temperatures ranging from 20°C to 30°C). The main activity in the area is livestock grazing.

The Wyoming TSP regulations are as follows:

- annual geometric mean of 60 μg/m^3
- maximum 24-hour arithmetic mean of 150 μg/m^3

322.1 Mine W1

322.11 Mine Data A brief summary of this large strip mining operation is given in Table 3-7. Surficial materials are removed by a shovel and dozer operation while a bucket wheel is used for overburden removal. Coal is extracted with shovels and front end loaders and loaded onto trucks for hauling to an enclosed crushing plant from where it is transported via an enclosed conveyor to silos. All the coal is stored in enclosed silos from where it is loaded onto unit trains by a tipple.

Besides enclosed coal crushing, conveying and storage, dust control measures include the wetting of haul roads with water and the use of surface binders on service roads. Parking lots have been paved.

322.12 Monitoring Results The locations of the four high-volume samplers at mine W1 are shown in Figure 3-4. Station 2 is located closest to the coal load-out area, station 3 is located within a kilometer of the railspur and a major road, and sites 1 and 4 are removed from the mining area.

TABLE 3-6

Coal Mine High Volume Sample Data Summary - Mine M3

Monthly Arithmetic Means and Annual Geometric Means

$\mu g/m^3$

Station No.	OCT (1977)	NOV	DEC	JAN (1978)	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	Annual	No. of Samples
1	46	32	63	48	28	67	28	24	32	30	42	41	33	59
2	38	48	88	66	30	58	32	33	33	34	55	41	36	57
3	14	6	18	17	12	19	19	10	14	20	25	17	13	58
5	26	18	35	21	27	52	23	20	39	32	44	54	26	58
6	26	9	20	12	15	22	20	14	16	20	29	27	15	57
7	35	9	21	13	15	27	19	14	23	23	31	34	17	59

TABLE 3-7

Mine W1 Data Sheet
(Site Not Visited)

Operational Details

Type of Mining: Thermal coal

Method of Mining: Strip mining, 3 shifts/day, 1 seam

Production: 1977 - 12.1 million tonne 1976 6.7 million tonne

Strip Ratio: .42 - 4.28 overburden:1 coal

<u>Equipment Used</u>

	Number
<u>Overburden Removal</u>	
Dragline	1
Stripping Shovels	3
Bucket Wheel	1
Dozers	4
OB Drills	1
<u>Coal Extraction</u>	
Shovels	3
Front End Loaders	11
<u>Hauling</u>	
Trucks	36
<u>Coal Loading</u>	
Tipple	-

Blasting: Information not available.

Haulroad: Information not available.

Storage: 4 silos, 11 000 tonnes each.

Waste: Overburden is stripped and refilled in mine area in one operation.

Associated Development: 2 Crushing plants.

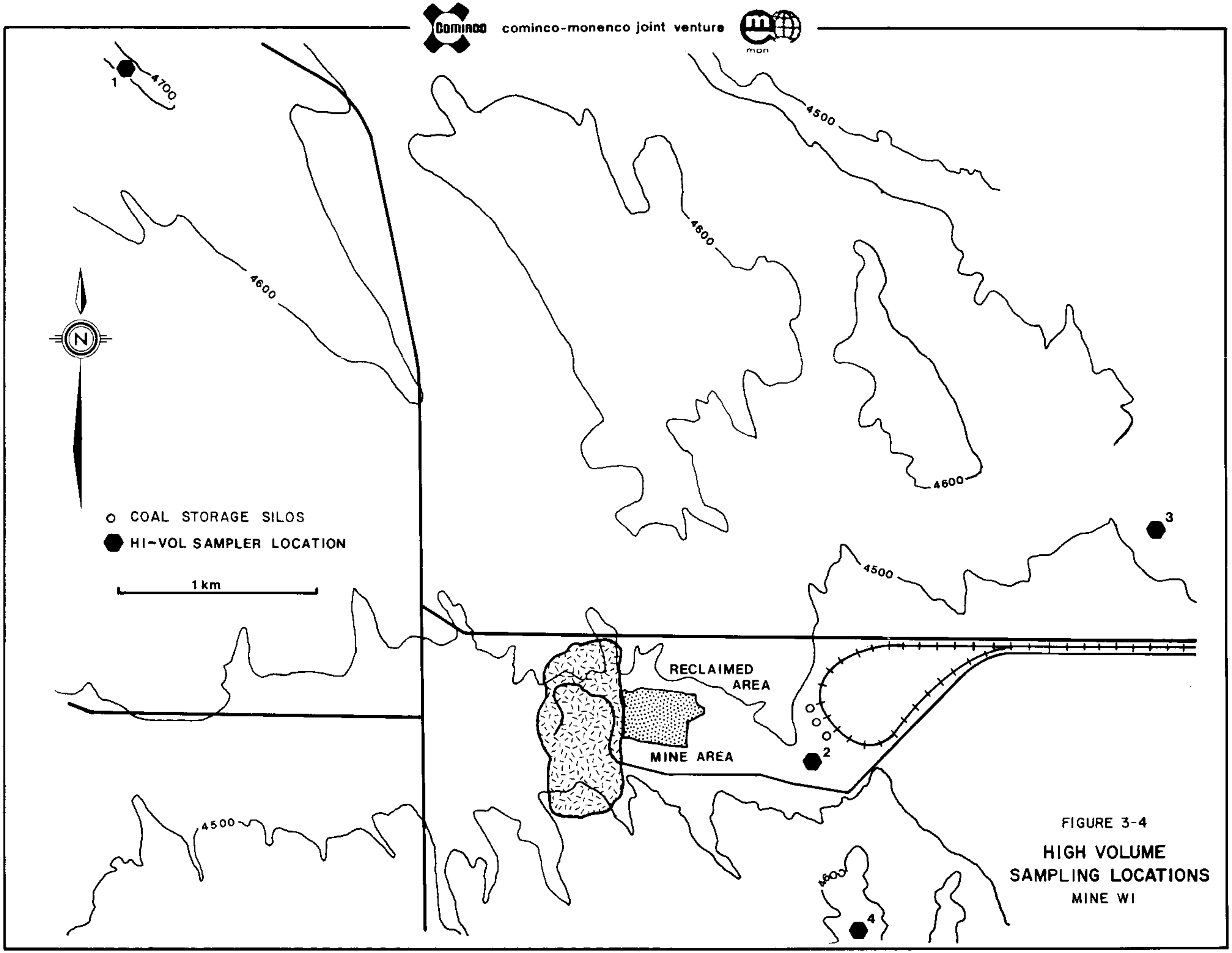

FIGURE 3-4

HIGH VOLUME SAMPLING LOCATIONS

MINE WI

Table 3-8 gives the results of the monitoring program over a two year period. The highest readings recorded were for station 2 which is near the coal load-out area. The annual geometric mean for the first year of data for station 2 is 72 μg/m^3 while that for station 3 was 65 μg/m^3. Both corresponding values dropped to well below 60 μg/m^3 during the second year of data recorded. A monthly arithmetic mean greater than 150 μg/m^3 was recorded for station 2. Values for all other stations were less than this value. Annual geometric means at the more remote monitoring locations (stations 1 and 2) are in the order of 30 μg/m^3 for both years reported.

322.2 Mine W2

.21 Mine Data About 7 million tonnes of thermal coal are produced at Mine W2 as shown on Table 3-9. Overburden removal is by dozers and a dragline. Coal is extracted by shovels and front end loaders and loaded onto trucks for transport to a crushing plant and then to enclosed silos. from the silos, the coal is loaded onto unit trains by a tipple system.

Dust control measures include enclosed coal storage and the watering of haul roads.

322.22 Monitoring Results Atmospheric particulates are measured at only two sites in the region of Mine W2 as shown in Figure 3-5. Both sites are about 1 to 1½ km from the mining activities. Table 3-10 gives the monthly and annual results measured at the two stations over the past 3½ years. In all cases the results are considerably below a monthly arithmetic mean of 150 μg/m^3 (except for November 1976 at Site 2) and below an annual geometric mean of 60 μg/m^3.

322.3 Mine W3

.31 Mine Data Mine W3 produces about 2.5 million tonnes of thermal coal. As noted on Table 3-11, overburden is removed by dozers and a stripping shovel while coal is extracted with a front end loader and a shovel. The coal is loaded onto trucks for transfer to an enclosed crusher house and then by an enclosed conveyor to enclosed storage silos. From the storage silos, the coal is loaded by a tipple system onto unit trains.

Dust control measures include enclosed coal crushing, conveying and storage operations and the watering of haul roads and service roads.

322.32 Monitoring Results Figure 3-6 shows the locations of the high volume samplers to be a few kilometers from the coal mining area. The results shown in Table 3-12 show that the monthly and annual atmospheric particulate levels to be very low over the two year monitoring. All monthly values are considerably less than 150 μg/m^3 for each station while in addition all geometric means are considerably less than 60 μg/m^3.

TABLE 3-8

Coal Mine High Volume Sample Data Summary - Mine W1

Monthly Arithmetic Means and Annual Geometric Means

$\mu g/m^3$

Station No.	JULY	AUG	SEP	OCT (1976)	NOV	DEC	JAN (1977)	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	Annual	No. of Samples
1				34	42	17	15	25	30	29	74	80	59	39	66	28	72
2			131	193	268	70	39	81	72	44	95	114	204	41		72	60
3				103	149	85	72	123	80	53	26	48	138	30	111	65	78
4			51	56	58	22	13	26	55	35	57	62	82	33		32	75
	(1977)						(1978)										
1	59	39	66	30	26	17	19	23	35	-	47	43				30	53
2	204	41	60	52	29	57	39	61	44	-	46	77				48	45
3	138	30	111	67	31	55	35	30	52	-	25	51				37	44
4	82	33	59	33	29	20	9	20	30	-	25	29				29	42

TABLE 3-9

Mine W2 Data Sheet
(Site Not Visited)

Operational Details

Type of Mining: Thermal coal

Method of Mining: Strip, start-up Aug. 1977, Peak 1985

Production: 27 200 tonnes/day, 2 shifts/day (about 7 million tonnes/year)

Strip ratio: 2 overburden:1 coal, 2 seams, 30 m overburden

Equipment Used

	Number
Overburden Removal	
Dragline	1
Overburden Drill	1
Dozers	2
Coal Extraction	
Shovels	2
Front End Loaders	2
Hauling	
Trucks	12

Coal Loading

Tipple: Characteristics not available.

Blasting: Information not available.

Haulroad: Information not available.

Storage: 100% indoor storage.

Waste: Overburden is levelled and revegetated.

Associated Development: None.

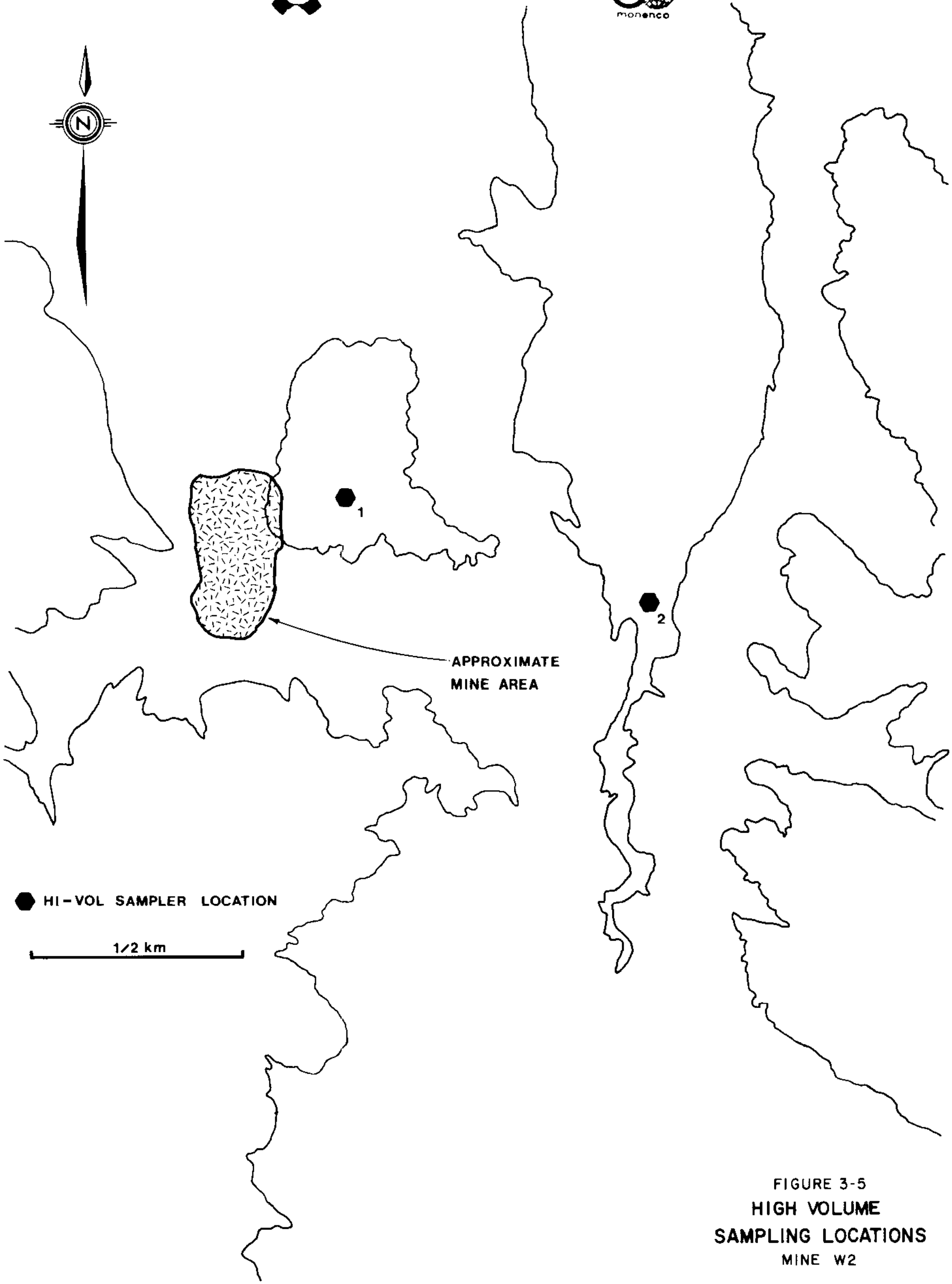

FIGURE 3-5
HIGH VOLUME
SAMPLING LOCATIONS
MINE W2

TABLE 3-10

Coal Mine High Volume Sample Data Summary - Mine W2

Monthly Arithmetic Means and Annual Geometric Means

$\mu g/m^3$

Station No.	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	Annual	No. of Samples
	(1975)													
1	14	11	15	18	11	25	37	32	38	17	14	15	16	65
2	-	-	-	28	39	34	52	39	72	36	26	9	30	37
	(1976)													
1	13	11	13	18	25	30	48	57	50	64	48	59	27	62
2	13	15	26	18	40	37	35	78	139	83	93	220	41	56
	(1977)													
1	50	10	51	64	67	62	67	28	59	32	46	46	38	57
2	23	21	40	42	74	38	55	20	69	25	46	46	32	59
	(1978)													
1	68	37	119	112	45	43							51	22
2	29	19	24	39	21	35							24	27

TABLE 3-11

Mine W3 Data Sheet
(Site Not Visited)

Operational Details

Type of Mining: Thermal coal

Method of Mining: Strip, 1 seam

Production: 10,000 tonnes/day 3 shifts/day (about 2.5 million tonnes/year)

Strip Ratio: .28 - 4.28 overburden:1 coal

Equipment Used

	Number
Overburden Removal	
Stripping Shovel	1
Dozers	2
OB Drill	1
Coal Extraction	
Loading Shovel	1
Front End Loader	1
Hauling	
Trucks	6

Coal Loading

Tipple: Characteristics not available.

Blasting: Information not available.

Haulroad: Information not available.

Storage: 4 silos, 11 000 tonnes capacity each.

Waste: Overburden is levelled and revegetated.

Associated Development: Crushing plant.

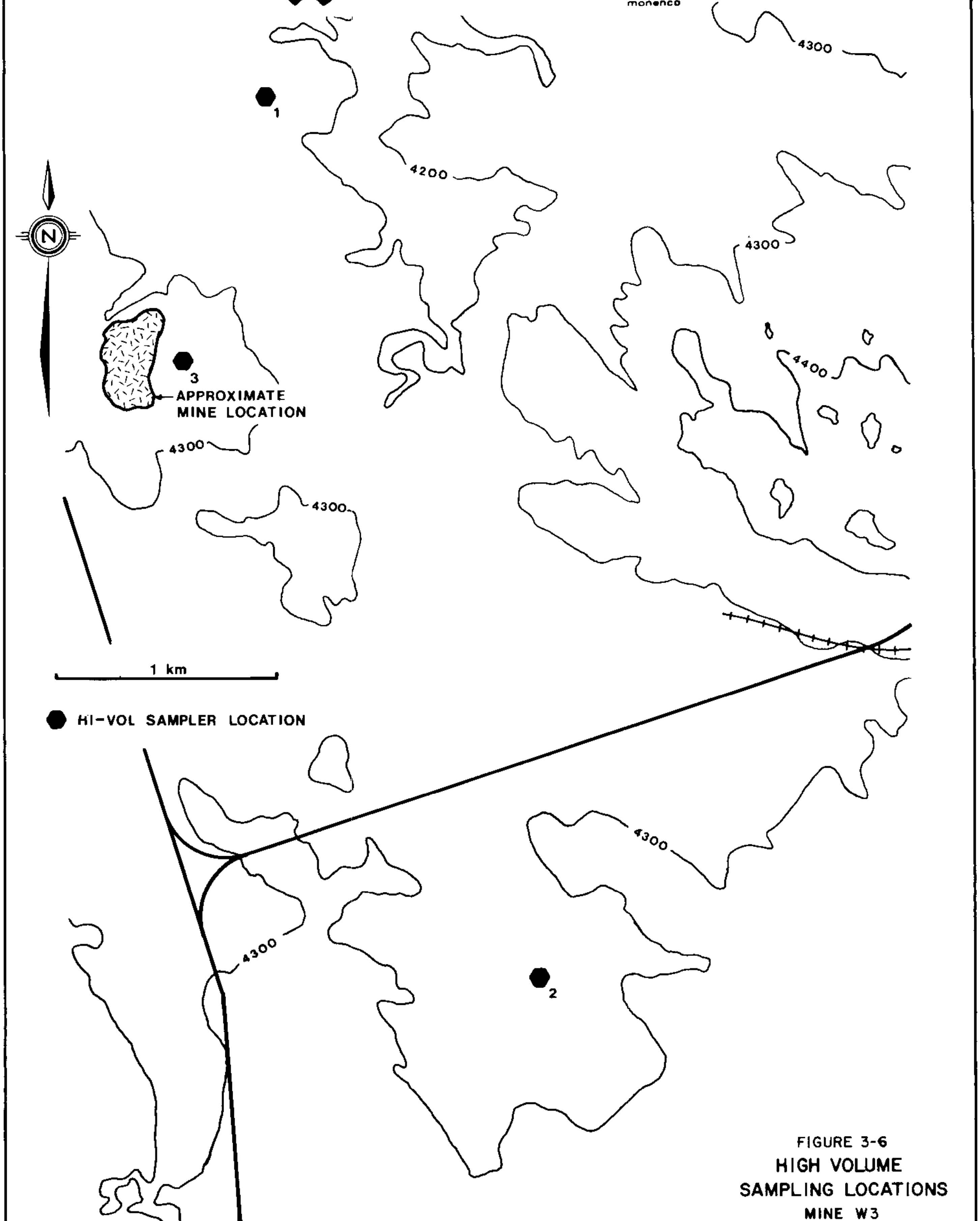

FIGURE 3-6
HIGH VOLUME
SAMPLING LOCATIONS
MINE W3

TABLE 3-12

Coal Mine High Volume Sample Data Summary - Mine W3

Monthly Arithmetic Means and Annual Geometric Means

$\mu g/m^3$

Station No.	JULY (1976)	AUG	SEP	OCT	NOV	DEC	JAN (1977)	FEB	MAR	APR	MAY	JUNE	DEC	Annual	No. of Samples
1	36	40	34	25	41	20	6	21	23	21	55	35		22	65
2	34	32	31	29	40	13	10	21	28	17	45	81		21	67
	(1977)						(1978)								
1	35	18	51	40	12	15	41	30	34	-	29	41		25	48
2	38	28	41	30	11	17	22	17	23	-	16	41		21	50
3	51	28	51	25	17	20	21	12	29	-	23	32		23	48

323 BRITISH COLUMBIA MINES SURVEYED

323.1 Mine BCl

As shown on Figure 3-7, this mine is located in a mountainous area near the intersection of three valleys. The open pit coal mining area, located at about 1800 m above sea level, is about 600 m above the valley floor. Bedrock is exposed over much of the mining area with glacial tills occurring in isolated pockets. Coal bearing strata are exposed along the valley walls. The floors of valleys and the north facing valley walls are heavily treed. Shrubs, forbs and grasses are found at all elevations, particularly on the south facing slopes which are sparcely treed.

323.11 Climate The average annual precipitation in the region of mine BCl is 1080 mm. Precipitation in the form of rainfall is heaviest in the spring and fall. The average annual wind speed is about 4.2 km/hr, with gusts up to about 50 km/hr. Wind direction in the region varies considerably. Channelling of winds along the length of the valley is quite noticeable while the diurnal temperature variation causes upslope and downslope winds to occur. The mean yearly temperature in the area is 4.5°C, with a yearly range from about -18°C to 25°C.

323.12 Mine Data As indicated in Table 3-13, the open pit operations at Mine BCl produce approximately 7.3 million tonnes of metallurgical coal per year for export markets. Overburden is blasted and removed by shovels while coal is broken by dozers and loaded onto trucks with loaders. The coal is hauled to a breaker plant from where it is transported via a conveyor, enclosed silos and then to a preparation plant. From the preparation plant coal is transferred by conveyors to enclosed silos at the load-out area and then loaded into trains by means of a tipple system. Overburden removed from the pits is either stockpiled adjacent to the pits or placed in abandoned pits.

Part of the coal taken from the mine BCl is transported by truck to a stockpile area near a second preparation plant (see Figure 3-7). The stockpile area covers about 1 ha and handles about 10 000 tonnes per week. After cleaning in the preparation plant, this coal is fired in coke ovens. The metallurgical coke product is sold to the base metal smelting industry in B.C. and the coke oven off-gases used to generate on-site steam.

Dust control measures at mine BCl include the enclosed storage of both raw and clean coal in the main preparation plant area, enclosed conveying of coal, the spraying of latex binder on piles sitting idle for long periods of time and the watering of haul roads.

323.13 Monitoring Results High volume data has been collected at mine BCl for the past two years at the 8 locations shown on Figure 3-7. The monthly arithmetic means and annual geometric means are shown on Table 3-14 (1977 data) and Table 3-15 (1978 data). Samples were taken 4 times per

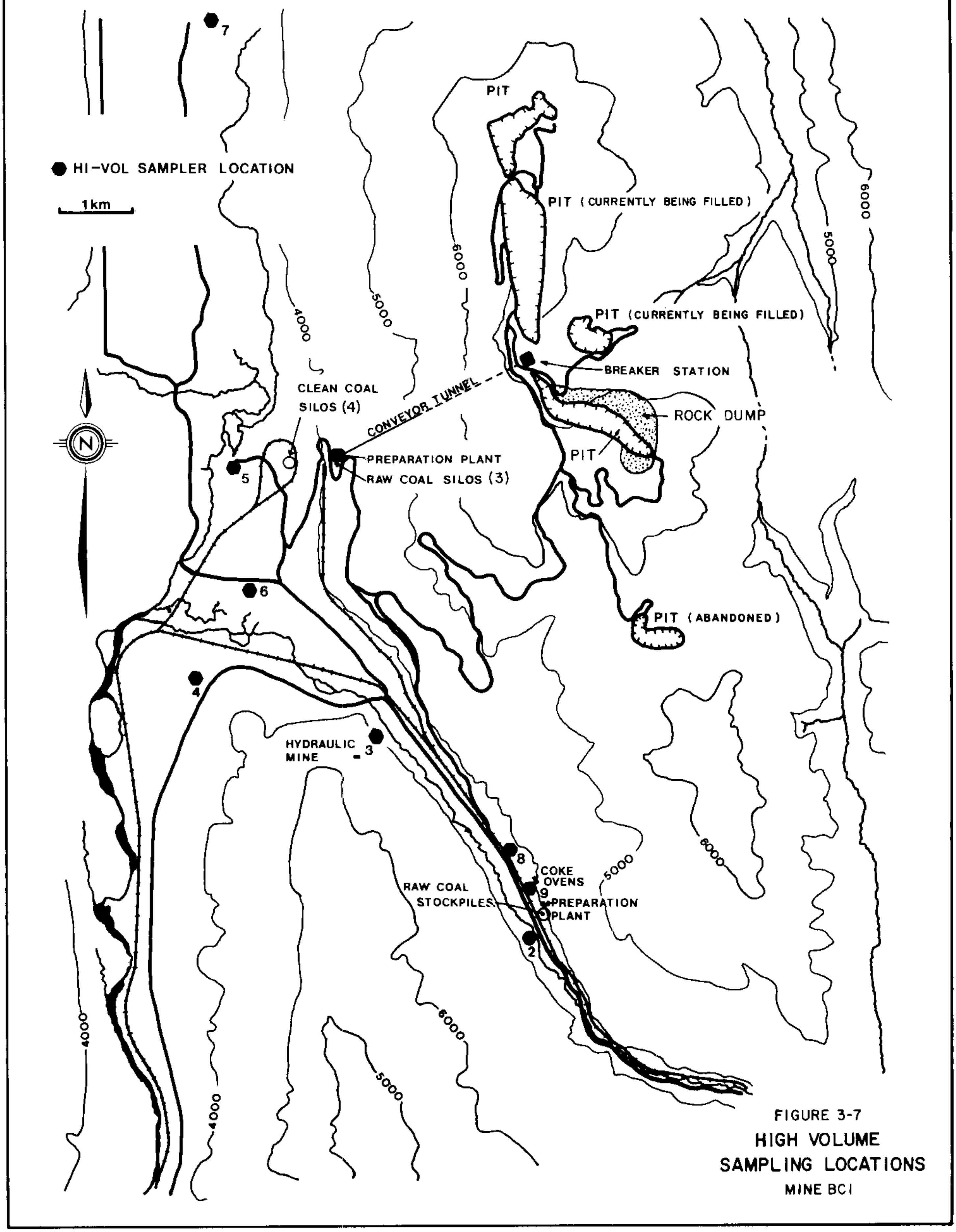

FIGURE 3-7
HIGH VOLUME
SAMPLING LOCATIONS
MINE BCI

TABLE 3-13

Mine BC1 Data Sheet
(Site Visited Nov. 30, 1978)

Operational Details

Type of Mining: Metallurgical coal - 15.24 m seam

Method of Mining: Open pit (4 pits)

Coal use: Export

Production: 7.26 million raw tonnes/year

Strip Ratio: 4.17 bank m^3 rock:1 tonne coal

Equipment Used

	Size	Number	
Overburden Removal			
Shovels:	2800 P&H 19 m^3	4	
	2100 P&H 11.5 m^3	4	
	Marion 6 m^3	1	
Coal Extraction			
Dozers:			
track		23	
rubber		5	
Loaders	D600 Dart 15.3 m^3	4	
	992 Caterpillar	1	
Hauling (to raw coal stock pile)			
Terex Titon	317 tonne	1	(Experimentation)
Electra Haul	181 tonne	22	(Rock)
Electra Haul	91 tonne	28	(Coal)
Wabco	32 tonne	3	(Coal)
Cat 769	32 tonne	1	(Coal)

Coal Loading (for export)

Tipple - Characteristics unavailable

TABLE 3-13 (Cont'd)

Blasting

9 drills - 1981 m/day total drilling. 17.4 m deep 31 cm diameter holes 2 blasts/week. Average blast nets 350,000 yd^3 rock, 181,400 kg/explosives coal is dozed not blasted.

Haulroad:	Shale and S.S. surface 57 m wide, 9.6 miles total length. Rock hauling distances average less than 1 mile 1 way.
Storage:	Clean coal - 4/13,605 tonne silos. Raw coal to breaker station - underground conveyor system - then to coal prep. plant raw coal silos.
Waste:	4,535 tonnes waste tailings/day from prep. plant rock waste is stockpiled near active pits or placed in abandoned pits.

Associated Development: Coal preparation plant.

TABLE 3-14

Coal Mine High Volume Sample Data Summary - Mine BC1

Monthly Arithmetic Means and Annual Geometric Means

$\mu g/m^3$

Station No.	JAN (1977)	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	Annual	No. of Samples*
2	332	269	109	249	115	323	151	78	83	82	145	115	118	194
3	88	95	146	72	139	82	63	62	95	95	69	55	70	194
4	27	120	116	138	47	113	57	64	69	90	108	37	58	196
5	26	24	21	77	36	66	21	19	24	23	33	22	22	196
6	46	59	61	125	56	90	47	65	67	81	78	47	51	191
7	13	25	6	18	11	20	7	9	10	10	7	2	8	129
8	-	-	258	528	252	305	208	211	180	301	181	171	221	160
9	-	-	2334	1417	818	1039	489	237	401	742	453	355	589	163

* Samples were taken 4 times a week

TABLE 3-15

Coal Mine High Volume Sample Data Summary - Mine BC1

Monthly Arithmetic Means and Annual Geometric Means

$\mu g/m^3$

Station No.	JAN (1978)	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	Annual	No. of Samples*
2	118	107	71	124	86	228	143	134	68	115	90	166
3	71	103	72	101	75	177	122	100	104	102	82	165
4	46	67	129	120	53	97	63	55	55	63	57	163
5	18	33	41	39	22	82	48	46	29	41	29	163
6	33	57	61	87	46	135	68	65	59	71	48	164
7	STATION TAKEN OUT OF SERVICE											
8	220	381	328	399	250	583	298	307	218	392	241	166
9	457	850	985	979	738	1282	966	910	539	862	566	164

* Samples were taken 4 times a week

week in most cases. As noted in Table 3-15 monitoring at station 7 which is about 4-5 km from the mining operations was discontinued in 1978, presumably because of the very low particulate levels measured in 1977. The annual geometric mean of 8 $\mu g/m^3$ measures at station 7 essentially reflects background conditions.

Stations 2,8 and 9 are located in the region of coke ovens and their associated preparation plant and close to the coal haul road and the raw coal stockpiles. The results on Tables 3-14 and 3-15 show that all three stations are very dusty (particularly station nine) and exceed a monthly atmospheric particulate level of 150 $\mu g/m^3$ for most months and an annual geometric mean of 60 $\mu g/m^3$ for both years for which data was collected. Given the location of these three stations and the predominant movement of the winds down the valley in the day and up the valley at night, one would anticipate that the particulate levels would be high. The extremely high levels measured at station 9 indicated that the outdoor coal storage area and the coke oven emissions are large sources of TSP.

Station 3 is located near the underground hydraulic mining area and about 4 km up the valley from the coke ovens and preparation plant. Measurements of particulate levels at station 3 are in excess of an annual geometric mean of 60 $\mu g/m^3$, however, a mean monthly value of 150 $\mu g/m^3$ was exceeded in only one month over the last two years. Particulate levels measured at stations 4, 5 and 6 do not exceed the above mentioned monthly and annual means. The lowest values measured were at station 5 which is located about 0.5 km from the coal load-out area.

323.2 Mine BC2

The second coal mine in British Columbia that was visited, mine BC2 is located about 50 km north of mine BC1. Very little monitoring data was available for this mine and hence only a brief summary is given here. A layout of this operation is given in Figure 3-8.

323.21 Mine Data As noted in Table 3-16, mine BC2 produces about 3.0 million tonnes/year of metallurgical coal recovered from draglining and open pit methods essentially cutting into mountain faces. The coal seams are parallel to the valley floor in horizontal plains. Raw coal is trucked from the pits to a crushing plant from where it is conveyed to a stacker/ reclaimer unit and loaded out into the raw coal storage area. The capacity of this storage area is about 400 000 tonnes in four piles although practice to date has been such that only about 100 000 tonnes of coal is in this storage area at any one time. Coal reclaimed from the raw storage area is fed by conveyor to a coal preparation plant from where it is conveyed to an enclosed cathedral storage area with a capacity of about 50 000 tonnes. One end of the clean coal storage building is open. Clean coal produced in excess of the cathedral storage capacity is stored outside. Dozers are used to push this material into the building. Coal is reclaimed from the cathedral by an underground conveyor system and loaded onto a 500 tonne surge bin from where it is loaded onto unit trains.

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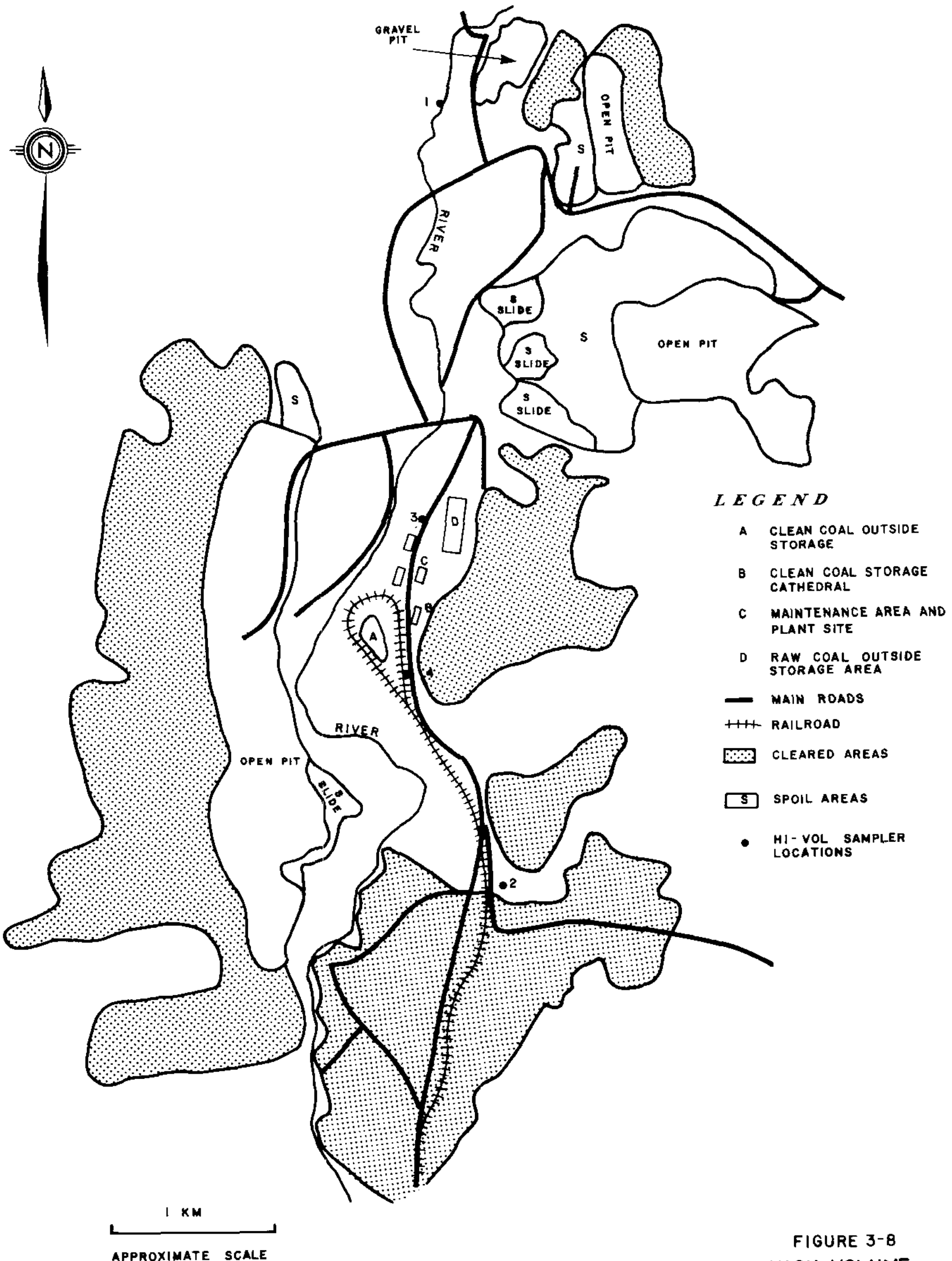

FIGURE 3-8
HIGH VOLUME
SAMPLING LOCATIONS
MINE BC 2

TABLE 3-16

Mine BC2 Data Sheet
(Site Visited Nov. 30, 1978)

Operational Details

Type of Mining: Metallurgical coal

Method of Mining: Open pit (2)

Production: 3.17 million tonnes/year

Coal Use: Export

Strip Ratio: ten seams 1.5 - 9.1 m thick

Equipment Used

	Size	Number
Overburden Removal		
Electra Dragline	46 m^3	1
Coal Extraction		
Front End Loader		
Mechanical Shovels		
Hauling		
Truck (Rock)	170 ton	-
Trucks (Coal)	109 tonne/154 tonne	31

Coal Loading (Export)

Tipple - Characteristics not available

Blasting

12.2 m benches exposing 3 or 4 seams
Open west end. fill by conveyor, catwork.

Haulroad: Information not available.

Storage: Partially covered clean coal storage, 36,280 tonnes cap. 1 outdoor clean coal storage pad. 1 outdoor raw coal storage pile.

Waste: Fine and coarse plant waste into tailings ponds.

Associated Development: Coal preparation plant.

Dust control measures at mine BC2 in addition to the provision of covered clean coal storage include the treating of haul roads and mine service areas with waste oil or water as required and the spraying of an ashpalt emulsion binder on the filled coal cars.

323.22 Monitoring Program Three high volume samplers were located in the region of the preparation and maintenance areas at mine BC2 (see Figure 3-8). The main reason for their location was to gain some information on losses from the excess clean coal stockpile area. Monitoring was carried out only for two months at one location and for three months at two locations, as shown on Table 3-17. In most cases the values exceeded a mean monthly value of 150 $\mu g/m^3$ which is not surprising given the location of the samplers. The main contribution to localized atmospheric particulate levels is expected to be that portion of the clean coal stockpile that is stored outside. The limited data available and the lack of stations located further from the mining operation does not allow one to determine the potential regional impact of fugitive dust emissions from BC2 in regard to particulate levels.

324 OTHER MINES

A number of inquiries were made at several other coal and base metal mines in Western Canada in regard to dustfall and high volume data. These mines included:

British Columbia

- two large open pit copper mines (mines BC3 and BC4);
- one large open pit molybdenum - copper mine (mine BC5).

Alberta

- one large open pit metallurgical coal mine with a preparation plant (mine A1);
- a combination open pit/underground metallurgical coal mine and its preparation plant (mine A2).

None of these sites were visited for the purposes of this study. Study questionnaires were filled in through telephone conversations with personnel at the various mines. Dustfall data was obtained for both the above-mentioned coal mines in Alberta and is presented in the Appendices.

No dustfall monitoring is being carried out at any of the three B.C. base metal mines surveyed.

325 GENERAL COMPARISON OF RESULTS

Table 3-18 presents a summary comparison of the data obtained for each of the mines surveyed. As noted, the coal mines surveyed range in size from 2.3 million tonnes per year to 12.1 million tonnes per year.

TABLE 3-17

Coal Mine High Volume Sample Data Summary - Mine BC2

Monthly Arithmetic Means and Annual Geometric Means

$\mu g/m^3$

Station No.	JULY (1978)	AUG	SEP	OCT	NOV	Annual	No. of Samples
A	-	-	152	135	102	106	13
C	187	383	248	-	-	247	29
D	423	637	-	-	-	448	4

TABLE 3-18
Comparison of Mine Data

Mine	Type & Method of Mining	Associated Development	Production	Strip Ratio	Major Mining Loading Equip.	Major Hauling Equip.	Haul Road Length	Storage Type [4]	Mine Waste Disposal	Mean Yearly Precip.	Mean Daily Wind Speed	Mean Temp.	Distance from Development	Annual Geometric Mean TSP Values [3]
			million tonne/year	waste: product	#	#	km			mm	km/hr	°C	km	ug/m3
Montana														
[1]M1	COAL/STRIP	POWER PLANT	8.2	4:1	6	13	1.6	0 / *	NONE	372	12.4 W	4	2 - from load out (6 from mine) 4 - from load out (7 from mine) 5 - from load out (6 from mine)	57 50 21
[1]M2	COAL/STRIP	NONE	2.3	8:1	6	5	ND	100 / *	NONE	277	12.4 W	4	2 - from load out and mine 1½ - from load out along rail-line	30 45
[1]M3	COAL/STRIP	OPEN PIT MINE	9.4	ND	4	10	ND	13 *	NONE	405	4.3 Various	5.4	1½ - from load out (2 from mine) 2 - from load out (2½ from mine) 3½ - from load out and mine	25 15 17
Wyoming														
W1	COAL/STRIP	CRUSHING PLANT	12.1	.42-4.28 :1	14	36	ND	ND	NONE	ND	ND	ND	0.5 - from mine and load out 1½ - from mine, 1 from load out	60 30
W2	COAL/STRIP	NONE	7.7	2:1	8	12	ND	ND	ND	ND	ND	ND	0.25 - from mine 1 - from mine	30 31
W3	COAL/STRIP	CRUSHING PLANT	2.7	.28-4.28 :1	6	6	ND	ND	ND	ND	ND	ND	1 - from mine 2½ - from mine	22
B.C.														
[1]BC1	MET. COAL/ OPEN PIT	PREP. PLANT	7.3	4.6 BANK M^3:1	14	50	9.6	ND / 100	ROCK DUMP TAILINGS POND	1080	14.7 ND	4.5	1 - from load out 2 - from load out	22 51
[1]BC2	MET. COAL/ OPEN PIT	PREP. PLANT	3.2	ND	5	31	ND	ND / 75	ND	ND	ND	ND	very limited data	(See Table 3-17)
[2]BC3	COPPER OPEN PIT	NONE	ORE 6.3 WASTE 19	3:1	5	19	8	ND	FREE DUMP	345	ND	ND	ND	ND
[2]BC4	COPPER OPEN PIT	SMELTER	ORE/WASTE 17.7	ND	4	11	4.8	0 / 100	ND	ND	ND	ND	ND	ND
[2]BC5	COPPER, MOLY OPEN PIT	SMELTER	ORE 15.9	2.1 :1	7+	34	14.4	0 / ND	FREE DUMP	345	ND	ND	ND	ND
Hat Creek	COAL/ OPEN PIT	THERMAL POWER PLANT	10	1.3:1	7+	27 (in pit)	1	0 / *	AREA WASTE DUMP	375	11 W	3.2	ND	ND

[1] Indicates sites visited

[2] Indicates no hi-vol data available

[3] Average annual geometric mean of measure of TSP levels

ND - Indicates no data

* Indicates not applicable

[4] % cover of raw/clean coal storage area

Most of the mines were strip mining operations and a few were open pit operations. In general, the following conclusions can be drawn:

- coal load-out and stockpile areas were the largest contributors to suspended particulate levels;
- measured particulate levels do not appear to be a function of mine size (i.e., larger mines are not necessarily dustier). In addition, no trend of a decrease in particulate levels with an increase in precipitation in the region of the mine was apparent;
- suspended particulate levels decreased with distance from the mining operations. In most cases levels within a few kilometers of the mine were less than a 24-hour value of 150 $\mu g/m^3$ and an annual geometric mean of 60 $\mu g/m^3$ and in many cases these values were met within 1 km from the development. Violations of the above values occurred within close proximity to the mine and coal handling and loading facilities;
- measures to control dust emissions included:
  - frequent watering of haul roads during frost free periods (surface binding agents and waste oil also used at some mines to control haul and service road dust),
  - enclosed storage of clean coal,
  - enclosed coal crushing house and conveyor belts,
  - housed coal dumping stations,
  - spraying of long-term outdoor storage piles,
  - progressive reclamation of mined areas.

3.3 SURVEY OF SPECIFIC COAL STOCKPILE AREAS

Because coal stockpile areas proved to be a major source of dust in the mines surveyed in Section 3.2 and because of the potential for dust generation at the large coal blending area proposed for Hat Creek, several coal stockpile/handling sites were surveyed to determine the type and success of specific schemes designed to control dust from the coal piles.

331 STOCKPILE S1

331.1 Description of Site

This site is a large coal/coke bulk shipping terminal on the southwest coast of British Columbia. As shown in Figure 3-9 the site is on a manmade island about 4 km from the shoreline to which it is connected by a causeway. The site covers about 20 ha on which the average quantity of coal stored is about 800 000 tonnes with the maximum storage quantity being about 1.0 million tonnes. The coal handled at this terminal, most of which

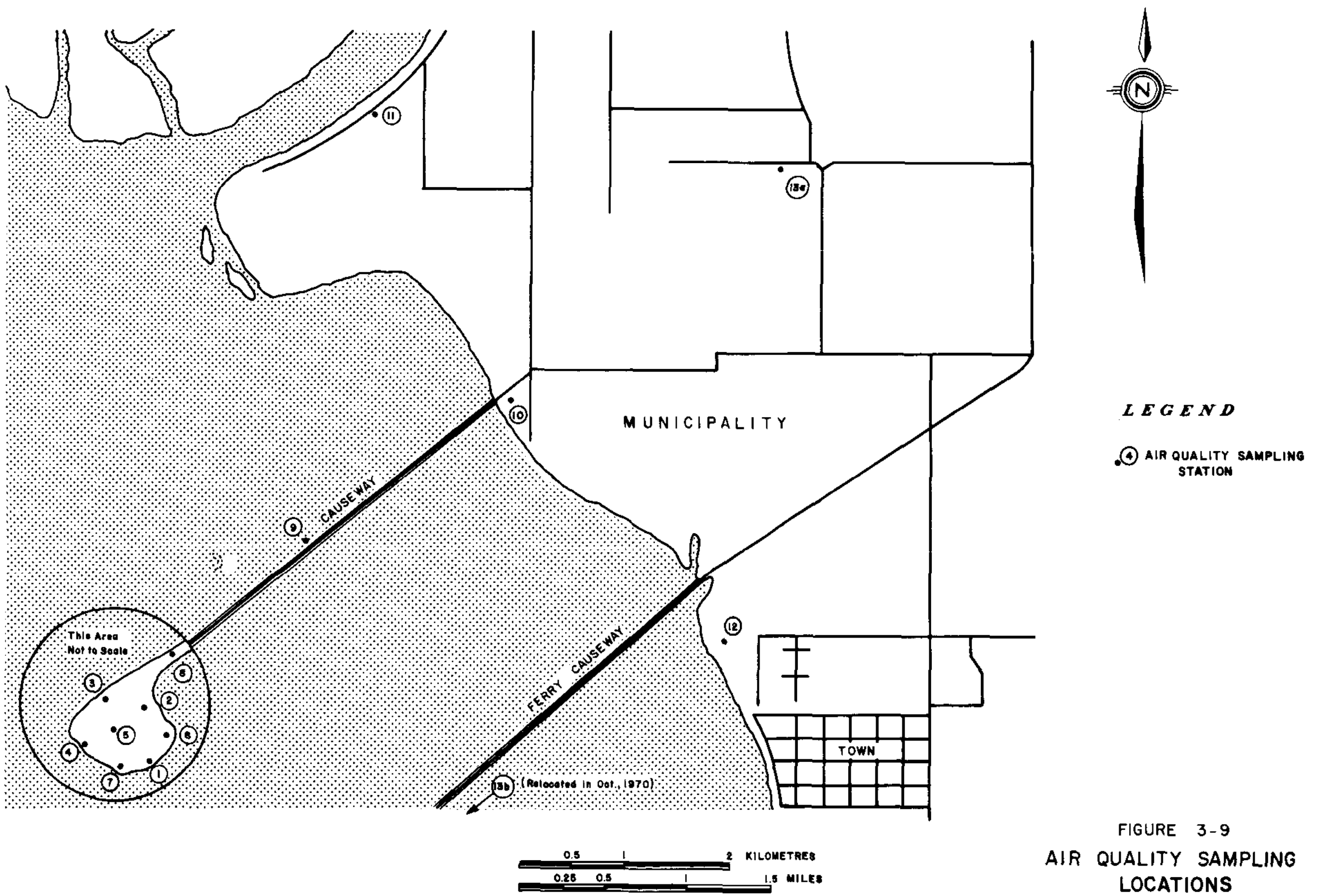

FIGURE 3-9
AIR QUALITY SAMPLING
LOCATIONS
STOCKPILE S-1

is metallurgical coal, is loaded onto ships throughout the year for export markets. The peak periods are six weeks in August and September and a similar period at year end. The peak load-out rate is about 800 000 tonnes per month and the average rate is about 650 000 tonnes per month.

The coal is piled in one of six conical stockpiles by means of a boom stacker and reclaimed by a rail-mounted bucket wheel reclaimer. Each pile is about 25 m high and 70 m in diameter at the base. The turnover time for coal at the site varies from 2 weeks up to as long as a year. The free moisture content of the coal is about 7-8% and the particle size distribution is such that about 30-35% is less than 60 mesh (250 μm).

331.2 Climate

The terminal region receives an average of 1003 mm of rainfall ranging from a low of 29 mm in July to a high of 149 mm in December. In addition the mean yearly snowfall of 517 mm falls from November to March. Measurable precipitation falls on an average of 161 days per year. The frost-free period lasts about 208 days each year. The mean annual daily temperature is 9.8°C. The hottest month of the year is July with an average temperature of 17.4°C and the coldest month is January with a mean temperature of 2.4°C. The average wind speed is about 12 km/hr with a monthly range from about 10.5 to 13 km/hr and a maximum hourly wind of about 88 km/hr.

331.3 Fugitive Dust Evaluation

There are three major sources of dust at the terminal site. The dumper house where the coal is dumped from the unit trains, the ship loading area and the working face of the stockpiles. Wind erosion of the piles also causes dust generation. Dust control measures at the site include the use of water sprays in the summer as required and the use of a latex binder sprayed from a truck into those piles for which the turnover is expected to be slow.

A study was conducted in 1970 to determine the potential impact of coal dust on the surrounding area including the impact on the aquatic environment. A summary of the results of the study is given below.

The locations of the dustfall collectors are shown in Figure 3-9. The results of the dustfall survey indicate that coal dust generated at the site was not air-borne to the mainland about 5 km or so from the storage terminal. There was some evidence of coal dust reaching a Ferry terminal located about 2.5 km from the site; however, total dustfall in November and December 1970 amounted to 5.6 and 14.6 tonnes/km^2/mo respectively of which 0.71 and 2.4 tonnes/km^2/mo were coal dust. Suspended particulate measurements were also made at the Ferry Terminal during selected 24-hour periods over the period March 1971 and January 1972. The levels were in the range of 25-50 μg/m^3 with the coal dust in the TSP samples making up from 0 to 20% and most values less than 10%. The conclusions of this study was that coal blown from the storage terminal was not contributing to impaired air quality in adjacent areas. It was further concluded that at distances of 1.0 to 1.5 km from the site of dust generation, dustfall and suspended particulates related to the terminal operations were essentially zero. The results of this evaluation indicate that stockpile dust control measures are successful.

332 STOCKPILE S2

This coal stockpile area is located at and feeds one of Ontario Hydro's thermal plants. Coal is transported to the site by ship through the Great Lakes during the 8½ month open water season. Coal is not transported to the site during the freeze-up period.

332.1 Description of Site

Figure 3-10 presents a layout of this site. The stockpile area is large enough to accommodate about 4.5 million tonnes of western Canadian and eastern United States coal. Such a large stockpile area is required since the plant does not receive coal during the winter months which is its heavy load period. Coal is unloaded from ships at the dock hopper at a maximum rate of 5450 tonnes/hr. From the dock hopper, coal is conveyed to a transfer house by two covered conveyors from where it can be delivered to the bunker house or to two stacker-reclaimers for stockpiling. Each unit stockpiles coal on one of two piles, either side of the conveyor. From the stacker-reclaimer coal piles, coal is moved to one of two main coal piles by scrapers which unload onto the main piles through a bottom dump. After scraper unloading, the surface of the main coal pile is smoothed and compacted by dozer and sprayed with water by a water truck. The coal is reclaimed from the main coal pile by a bucket wheel reclaimer and conveyed to the crushing plant and then to a silo blending operation before it goes to the power plant.

The stockpile area is located less than 1 km from a number of cottages, the first of which is located about 600 m from the piles as shown on Figure 3-10. Fugitive dust from the stockpile area had been the cause of a number of complaints by the cottage owners and the utility had paid compensation for damages (cleanup and repainting). Dustfall measurements were below the Ontario ambient air quality criteria, however, over 90% of the samples were coal dust.

332.2 Fugitive Dust

As a result of the situation, the utility conducted a number of evaluations which concluded that the major sources of dust generation were the dock hopper during ship unloading; the movement of rubber tired vehicles on the piles or along haul roads; the stacker-reclaimer coal piles during stockpiling and reclaiming operations; the main coal pile when the scrapers

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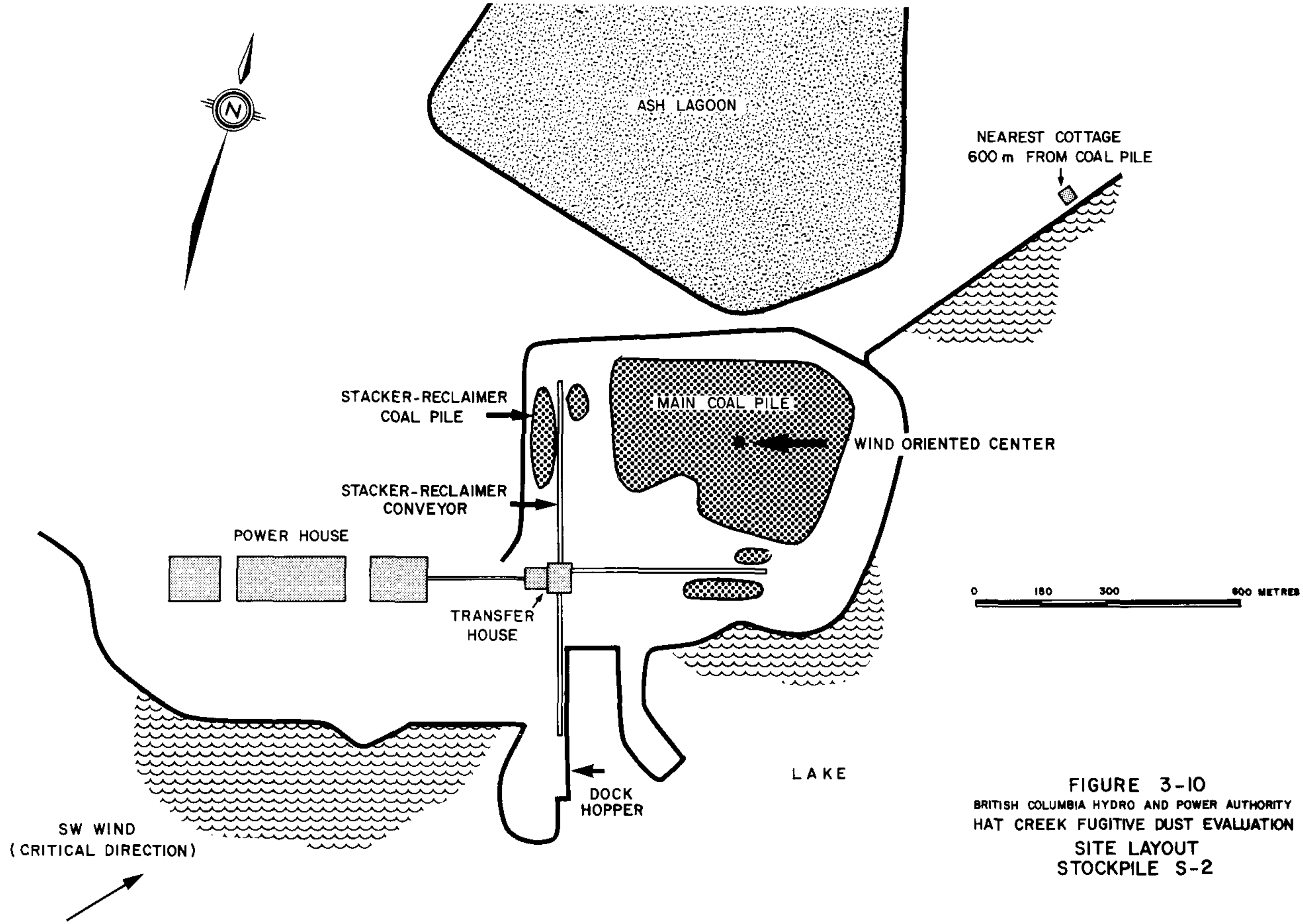


FIGURE 3-10
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK FUGITIVE DUST EVALUATION
SITE LAYOUT
STOCKPILE S-2

unload; the haul roads and ramps; and the sides and leading edges of coal piles during dry and windy conditions. The study also determined that wind erosion of the sides of the coal pile resulted in significant coal dust losses with winds in the range of 10-30 km/hr. The utility also commissioned wind tunnel and water flume studies by an independent consulting firm. These latter studies determined the areas that were subject to high wind erosion, evaluated a number of alternative arrangements for the coal piles in the stockpile area and made a number of recommendations for control of dust from the stockpile area.

Dust control measures resulting from the above studies were instituted at the time of modifying the stockpile to accept western Canadian coal in addition to the coal traditionally received from the United States. A second main pile was required (in addition to load-out or surge piles adjacent to the stacker rails) in the stockpile area. The shape and orientation of the two piles was changed substantially from the previous one pile situation. The piles are now compacted to their edge and sealed with oil to prevent erosion. Previous experience had identified pile erosion as a significant cause of fugitive dust. Other control measures instituted include:

- contouring of the piles to reduce areas of high turbulence;
- increased dedication to watering haul roads and the coal piles. It is felt that if the free moisture content in the coal piles is maintained at about 8%, dusting will not be a problem. Water is used all year on the haul roads without adverse effects;
- relocating the location of the reclaim operation from a bowl in the centre of the stockpile area to the lee side of the pile with respect to the critical wind direction. This changed the reclaim operation from an exposed area to a protected area. The experience at this plant is that the handling of fresh moist coal does not result in significant dust generation compared to exposed surface areas;
- reduction in the free-fall distance during load-out.

The consultant recommended the use of a porous fence skid mounted in sections on the coal pile to help shield the reclaim and scraper dumping operations, but this was found to be very expensive and was not instituted.

The dust control measures at this site proved to be most successful. Since September 1977, no complaints have been received about fugitive coal dust. The utility has received letters of compliment from several cottages on their success in controlling dust from the stockpile area. The personnel at this site stress the fact that in order for dust control measures to be successful, a firm commitment must be made by all concerned. Their conclusion was that coal dust was not difficult to control.

333 STOCKPILE S3

This stockpile area services a large steelmaking operation on the shore of Lake Ontario.

333.1 Description of Site

The stockpile area covers about 40 ha and has a capacity of about 1 million tonnes of coal. Coal is transported to the site through the Great Lakes, unloaded from the ships, and stacked out in piles about 10 m high by a stacker. The coal is reclaimed from the piles by front end loaders and dumped into an underground conveyor system which feeds the plant. The free moisture content of the coal is about 6%.

A number of complaints had been registered for several years about coal dust blown from the piles by residents living downwind from the stockpile. The municipalities had also expressed serious concern over the fugitive dust situation.

333.2 Fugitive Dust Studies

Because of the fugitive dust problem, the industry commissioned a study of their stockpile area to determine measures to reduce wind erosion of the piles and eliminate high fugitive dust levels. The nature of these studies were similar to those conducted for stockpile S1 (Section 332) and included wind tunnel studies to determine the critical wind speed for the pickup of coal fines from the piles and water flume studies to identify the regions of high wind erosion and to evaluate the effectiveness of various mitigative measures.

One of the major recommendations of the study instituted, was to re-orientate the piles such that the wind from the critical wind direction (from the piles to the communities) blew along the length of piles and not at an angle to their length. With the critical wind blowing across the piles, a high turbulent zone was created between the piles, which resulted in significant wind erosion of the piles. In addition the study recommended that the piles be contoured more to reduce the localized generation of areas of high erosion. The use of a porous fence was also recommended on the windward side (with respect to the critical wind direction) of the stacking or reclaiming operations to act as a wind shield for these operations and hence reduce the pickup of dust. This fence was to be skid mounted in sections so that it could be moved as required.

In addition to these measures, the practice of spraying of the piles with water in the summer to help maintain the free moisture content of the surface layers of the piles and with oil in the winter to bind the pile surfaces was continued.

A test of the effectiveness of the study recommendations in controlling the aerodynamics around the pile to significantly reduce wind erosion, came during a major storm in January of 1978, in which winds gusted up to 160 km/hr. During this storm there was no evidence of wind erosion from the piles and no complaints about fugitive coal dust. The consultants that performed the studies were commended for their work in effectively eliminating the problem by the local municipalities.

334 STOCKPILE S4

This site is a coal handling terminal on the Great Lakes and is a trans-shipment point for western coals used in thermal plants in Ontario. The site was opened in the summer of 1978 and is presently being expanded.

334.1 Description of Site

The 236 acre site is located on an island about 0.4 km from the shoreline. The site presently handles about 1.3 million tonnes of coal per year. The ultimate handling capacity of this site will be 4.5 million tonnes per year. At the present time about 550 000 tonnes of coal are stored at the terminal, however, the ultimate storage capacity is about 1.3 million tonnes of coal to offset the fact that the Great Lakes are open for only 8½ months of the year. The coal arrives at the site by unit train and is offloaded by an automatic rotating dumper onto a conveyor feeding a boom stacker. The stacker is track mounted and loads out onto one pile which is about 76 m wide, 366 m long and 9 m high. At full capacity the site will consist of 2 piles developed to 18 m in height. From the stockpile area coal is reclaimed, using bucket wheel reclaimer, into a surge bin from where it is loaded onto ships at the rate of about 540 tonnes per hour. Present facilities at the terminal can handle ships up to 730 feet long but expansion is planned to accommodate vessels up to 1000 feet in length. The entire site is surrounded by an embankment which is about 4.5 m high and on top of which is the access rail line.

334.2 Dust Control Measures

The dust control measures at this terminal were developed in close association with the regulatory officials. To control dust in the dumping shed, the entire dumper has been housed in a self-contained dust shroud which collects dust generated from the dumping operation by drawing air at the rate of about 4 m^3/min through a filter and discharging it to the atmosphere. The conveyor moving coal to the stacker loadout operation is enclosed. Dust control on the pile is effected by means of a semi-automatic water sprinkling system. Water is supplied to the series of sprinklers through a dedicated underground main. The sprinkler system is such that the pile is sprayed according to a pre-set timetable.

Runoff from the pile is collected in settling ponds and reused in the sprinkler system. A water truck is used to wet other areas not equipped with sprinklers. During the winter, a 30% solution of calcium chloride is sprayed onto the pile which binds their surfaces. This solution freezes at about -35°C.

The terminal has only been in operation since July 1978. Further operating experience is needed before the overall success of the dust control measures can be evaluated. To date, the dust control measures have been successful in meeting the standards.

335 OTHER STOCKPILE AREAS

Table 3-19 presents a summary of the results of the survey of several other coal stockpile areas in western Canada and in western United States. Besides basic site data, control measures used to control dust from the various stockpiles are given in Table 3-19. Most of the stockpile areas provide coal storage for on site power production. The size of the live stockpile areas varies up to 500 000 tonnes while the dead storage piles vary in size up to 2 million tonnes.

As noted, stockpile dusting was reported not being a problem at several of the stockpile sites represented in Table 3-19. Since stockpile area layouts relative to the layout of the facilities were not available, an evaluation could not be made of aerodynamic control factors at the sites. Although it would appear that dusting was not a problem for those sites whose coal had a moisture content greater than about 20% no information was available in the free moisture content of the coal piles. From a dust control point of view, the critical factor is the free moisture of the coal and in particular the free moisture of the surficial layers of the coal pile.

336 CONCLUSIONS

Based on the survey of coal stockpile areas the following conclusions can be made:

- coal stockpiles are potentially significant sources of dust, particularly when the free moisture content of the coal is less than about 6-8% (S2). Sites for which the coal moisture content was between 25-35% did not report any dust problems. The breakdown of moisture contents into combined free moisture contributions was not available, however, and hence no quantitative conclusions can be drawn in regard to moisture content;

- the stockpile operations with the greatest potential for dust generation are the loading out operations and the movement of vehicles on the piles;

TABLE 3-19

Data Summary of Stockpiles S5-S11

Stockpile	Location	Usage and Total Yearly Consumption	Stockpile Capacity: Live Storage	Stockpile Capacity: Dead Storage	Turnover Rate: Live	Turnover Rate: Dead	Coal Characteristics: Type	Coal Characteristics: Moisture Content	Equipment: Stack	Equipment: Reclaim	Dust Control Measures	Comments
		Tonnes/Year	Tonnes	Tonnes	Tonnes/ Year	Tonnes/ Year		%				
S5	Saskatchewan	On Site Power Plant - 500,000	None	50,000	-	-	Lignite	25-30	-	-	Ocassional Water spray	Dust no problem because most of required coal received direct from mine
S6	Saskatchewan	On Site Power Plant - 400,000 to 750,000	400,000 (Seasonal)	None	200,000	-	Sub-bituminous	25	Conveyors (Mine to stockpile)	Underground conveyor	Enclosed conveyor to stock pile equipped with dust vacuum system	Dust no problem
S7	Saskatchewan	On Site Power Plant - 5,000,000	None	1,000,000	-	360,000	Lignite	30-35	Stacker	Bucket Wheels & Trucks	None	Dust is no problem because required coal is received directly from mine
S8	Wyoming	On Site Power Plant - 5,000,000	120,000	750,000	500,000	None	Sub-bituminous	12-24	Stacker and telescopic shute	Bottom reclaimer	- telescopic shute - bottom reclaimer - water spray with surface binder	Dust was a problem, control measures have reduced it to meet regulatory limits
S9	Washington	On Site Power Plant - 5,000,000	80,000	2,000,000	2,600,000	1,000,000	Sub-bituminous 'C'	30	Conveyor Stacker	Bucket wheel reclaimer	None	Dust is no problem - Coal is received and reclaimed moist
S10	North Dakota	4 Power Plants within 60 km - 4,000,000	50,000	1,600,000	4,000,000	None	Lignite	38	Lowering Valves and scrapers	Bulldozers and scrapers	Johnsons Marsh System and dust collectors	Dust is a problem but under control
S11	Arizona	On Site Power Plant - 1,000,000	500,000	500,000	1,000,000	None	Sub-bituminous	10	Conveyor belts and belly dump trucks	Front-end loaders and trucks	None Tumble weed has grown on dead pile	Dust is no problem

- design measures for the control of coal dust from stockpile areas include the spraying of water on active piles during the frost free period (oil or a low freezing temperature binding solution during the frozen period), the use of binding agents on inactive piles to seal surface layers, the use of a telescopic chute to minimize the free fall distance during the stacker load-out operation, and enclosing operations such as coal crushing and conveying;

- control of stockpile wind erosion and fugitive dust levels can be effected by measures that exercise some influence over the aerodynamics around the piles. These measures which can be successfully retrofitted to existing stockpiles or designed into new facilities, include: orienting piles so that the minimum projected area is presented to the critical wind direction, developing a wind break embankment or porous fence on the windward side to the critical winds for the overall area or for specific operations, reduce highly turbulent zones by pile contouring, protecting leading edges of the piles, and the planting of trees and other vegetation to act as natural wind breaks;

- through a combination of physical control measures and aerodynamic control factors, dust can be controlled from coal stockpile areas to meet regulated standards at least within 1 km from the stockpile area as indicated specifically by experience at stockpiles S1 and S2.

SECTION FOUR

FUGITIVE DUST AT HAT CREEK

SECTION FOUR

FUGITIVE DUST AT HAT CREEK

CONTENTS

CONTENTS (Cont'd)

LIST OF TABLES

CONTENTS (Cont'd)

Page

LIST OF FIGURES

Figure

4.1 INTRODUCTION

This part of the report presents a summary of the development of the Hat Creek mine; the background studies conducted to date in the study area; a comparison of the basis for the ERT calculations with the more recent CMJV mine plan; recommendations to control dust at the pre-production and production stages of the mine; and anticipated dust levels at Hat Creek based on a probability analysis of wind speeds and directions and on the survey results. Additional updated information is now available which has a significant impact on the anticipated fugitive dust levels but which was not generated in time for use by ERT. Noticeable in this regard are the results of the bulk sampling program.

4.2 BACKGROUND STUDIES

B.C. Hydro undertook a bulk sampling program at the Hat Creek coal deposit during the summer of 1977. The program included the excavation of two trenches, processing of part of the extracted coal and shipment of same to the Battle River generating station in Alberta for a comprehensive series of combustion tests. Part of this program was to monitor various environmental parameters during the excavation period (water quality, air quality and noise) and to initiate a preliminary reclamation program. The prime purpose of the reclamation program was to separate and characterize various waste materials as they were excavated and to establish revegetation plots on the materials, at various slope angles, for future reclamation planning.

In 1974 B.C. Hydro established a network of eight mechanical stations in the Hat Creek Valley to monitor surface wind speed and direction on an hourly basis. Besides gathering basic wind data these stations were located so as to reflect the effects of terrain on the distribution of winds in the project area.

The results of these background programs and their implications to the fugitive dust question at Hat Creek are summarized where applicable in this section of the report. Further details of the bulk sampling program are given in the Bulk Sample Program Report, Acres (1977).

421 RECLAMATION TRIALS

The results of the reclamation program to date show vegetation can be readily established on most waste materials within one growing season. On surficial materials such as gravel and till, revegetation has been demonstrated on slopes up to 30°. Carbonaceous materials present greater difficulties and would require a surface treatment. Clayey, sandstone or bentonitic material can be revegetated but with less success than surficial materials partly because of their tendency, upon weathering, to form a hard surface crust.

The success of the reclamation trials indicate that revegetation of waste materials will readily and effectively eliminate wind erosion and dust generation of gravel and tills. The tendency of the clayey sandstone and bentonitic materials to form a hard surface crust will significantly reduce their susceptibility to wind erosion even without a vegetative cover.

422 NATURE OF WASTE MATERIALS

In addition to the sodicity of waste materials excavated from the pit as indicated above, the mine wastes are high in moisture content. A significant percentage of the mine waste is comprised of clayey materials which will have a high, in-situ moisture content and will remain at field capacity within the dumps for extended periods of time (Acres 1977). Geotechnically, the waste dumps are viewed as saturated at all times. In addition, it is presently proposed to dispose of a percentage of mine waste water by spray evaporation on portions of the Houth Meadows waste dump. This will serve to maintain soil moisture on inactive areas at high levels.

The nature of the mine wastes, indicates that the waste dump areas will only be minor sources of fugitive dust at Hat Creek. Progressive reclamation will eliminate the waste areas as dust sources.

Experience gained during the topsoil stripping and pit excavation operations during the bulk sampling program indicated the topsoil material in the project area to be very friable and subject to wind erosion during dry, windy periods. This result identifies the topsoil stripping operation as one of the more critical ones in terms of potential dust generation that will probably require on site mitigation.

Table 4-1 presents a summary of the particle size distribution of the raw coal before and after crushing. Of concern from a fugitive dust viewpoint is, of course, the percentage of fines which can be taken as the fraction less than 0.6 mm. The percent of fines increases with subsequent coal crushing and handling from 5% at the mine breaker, to 11% as delivered to the blending area, and to 15% as delivered to the thermal plant. Compaction increases the percentage of fines to about 25%. The 15% fines in the blending area is considerably less than at stockpiles S1 and S2 (see Part Three).

The field program indicated that handling of the carbonaceous material during pit excavation resulted in localized dusting during dry, windy periods from which one would conclude that control measures will be necessary to control dust in the region of coal handling facilities. Water spraying on access roads and in trench areas was used during the excavation to control dust.

TABLE 4-1

Size Distribution of Raw Coal Before and After Crushing

	Raw Coal from Mine Breaker	Fresh Raw Coal Crushed to 50mm	As Delivered to Thermal Plant	After Storage*
Effective top size (mm)	200	50	50	50
Size (mm)		% by weight		
+50mm	15	-	-	-
50 - 25	18	13	10	7
25 - 13	26	19	16	15
13 - 6	15	18	17	16
6 - 3	10	15	15	15
3 - 1.5	7	10	13	10
1.5 - 0.6	4	14	14	12
0.6 - 0 (fines)	5	11	15	25
TOTAL	100	100	100	100

* Compacted piles at thermal plant

SOURCE: CMJV (1978)

423 DUST MONITORING

A series of six high-volume samplers were installed to monitor suspended particulate concentrations on an ongoing basis in the project area prior to the bulk sampling program. Based on the results collected during the bulk sample program (spring and summer of 1977) it was concluded (Acres, 1977) that, in general, localized dusting became a problem in and around the Trench A workings during periods of dry, windy weather. The topsoil material and the carbonaceous material were most susceptible to dusting under these conditions. Except under very windy conditions, dust emissions were contained to the immediate trench area. The location of the sampling sites are indicated on Figure 2-1, Section Two.

Based on the fact that no change in ambient suspended particulate levels, outside the immediate areas of activity, were attributable to the excavation operations, the dustfall values presented in Tables 4-2 and 4-3 reflect background conditions. The TSP results for 1977 and 1978 were very similar even though no major activity was carried out during 1978.

424 WIND CHARACTERISTICS

The data from the eight mechanical wind stations indicate that the terrain exerts a significant influence on the distribution of winds in the project area. The predominant circulations are drainage winds along the valleys which result in marked differences in the wind patterns at the eight stations. This latter fact is shown in the ERT report (based on one year of data). Large differences in wind characteristics were observed for stations separated by only a few kilometers.

Wind data for the three year period (1974-1977) were analyzed for two wind stations closest to the project, station 2 and station 4 (for location see Figure 4-2).

A summary of the wind data for these two stations is presented in Table 4-4 in terms of percentage frequency of occurrence distributed on an eight point compass and wind speed (five ranges including calm). The most predominant winds at station 2 are associated with south and southwest direction and occur about 33.5 percent of the time. Calm conditions were recorded for 21.4 percent of the time. The most predominant winds at station 4 were from south and southeast direction and occur about 51.4 percent of the time. Calm conditions at station 4 occur for 8.3 percent of the time.

TABLE 4-2

Ambient Air Quality Monitoring
24-hour Suspended Particulate Concentrations (Hi-Volume Sampler) in $\mu g/m^3$
1977

Month		Station 1	Station 2	Station 3	Station 4	Station 6
April	13	*			6	
	19	10			6	
	25	28			32	
May	1	13			14	
	7	7			19	89
	12	9			11	
	13					*
	15		*	9		
	18	10	9	*	39	
	19					39
	22		21	13		
	25	8	11	11	9	*
	28		10	11		
	31	5	10	7	9	69
June	3		19	15		
	6	11	13	35	20	*
	9		*	78		
	12	16	57	22	21	*
	14					54
	15		41	24		
	18	21	58	19	20	56
	21		*	34		
	24	33	53	*	*	44
	27		*	36		
	30	*	*	26	12	*
July	1					93
	3		*	8		
	6	*	16	5	7	*
	9	7	13	13		
	12	4	9	*	4	103
	15	10	19	*		29
	18	6	62	*	7	*
	19					26
	21	15	131	*		*

Month		Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
July	24	13	36	*	22		52
	27	21	61	*			64
	30	8	17	*	19		17
Aug.	2	9	28	*			*
	5	16	43	*	20		*
	8	7	36	*			36
	11	25	49		16	27	60
	14	*	18	*			58
	17	*	77	*	36	20	72
	20	*	*	*			17
	23	*	*	*	17	12	*
	26	*	*	*			*
	29	3	8	*	4	4	*
Sept.	4	5	9	*	*	3	23
	10	*	*		*	10	33
	16	*	*	16	8	12	26
	22	*	10	9	3	3	23
	28	*	44	18	*	7	44
Oct.	5	16	*	39	*	13	51
	10	4		6		4	21
	16	7	32	*	5	6	33
	22	13	38	63	9	11	86
	28	12	*		*	1	64
Nov.	3	*	14	*	*	20	31
	9	*	*	*	*	*	*
	21	8	*		5	11	34
	27	6	*		3	7	23
Dec.	3	4	*		*	6	7
	9	8	*		7	14	*
	15	4	4		1	5	17
	21	10	5		4	6	22
	27	4	3		4	8	20
Total Number		52	54	46	42	23	50
Number of Valid Observations		38	36	23	33	22	35
Maximum 24-Hour Concentration		33	131	78	39	27	103
Geometric Mean Concentration		9.2	21	17.2	9.6	7.6	37.3

Blank = No Testing Done   * = Test Not Valid

TABLE 4-3

Ambient Air Quality Monitoring
24-Hour Suspended Particulate Concentrations (Hi-Volume Sampler) in $\mu g/m^3$

Month		Station 1	2	4	5	6	Month		Station 1	2	4	5	6
Jan.	2	4	4	2	4	*	June	1	14	26	71		
	8	5	*	6	14	18		7	20	39	58		67
	14	17	16	7	27	40		13	6	11	11		32
	20	9	7	3	7	*		19	12	26	16		
	26	8	3	2	4	25		25	14	14	13	22	55
Feb.	1	10	10	5	11		July	1	13	19	17	20	32
	7	5	3	2	5	16		7	19	29	21	20	58
	13	30	14	12	20	*		13	12	18	11	19	60
	19	8	7	3	7	41		19	14	33	14	15	
	25	8						25	18	59		19	77
								31	11	28		9	43
Mar.	3	13					Aug.	6	9	23		8	
	9							11	5	7		38	27
	15	7						18	7	11	5	5	
	21	5						24	6			7	9
	27	4						30	9	32	14	8	52
Apr.	2	5	9	9		25	Sept.	5	5	9	3	3	14
	8	8	17	8	8	58		11	6	9	2	6	50
	14	4	7	6		35		17	4	6	4	4	
	20	3	5	2		31		23	7	39		7	65
	26	10	25	10	12	96							
May	2	7	9	8	7								
	8	7	10	12		44							
	14	4	6	6		27							
	20	16	21	31		97							
	26	6	10	7		37							
Maximum 24-Hour Concentration									30	59	71	39	97
Annual Geometric Mean									8.5	13.9	8.2	10.5	43.7
Number of Observations									43	36	32	27	27

Blank = No Testing Done

* = Test Not Valid

TABLE 4-4

Wind Frequency Distribution at Station #2

Wind Speed Direction	Calm	2-5	6-11	12-19	>19	Total
			km/hr			
			Percent of Time			
NE	-	3.6	6.2	0.9	0.0	10.7
E	-	3.2	2.7	0.4	0.0	6.3
SE	-	2.8	0.7	0.1	0.0	3.6
S	-	11.4	3.1	1.0	0.0	15.5
SW	-	12.0	5.4	0.6	0.0	18.0
W	-	4.6	4.8	1.7	0.0	11.1
NW	-	1.7	5.7	4.1	0.3	11.8
N	-	0.9	0.6	0.1	0.0	1.6
Calm	21.4	-	-	-	-	-
Total	21.4	40.2	29.2	8.9	0.3	100.0

Wind Frequency Distribution at Station #4

Wind Speed Direction	Calm	2-5	6-11	12-19	>19	Total
			km/hr			
			Percent of Time			
NE	-	2.2	1.0	0.0	0.0	3.2
E	-	2.0	0.6	0.1	0.0	2.7
SE	-	18.3	11.4	0.6	0.1	30.4
S	-	8.2	9.1	3.2	0.5	21.0
SW	-	1.2	3.0	1.8	0.1	6.1
W	-	1.6	1.7	0.6	0.0	3.9
NW	-	4.7	6.4	1.4	0.3	12.8
N	-	4.5	5.8	1.3	0.0	11.6
Calm	8.3	-	-	-	-	3.8
Total	8.3	42.7	39.0	9.0	1.0	100.0

The critical wind speed in terms of wind erosion of exposed surfaces and the transport of dust emissions downwind has been taken as 11 km/hr for the Hat Creek study based on the results of the surveys presented in Part Three of this report and on the discussions with wind erosion consultants (Baker 1979, pers. comm.).

Figure 4-1 is a probability graph and shows average wind speed as a function of cumulative percentage frequency of occurence for both stations. Figure 4-1 indicates that the probability of occurrence of wind speeds greater than 11 km/hr from all directions at both stations is about 10% of the time. The effect of this distribution of wind speeds is noted by the fact that of the 33.5 percent of the time that winds were measured for the predominant directions of south and southwest at station 2, the wind speed was greater than 11 km/hr only 1.6 percent of the time.

4.3 CMJV MINE PLAN - SUMMARY

This section of the report presents a summary of the mine plan developed by CMJV for Hat Creek. The discussion of mine development is broken down into pre-production, production years 1-15, and production years 16-35. A summary of mining and coal handling equipment and methods is also presented. Figure 4-2 shows the CMJV arrangement of coal blending and stocking facility and general mine plan. Details of the CMJV mine plan can be found in the CMJV reports.

431 MINE DEVELOPMENT

431.1 Pre-Production

A number of pre-production or construction activities will take place at the site to prepare for coal production. The anticipated timing of the major activities during the period prior to coal production are summarized in Table 4-5. The activities that are the major potential sources of dust are the development of access roads and temporary construction facilities, the construction of the permanent mine facilities, top soil stripping in the pit and Houth Meadows areas and overburden removal. The results of the field studies indicate that the stripping operations are potentially the greatest source of fugitive dust because of the friable nature of the topsoil material as indicated in Section 4.2.

431.11 Support Facilities The site for support facilities will be prepared northeast of the open pit by cutting, filling and levelling a gently sloping hillside composed of glacial till and glaciofluvial sands and gravels (see Figure 4-2). An alternative arrangement of the support facilities relative to the coal blending area is given in Figure 4-3.

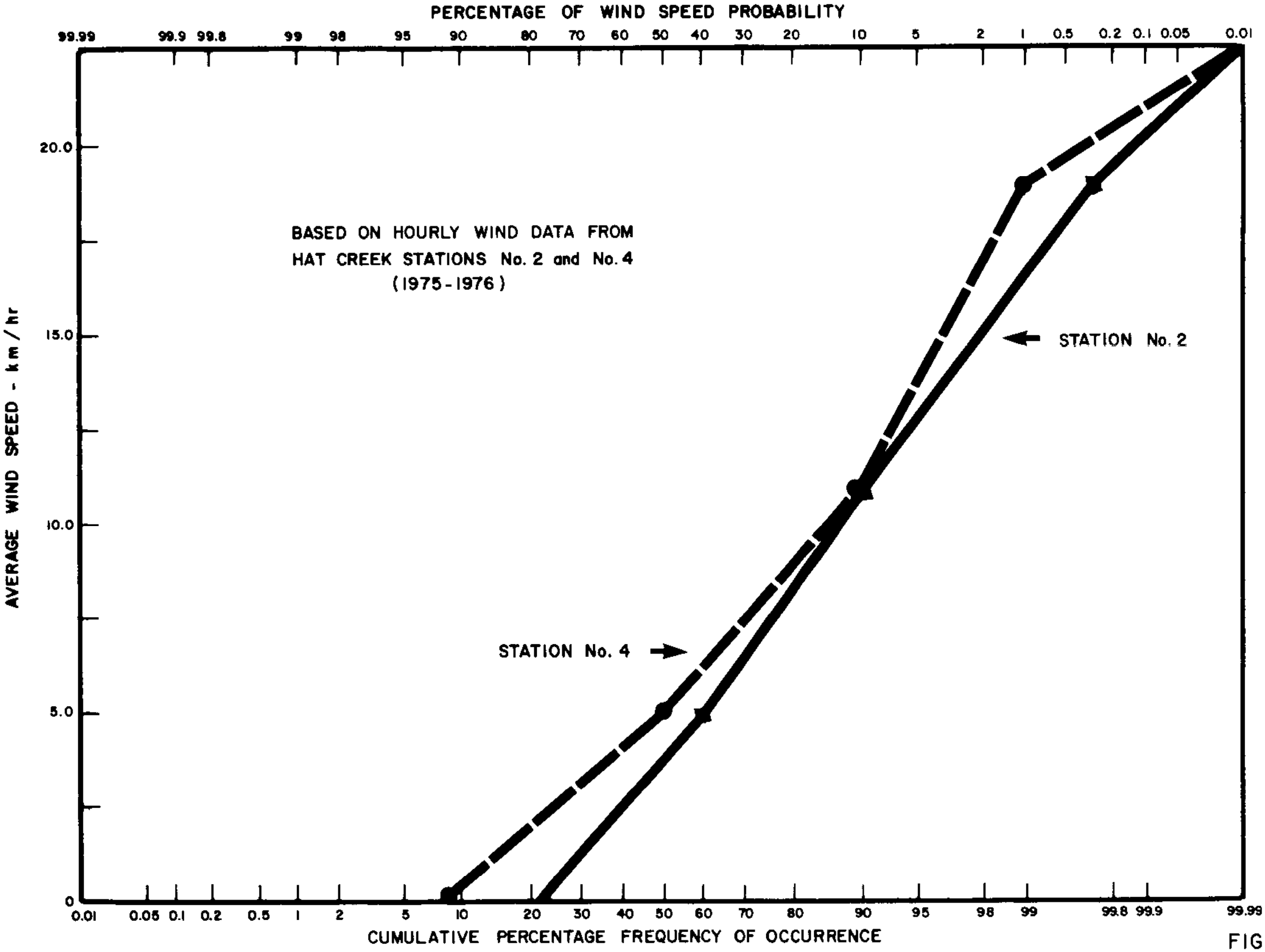


FIGURE 4-1
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK FUGITIVE DUST EVALUATION
WIND SPEED PROBABILITY

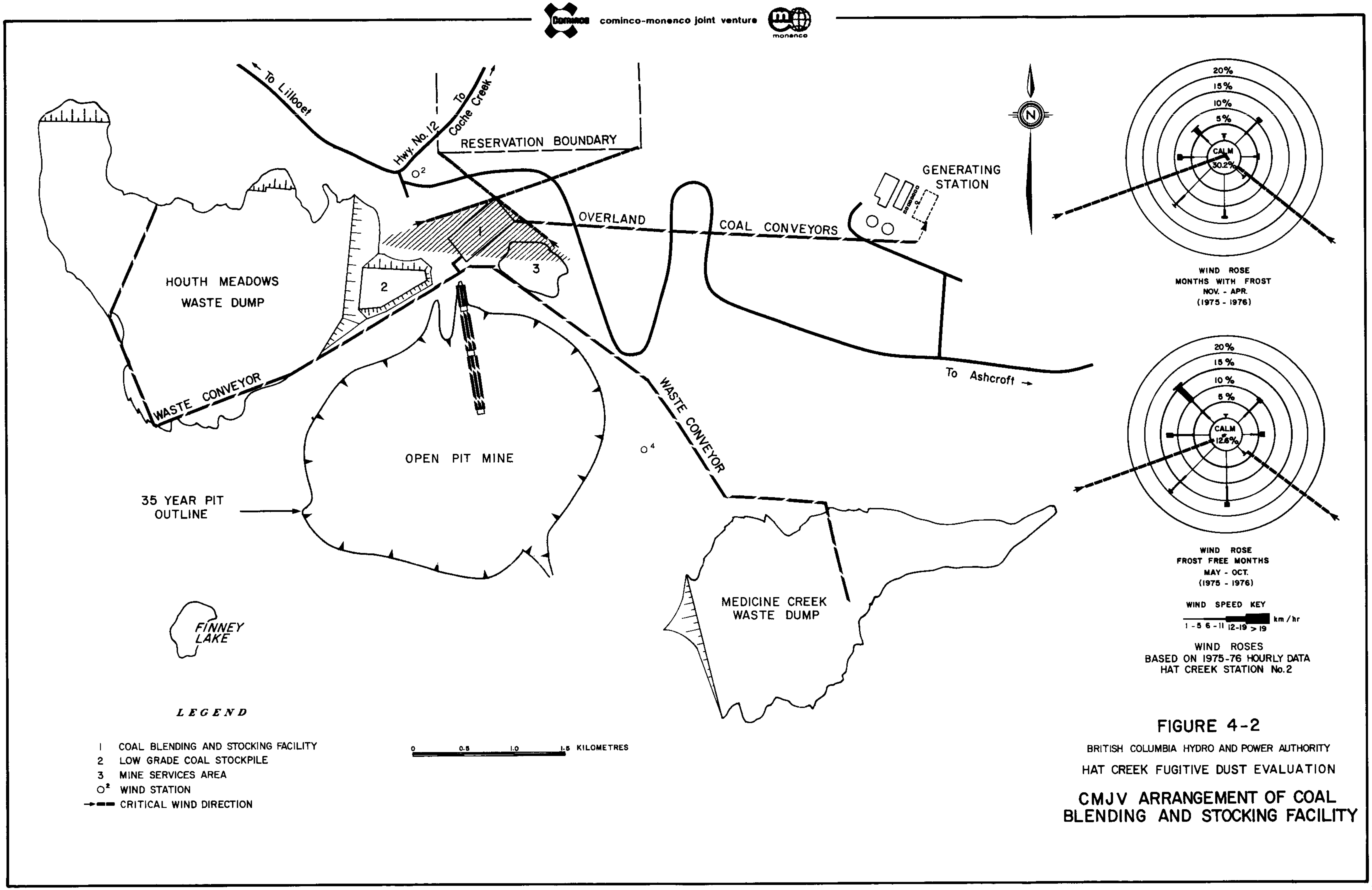


FIGURE 4-2

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK FUGITIVE DUST EVALUATION

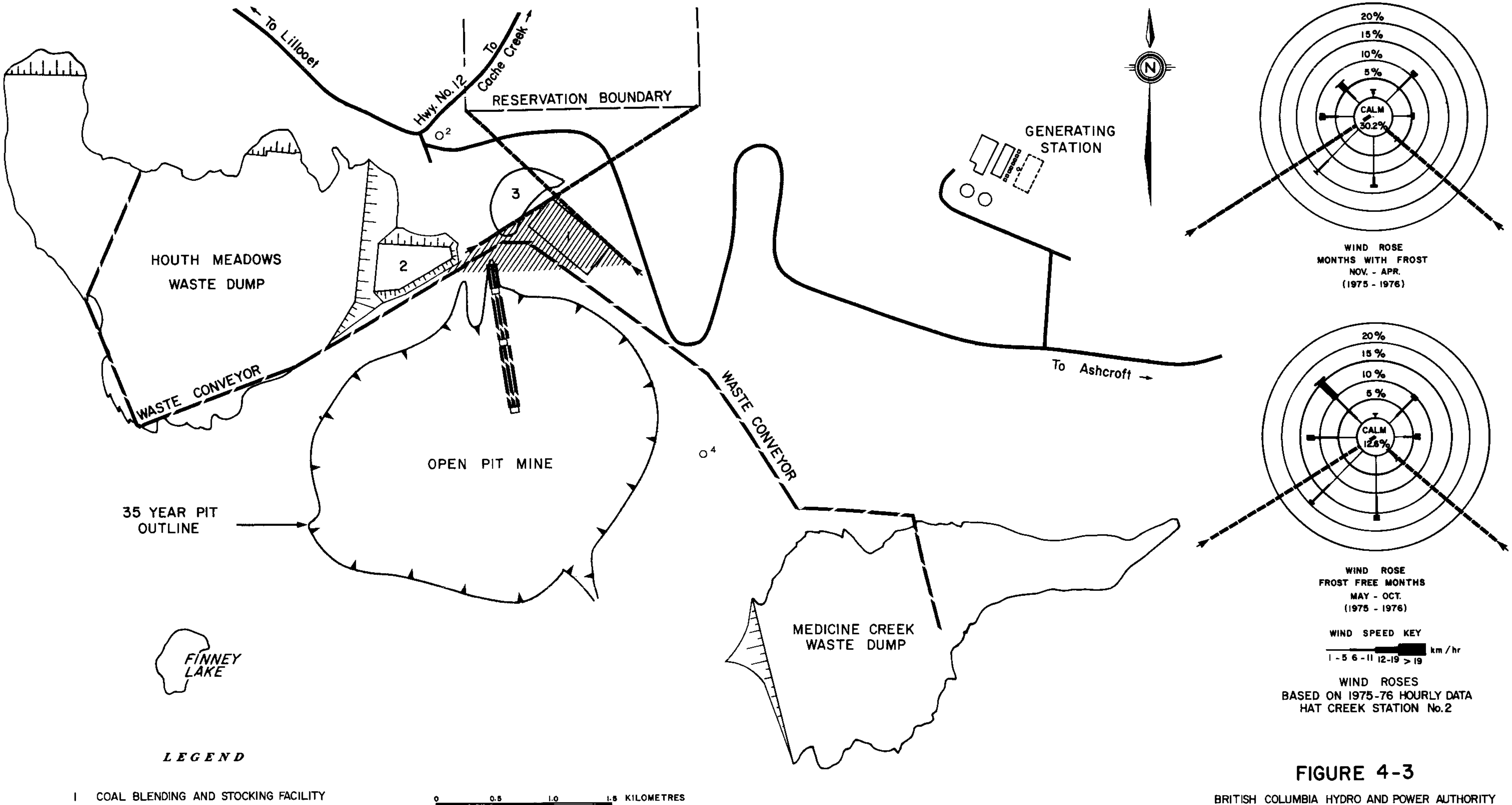
CMJV ARRANGEMENT OF COAL BLENDING AND STOCKING FACILITY

TABLE 4-5

Simplified Construction Schedule
Hat Creek Project Mining Feasibility Report 1978

Year	Quarter	Location	Activity
-5	second	open pit	development drilling
	third	open pit	slope depressurization
		service area	power supply
-4	second	service area	surface drainage systems
			water, sewer, and fire protection
			temporary construction facilities
		open pit	lake and surficials dewatering
	third	service area	construction of maintenance and warehouse facilities
-3	first	open pit	completion of Hat and Finney Creek diversion
	second	open pit	soil and overburden removal by scraper
			water treatment lagoons
			waste embankment construction
		service area	administration buildings
			mine dry and miscellaneous facilities
-2	second	open pit	overburden and waste removal by shovel
-1	second	open pit	coal production

cominco-monenco joint venture



LEGEND

1 COAL BLENDING AND STOCKING FACILITY
2 LOW GRADE COAL STOCKPILE
3 MINE SERVICES AREA
O² WIND STATION
CRITICAL WIND DIRECTION

FIGURE 4-3

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK FUGITIVE DUST EVALUATION

ALTERNATIVE ARRANGEMENT OF COAL BLENDING AND STOCKING FACILITY

Mine service facilities will include a maintenance building, office and administration buildings, mine changehouse, fuel storage and dispatch area, ancillary maintenance and service facilities, gatehouse and security control, sewage collection and treatment system, fire fighting equipment, and vehicle access and parking.

Roads will be constructed at a gradient 5° or less and will be bordered by suitably constructed ditches. Service roads will be surfaced with gravel and average 15 m in width. Haul roads, located mainly in the open pit, will be about 30 m wide and surfaced with burnt zone material (baked detrital rocks and burnt coal residue) or crushed rock. The road and ditch corridor around the pit perimeter will average about 20 m wide and be constructed through glacial till and glaciofluvial gravels.

Fire hydrants will be installed in the mine service area, coal stockpile and blending area, and the main pit conveyor incline, with two pumper units available to fight spot fires remote from the permanent water supply system.

Provision has been made for supply of sufficient water to irrigate approximately 2 ha of lawns and landscaped area near support facilities. To the south of the open pit, a reclamation nursery, approximately 10 ha in size, will be supplied with water from the Pit Rim Reservoir.

431.12 Conveyor Corridors Conveyor beds will be constructed in glacial tills and anchored in concrete where required. About 3 m of the level (10 m) bed surface will support the conveyor, the remaining area will consist of a service road. Conveyor corridors will vary in width up to 40 m depending on cut and fill requirements. The coal conveyors will be covered.

431.13 Pre-Stripping and Waste Disposal Surface soil and overburden removal by scraper will begin in the open pit and Houth Meadows starting in Year -3, after site clearing is completed. Waste removal by shovel will begin in Year -2 as indicated on Table 4-5.

During pre-production approximately 0.34 million bank cubic meters (BCM) of topsoil, 0.01 million BCM of low-grade coal, 0.30 million BCM of bedrock waste, 0.70 million BCM of coal, making up a total of about 20 million BCM of waste above bedrock will be excavated (see Table 4-6).

About 10 million BCM of construction material will be required for building the Houth Meadows conveyor causeway and pad, Hat Creek Valley fill, road construction, and Houth Meadows embankments. Houth Meadows will contain about 15 million BCM of disposed waste by the end of pre-production (see Table 4-7). The remaining waste material, about 5.1 million BCM, is used for construction of roads, conveyor causeway, pads and fill.

Initially, waste will be removed and hauled by 136 tonne truck to dump areas. As conveyors come on line, waste will be handled by a combination of conveyor and waste spreader. Pit development at Year -1 is to a level below the 850 m elevation with the pit covering an area of about 105 ha as shown in Figure 4-4.

TABLE 4-6

Simplified Materials Handling Schedule

(BCM x 10^6)

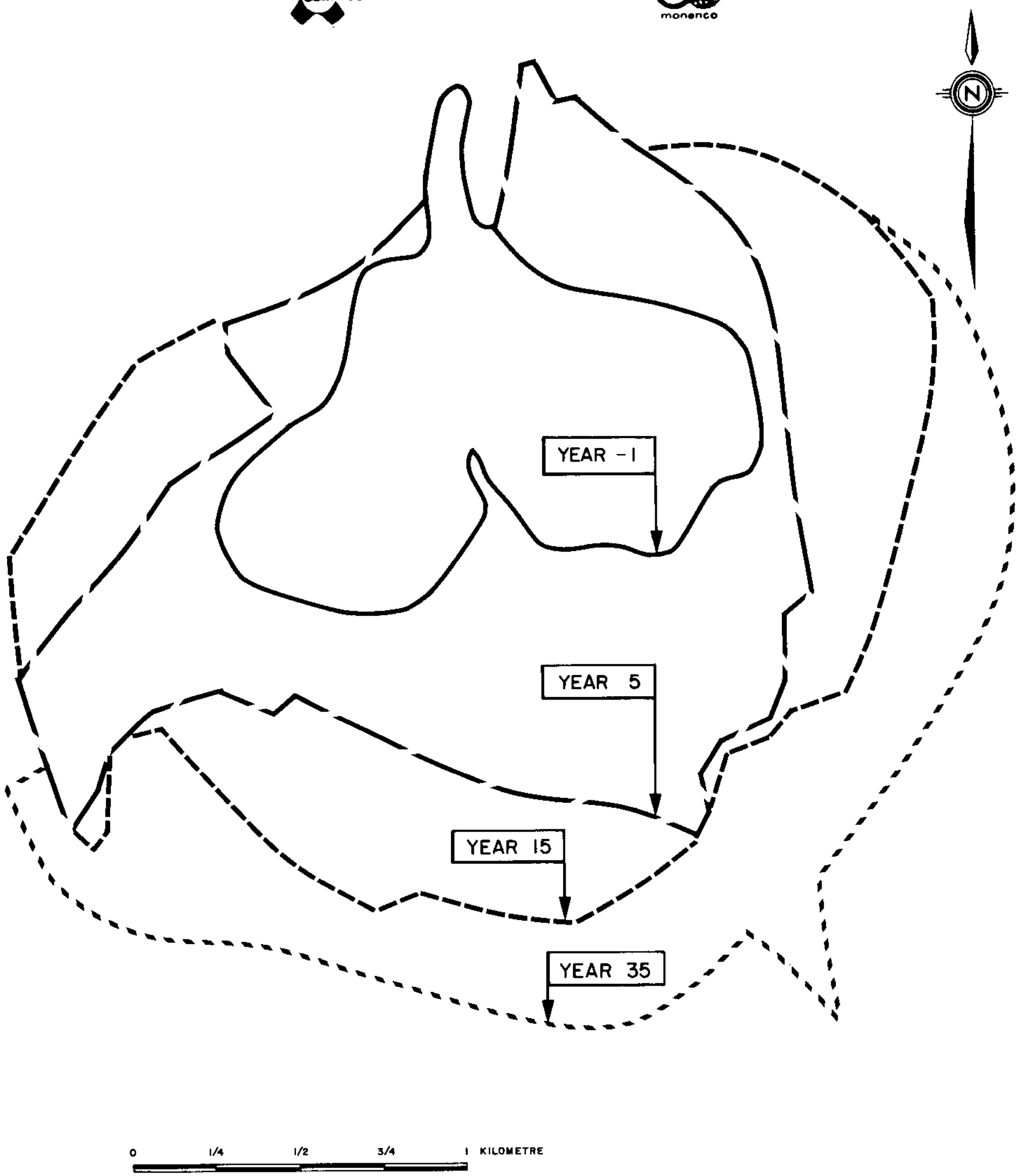
Destination	Pre-Production	Yrs.1-15	Yrs.16-35	Total
Thermal Plant (coal)	0.70	102.24	131.38	234.32
Low-grade coal stockpile	0.01	4.70	4.26	8.96
Houth Meadows waste dump	15.22	182.08	94.26	201.56
Medicine Creek waste dump	0.00	0.00	139.55	139.55
Other *	5.13	4.76	2.00	11.89
Total	21.06	293.78	371.45	686.28

* includes construction material used for conveyor causeway and pads, road construction, and fill.

TABLE 4-7

Simplified Production Schedule (BCM x 10^6)

Material	Pre-Prod.	Yrs. 1-15	Yrs. 16-35	Total
Coal	0.70	102.24	131.38	234.32
Low-grade coal	0.01	4.70	4.26	8.96
Bedrock waste	0.30	40.42	120.43	161.15
Waste above bedrock				
Pervious materials	11.70	102.84	68.46	183.00
Impervious materials	7.43	29.14	29.47	66.04
Hard pan/consolidated till	0.00	7.40	14.60	22.00
Burnt zone	0.58	6.44	2.35	9.37
Surface soil	0.34	0.60	0.50	1.44
Sub-total	20.05	146.42	115.38	281.85
Grand Total	21.06	293.78	371.45	686.28



END OF YEAR	ELEVATION (m)	ESTIMATED TOTAL AREA (ha)	ESTIMATED INCREMENTAL AREA (ha)
-1	850	105	105
5	805	327	222
15	730	506	179
35	640	606	100

FIGURE 4-4

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK FUGITIVE DUST EVALUATION

PIT DEVELOPMENT

Of the 0.34 million BCM of topsoil removed during the pre-production years, 0.26 million BCM is removed in Year -3. The quantity of topsoil stripped during subsequent years is evenly distributed at 0.04 million BCM until Year 20 and at 0.03 million BCM from Year 20 to Year 30 when topsoil stripping is completed. This distribution of topsoil removal in time indicates that considerably more effort will have to be expended in Year -3 to control dust generated from the topsoil removal operation than in any other year of the mine life.

431.2 Production Years 1-15

As shown in Figure 4-4, the open pit will be significantly developed in areal extent between Year -1 and Year 5 at which time the pit will cover an area of about 327 ha and be developed in depth below the 805 m elevation. During the ten year period between Years 5 to 15, the pit will be expanded areal extent by 179 ha and in depth to the 730 m elevation. The total area of the pit at year 15 will be about 506 ha.

The production of coal that is delivered to the plant builds up about 3 million tonnes in Year 1 to about 11.3 million tonnes in Year 5 after which time the production rate during Years 6 to 15 varies only slightly (11.32 to 11.4 million tonnes per year).

Table 4-6 shows that during the first 15 years of mine operation, production is estimated to be about 102.2 million BCM of coal, 14.7 million BCM of waste above bedrock. The latter includes 0.6 million BCM of topsoil removed at regular rate of 0.04 million BCM per year as noted previously.

During Years 1-15, the Houth Meadows waste dump will receive an estimated 182 million BCM as shown on Table 4-7. About 4.76 million BCM of waste material will be used for construction purposes during this period.

431.3 Production Years 16-35

During the Years 16-35, the pit will be developed to cover a total area of 606 ha as shown in Figure 4-4 and will be developed in depth to an elevation of about 640 m. The final surface perimeter is actually reached in Year 25 and the final depth reached in Year 32. The incremental size of the pit area at Year 35 compared to Year 15 is 100 ha. During this period, the following quantities will be produced (see Table 4-6): 131.4 million BCM of coal, 4.7 million BCM of low grade coal, 120.4 million BCM of bedrock waste and 115.4 BCM of waste above bedrock of which 0.5 million BCM is topsoil. In addition 94.6 million BCM of waste material will be disposed of in the Houth Meadows dump area and 139.6 million BCM to the Medicine Creek waste dump as noted in Table 4-7. Dumping waste material in the latter waste dump begins in Year 16. Construction requirements will account for about 2 million BCM during the period from Year 15 to Year 35.

432 EXTRACTION METHODS

Coal and waste will occasionally be blasted or dozer ripped as required before excavation by electric shovels and loading onto rear dump diesel-electric trucks. The trucks deliver the material to one of three in-pit transfer points for delivery out of the pit in one of three conveyors to a surface interchange. Coal of sufficient quality will be directed to a crushing plant (where it is reduced in nominal size from 200 mm to 50 mm) from where it is conveyed to a stockpile blending area. The coal is loaded-out and blended by the windrow method.

Low-grade coal will be conveyed to a small surge pile from where it is sent to a crusher, sized and transported by truck to a separate stockpile for possible future use. Waste materials excavated from the pit will be conveyed to either the Houth Meadows or Medicine Creek disposal area as described previously.

The mine plan permits experience to be gained with slope stability and pit design alterations before the pit gets too deep. This experience along with the development of flatter pit slopes during the early year of mining reduce the possibility of slope failure.

433 MINING EQUIPMENT

As mining progresses, the inventory of mining equipment will build up. The principal units of equipment are outlined in Table 4-8. The list is applicable to Year 17, one of several peak production years. Additional mine fleet requirements have been included to accommodate periodic increases in generating station-coal production requirements. A capacity factor for the generating station of 85% for periods of time up to five months was used as the basis for fleet requirements (CMJV, 1978).

434 COAL BLENDING

Because of the wide variation in coal quality from less than 4000 BTU/lb to about 10 000 BTU/lb in the Hat Creek No. 1 deposit, the coal will have to be blended to ensure some consistency in the quality of coal delivered to the thermal plant. The target average colorific value is estimated to be about 7327 BTU/lb (dry basis) and ranging from 7000 BTU/lb to 7800 BTU/lb.

Of the two methods for blending coal, windrow and chevron, the windrow method was recommended from equipment cost and effectiveness points of view and because dusting was considered less of a problem.

The run-of-mine coal from the various mining areas would be brought out of the pit and directed by conveyor to one of three blending areas termed as follows:

TABLE 4-8

Summary of Mining Equipment
End of Year 17
Hat Creek Project Mining Feasibility Report 1978

Item	Number
Shovels 16.8 m^3 bucket capacity	7
Trucks 109-tonne	9
136-tonne	18
32-tonne	10
Scrapers 24 LCM	6
Graders	6
Dozers track	17
wheeled	2
Front-end loaders 11.5 m^3	2
5.4 m^3	3
1.5 m^3	3
Drills - Auger, Rotary, Rotary Percussion	3
Blasting Truck	1
Compactors	4
Gradall	1
Backhoe 1 m^3	1
Water Wagon	3
Mobile crusher	1
Mobile cranes 5 to 90 tonne	6
Mobile service vehicles	21
Light vehicles	130
Truck unloading stations	2
Crawler mounted waste spreaders	2
Rail mounted stackers	2
Bridge type bucketwheel reclaimers	2
	<u>Length</u>
Mine conveyors	2490 m
Coal transfer conveyors in preparation area	3290 m
Overland coal conveyors to generating plant	4000 m
Low-grade coal transfer conveyors	355 m
Waste conveyors	15 500 m

- average-grade stockpiles;
- high-grade stockpiles;
- emergency stockpiles.

Two qualities of coal could be deposited separately in the above locations, and the emergency stockpile used to receive either average or hi-grade depending on the particular needs at any point in time.

The average and high-grade blending areas consist of two stockpiles each, one for the deposition of material and the other for reclamation. The average-grade piles contain about 280 000 tonnes of coal, or one week's production. The high-grade piles are designated to receive only low sulphur high-grade coal. Each of these would contain about 135 000 tonnes of high-grade coal, or one-half week's mine production. Each pile will average about 17 m high and 48 m wide. The average-grade coal pile will be about 520 m long while the high grade piles will each be about 250 m long.

When required, the material from both systems is mixed on the overland conveyor in the proportions required to achieve the desired coal quality.

The emergency blending area is available to receive coal should the other blending areas be unable to take additional coal. The capacity of this pile is about 280 000 tonnes of coal.

Two stackers have been provided in the blending area. During normal operation, one stacker would be in full time use at the average-grade blending pile. The second stacker would be in operation from time to time to stockpile high-quality, low-sulphur coal.

Similarly, two reclaimers have been recommended for the blending operation, one in the average-grade areas and the other in the high-grade and emergency areas.

435 DUST SOURCES

During the pre-production period the major dust sources include construction activities such as the development of access roads, construction facilities and permanent mine facilities, topsoil stripping, and overburden removal. The operations with the greatest potential for generating dust during the production period include:

- movement of coal haulers and waste haulers along the haul roads within the open pit;
- movement of vehicles along pit access roads;,
- the stripping of surficial materials and removal of overburden using scrapers, trucks and shovels;

- blending and reclaiming of coal in the coal stockpile reclaim area;
- wind erosion of unreclaimed land and stockpiles of coal.

Other operations that may contribute to a lesser extent to fugitive dust include the following:

- drilling and blasting of overburden and coal;
- the removal of coal and waste material by shovel and loading onto trucks for transfer to the dumping station;
- the dumping of coal and waste rock at the out-of-pit conveyor transfer points;
- the maintenance of roads using graders;
- dusting from waste material and coal being transported out of the pit by conveyor.

4.4 COMPARISON OF ERT BASIS WITH CMJV BASIS

This section of the report briefly presents the differences between the mine plan and assumptions for the ERT calculations (outlined in Section Two) and the updated CMJV mine plan (outlined in Section 4.3) as well as the background data now available (see Section 4.2). The implications of these differences on the fugitive dust estimates at Hat Creek are also discussed. This discussion is based on year 35 of the mine only, since ERT did their calculations only for one comparable year.

441 MINE PLAN

A comparison of the mine plan at Year 2017-2018 on which ERT based their calculations (Figure 2-1) and the CMJV plan at Year 35 (Figure 4-2) indicates that the mine plans are very similar. The only differences of note from a dust point of view are the elimination of the small north valley dump by the CMJV mine plan and the moving of the low grade coal stockpile from an area just north of the Medicine Creek dump (see Figure 2-1) to an area adjacent to the pit and just east of the Houth Meadows dump in the CMJV mine plan (see Figure 4-2). The area of the low grade stockpile has also been reduced in size in the CMJV plan. From an overall potential dust generation point of view there is not much difference between the two plans.

442 EMMISSION SOURCES

As noted in their report, ERT, not having the benefit of the results of the bulk sample program and other background studies, assumed that the major emission sources would be the waste dumps, the open pit, the low grade stockpile area and the blending area. Table 2-3 gives ERT's estimates of dust emissions, after dust control has been taken into account, for the various dust producing activities identified in the various source areas. The largest contribution to fugitive dust was determined by ERT to be wind erosion and the largest source would be the waste dumps since they present the largest surface area of sources prone to wind erosion.

Information on the nature of the waste materials obtained from the bulk sample program would significantly reduce the contribution of the waste dumps to the fugitive dust levels. As noted in Section 4.2, the waste materials have a high clay content giving them good moisture retention properties while in addition there is a tendency of the clayey sandstone and bentonitic materials to form a hard crust. These properties will effectively eliminate the waste dumps as sources of fugitive dust emissions.

443 MODEL LIMITATIONS

There are two main limitations in the ERT model that result in over-estimates of fugitive dust levels. The ERT model does not account for the fact that for the year on which the calculations were based, the mining operations occur at a substantial depth below groundlevel. The model assumes that emissions (such as in-pit haul road dusting) occur at groundlevel and makes no attempt to estimate reduction in the contribution of in-pit emission sources to downwind fugitive dust levels. Beyond about Year 5, the depth of the mine will significantly reduce the effect of in-pit emissions.

A second significant limitation of the ERT model is the lack of a fall out function. The model assumes that the particulates are distributed in the first 10 m above groundlevel and uses a Gaussian model to calculate downwind suspended particulate levels. Since the TSP level is inversely proportional to wind speed in the Gaussian model, the model, without a fall out function, predicts concentrations to approach infinity at wind speeds less than 3.6 km/hr (PEDCo, 1978). When a model includes a fall out function, maximum TSP concentrations are not predicted to occur for low wind speeds. As a result of the lack of a fall out function in the ERT model, the worse TSP episodes resulting from the Hat Creek mining operation are predicted to occur at 2.8 km/hr (1.7 mph), as noted in Section Two. A velocity of 2.8 km/hr is only slightly higher than the range of calm conditions (0-2 km/hr) defined by B.C. Hydro for the Hat Creek wind data. The prediction of TSP violations by ERT for very low wind speeds, contradicts experience elsewhere (see Section Three) where dusty conditions and fugitive dust problems are reported for windy periods.

4.5 RECOMMENDED FUGITIVE DUST CONTROL MEASURES FOR HAT CREEK

Based on the results of the survey of fugitive dust levels around a number of operating mines and of the experiences and control measures instituted at several large coal stockpile areas (see Section Three), a number of specific dust control measures applicable to the Hat Creek situation have been identified. These measures are outlined below for the pre-production period and for the production years.

An analysis of the anticipated fugitive levels, after the effects of dust control measures are accounted for, is given in Section 4.6.

451 PRE-PRODUCTION PERIOD

During the period from Year -5 to Year -1, the operation that has the greatest potential for generating dust is the topsoil stripping operation as discussed in Section 4.3. Most of the topsoil removal takes place in Year -3 (260 000 BCM) when the pit is initially opened up. Other minor sources of dust during this period include: the development of access roads and temporary construction facilities, construction of the mine facilities and services, and the development of the first haul roads.

Recommended practices and measures to control dust during this period include the following:

- as much as is practically possible, trees around the active working area should be left intact. If these are sufficiently dense, they will effectively cause near-source deposition of dust particles released at groundlevel. Consideration should also be given to the effectiveness and practicality of minimum advance clearing in the pit area (i.e. clearing of vegetation only slightly in advance of the stripping operation);

- as far as is practical, minimum advance stripping should be used (i.e. the topsoil stripping operation should stay as close as practical to the overburden excavation operation). This will reduce the area exposed to wind erosion in advance of excavation operations, particularly with regard to friable materials;

- during times of dry, windy weather, the area stripped should be sprayed with water to control dust generation at source. Water spraying is normally not practiced in conjunction with soil stripping operations, however, it is recommended in this case because of the friable nature of the topsoil material;

- service roads (temporary and permanent) and haul roads should be sprayed with water as required during the frost free period to control haul road dusting. Experience at Mine BC2 (see Section

Three) indicates haul road dusting is much less of a problem during the winter months. Spraying of waste oil on these roads during this period should be practiced if winter haul road dusting proves to be a problem at Hat Creek;

- surface binding agents should be sprayed on those surfaces (such as the edge of the stripped area) that will remain exposed for long periods of time. Such surfaces should also be contoured to reduce turbulence effect;

- consideration should be given to the use of a portable porous snow fence (50% porosity) mounted in sections on skids as a wind screen on the windward side of the stripping operations with respect to the critical wind direction (winds blowing from the stripping operations to the IR 1). These screens should be higher than the scrapers and other equipment used in the stripping operations and will effectively screen the operation and reduce dust emissions. The need for this dust control measure can be evaluated as experience is gained with actual stripping operations in the field.

452 PRODUCTION YEARS

During the production Years 1 to 35, the mine and associated facilities and developments such as haul roads and waste dumps will be progressively expanded as indicated in Figure 4-4. Progressive reclamation will be practiced as noted in Section 4.3 and outlined in detail in the CMJV reports. Based on the results of the mine surveys, it has been concluded that the activities that occur within the open pit will not be a major source of dust (see Section 4.6), and that the source with the greatest potential for dust generation is the blending area. The waste dumps are considered to be minor sources of dust only based on the nature of the materials (see Section 4.2).

Recommended design features and specific dust control measures for the production period are outlined below:

- exposed surfaces subject to wind erosion, such as the edges of the stripping operation, or the edges of the pit, should be contoured, sprayed with surface binders and possibly seeded if they are to remain inactive for long periods of time;

- because of the proximity of the blending area to IR1, an arrangement similar to that shown in Figure 4-3 is preferred to that given in Figure 4-2 from an air quality point of view;

- using waste materials excavated from the pit, a dike should be built on the southwest face of the blending area to a height 2 to 3 m above the height of the coal piles (see Figure 4-5). This will ensure that the blending area will be in the lee of critical

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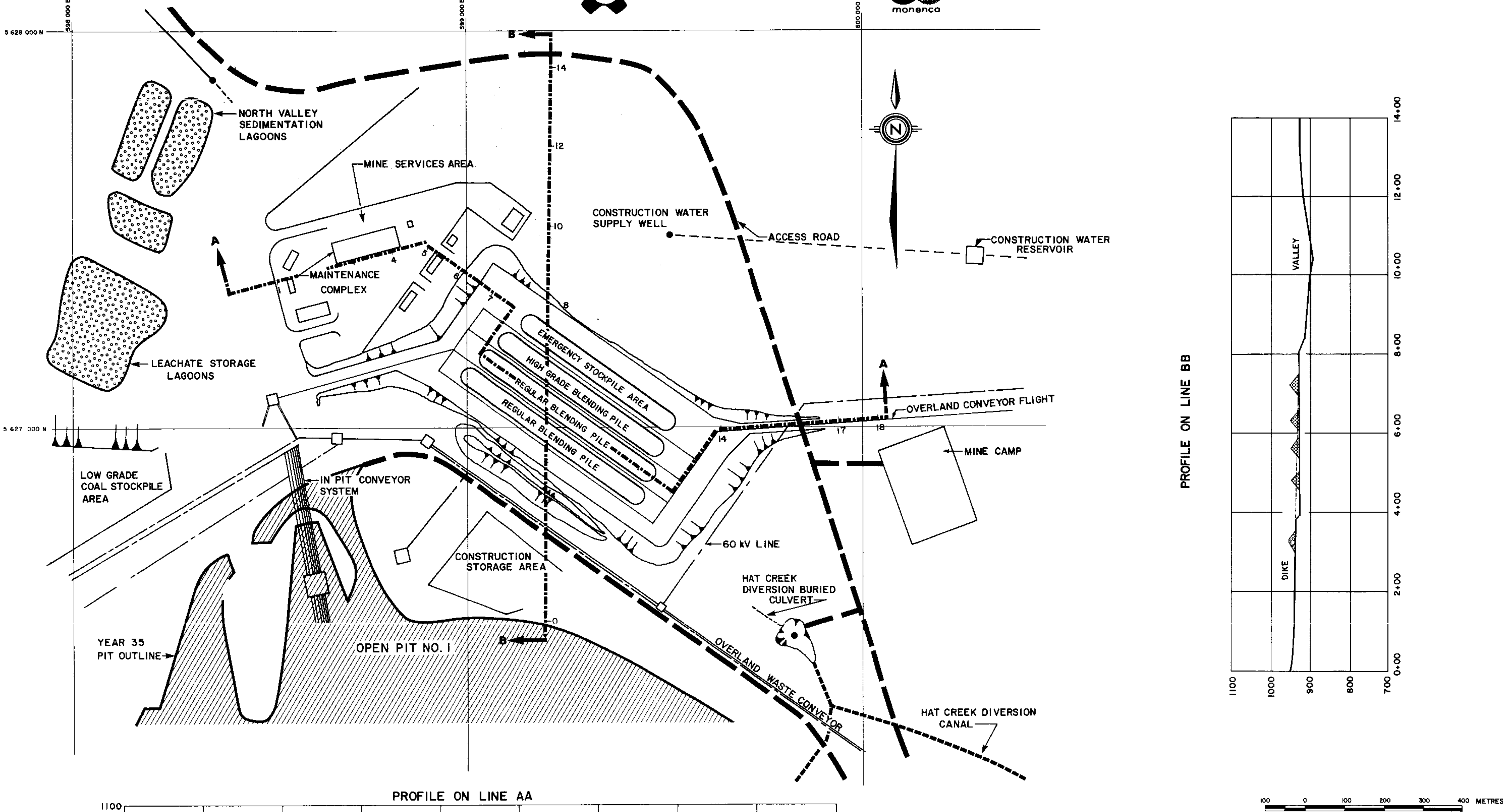

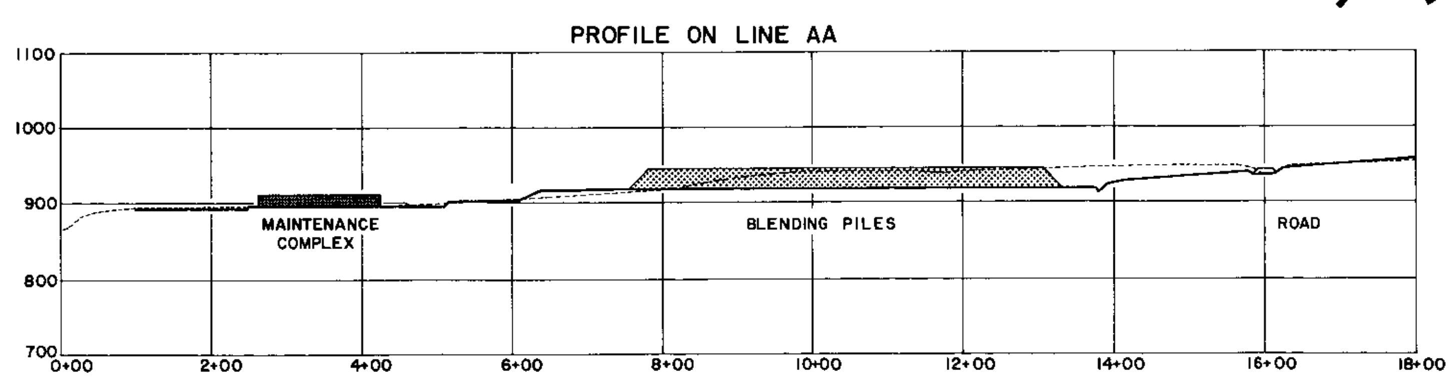

FIGURE 4-5

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK FUGITIVE DUST EVALUATION

LOCATION PLAN - BLENDING PILES AND SERVICE AREA winds blowing from the piles toward IR1 and hence will reduce wind erosion of the piles. Grass and trees should be planted on the dike to enhance the effect of protecting the blending area. The height of this cover should be graduated from the bottom to the top with the taller species ocurring higher on the dike to help lift the wind and further reduce turbulence effects. Although the vegetative cover is not an absolute necessity to creating the desired effect, it will increase the effectiveness of the dike in controlling wind erosion under low probability, high wind episodes;

- the orientation of the coal piles in the blending area should be along a northwest-southeast line of direction as shown in Figure 4-5. This orientation respects the sensitivities of two critical wind directions (1) from the piles to the maintenance/service area located a few hundred meters from the blending area and (2) from the piles to IR1, about 1.0 km from the blending area. Southeast winds blowing to the maintenance area will see the minimum projected area of the piles and essentially blow along the length of the piles which is the preferred orientation from a wind erosion point of view. Because the blending area is cut into a hill and protected by a dike on the southwest side, the preferred pile orientation should not be required to provide protection for pile erosion for winds blowing from the piles toward IR1;

- develop the two working piles of the blending area closest to the dike (with the first pile being about 25 m from it). Pile end turbulence effects and enhanced wind erosion can be reduced by developing subsequent piles slightly shorter in length;

- contour those portions of the blending area piles that are to remain inactive for periods of time and apply surface binding agents;

- leave as many trees as possible around the site and in particular on the hill into which the blending area is cut in order to enhance the development of a claim region in the wake of the face of the cut. In addition, trees should be left intact (as is practical) in the area between the blending area and IR1 to take advantage of any natural turbulence created that could reduce dust levels;

- spray haul roads with water during the frost free periods and waste oil as required, during the frozen period;

- use a telescopic shute and sensing system on the stacker to maintain a minimum free-fall distance to the piles;

- spray the coal piles with water during the frost free period by means of a series of fixed, stand mounted spraying stations connected to a dedicated main system and automatically controlled.

Such a system would be activated as required according to a preset timetable. Because of the wetness of the pit, it is anticipated that freeze binding of the blending area piles will occur during the winter.

In addition to the above points, it is also important to make a firm company commitment to dust control if dust control is to be successful. This point was very strongly emphasized by personnel at stockpile site S3.

4.6 ANTICIPATED DUST LEVELS AT HAT CREEK

This Section of the report presents the basis for and estimations of dust levels at Hat Creek for the pre-production and production periods.

461 PRE-PRODUCTION PERIOD

As indicated in Section 4-3, the stripping of the friable topsoil material has the greatest potential for causing dust emissions during the pre-production period. Of the 340 000 BCM of topsoil material removed between Year -3 and Year 1, an estimated 260 000 BCM will be removed in Year -3 as noted previously, making the frost free period of Year -3 a potentially dusty period.

Based on the experiences gained through the bulk sample program where dusting was localized to the trench except during dry, windy periods; on the success of aerodynamic control factors in providing effective protection for dust producing operations (see Section 3.3); on the dedicated use of specific schemes to control dust during the topsoil stripping and other operations during this pre-production period (see Section 4.5); and on the planning of operations with dust control in mind (i.e. minimum advance stripping as noted in Section 4.5), it is concluded that dust levels can be controlled during the pre-production period so that there will be no violations of the provinces TSP regulations except perhaps during high wind episodes which are estimated to occur for a maximum of 0.3 to 1.0 percent of the time (see Table 4-4).

Given the results of the mine surveys in which TSP regulations were met within 1 km of several large operating strip mining operations (see Section 325) in addition to the above discussion, it is estimated that the daily and annual TSP objectives will be met within about 0.25 km of the stripping operations. Because of the concentration of stripping activities during Year -3, the above estimates would be conservatively doubled to 0.5 km for Year -3. Violations of TSP regulations should not occur during the pre-production period except perhaps under low probability, high wind, (20 km/hr) episodes of several hours duration.

462 PRODUCTION PERIOD

During the production years of the Hat Creek mine the principal activities that will generate dust are related to the mining and coal blending operations (see Section 4.3). Of particular concern during this period are the dust levels on the Indian Reservation (IR1), located about 1 km to the north of the mine boundaries (see Figure 4-3), resulting from the mining operations. Estimates of dust levels resulting from operations are developed below based on a comparison with the survey results and on site specific information available.

462.1 Comparison with Mines Surveyed

A summary comparison of the Hat Creek mining operation with those surveyed is presented in Table 3-18. The average annual production rate for the Hat Creek mine is about 10 million tonnes over the lifetime of the mine. Of the mines surveyed, one was larger than Hat Creek (mine W1 - 12.1 million tonnes/year), one was about the same size (mine M3 - 9.4 million tonnes/year), while the other six were smaller than the proposed Hat Creek operation (see Table 3-18). In terms of equipment used a comparison is made in Table 3-18 on the basis of major mining equipment and hauling equipment used for each mine. The Hat Creek operation would use about the same number of major pieces of mining equipment as the mines surveyed. The quantity of units of hauling equipment at Hat Creek would be 27 which compares to a range of 12 to 36 hauling units for the five largest mines surveyed. As noted in Table 3-18, most of the mines surveyed were strip mining operations while the proposed Hat Creek mine is a deep open pit operation.

The summary of the Hat Creek mine development presented in Section 4.3 indicates the rapid development of the mine from 105 ha in areal extent and a pit elevation of about 850 m in Year -1, to a pit size of about 327 ha and a depth to less than 805 m in elevation by Year 5. (See Figure 4-4). As a result the mining operations and hence the dust generation activities associated with mining will be at a substantial depth below groundlevel beyond about Year 5. Because of the effect the deep pit will have on reducing the amount of dust generated in-pit from being transported downwind, and due to the wetness of the pit, it is reasonable to assume that fugitive dust levels resulting from the Hat Creek operation will be influenced more by emissions resulting from the coal handling and blending operations than by emissions from the actual coal mining operation. This conclusion is consistent with the fact that the location of the high-volume samplers at the mines surveyed, (as approved by regulatory agencies) were largely in the region of the coal storage and load-out areas presumably because these areas were dustier than the mines (see Section 3-2 and Table 3-18).

The presence of the large waste dumps adjacent to the open pit at Hat Creek to dispose of the materials excavated from the pit, does not change the above conclusions since these dump areas will not contribute significantly to the suspended particulate levels. As discussed in Section 4.2 the waste materials have a tendency to form a surface crust upon weathering while in addition they exhibit substantial water retention properties.

In terms of an overview comparison of climates, the Hat Creek area received a comparable amount of precipitation to the mines in Montana for which data was available, and considerably less than the quantity received in the region of mines BC1 and BC2. The average wind speed for Hat Creek (11 km/hr) is about the same as that for mines M1 and M2 and higher than for mines M3 and BC1. Data was not available on atmospheric stabilities and the occurrence of the various stability classes for the sites surveyed. It is concluded that the differences in climate between Hat Creek and the areas surveyed will not have a significant effect on relative particulate levels.

On the basis of the foregoing discussions, an analysis of the fugitive dust levels at Hat Creek must centre around the largest potential emission source, the blending area. As noted previously, two alternative locations and arrangements of the blending area have been discussed. In Figure 4-2, the blending area is located about 0.5 km from IR1 while in the arrangements shown in Figure 4-3, the blending area is about 1 km from IR1.

462.2 Blending Area Analysis

462.21 Frequency of Critical Winds In order to put the concern regarding TSP evaluations on IR1 into perspective, an analysis was made of the wind data measured at mechanical wind station 2 for the frost free period and the period of frost. Table 4-9 gives the results of the frequency distribution analysis. For the period of frost, calm conditions occur for 30.2 percent of the time and winds greater than 11 km/hr for 6.1 percent of the time. For the frost free period, calm conditions persist for 12.6 percent of the time and speeds greater than 11 km/hr occur for 12.1 percent of the time.

The wind roses presented on Figures 4-2 and 4-3 define the sector from which winds must originate to blow from the blending area to IR1 for the CMJV mine plan arrangement (Figure 4-2) and for the alternative blending area configuration (Figure 4-3). In both cases, wind roses are presented for the frost free period and for the period of frost. For both blending area/maintenance area arrangements the critical wind sector is from SE to WSW. For the purposes of this evaluation the critical sector is conservatively extended to be from the SE to W. For wind velocities greater than 11 km/hr Table 4-9 shows that during the frost period, winds from the critical sector blow 2.6 percent of the time (equivalent to 5 days per year) while during the frost free period the corresponding value is 4.1 percent of the time (about 8 days per year).

During the winter months, it is anticipated that freeze binding of the surface layers of the coal piles will occur and reduce the potential for dust emissions from the coal piles.

TABLE 4-9

Wind Frequency Distribution at Station #2
Frost Period (November - April)

	Calm	2-5	6-11	12-19	19	Total
NE	-	4.6	5.8	0.8	0.0	11.2
E	-	4.0	1.7	0.1	0.0	5.8
SE	-	3.4	0.4	0.1	0.0	3.9
S	-	11.0	2.1	0.8	0.0	13.9
SW	-	11.4	4.6	0.4	0.0	16.4
W	-	4.3	3.4	1.3	0.0	9.0
NW	-	1.5	3.4	2.3	0.2	7.4
N	-	1.2	0.9	0.1	0.0	2.2
Calm	30.2	-	-	-	-	30.2
Total	30.2	41.4	22.3	5.9	0.2	100.0

Frost Free Period (May - October)

	Calm	2-5	6-11	12-19	19	Total
NE	-	2.6	6.6	1.0	0.0	10.2
E	-	2.5	3.7	0.7	0.0	6.9
SE	-	2.2	1.0	0.1	0.0	3.3
S	-	11.8	4.0	1.2	0.0	17.0
SW	-	12.7	6.2	0.7	0.0	19.6
W	-	5.0	6.2	2.1	0.0	13.3
NW	-	1.8	8.0	5.9	0.3	16.0
N	-	0.6	0.4	0.1	0.0	1.1
Calm	12.6	-	-	-	-	12.6
Total	12.6	39.2	36.1	11.8	0.3	100.0

Estimated fugitive dust levels at Hat Creek can be estimated from a comparison with the stockpile areas surveyed.

462.22 Comparison with Stockpile Areas Surveyed The Hat Creek coal blending area will have a storage capacity of 560 000 tonnes in two active piles of regular coal and 270 000 tonnes of high-grade coal in two piles making a total capacity of 830 000 tonnes. In addition, the emergency stockpile area has the capacity to hold an additional 280 000 tonnes in one pile (see Figure 4-5). The stockpile areas surveyed ranged in size from several thousand tonnes in capacity to 4.5 million tonnes in capacity (see Section 3.3). The results of the survey indicate that dust emissions from large coal handling/stockpile areas can be controlled by specific control measures and/or retrofitted aerodynamic control factors (see Section 3.3). Specific experience at stockpile area S2 and S3 indicate that measures can be instituted such that regulated TSP levels can be met within less than 1.0 km of the stockpile area. Experiences at several of the stockpile areas, particularly S2, indicate that dust is not a problem when handling fresh, moist coal (as would be handled in the blending area at Hat Creek).

462.23 Estimated Levels Specific features on the design of the blending area aimed at preventing dust emissions include protecting the area by cutting it into a hill and developing a dike along the windward side of the blending area with respect to the critical wind direction (see Section 4.5). In addition to design features and a commitment to dust control during operations, it is concluded that control measures such as the use of a telescopic chute and water spray in the stack-out boom and the spraying of water on the pile from a dedicated series of water spray monitors will effectively control dust emissions such that there are no TSP violations on IR1 during the estimated 8 days per frost free period per year that winds from the critical sector are experienced. During the winter months, the cold temperatures and the anticipated freeze hardening of the surfaces of the coal piles will effectively prevent violations during the 5 day period when critical winds blow. Potential violations could occur for high wind episodes which are estimated to occur from 0.3 to 1.0 percent of the time.

In terms of actual TSP levels, it is estimated, based on the analysis presented above, that for all but high wind conditions, (20 km/hr), the PCB,TSP objectives will be met at a distance of about 0.5 km from the blending area. This distance is expected to be decreased to about 0.25 km in the region of the open pit.

These estimates are based on the assumptions that the wind data in the region of the mine and blending area are as described by station 2. Significant variations in wind directions could occur in the mine area from that measured at station 2; however, since the distribution in velocities is not expected to change dramatically (as noted by the comparison of stations 2 and 4 in Table 4-4) the above conclusions would not be expected to change since aerodynamic design measures like pile orientation and development of a protection dike can be incorporated to compensate for variations. The assumption is also made that beyond Year 5, the open pit will not have a major influence on wind distribution within the immediate project area. Given the eventual size of the pit, it is anticipated that pit induced wind changes will not be of sufficient magnitude to significantly alter the conclusions of the above analysis regarding fugitive dust. However, consideration should be given to doing some preliminary evaluations of pit induced effects on wind patterns to provide a more accurate basis for the detailed design of the Hat Creek blending area.

APPENDIX 1

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APPENDIX 2

SELECTED MINE DATA
MONTANA, USA

M1 SITE VISIT DATA SHEET

Type of Mining:

Sub-Bituminous Coal 8600 BTU/lb
680 million tonne - Reserves

Production (Quantity per year, working days/year):

8.2 million tonne/year/365 days /year
peak 17.2 million tonne/yr 1983

Time Setting:

1924-1958 produced 40 million tonne
1968-1978 produced 41 million tonne

Description of Mining and Transportation Methods:

Mining Method:

Strip - 7.6 m seam, 30 m overburden

Coal Analysis

Sulphur .8%
Moisture 25%
Ash 9%

Coal Use: thermal power on site or to market

2.3 million tonnes/year to mine mouth thermal plant
5.9 million tonnes to other markets

Equipment Used:

Unit	Size	Number	Cycle (Daily and Seasonal)	Other
Mining				
Draglines	46 m^3	2	Not available	
Stripping Shovel	19 m^3	1	Not available	
Loading				
Coal Loader	13 m^3	3	Not available	
Tipple	3628 tonne/hr	1	2 trains/day	
	1134 tonne/hr	1	Not available	
Hauling				
Trucks	108 tonne	9	Not available	
	91 tonne	4	Not available	
Overburden Drills		3	Not available	

Stripping Ratio:

4 overburden:1 coal

Drilling and Blasting:

Information not available

Haul Road Characteristics: (length, design, material)

- surface composed of overburden on site material
- length 1.6 km pit to plant
- width 27.4 m

Storage Practices:

Outside stock piles - no windbreaks 90,000 tonne capacity Piling method by stacker. Reclaimed underground.

Waste Handling Techniques:

The associated mine mouth thermal power generating station disposes of ash in nearby lagoons.

DESCRIPTION OF THE EXISTING ENVIRONMENT

- Is met station data being used? If yes, what is source of data? Can we get a copy of this data?

Met data from a local station is being used and is incorporated into hi vol data. Relative humidity, barometric pressure, wind speed/direction and temperature is monitored. No precipitation data is available. A nearby mine (M2) monitors precipitation.

Seasonal Description:

Hot summer - cold winter - little precipitation 305 mm/year. Approximately 1143 mm of water evaporates May-September.

Regional Overview:

Geography:

Town 1 km from thermal plant and mine
Land use - cattle-sheep grazing.

Rolling hills with little relief in surrounding mine area to foothills and mountains westward - rolling hills east, south and north.

Geology:

Sedimentary overburden, glacial till cover.

Vegetation:

Sparse - grasses - some isolated conifers on North facing slopes - sedges - tumbleweeds.

DESCRIPTION OF THE EFFECTS OF DUSTFALL BY THE DEVELOPMENT

Description of the Dustfall Monitoring Program: Date of Implementation

Monitoring Unit	Number	Location (See Map)

The area is well monitored by the mine, the Power Company, the EPA and the State of Montana. Most Units are hi vol - some dustfall are also used.

Results:

Emission -	allowable particulates	32 percent of regs.
	allowable sulphur dioxide	13.3 percent of regs.
	allowable nitrous oxides	40 percent of regs.

Description of Mitigative Measures for Fugitive Dust Control:

(When are the measures instituted?)

The Mining Areas:

Dust is not a problem in the immediate mining area. Blasting information was not on hand. The usual small amount of dust from loading and dragline operations.

The Handling Areas:

Water spray at conveyor transfer points and loadout. Storage pile is not a dust problem area, therefore, no mitigation.

Other:

Haulroads - water only - when necessary
Country roads are more of a dust problem than coal haul roads.

- Is the dustfall problem site specific or widespread?

The problem is site specific. Its results are widespread (3 miles from source levels are background).

- Is the effect periodic or continuous?

Periodic.

- What are the regulatory levels ($\mu gm/m^3$)? Where must they be met - Mine Boundaries?

  75 $\mu gm/m^3$ annual geometric mean. 200 $\mu gm/m^3$ not to be exceeded more than 1% of time (3.65 days).

  Regulations must be met outside the boundary. "The people who work at the mine are not the public and are not protected by air quality standards".

- Have regulatory people shown concern about the developments dust problems?

  They are concerned that emission level regulations are not broken. "We keep within the limit".

- Is the effect amenable to mitigative input, or is it inherent to the operation?

  Loading, blasting inherent - also dragline work.

Major Fugitive Dust Problem Areas:

In order of estimated magnitude

- Haul roads
- Mining area including blasting
- Stockpiles
- Handling

This mine is now trying to figure out exactly which phase of mining causes the worst problem.

M2 SITE VISIT DATA SHEET

Type of Mining:

Thermal coal, sub-bituminous

Production (Quantity per year, working days/year):

2.3 million tonne/year
3 shifts/day of which 2 are loading shifts.

Time Setting:

Operations began in Fall 1969.

Description of Mining and Transportation Methods

Mining Method:

Strip mining using draglines, shovels and hauling by truck to storage and loadout.

Coal Use:

To market for power generation.

Equipment Used:

Unit	Size	Number	Cycle (Daily and Seasonal)	Other
Mining				
Dragline	7800, 7400	3	Not available	
Drill	50R, 30R	2	Not available	
Loading				
Shovels	-	3	-	
Frontend Loader	-	1	-	
Dozers	-	5	-	
Hauling				
Dirt Trucks (converted)		5	2 loading shifts/day	
Scrapers		5	periodic topsoil removal and replacement	

Stripping Ratio:

8:1

Drilling and Blasting:

2 large blasts/week

Haul Road Characteristics: (length, design, material)

Surficial material, length unknown, width unknown.

Storage Practices:

- 1 covered silo, size not available
- no outside stock pile

Waste Handling Techniques:

Information unavailable

DESCRIPTION OF THE EXISTING ENVIRONMENT

- Is met station data being used? If yes what is source of data? Can we get a copy of this data?

  Yes, private consultant, we have already obtained.

Seasonal Description:

Hot summers - cold winters - little precipitation 305 mm/year. Approximately 1143 mm of water evaporates May-September.

Regional Overview:

Geography:

Land use - sparsely populated - cattle and sheep grazing. Rolling hills with little relief in the surrounding area. Mountains and foothills occur westward - rolling hills east, south and north.

Geology:

Sedimentary overburden, glacial till cover.

Vegetation:

Sparse - grasses, sedges, tumbleweeds - some isolated conifers on north facing slopes.

DESCRIPTION OF THE EFFECTS OF DUSTFALL BY THE DEVELOPMENT

Description of the Dustfall Monitoring Program: *Date of Implementation*

Monitoring Unit	Number	Location (See Map)
Hi-Volume Air Sampler Sites	1	Mine Entrance
	2	Mine Office
	3	Substation
	4	Powder Magazine

Results:

Site 1 - Exceeded Standard on 7 of 54 days sampled
- Exceeded Federal Standard on 4 days

Site 2 - Exceeded State Standard 12% of days sampled
- Exceeded Federal Standard on 4 days

Site 3 - Exceeded State Standard 5% of days sampled
- Exceeded Federal Standard on 3 days

Site 4 - *Did not exceed standards*

Description of Mitigative Measures for Fugitive Dust Control:

(When are the measures instituted?)

The Mining Areas:

Haulroads are watered continuously when needed by 2 trucks.

The Handling Areas:

All transfer points on conveyor systems are sprayed with water.

Other:

Coal is stored in an enclosed silo of unknown size (information not available).

- Is the dustfall problem site specific or widespread?

  Site specific.

- *Is the effect periodic or continuous?*

  Periodic

- What are the regulatory levels ($\mu gm/m^3$)? Where must they be met - Mine Boundaries?

  Met at Mine Boundary. State Standard of 200 $\mu gm/m^3$ (24 hour) not to be exceeded more than 1% (3.65 days/year).

- Have regulatory people shown concern about the developments dust problems?

  No.

- Is the effect amenable to mitigative input or is it inherent to the operation?

  Information unavailable.

Major Fugitive Dust Problem Areas:

Haulroads
Blasting
The Mining Operation

M3 SITE VISIT DATA SHEET

Type of Mining:

Coal - Sub-bituminous.

Production (Quantity per year, working days/year):

9.4 million tonne/year/continuous/365 days/year.

Time Setting:

Operations began August 1972.

Description of Mining and Transportation Methods

Mining Method:

Strip mining 2 lift operation - expose and remove 15.8 m coal seam.

Coal Use:

To market for power generation.

Equipment Used:

Unit	Size	Number	Cycle (Daily and Seasonal)	Other
Mining				
Dragline	32 m^3	1	Unavailable	
Dragline	54 m^3	1	Unavailable	
Loading				
Loading Shovel	12 m^3	-	Unavailable	
Frontend Loader	18 m^3	-	Unavailable	
Hauling				
Wabco	136 tonne/load	-	Unavailable	

Stripping Ratio:

Unavailable

Drilling and Blasting:

9.3 square meter bench - drill 3.7 x 4.6 m - drill down to about 15.25 m - ammonium nitrate. Fired by primacord.

Haul Road Characteristics: (length, design, material)

Unavailable.

Storage Practices:

2 silos 12,245 tonnes each
Periodic 63,500 tonne stock pile (outdoor as required when silos are full)
Piling method for outdoor pile is truckdump. Retrieve by front end loaders

Waste Handling Techniques:

Unavailable

DESCRIPTION OF THE EXISTING ENVIRONMENT

- Is met station data being used? If yes, what is source of data? Can we get a copy of this data?

On site met data is being monitored. We have all data on hand.

Seasonal Description:

406 mm precipitation/year
Mean yearly temperature = 5.4°C

Regional Overview:

Geography:

Land use - grazing/sparsely populated.

Geology:

Sedimentary/glacial till cover

Vegetation:

Grasses/isolated conifer stands predominate.

DESCRIPTION OF THE EFFECTS OF DUSTFALL BY THE DEVELOPMENT

Description of the Dustfall Monitoring Program: Date of Implementation

Monitoring Unit	Number	Location (See Map)
Hi-Volume Samplers	1	
	2	
	3	Unknown
	5	
	6	
	7	

Results:

Information unavailable.

Description of Mitigative Measures for Fugitive Dust Control:

(When are the measures instituted?)

The Mining Areas:

Coherants were found to be too slippery.

Calcium chloride - too costly and required too many applications to become effective.

The Handling Areas:

When outdoor storage pile is used, water trucks over top after packing. Coal at loadout is oil sprayed.

Other:

Some coal stored in silos.

- Is the dustfall problem site specific or widespread?

  Site specific (Haul roads).

- Is the effect periodic or continuous?

  Continuous

- What are the regulatory levels ($\mu gm/m^3$)? Where must they be met - Mine Boundaries?

  200 $\mu gm/m^3$/24 hr not to be exceeded more than 1% (3.65 days) year (State Regulation).

- Have regulatory people shown concern about the developments dust problems?

  No.

- Is the effect amenable to mitigative input or is it inherent to the operation?

  Information unavailable.

Major Fugitive Dust Problem Areas:

Haul roads continuously.
Storage pile continuously (70,000 ton stock pile).

APPENDIX 3

SELECTED MINE DATA
WYOMING, USA

W1 DATA SHEET

Type of Mining:

Sub-bituminous coal

Production (Quantity per year, working days/year):

1977 Tonnage: 12 million tonnes, (Record for yearly production and total production in U.S. history).

1978 Projected Tonnage: 16.3 - 17.2 million tonnes

Single Day Records: Production of 86,876 tonnes on February 27, 1978; 81,270 tonnes shipped (eight unit trains) on August 26, 1978

Monthly Record: 1,539,563 tonnes shipped in August, 1978

Maximum Projected Tonnage: 18,140,000 tonnes

Totals (tonnes shipped): 1973, 814,039; 1974, 2,995,000; 1975, 2,982,000; 1976, 6,670,000; 1977, 12,092,000

Coal Use:

All coal used for electrical generation by utilities located in Colorado, Kansas, Iowa, Wisconsin, Ohio, Oklahoma, Texas, Arkansas, and Louisiana.

Time Setting:

Production began in October, 1973.

Description of Mining and Transportation Methods

Shovel/Truck Operation:

Seven Bucyrus-Erie 295B shovels. Bucket sizes: approximately 17 cubic meters for dirt, 31 cubic meters for coal.

Three dozen 109-tonne haul trucks, manufactured by WABCO and Unit Rig (Lectra Haul).

Stripping:

Unknown

Coal thickness is 21.5 meters

Approximately 90,700 tonnes of coal per acre of surface

Storage Practices:

Four silos of 11,000 tonnes each maximum capacity. Loading by gravity flood method into unit trains at rate of approximately 91 tonnes in 35-40 seconds.

Waste Handling Techniques:

Overburden stripped and refilled in mined areas in one operation.

Preparation Facilities:

Two crushing plants of two thousand and four thousand tonnes per hour, respectively. No washing or special treatment.

Coal Characteristics:

Classification: Sub-bituminous.

BTU Range: 8000 to 8500 per pound in most applications

Sulphur Content: Less than one-half of one percent.

Ash Content: Six to eight per cent.

Reclamation:

Two hundred acres placed in permanent reclamation and 180 in deferred acreage as of December, 1978.

Reclamation proceeds simultaneously with mining. Topsoil stripped and segregated ahead of mining. Overburden stripped and refilled in mined area in one operation. Recontoured overburden coverage with 457 - 610 mm of topsoil before seeding. Eighteen ingredients in seed mix; Russian Olive and willow trees transplanted in selected area.

DESCRIPTION OF THE EXISTING ENVIRONMENT

Relief:

rolling to steeply rolling

Precipitation:

Dry - mean annual precipitation about 254 mm

Temperature:

Average annual is 8°C
January - August is -10° to 0°C
July - August is 20 to 30°C

Land Use:

Livestock Grazing

DESCRIPTIONS OF THE EFFECTS OF DUSTFALL BY THE DEVELOPMENT

Description of the monitoring program: Date of implementation - October 1976.

Four high volume samplers are used to monitor particulate levels around the mine. (See map for locations).

Description of Mitigative Measures for Fugitive Dust Control:

The Mining Areas:

When necessary water is applied to haulroads. Chemical emulsions are not used.

The Handling Areas:

Coal is stored in silos. There are no outdoor stockpiles. Hoppers, conveyors and the crushing plant are all enclosed. Trains run under coal storage silos to be loaded.

Mine Service Area:

Surface binders are used in parking areas and one service roads around the mine.

W2 DATA SHEET

Type of Mining:

Sub-bituminous coal
Strip Ratio 2:1
2 seams mined, 30 meters overburden

Production (Quantity per year, working days/year):

27,200 tonnes/day, 2 shifts/day
approximately 7 million tonnes/year

Coal Use:

Electric power generation

Description of Mining and Transportation Methods

Mining Method:

Dragline/Shovel/Truck

Equipment Used:

Overburden Removal

Dragline	1
Overburden Drill	1
Dozers	2

Coal Extraction

Shovels	2
Front End Loaders	2

Hauling

Trucks	12

Loading:

Tipple system - characteristics not available

Storage Practices:

100% indoor storage

Associated Development

None

Waste Handling Techniques:

Overburden is leveled and revegetated.

DESCRIPTION OF THE EXISTING ENVIRONMENT

Mine W2 is situated in generally the same area as W1 and W3. Geography, geology, vegetation and the seasonal descriptions for W2 is essentially the same as it is for W1 and W3.

DESCRIPTION OF THE EFFECTS OF DUSTFALL BY THE DEVELOPMENT

Two High Volume samplers are used to determine particulate levels. Their locations are 1 to 1½ kilometers from the mine (see map for locations).

Description of Mitigative Measures for Fugitive Dust Controls

There are no outdoor stockpiles. All coal is stored in silos. Their size was not available. When dust is a problem on haulroads and service roads water is used. All conveyor systems and the crushing plant are enclosed.

W3 DATA SHEET

W3 is operated by the same company as W1. Both are located within the same general area of Wyoming. Mining methods and dust control techniques are essentially the same for both mines.

Type of Mining:

Sub-bituminous coal

Production:

10,000 tonnes/day
3 shifts/day
about 2.5 million tonnes/year

Description of Mining and Transportation Methods

Mining Method:

Shovel/truck stripping operation
1 coal seam
strip ratio is .28 - 4.28 overburden : 1 coal

Equipment Used:

	Number
Overburden Removal	
Stripping Shovel	1
Dozers	2
OB Drill	1
Coal Extraction	
Loading Shovel	1
Frontend Loader	1
Hauling	
Trucks	6

Storage Practices:

4 silos, each with an 11,000 tonne capacity

Waste Handling Techniques:

Overburden is leveled and revegetated

DESCRIPTION OF THE EXISTING ENVIRONMENT

Relief:

Rolling to steeply rolling

Precipitation:

Dry - mean annual precipitation is about 254 mm

Temperature:

Average annual is 8°C

January - August is -10° to 0°C

July - August is 20 to 30°C

Land Use:

Livestock grazing

DESCRIPTION OF THE EFFECTS OF DUSTFALL BY THE DEVELOPMENT

Description of the Dustfall Monitoring Program: Date of Implementation - July 1976.

Three high volume samplers are used to measure particulate levels around the mine. Station 1 is approximately 1 km north of the mining operation; station 2 approximately 3 km SE of the mine; station 3 at the mine.

Description of Mitigative Measures for Fugitive Dust Control

Hoppers, conveyors and the coal crushing plant are all enclosed. All coal is stored in 4 silos, each having an 11,000 tonne capacity. Trains run under coal storage silos to be loaded. When necessary, water is used to control dust on haulroads. Surface binders are not used on haulroads, but are used to some extent in parking areas and on service roads around the mine. Some parking areas are paved.

APPENDIX 4

SELECTED MINE DATA
BRITISH COLUMBIA, CANADA

BC1 SITE VISIT DATA SHEET

Type of Mining:

Coal - open pit - 4 covering 8 square km at an elevation of 1829 m above sea level - 15.25 m seam.

Production (Quantity per year, working days/year):

7.3 million tonnes raw coal/year/three shifts/day 7 day/week continuous operations. Daily production 99 bank m^3 rock 18,000 tonnes coal 1981 m drilling.

Time Setting:

Start up 1969 - since 187 million m^3 rock
36 million tonne coal

Description of Mining and Transportation Methods

Mining Method:

Open pits x 4 - blast OB - remove by shovel expose coal - load - clean - train.

Coal Use:

Metallurgical coal to market for steel production

Equipment Used:

Unit	Size	Number	Cycle (Daily and Seasonal)	Other
Mining				
Dozers	Track Dozers	23	Unavailable	
	Rubber Dozers	5	Unavailable	
Shovels	2800 P and H 19 m^3	4	Unavailable	
	21 P and H 11.5 m^3	4	Unavailable	
	Marion 6 m^3	1	Unavailable	
Loading				
Loaders	15 m^3 D600 DART	4	Unavailable	
	992 Caterpillar	1	Unavailable	
Hauling				
	317 tonne Terextiton	1	Experimentation	
	181 tonne Electra Hauls	22	Rock Haul	
	91 tonne Electra Hauls	28	Coal Haul	
	32 tonne WABCO	3	Coal	
	32 tonne Cat 769	1	Coal	

Stripping Ratio:

4.2 Bank m^3 rock:1 tonne coal

Drilling and Blasting:

1 Bucyrus-Erie 45 R 23.5 cm
6 Bucyrus-Erie 60 R 31.1 cm
1 Gardner-Denver 120 31.1 cm
1 pack Track 2 (Tank Drill)
1981 m/day total drilling
17 m deep 31.1 cm diameter
Ammonium Nitrate dry/slurry
2 blasts/week (much dust)
.55kq blasting agent/.765 m^3 rock
Average blast produces 350,000 yd^2 rock/400,000 lbs/explosive
50 million lbs/year explosives
Coal is not blasted - it is dozed.

Haul Road Characteristics: (Length, design, material)

Shale and sandstone material 190' wide
1.6 km one way
Calcium chloride 1 application/year
9.6 km total length
Rock hauling distances average less than 1.6 km one way

Storage Practices:

Raw coal outdoor storage pile 10,000 tonnes/week
Piling method - truck dump
Retrieving method - frontend loader
When pile is dormant it is sprayed with latex
Dust problems during dumping and loading
Clean coal - 4 - 13,605 tonne silos
Raw coal silos - capacity unavailable

Waste Handling Techniques:

Coal Prep Plant 22,600 tonnes raw coal - 18,000 tonnes clean - 4935 waste - coarse refuse pile and fine refuse lagoons. Raw coal 16% ash clean 9.5% ash. Waste rock is dumped into abandoned pits or around the edges of existing operational pits.

DESCRIPTION OF THE EXISTING ENVIRONMENT

Is met station data being used? If yes what is source of data? Can we get a copy of this data?

There is a Company operated met station from which data is available.

Seasonal Description:

Average annual precipitation 1080 mm.
See text.

Regional Overview:

Geography:

Surficial deposits are uncommon having been eroded away. 3 m till deposits.

Geology:

Basement - Jurassic aged sed rock (Fernie Formation) dark grey shales/calcareous sandstones/sandy limestones.

Coal Formation - Kootenay formation - carbonaceous mudstones, silts/sandstones - coal interlayed 1.5 - 15.0 m.

Vegetation:

Alpine
Heavily treed in valleys and N slopes
Shrubs/grasses S slopes

DESCRIPTION OF THE EFFECTS OF DUSTFALL BY THE DEVELOPMENT

Description of the Dustfall Monitoring Program: Date of Implementation

Monitoring Unit	Number	Location
High Vol	8	(see map)

Results:

Not summarized herein

Description of Mitigative Measures for Fugitive Dust Control:

(When are the measures instituted)

The Mining Areas:

Haulrods are watered continuously.

The Handling Areas:

- enclosed conveyor systems
- stockpiles - chemical binders periodically (latex)
- most coal is stored in silos

Other:

Blasting/none
Trains/sprayed

The dustfall problem is site specific.

The effect is periodic.

- What are the regulatory levels ($\mu gm/m^3$)? Where must they be met - Mine Boundaries?

	Max 24 hr	Background
A 60 - new plants	150	15
B 70	200	20
C 75	260	30

- Have regulatory people shown concern about the developments dust problems?

  Yes.

- Is the effect amenable to mitigative input or is it inherant to the operation?

  Information unavailable.

Major Fugitive Dust Problem Areas:

Outdoor storage
Tailings dumps (fines)
Haul roads
Handling from stock piles chemical binders are used.
Winter freeze drying effects adds to dust from stockpiles.

Meteorological Data
Mine BCl
Nov. 1977-Oct. 1978

	1977 N	D	J	F	M	A	M	1978 J	J	A	S	O	Annual
Mean Wind Speed (km/hr)	5	2	2	2	4	4	4	6	4	2	6	9	4.17
Max. Mean Wind Speed (km/hr)	42	21	21	18	36	31	33	42	38	28	40	49	33.25
Min. Mean Daily temp. (°C)	-11	-18	-17.7	-12	- 5.5	- 1.7	2	13	7	6.2	3.6	- 2.1	-17.7
Max. Mean Daily temp. (°C)	0.5	- 6.1	- 4.4	1.1	7	11	12	13.4	25	23.5	16.8	12.9	25
Mean Daily Precip. (mm)	1.52	3.3	2.03	.25	.57	2.29	3.05	1.27	4.1	1.1	2.8	.9	2.0

BC2 SITE VISIT DATA SHEET

Type of Mining:

Open pit coal
Low volatile bituminous Ash 9.5% Moisture 8%.

Production (Quantity per year, working days/year):

3.2 million tonne/year/continuous

Time Setting:

Operations began in 1972.

Description of Mining and Transportation Methods

Mining Method:

2 open pits
Ten seams varying from 1.5 - 9 m thick in each pit
60 ha is actively mined at any given time
Waste rock fills mined out areas

Coal Use:

Metallurgical coal to market for steel production.

Equipment Used:

Unit	Size	Number	Cycle (Daily and Seasonal)	Other
Mining				
	Electric Dragline 46 m^3	1	-	
Loading				
	Frontend Loader	-	-	
	Mechanical Shovels	-	-	
Hauling				
Rock	109 tonne Trucks	-	-	
	154 tonne Trucks	-	-	
Coal	31 Trucks unknown size	-	-	

Stripping Ratio:

Unavailable.

Drilling and Blasting:

12.2 m benches exposing 3 or 4 seams - Rock is blasted leaving coal.

Haul Road Characteristics: (length, design, material)

Not available.

Storage Practices:

Three coal storage areas are used. See map BC2 for locations.

(1) Raw coal from pit to a 400,000 tonne capacity storage area stacker reclaimer facility average 50,000 to 100,000 tonne on pile at any given time. Constant turnover.

(2) Clean coal storage "cathedral" capacity 36,500 tonne. One end is open. When too much clean coal is produced it is piled outside the open end and later pushed into the cathedral by dozers. Dust is problem.

(3) Outside the railroad loop is an outdoor clean coal storage area. Capacity is 100,000 tonnes, however, it is rarely full. Piling method by truck dump, dozer compaction. Retrieve by front end loader on to unit train.

Service Area:

Size of mine service area including prep plant, maintenance buildings, mine offices, storage areas, loadout, etc. is 235 acres. Raw coal stockpile is 500 ft from office, cathedral 1000' from office.

Dust in mine service area is always of concern. Roads within the area are treated with used oil or water when needed. There are no problems associated with residential areas.

Waste Handling Techniques:

Not available - there is fine and coarse waste material from coal prep plant - into tailings ponds. See Map BC2 for waste dump locations.

DESCRIPTION OF THE EXISTING ENVIRONMENT

Met station data not being used.

Seasonal Description:

Cold winter - hot summer.
Moderate rainfall.

Regional Overview:

Geography:

Sparsely populated wilderness area.
Town 32 km southeast.

Geology:

Folded sedimentary Kootenay Formation coal thickness 1.5 - 9 m - 10 seams.

Vegetation:

Typical coniferous - heavily forested.

DESCRIPTION OF THE EFFECTS OF DUSTFALL BY THE DEVELOPMENT

Description of the Dustfall Monitoring Program: Date of Implementation September 1978.

Monitoring Unit	Number	Location (See Map)
A) B) C) D) Hi Vol		See map
1-8 Dustfall		

Results:

Information unavailable.

Description of Mitigative Measures for Fugitive Dust Control:

(When are the measures instituted?)

The Mining Areas:

Water haul roads.

The Handling Areas:

None.

Other:

Information unavailable.

- Is the dustfall problem site specific or widespread?

  Site specific.

- Is the effect periodic or continuous?

  Continuous.

- What are the regulatory levels ($\mu gm/m^3$)? Where must they be met - Mine Boundaries?

  See BC1

- Have regulatory people shown concern about the developments dust problems?

  Yes.

- Is the effect amenable to mitigative input or is it inherent to the operation?

    Major problem areas are amenble to mitigative input.

Major Fugitive Dust Problem Areas:

Haul roads
Clean Coal Storage Cathedral

Coal must be pushed by dozer into the storage bin which is open on one end. This produces a major dust problem.

BC3 SITE VISIT DATA SHEET

Type of Mining:

Copper
Open pit(s)
Shovel - Truck

Production (Quantity per year, working days/year):

Ore - 6.4 million tonne/yr
Waste - 19 million tonne/yr
Operating 365 day/year.

Time Setting:

1960-1962 - preproduction
1962-1965 - full production (initial pit - now abandoned)
1965-1970 - full production (first pit opened)
1970- - full production (second pit opened)

Description of Mining and Transportation Methods

Mining Method:

Open pit - truck/shovel.

Equipment Used:

Unit	Size	Number	Cycle (Daily and Seasonal)	Other
Mining				
195 BE	9 m^3	*3		(primarily)
Dart loader	12 m^3	*2		(backup)
Michigan	475	1		
Hauling				
Unit Trucks	M 100	19	15/16 Normally in operation	If breakdown occurs haul fleet is supplemented by 1 or more of old fleet tonne Wabso haulers

* 3 of the above in operation on continual basis (24 hrs - 365 day/year).

Stripping Ratio:

Formerly 3:1
Reduced to 1.25:1 at present due to mine planning and economics.

Drilling and Blasting:

2 45R BE rotary drills (20 cm hole) using ammonium nitrate (dry hole), aluminized, slurry (wet holes). Blast once per day 5 days per week.

Haul Road Characteristics: (length, design, material)

- Main haul road 2 mi round trip. All haul roads are 10% max grade and 25 m min. width. Composed of waste rock out of pit (quartz diorite) and blasted out of rock in pit.
- Approximately 8-10 km of total haul road.
- Approximately 40-48 km at total road within property including access roads.

Storage Practices:

No waste, ore, or topsoil overburden stored on large scale.

Waste Handling Techniques:

By ore truck to either abandoned open pit (7.25×10^6 tonne to date) or to dumps. Dumps are on side slopes and waste is free dumped - final slope is = to angle of repose (37°) for material which is rock. Dumps are wrap around type. Waste from concentrator operations (sand), is delivered by slurry (pipe) to tailings pond.

DESCRIPTION OF THE EXISTING ENVIRONMENT

- Is met station data being used? If yes what is source of data? Can we get a copy of this data?

Met station not used.

Location is nearby (approx. 65 km) Hat Creek. Altitude is 1220 m - 1525 m (305 - 610 m higher than Hat Creek).

Use Kamloops met data for correlation and refers to ERT Hat Creek met data.

Seasonal Description:

Mean ann. temperature, max 29.1°C
min -10.6°C
Rainfall - 344.7 mm/yr with 196.1 as snow
Growing degree days 1350
Frost free period 20 days

Regional Overview:

Geography:

- mountainous (above the highland valley on North side)
- relief to 254 m
- mixed forest and grasslands
- most operations have a southern aspect
- some logging roads in the area.

Geology:

- Porphyry copper - host rock contained in a batholith at quartz diorite (granite like composition). Chief minerals are chalcopyrite and bornite.
- Overburden is glacial till. Thin topsoils (1m) to exposed bedrock on upper slopes (brunisols-luvisols).

Vegetation:

Interior Douglas Fir Zone (Krajina)
Forest - grassland transition zone
Rangeland - wildland

DESCRIPTION OF THE EFFECTS OF DUSTFALL BY THE DEVELOPMENT

Description of the Dustfall Monitoring Program: Date of Implementation

Monitoring Unit	Number	Other
Hand dust detectors (on hand) (Used around machine areas for in-property examination only). Dustfall cannister (on hand) High Vol sampler (consultant)		Sampling done on a monthly (dustfall) and annual basis (high vol) in past years and results reported to PCB. Since results were below regulatory levels PCB advised that sampling not necessary at present.

NOTE: Regulations for in-property are controlled by Department Mines not PCB and are much stricter than off property.

Results:

No violation at BC-PCB regulatory levels.

Description of Mitigative Measures for Fugitive Dust Control:

(When are the measures instituted?)

- as required (summer - water)
  (winter - sander)

The Mining Areas:

- mine operations utilize 1 45 tonne Wabco haul truck converted to water sprayer for haul roads during summer. Capacity 9000 imp gal. supplied from a 3 x 10^6 gal tank equipped with quick fill apparatus. Also use a Kenworth truck water sprayer. Watering is almost continuous in summer. Very little problem in winter months.

The Handling Areas:

- During winter 1 45 tonne converted Wabco used as a sanding vehicle for haul roads.
- No binder agents used.
- Most dust comes from main access road (employee, visitor travel) and controlled by sprayer truck as required (gravel road).

Other:

- Wet scrubber on stacks from crusher/dryer operations.
- Snow fences (parallel to prevailing winds) on reclamation test plot areas.

Sprinklers were considered for some operations but idea dropped due to cost/operating - spray trucks control any present dust emissions.

- Is the dustfall problem site specific or widespread?

Site specific - main concern is health (Department Mines) within property boundary. Outside boundary no problem.

- Is the effect periodic or continuous?

Blasting periodic. Hauling continuous.

- What are the regulatory levels ($\mu gm/m^3$)? Where must they be met - Mine Boundaries?

BC - PCB - at property boundary.
TSP ann. geom. mean 60 $\mu gm/m^3$
Max. 24 hrs 150 $\mu gm/m^3$
Dustfall - 15 ton/mi^2/month

- Have regulatory people shown concern about the developments dust problems?

Monitored in past years - with control measures (scrubber, sprayer) no problems and sampling discontinued.

- Is the effect amenable to mitigative input or is it inherent to the operations?

Information unavailable.

Major Fugitive Dust Areas:

Pit blasting - not controlled - no problem
Haul roads - water spray control
Dumping - minor only - no problem
Crushing)
Concentrator) - wet scrubber control

NOTE:

- Total area out of production including disturbed, pits, ponds, buildings, etc., is 688 ha. (Does not include odd logging road - only the mine related area).

- Area is generally well drained (rock slopes; till and impeded drainage in bottom areas.

- Open pit mining areas 914 x 254 m.

- Tailings ponds - 1 operational 280 ha
  1 in construction 160 ha
  - construction rock and overburden till with some tailings sands.
  - 80% of tailing's water is recycled to process (15-20% tail water evaporated).
  - seepage to valley bottom is monitored.

- On tailings sands, dusting is only a problem when initially dumped - have found that by levelling the sands, 80% control is achieved even though it is not vegetated. (Particles from tailings area are 65-200 mesh - coarse fraction from cyclone separator - and drop very quickly).

BC4 SITE VISIT DATA SHEET

Type of Mining:

Open Pit - Copper/Smelter on site.

Production (Quantity per year, working days/year):

68,000 tonne per shovel shift/2800 tons per truck shift 5 days/ week, 3 shifts/day. 195 m per drill shift.

Time Setting:

Site preparation began March 1976
Production (full) February 1978

Description of Mining and Transportation Methods

Mining Method:

Truck - shovel

Equipment Used:

Unit	Size	Number	Cycle (Daily and Seasonal)	Other
Mining				
P & H A1 shovels		2	5 day/week	3 shifts/day
2 B-E 40R drills				
Loading				
Information unavailable				
Hauling				
Unit Rig Haul trucks		11	5 day/week	3 shifts/day

Stripping Ratio:

Information unavailable.

Drilling and Blasting:

195 m per drill shift (total)

Haul Road Characteristics: (length, design, material)

- about 5 km of road on site (haul road)
- access very short between mine and paved highway

Storage Practices:

Mine ore excavated, hauled to crushed operation and conveyed to a 22,700 tonne live load stockpile. Product (concentrate) is dried and bin stored.

Waste Handling Techniques:

Concentrator/swelter waste fed by slurry pipe to a tailings pond. Waste rock on site used for tailings dams and haul road construction. (Balance of waste dumped on site?)

DESCRIPTION OF THE EXISTING ENVIRONMENT

- Is met station data being used? If yes what is source of data: Can we get a copy of this data?

- Assume met data not being used.

- Since property is adjacent to Kamloops, all met data at government station is applicable. See Hat Creek - ERT Climate Report.

Seasonal Description:

See Kamloops met data.

Regional Overview:

Geography:

Above the city of Kamloops (west) and above the Thompson River Valley. Relief approx. to 30 m on property aspect-mixed. Terrain flat to rolling, odd hilly portion at the south side of property.

Land use was (agriculture/forestry defined) grazing (cattle). Mine presently operates through a subsidiary, a 200-300 head cow/calf grazing operation on unused portions of the property.

Geology:

Western end of the Ironmask batholith - on intrusive compared to coarse grained granodiorite and fine-grained microdiorite - micromonzonite. Associated with 2 other porphyritic intrusives. Mineralization includes native copper, chalcoute, bornite and chalcopyrite.

Vegetation:

Sparse, sagebrush, rabbit-bush, bunch-grass. Scattered pine groves on north slopes and at higher elevation.

Semi-desert vegetation communities - poor grassland at site.

DESCRIPTION OF THE EFFECTS OF DUSTFALL BY THE DEVELOPMENT

Description of the Dustfall Monitoring Program: Date of Implementation

Monitoring Unit	Number	Location (See Map)
No Cannisters		
No high volume sampling		

Results:

Not available.

Description of Mitigation Measures for Fugitive Dust Control:

(When are the measures instituted?)

- Use a water truck sprayer as required during summer months. Normally all days, 7 days a week and at night if required for roads.
- No spray or binders used during winter months.

The Handling Areas:

Information unavailable

Other:

- Drilling and blasting operations dust levels controlled by water spray and vacuum bags.
- Stack dust (concentrator/crusher), product loading etc., uses vacuum bags, wet process etc., and no apparent dust problem.

- Is the dustfall problem site specific or widespread?

  Apparently only roads need control and this is by water spray only.

- Is the effect periodic or continuous?

  The effect is not periodic, it is continuous on roads.

- What are the regulatory levels ($\mu gm/m^3$)? Where must they be met - Mine Boundaries?

  PCB Level A (off property)

- Have regulatory people shown concern about the developments dust problems?

  No action, monitoring requests etc. from PCB regarding dust.

- *Only Dept. Mines - health branch has investigated dust levels and this is just in and around machinery for worker safety.*

- Is the effect amenable to mitigative input or is it inherent to the operations?

  Information unavailable.

Major Fugitive Dust Problem Areas:

Roads but controlled.

NOTE

1. Permits required and issued by PCB are:

   1. Construction camp sewage
   2. Refuse
   3. Concentrator ore emissions
   4. Concentrator tailings
   5. Smelter air emissions

2. Shelter stack gases:

   - dust removal by electrostatic precipitator.
   - SO_2 treated by a dual-alkali scrubber.

BC5 SITE VISIT DATA SHEET

Type of Mining:

Copper - Molybdenum concentrate
Open-pit

Production (Quantity per year, working days/year):

Waste (rock and overburden) - 36.5 x 10^6 tonne/year
Ore (copper and moly) - 15.9 10^6 tonne/year

Time Setting:

'65-70	-	exploration
'70-72	-	construction and preproductions
Oct. '72	-	production

Description of Mining and Transportation Methods

Mining Method:

Shovel - truck

Dump waste to wrap around 37° hillside dumps (waste is rock)

Equipment Used:

Unit	Size	Number	Cycle (Daily and Seasonal)	Other
Mining				
P & H 2300	17 m^3	1		
P & H 2100	11.5 m^3	5	4 operating per shift all year round	
BE 280	15 m^3	1		
Loading				
Direct from above shovels to haul truck and front end loader if required in some areas.				
Hauling				
Wabco 3200	190 tonne	11		
Wabco 120	100 tonne	23		

Shipping Ratio:

2.17:1

Drilling and Blasting:

- blasting done once per day, 5 day/week, year round
- normally try for 60 holes blasted each time and each one is 12 m deep
- this allows approximately 2.7 x 10^6 tonne of broken rock to be ahead of the shovels at any time
- blasting is done wet and dry
- drilling is all water spray injection so dust is minimal

Haul Road Characteristics: (length, design, material)

Haul roads are covered with crushed pit rock. Access roads gravel. Haul roads 14.5 km approximately main haul roads in put 8% grade, most others 6%. Access roads on mine property approximately 16.2 km plus approximately 16.2 km in lower valley associated with tailings pond use.

Storage Practices:

After crushing, ore is delivered to a static pile by conveyor to assume concentrator of continuous supply. Product truck hauled by paved road to railhead. No other storage of material.

Waste Handling Techniques:

Waste rock from pit hauled out by Wabco 190 or 100 tonne to nearby wrap around dumps built up and out from hillside in 15.25 m (width) x 12.2 m lifts.

DESCRIPTION OF THE EXISTING ENVIRONMENT

- Is met station data being used? If yes what is source of data? Can we get a copy of this data?

  Met station data is not being used.

  Kamloops - see Hat Creek ERT reports.

Seasonal Description:

Temp.	Jan.	-10.6°C	Mean Average Minimum
	July	+29.1°C	Mean Average Maximum

Precipitation - 344.7 mm/yr with 197.1 as snow.

Growing degree days 1350

Frost free period 20 days.

Regional Overview:

Geography:

- mountainous 125 - 1525 m ASL
- relief to 305 m
- operations on south side of Highland valley approximately 30 miles from Ashcroft, B.C.
- aspect is generally north

Geology:

Granodiorite batholith with magmatic intrusions of lower Jurassic age. Main rock types and minerals quartz diorite, calcopyrite, bornite, molybdentite, and sulphides.

Vegetation:

Interior Douglas Fir zone (Krajina) forest grassland transition zone.
soil = luvisols - brunisols

DESCRIPTIONS OF THE EFFECTS OF DUSTFALL BY THE DEVELOPMENT

Description of the Dustfall Monitoring Program: Date of Implementation

Monitoring Unit	Number	Location (See Map)

No cannisters or high vol. units used now or in the past.

Results:

Not available
PCB have never asked, required or measured any dust levels.

Description of Mitigative Measures for Fugitive Dust Control:

(When are the measures instituted?)

During summer, June through September 2 - 769 cat trucks equipped with approximately 7 x 10^3 gallon water tank are used on road network 7 days a week (2 trucks from approximately 6:00 a.m. to 11:00 p.m.) utilize pit waste water for supply.

During winter, November - March, above trucks are re-equipped with a box to spread CaCl plus sand (together).

All drilling operations utilize a water spray injection and dust is controlled with acceptable limits (although no one measures it to see the result). Utilize a wet crushing process so no dust.

- Is the dustfall problem site specific or widespread?

  Haul and access roads only.

- Is the effect periodic or continuous?

  Continuous on haul roads.

- What are the regulatory levels ($\mu gm/m^3$)? Where must they be met - Mine Boundaries?

  BC PCB - at property boundary
  TSP - annual geometric mean - 60 $\mu g/m^3$
  max. 24 hours. - 150 $\mu g/m^3$

  Dustfall - 15 tons/mi^2/mo

- Have regulatory people shown concern about the developments dust problems?

  No.

- Is the effect amenable to mitigative input or is it inherent to the operation?

  Information unavailable.

<u>Major Fugitive Dust Problem Areas:</u>

Haul roads.

NOTE:- Total area out of production 1200 acres (includes logging roads).
- Area is well drained (some impeded in valley bottoms due to till accumulation).
- Waste dumps are rock, wrapped around hillside at .9 x 10^6 tonne per lift. 36° overall slopes, 15.25 m berms between lifts of 12.2 m height.
- Tailings pond in lower valley are delta discharge (i.e. fixed pipe).

APPENDIX 5

MINE DATA, ALBERTA

A1 DATA SHEET

A1 is an open pit metallurgical coal mining operation located on the central eastern slopes of Alberta's Rocky Mountains. Coal is extracted by the shovel/truck method from 3 open pits at a rate of approximately 2 million tonnes per year. Waste is dumped into abandoned pits. Coal is washed at an on site preparation plant before it is loaded on to unit trains bound for B.C. terminals.

Precipitation averages approximately 500 mm yearly. The area surrounding the mine is mountainous and densely forested.

High volume samplers are not being used to measure suspended particulate levels. A system of 11 cannisters measure dustfall levels around the mining area. These are located primarily east of the operation. Winds are predominantly from the west. The following tables represent data collected during the period from October 1977 to July 1978.

Dustfall Determinations in the Al Mine Area
(Tons particulate matter/sq mi/30 days)

Station #	January By Evaporation	January After Ignition	February By Evaporation	February After Ignition	April By Evaporation	April After Ignition	May By Evaporation	May After Ignition
1	15.47	5.45	32.30	11.32	15.23	7.53	43.06	35.43
2	25.56	7.16	11.69	4.40	9.87	5.92	11.58	5.42
3	20.76	4.44	107.05	26.89	20.79	11.75	25.78	13.01
4	40.14	9.57	102.53	33.62	10.25	3.74	44.25	19.58
5	7.14	2.58	20.98	11.80	21.68	13.58	29.55	18.18
6	24.23	7.50	35.75	16.30	18.54	12.69	33.90	21.29
7	1.26	1.19	-	-	12.05	5.00	9.43	4.23
8	11.53	4.97	-	-	13.54	6.88	23.72	11.67
9	91.00	42.45	15.72	7.73	9.02	1.01	12.33	4.95
10	11.51	4.56	-	-	15.33	6.51	17.31	9.65
11	62.94	14.33	110.17	36.77	18.79	6.26	51.87	18.99
12								

Dustfall Determinations in the Al Mine Area
(Tons particulate matter/sq mi/30 days)

Station #	June By Evaporation	June After Ignition	July By Evaporation	July After Ignition	October By Evaporation	October After Ignition	November By Evaporation	November After Ignition	December By Evaporation	December After Ignition
1	12.10	5.82	13.25	3.97	17.02	11.23	20.12	10.86	15.03	5.82
2	11.73	6.95	15.60	7.22	-	-	157.25	78.44	45.97	18.90
3	25.40	15.57	29.84	14.03	157.69	70.03	9.61	2.67	41.03	10.86
4	43.80	20.02	61.29	24.38	9.02	4.13	450.72	156.13	183.40	57.58
5	24.67	17.10	13.22	10.02	7.73	6.39	61.78	26.95	10.05	5.24
6	29.92	17.12	29.68	21.14	198.45	162.21	99.85	67.47	45.36	28.40
7	12.78	8.57	24.51	16.10	-	-	11.31	9.10	7.97	4.19
8	26.56	16.63	21.01	10.08	-	-	134.10	63.12	16.70	6.37
9	14.87	6.14	13.71	8.22	38.89	25.59	-	-	-	-
10	25.81	16.77	8.78	4.36	-	-	-	-	16.62	7.25
11	56.69	27.37	54.25	24.31	113.97	56.80	-	-	215.75	58.36
12			113.96	71.63						

APPENDIX 6

CORRESPONDENCE

THE STATE OF WYOMING

ED HERSCHLER
GOVERNOR

Department of Environmental Quality

AIR QUALITY DIVISION

HATHAWAY BUILDING CHEYENNE, WYOMING 82002 TELEPHONE 777-7391

November 16, 1978

Dear

Attached is a draft copy of the Air Quality Division's most recent analysis and recommendations of emission factors to be used in the development of fugitive emissions from coal and uranium mining activities.

This document is undergoing final review within the Department and is forwarded for your review and comments.

The final version will represent the basis upon which the Division will analyze permits for mining operations. We would appreciate receiving comments on this document.

Very truly yours,

Randolph Wood
Administrator
Air Quality Division

RW:cn

A REVIEW OF FUGITIVE DUST EMISSION FACTORS

INTRODUCTION

The Division of Air Quality of the Wyoming Department of Environmental Quality has, for several years now, required applicants wishing to construct and operate facilities which produce significant quantitities of fugitive dust to submit ambient impact analyses. The task of preparing such analyses involve the calculation of potential fugitive dust emissions from the various activities involved and the subsequent dispersion modeling to predict expected increases in total suspended particulate concentrations in the vicinity of the facility.

At the time that the Division initiated this requirement no official guidelines were provided in regard to what were acceptable emission factors or applicable modeling techniques. It was hoped that by doing such, prospective applicants would develop their own emission factors as there was a significant lack of reliable data available at the time. A variety of developed dispersion models have since been utilized but basically all employ a Gaussian dispersion equation and it is felt significant disparities do not exist at present due to the dispersion models themselves as opposed to the use and selection of emission factors.

To eliminate some of the frustrations and confusion in selecting activity emission factors, this report will review all in office data available and propose those factors believed to be most applicable for use in reviewing applications concerning fugitive dust impacts - namely surface coal and uranium mines. Also guidance will be provided concerning the use of particulate deposition rates in dispersion models.

REVIEW OF CURRENTLY USED EMISSION FACTORS

Emission factors currently in use by the Division in the application review process were developed by PEDCo-Environmental for a single lignite surface mine in North Dakota. These emission factors were subsequently used to develop a mine emission factor which was used in the Wyoming Air Quality Maintenance Area Analysis[4] for the Powder River Basin. A research of these emission factors indicates that except for haul roads, wind erosion, and vehicle exhaust, they are engineering estimates only and are not measured values. These emission factors as currently used by the Division are as follows:

Dragline Operation (Overburden Removal)

Emission Rate = 0.05 lb/ton of overburden removal
Control Factor - None
Moisture Days - None

Scrapers

Emission Rate = 32 lbs/hr of operation
Control Factor = 0.5 for watering
Moisture Days - In some cases an assumption is made that hours of operation is during dry days. In other cases a reduction in emissions is made to account for moisture days (days in which rain or snowfall $\geq$ 0.01" H_2O).

Haul Road Traffic

$$\text{Emission Factor} = 0.81 \times s \times S/30 \times \frac{365-W}{365} \text{ lbs/VTM}$$

where s = silt content (-200 mesh or $\leq$ 75 μm)
S = vehicle speed mph
W = moisture days (0.01" H_2O or more)
Control Factor - 0.5 for watering
- 0.5 for application of chemical stabilizers

Particle Size Fraction - multiply by 0.6 to account for 30 μm and less
Wheel Size - Multiply by 2.5 for haul trucks.

Access Road Traffic

Emission rate same equation as haul roads - no correction for wheel size.
Control - 0.5 for watering, chemical stabilization, or binder with chip and seal surface.

Haulroad Repair and Construction

Scrapers & Graders - 32 lbs/hr of operation
Control - 0.5 for watering
Moisture Days - hours of operation are assumed on dry days in some cases and not in others.

Product Removal - Shovel or Frontend Loader

Emission = 0.02 lbs/ton of coal removed

Overburden Removal - Truck/Shovel

Emission rate = 32 lbs/shovel hr with control factor of 0.5 or 0.02 lbs/ton overburden with adjustment for moisture days.

Wind Erosion

0.25 ton/acre/year based on Universal wind erosion equation
E = AIKCL'V' from reference 4 using a typical mine in Powder River Basin.

Product Dumping

0.02 lbs/ton
Control - 70% water or negative pressure at dump hopper.

Stockpiles

Variable but mostly from AP-42 for sand & gravel stockpiles.

It should be noted that the above emission factors are used in the dispersion modeling with no fallout function.

REVIEW OF CURRENT EMISSION FACTORS

In the task of selecting the most applicable emission factors two primary goals were attempted. The first goal was to select factors which could be used in a dispersion model in conjunction with a fallout rate. As it is generally accepted that significant fallout does occur for fugitive dust particules associated with mining and materials handling facilities, it was felt that an attempt should be made to approximate reality. The second goal was to select factors which were specific to Wyoming mines. With these goals in mind a recent survey performed by PEDCo came to the forefront among available materials. A table of emission factors were developed as a result of this survey (see attachment I) from 5 western coal surface mines.[1]

Another set of emission factors were developed by the Midwest Research Institute for particles 30 μm and less in diameter. A portion of these factors were verified by isokenetic sampling methods at a steel plant.[2] In general these factors were not selected for use in a Division guideline due to a particle size cutoff of 30 μm and calculated large emission rates for haul truck traffic on unpaved roads as compared to those measured in Reference 1 or calculated in accordance with the equation in AP-42. The entire report (Reference 2) is contained in attachment 2 for the reader's review. Attachment 3 (reprinted from reference 6) contains two tables, one summarizes the range of various emission factors for different types of mineral mining and the second table summarizes control techniques, efficiencies and cost. The data contained in this reference was essentially all that was avialable up to several years ago.

SELECTED EMISSION FACTORS

Following this review are guidelines for selected emission factors, control techniques and control efficiencies. The following outlines the reasoning behind these selections.

1. Overburden Removal

   A. Dragline - 0.053 lb/yd^3
      Source - Reference 1 (see Attachmentl). Represents Wyoming mine and is not much different than what was previously used (.05 lbs/ton)

   B. Truck/Shovel - 0.037 lbs/ton
      Source - Reference 1 (see Attachment 1. Represents Wyoming mine and is only measured data available.

   C. Scraper - 32 lbs/hr
      Source - Estimate (Reference 4). Factors contained in Reference 1 (Attachment 1) are for top soil removal only. Considerable work is done with a scraper removing overburden in preparation to using a shovel as well as in haul road construction. In essence too many activities associated with this equipment was left out.

      Control Technique - Watering 50%, in common use.

2. Haul Roads & Access Roads

$$E = 0.81\ s\ (S/30)\frac{(365-W)}{365}\ \text{lb/VMT}$$

Source - Reference 5 (see Attachment 4). This factor using mine specific variables compares favorably with those presented in Reference 1 (Attachment 1). It was felt that a factor which accounted for silt content, vehicle speed, and wet days was essential.

Control Technique

Watering - 50% Widely Accepted

Oil or Chemical Dust Suppressant - 60%.
There is no basis for this efficiency although it is reported that a research program conducted in Arizona achieved much higher efficiencies. Finally it seems prudent that if the Division considers this to be BACT then some credit ought to be given for such.

Stabilization of Base with Chip and seal surface - 70%. No basis for efficiency although it was felt that if properly maintained this technique ought to be better than an oil or chemical dust suppressant treatment.

Asphalt Paving - 85% Widely Accepted

3. Haul Road Repair and Construction

Graders & Scrapers - 32 lbs/hr
Source - Estimate, no measured data.
Control - Watering 50%, widely accepted.

4. Wind Erosion - E = AIKCL'V' ton/acre/yr
Source - Reference 3, only widely accepted equation.

5. Product Removal

Coal - truck/shovel - 0.007 lbs/ton
Source - Reference 1 (see Attachment 1), highest of two Wyoming mines.

Coal-Frontend Loader - 0.007 lbs/ton
Source - Estimate, only available data (Reference 1) 0.12 lb/ton seemed too high in comparison to a truck/shovel operation. From an operation standpoint there is very little difference in the mechanics of how the equipment extracts and loads the coal.

Uranium - Front loader - 0.007 lbs/ton
Source - Estimate, given the fact that uranium ore in surface mines is usually wet, it is hard to see how this could be higher than the same operation for coal.

6. Product Dumping

Coal - Truck Dump - 0.02 lb/ton
Source - Reference 1(Attachment 1), measured at mine B in Wyoming. Mine E in Wyoming was much lower; however, controls could have been operating at this mine.

Control Technique - water sprays 50%; Negative Pressure 85%; Reference 6 (Attachment 3).

Uranium - 0.02 lb/ton
Source - Estimate, same reasoning as 5 above.

7. Stockpiles (wind erosion)
   Coal - 1.6 u lb/acre/hr, where u is wind speed in m/sec.
   Source - Reference 1 (Attachment 1)

   Uranium - E $\doteq$ 0.05 (s/1.5)(d/235)(f/15)(D/90) lbs/Ton throughput in pile.
   Source - Reference 2 (Attachment 2), developed equation is for sand and gravel stockpiles. An alternate source of information pertaining to stockpiles is contained in Attachment 5.

   Control Technique - Enclosure 99%, watering 50%.

8. Blasting

   Overburden - 90 lbs/blast
   Coal - 80 lbs/blast
   Source - Reference 1 (Attachment 1)
   Attachment 6 contains a good review of data available concerning blasting.

USE OF A FALLOUT FUNCTION IN MODELING

A fallout function suggested for use in conjunction with emission factors developed in Reference 1 has been selected for use with guideline factors outlined in the attached tables. (See Attachment 7)

The equation which is easily incorporated into computerized dispersion models is as follows:

$$\frac{Q_x}{Q_o} = \exp\left[-\frac{aV_d\, x^b}{u}\right]$$

Where a & b are constants which are a function of stability class

V_d = settling velocity cm/sec (use 5.0 unless better data is available)

x = downwind distance, m

u = windspeed, m/sec

Q_o = initial emission rate

Values for a & b are summarized below:

Stability Class	a	b
A	0.120	0.14
B	0.135	0.15
C	0.183	0.18
D	0.115	0.30
E	0.160	0.30
F	0.114	0.40

Some examples of Q_x/Q_o are given below for different stabilities holding winds at 5 m/sec:

Stability	x	u	Q_x/Q_o
C	500	5	.57
C	1000	5	.53
C	2000	5	.49
C	3000	5	.46
D	500	5	.48
D	1000	5	.40
D	2000	5	.32
D	3000	5	.28
E	500	5	.36
E	1000	5	.28
E	2000	5	.21
E	3000	5	.17

CONCLUSION

The emission factors and fallout function selected in this review represent what the Division will use in review of permit applications. A table summary of emission factors, control techniques, and control efficiencies is presented near the back of this review. It is not intended that applicants be forced to use this information in their impact analysis if they feel more applicable information which is documented is available. The Division of Air Quality will, on a regular basis, strive to up date this guideline as better data becomes available.

REFERENCES

1. EPA-908/1-78-003, "Survey of Fugitive Dust from Coal Mines," by PEDCo Environmental, Inc., February 1978.

2. C. Cowherd, and R.V. Hendricks, "Development of Fugitive Dust Emission Factors for Industrial Sources, "Paper No. 78-55.4, Annual Meeting Air Pollution Control Association, Houston Texas (June 1978).

3. EPA-908/1-78-003 "Evaluation of Fugitive Dust Emissions from Mining" by PEDCo Environmental, Inc., April 1976.

4. EPA-908/1-76-008, "Wyoming Air Quality Maintenance Area Analysis," by PEDCo Environmental, Inc., May 1976.

5. AP-42 "Compilation of Air Pollutant Emission Factors (Supplements 1-8)" May 1978.

6. EPA-450/3-77-010, "Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions", by PEDCo Environmental, Inc., March 1977.

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A.C. Knight, M.D.
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January 9, 1978

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Dear

Several other projects have kept me from meeting your December 22 comment deadline. My comments are as follows:

1. High volume samplers were used as the standard particulate sampler in the report.

   Bottom page 14 states two upwind hi-vols were placed together. If the field data sheet on page 19 is typical the upwind collocated sampler readings differ by 15.5%. This deviation is great for samplers highly tended in a special study. The April, 1977 "Environmental Science and Technology" issue page 387 shows that the hi-vol roof orientation can account for great deviations. The article shows the larger the particulate and the greater the wind speed the less the hi-vol collection efficiency. At 4.6 m/sec with 15 micron particles, efficiency is 55% at best. 50 micron particles are collected only 34% of the time at the 4.6 m/sec wind speed. Tables C-1 to C-5 pp. 99 to 103 show about 200 wind values with 27% less than 5 mph, and almost entirely at mine A. It looks like the average is about 8-12 mph. (4.6 m/sec is 10.3 mph). Thus the field hi-vol samplers were generally gathering about 50% or less of the particulates, especially the large particles. It is not clear how much attention was given to orientation during the operation of the hi-vol samplers.

   In large particle size areas, near coal mine activities I strongly suspect the sampler orientation and wind will cause greater hi-vol sampling errors than were indicated in the Colorado A&M study. It appears to me the use of hi-vol samplers contributed to low data precision with errors possibly coming from (1) operation (15.5% variance as above), (2) orientation (10 - 90% Colorado study),

(3) high filter loadings and (unknown loss-see page 24) and (4) other.

2. On page 22 it states the hand held instrument could not measure wind speeds less than 5 miles per hour. In rough terrain as shown in photographs on page 16, the low level measurements of winds (probably 2 meter height or less) would not be representative for the sampled area. I would guess also that the 5 mph starting wind threshold would have created many data problems low in box-cuts and close to spoil piles. If table 4-10 on page 53 gives typical wind conditions, 34% of the wind speed readings were less than 5 mph and the hand held wind instrument would have produced no results. Orientation was apparently read to the closest 5^0 at 5 minute intervals.

   If the Bendix Aerovane was the propeller type, it would have been rather unresponsive to low wind conditions. The continuous wind system at 24 meters was too low to the ground. For example on page 18 the two measurements had a net difference in velocity and direction of 42% and 26.5% respectively. The example rightfully indicates the continuous system wasn't appropriate for the test this was probably the case most of the time. Wind characterization appears to have been a large source of error.

3. Particle sizing was done microscopically using 67 millipore filters on about 6% of the hi-vol filters (page 11). Such microscopic analysis is different to perform. It is interesting that after performing 67 of these expensive analysis - they were all thrown out. A recent field study (of highways) mass media diameter of 15 microns was instead substituted in for this coal field study.

   From table 4-10, page 53 - Haulroads, samplers were placed at distances from the haul roads with the following results:

	MM Diameter	Std. deviation
10 meters	17.9 microns	6.0
20 meters	24.8 microns	7.3
30 meters	25.7 microns	12.6

   This increase, or absence of a trend in other cases, in particle size with distance seems to have frustrated the study, but to choose (page 55) a mass mean diameter of 15 microns, to obtain a reasonable settling velocity of 5 cm/sec is irresponsible.

   You could have used your own particle sizing information to calculate settling velocities. Why was this not done? Instead of choosing an unrelated factor.

   The note on page 8 that small particulates adversely affect health is certainly correct. Generally such data is gathered with aerodynamic type samplers instead of microscopy as was done here.

4. The dispersion equation used is a very simple equation. Noted problems with its use follow:

a. The model page 30 assumes no wind variation. But at ground level wind variations are the greatest, especially in such irregular coal mine surface conditions.

b. The model page 22 assumes a stationary point source, but the example of the dragline with its great movement violates the assumption.

c. Often visual observations page 24 were used to indicate whether samplers were in the plume centerline. Sometimes they couldn't even predict where the plume was located. Through trigonometric or other relationships page 30, they derived empirically the plume centerline horizontally and vertically. With noted variance in wind characterization as above, this correction factor could contain considerable error, especially when a Gaussian distribution is being used. As one ascends or descends the curve to centerline great variations occur.

d. It is very probably that the 2.4 meter sampling height was generally at the bottom of the plume. The standard deviation for this large construction type equipment in the coal mining would be considerably greater than the deviation for highway traffic as cited on page 18 and 19. I would thus assume the verticle standard deviation to be several times higher than 2.4 meters. From the data and the page 45 note that the 1.2 and 2.4 meter heights differ in emission rates by 14%, nothing of value can be said about the vertical aspects of the plume.

e. In the horizontal plane there seemed to be chaos. On page 24 where it states "the reduction in apparent emission rates with distance from the source was not as consistent as was expected" was an understatement. If I am not mistaken you used factors from other studies to obtain some what reasonable emission factors because your sampling data didn't fit any predictable trends. Figure 4-1, page 52 shows this disparity - with distance from the source, emissions should fall off. More often than not this expected trend was not observed even with "supplied" factors.

Why was so much variation observed?

From the tables 4-1 tp 4-7 pages 41-47 only about 20% of the hi-vols were spread apart at 10, 20, 30, 40 meters or such equivalent distances and only at 2 of 7 sources at 3 of 5 mines if I'm not mistaken.

The majority of the sampling was performed with samplers generally speárated by roughly 8 meters in set-ups of threes. At 10, 20, 30, 40 meters the range is a factor of 4. But for 70, 78.5, 87 the factor is 1.2 This implies rather poor coverage in the horizontal plane.

Perhaps there were not enough extension cards - what ever the reason, the samplers were probably too close together for such large sources. Again data gathered did not support the fall-out theory which expects to 7% emission reduction with each 10 meter interval to 40 meters from the source.

In the horizontal plane no real data or conclusions were obtained which could help derive emission factors.

5. On page 24 if it is to be understood that emissions from storage piles and expected areas are negligible, then there must be a mistake. Many visual observations certainly dispell this idea.

6. On page 32 you state that inaccuracies (deviations from a Gaussian distribution) cancel out because the calculated emission rates are subsequently substituted back into a Gaussian model for comparison against ambient readings. This defeats the purpose of the study. Emission factors should be additive and stand as such. Perhaps your indications on page 75 that the situation was non-Gaussian is correct or a sophisticated dispersion equation should have been used. Perhaps the upwind-downwind concept will not work. I don't think errors just cancel themselves out.

7. I feel that the study should have related to the type or nature of activity rather than to set apart different mines and geographical areas. If it is known what operations are or will occur, then a straight mass balance could be made to characterize the operation. From the data in this study such general emission factor use toward applications can not be done.

8. About 20% of the data was eliminated for various reasons. Somewhere I think I read that you felt you were within a factor of $\pm$ 2 for accuracy. This might be the case for a good diffusion model having good wind and source information neither of which you had. With large biases noted above my guess is that you might be within a factor of $\pm$ 10 fold in accuracy. The dispersion equation discussion has too many assumptions; not all problems and possible errors were discussed. Too much data was thrown out.

9. The study does indicate which sources might be major and minor contributions to particulate emissions but great refinement is necessary before the factors would be of any use to the State of Montana.

Sincerely,

David Maughan

David Maughan
Air Analyst

DM:es
cc: Butch Rachal, Region VIII EPA, Denver