BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

Environmental Research and Technology Inc. - Air Quality and Climatic Effects of the Proposed Hat Creek Project Report - April 1978.

ENVIRONMENTAL IMPACT STATEMENT REFERENCE NUMBER: 14a

Document P-5074-F
April 1978

Prepared for
British Columbia Hydro and Power Authority

Air quality and climatic effects of the proposed Hat Creek project

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FORT COLLINS, CO. • WASHINGTON, D.C. • HOUSTON • CHICAGO

PRINTED IN U.S.A.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

1.0 INTRODUCTION

This report describes an assessment of air quality and climatic effects of the Hat Creek Project, a proposed electrical generating complex in south-central British Columbia, to be built and operated by British Columbia Hydro and Power Authority (B.C. Hydro). The project will consist of a (nominal) 2000 Mw coal-fired power plant, an open-pit coal mine with a projected peak annual run-of-mine production level of 9.8 million tonnes and associated facilities. This assessment was prepared by Environmental Research & Technology, Inc. (ERT), with contributions from Western Research and Development Ltd. (WR&D) and Greenfield, Attaway and Tyler, Inc. (GAT) (now Flow Resources). The required studies were performed in fulfillment of B.C. Hydro specifications in the Terms of Reference for Hat Creek Project Detailed Environmental Studies, Appendices D, D1, D2, D3, D4, D5, and E3. As required by the Terms of Reference, a comprehensive program of work was developed to accomplish the objectives of B.C. Hydro. The study approach was designed to make full use of relevant scientific literature and available data and, to augment these information sources, as required for thorough evaluation, on-site field measurements and mathematical model predictions. Specific tasks include:

- collection, organization, processing, and analysis of existing meteorological and air monitoring data to characterize the present air quality and climatology, with particular regard to documentation of atmospheric dispersion potential in the project area;
- design, installation, and operation of an aerometric monitoring network for intensive evaluation of air quality and meteorological conditions in the immediate vicinity of the project before and during its operational lifetime;
- selection, calibration, and application of mathematical models to predict incremental air quality and climatic effects of project emissions from the power plant stack, evaporative cooling towers, mining operations, make-up water reservoir and ash pond, including evaluation of alternative control technologies;

- investigation of air quality consequences of project construction and retirement, and of various off-site activities and facilities;
- evaluation of potential epidemiological effects due to project emissions; and
- analysis of the project's potential influence on trace element levels in the ecosystem.

Eight Appendices to this report are attached as separate volumes. Appendix A includes complete listings and descriptions of the meteorological and air quality data used throughout the analyses. Appendix B provides technical descriptions and the rationale for selection of analytical tools to address specific air quality issues. Diffusion model results for three alternate sulfur dioxide control strategies are presented in Appendix C. Appendix D is a comparative analysis of atmospheric effects due to four evaporative cooling tower systems. An assessment of existing climate and potential climatic effects of the project is included as Appendix E. Appendix F describes a comprehensive study of trace elements in Hat Creek source materials and their pathways through the environment. Appendix G documents an analysis performed by WR&D and GAT to investigate threshold contaminant concentrations associated with human health. Finally, the design of a sophisticated new aerometric monitoring program in the vicinity of the project site is presented in Appendix H.

The nature of the integrated assessment approach is illustrated by tracing the procedures followed to evaluate the effects of emissions from the proposed power plant on ambient sulfur dioxide (SO_2) levels in the project area. Specific ambient guidelines and emission objectives for coal-fired electrical generating stations have not yet been established in British Columbia. Consequently, a thorough literature search was conducted to identify allowable contaminant thresholds in terms of chronic and acute human health effects (Appendix G). Next, 'guideline' concentrations well below those associated with adverse health were postulated for various averaging times. A mathematical diffusion model was selected and calibrated (Appendix B) on the basis of on-site measurement experiments to characterize dispersion processes in the lower atmosphere at the site (Appendix A). The calibrated model was then used with inputs reflecting local weather and topography (Appendix E) and expected emissions corresponding to various methods for SO_2 control (Appendix C) to calculate ground level concentrations for each hour of a 1-year period. The results were analyzed for compliance with assumed 'guidelines' and processed as required to allow evaluation of specific potential impacts.

Similar procedures were followed to examine the potential effects of other atmospheric contaminants from the power plant, the cooling towers, and the mine. In some cases, limitations of present modeling techniques or requirements for further information precluded the use of mathematical prediction techniques. As a result, some air quality issues of interest were addressed by means of literature surveys, order-of-magnitude analyses and other qualitative and semi-quantitive methods. Appendix B provides complete descriptions of the rationale and technical basis for the selection of assessment methods to meet the program objectives.

2.0 SUMMARY OF CONCLUSIONS

2.1 EFFECTS OF THE PROJECT

(a) Construction

Fugitive dust emissions will result from a number of activities during construction of the power plant, coal mine, and off-site facilities. Vehicular traffic from trucks, construction equipment, and workers' passenger cars will emit hydrocarbons, sulfur oxides, carbon monoxide, and particulates. Detailed information regarding specific aspects of construction processes that will affect air quality has not been developed, and no quantitative estimate of these effects is possible. However, it is anticipated that directly emitted gaseous and particulate contamination will not produce excessive ambient concentrations. High localized particulate concentrations may occur as a result of dust from construction, although it is expected that B.C. Hydro will implement dust prevention techniques to minimize such impacts. The temporary nature of these activities and their limited geographical extent (primarily on the project site) precludes the possibility of any substantial adverse air quality impact in the site environs.

(b) Project Operation

(i) Climatic Effects

The following conclusions are based on a thorough review of the scientific literature pertaining to climatic effects of thermal power generation, to field programs designed to ascertain these effects, and to calculations using projected emission characteristics of the Hat Creek Project.

The project will have no appreciable effect on global atmospheric processes. Its discharges of heat, moisture, particulates, and gaseous contaminants are very small compared to world-wide natural and anthropogenic emissions. Project operation will not alter the temperature structure of the atmosphere, nor will it affect its energy balance in any discernible manner.

Emissions from the mine and generating station will not measurably alter the chemical and radiative processes governing the composition of the stratosphere.

Waste heat and moisture from the cooling towers are expected to produce slight increases in precipitation amounts (no more than 1% annually), primarily in the very near vicinity of the site, but potentially to a distance of perhaps 50 km. Precipitation enhancement will normally involve augmentation of natural processes. On rare occasions, snowfall amounts may be increased by a few centimeters due to cooling tower emissions. Local cumulus cloud initiation may result during days characterized by natural convective instability.

Visible plumes from the cooling towers will occasionally extend to distances more than 15 km from the generating station. Shadowing by the plumes is not expected to occur more than 20 hours per year at any location beyond 2 km. No ground-level icing or fogging are predicted for natural draft cooling towers due to the plume exit height of over 100 m. The power plant stack plume may be visible on some occasions due to particulate emissions and sulfate formation, but neither this plume nor that from the cooling towers is expected to decrease noticeably the incidence of solar radiation at the ground.

Mining activities are expected to substantially reduce visibility on a local scale within the Hat Creek Valley. An object that could be seen in fine detail at a distance of 14.6 km will be seen in the same detail after commencement of mining operations at no greater a distance than 3.6 km because of dust loading on the atmosphere. Although the power plant plume will be partly opaque near the stack, no significant effects on local visibility are expected. Sulfate formation and particulates far downwind of the project site will degrade regional visibility by a small amount, approximately 6% on an annual basis.

Evaporation from the ash pond and make-up water reservoir will increase the local relative humidity within a region defined by a radius of about 5 km. The increased moisture will occasionally saturate the atmosphere and produce local fogging that could persist over a small portion of this area for a few days during the late fall, winter, and early spring. The two natural draft cooling towers will typically increase the ground-level humidity in their vicinity by less than 1%, although during particularly adverse meteorological conditions this effect could amount to as much as 10 to 15%.

A slight and very localized annual temperature decrease may occur directly over the mine pit due to scattering of incoming radiation by sustained particulate loadings in that area. Theoretical model simulation of atmospheric processes support this contention. Any effect of this kind would certainly be smaller in magnitude than the natural year-to-year variability of annual average temperature and will not have any significant impact on agricultural activities.

Emissions from the power plant will cause intermittent changes in the chemistry of precipitation falling at downwind locations. It is expected that short-term pH values between 3.0 and 4.0 will occur beneath the plume within 20 km from the stack during typical summer showers. A long-term average precipitation pH reduction to about 4.2 is predicted to occur within limited areas. (This result is based on calculations made with extremely conservative assumptions and a background pH of 5.0 to 5.5.) Natural wind variability will preclude serious or widespread acidification of precipitation due to project emissions.

(ii) Air Quality Effects

Relevant air quality criteria were reviewed in detail for the provinces of:

- British Columbia,
- Alberta, and
- Ontario;

and for the states of:

- Washington,
- Idaho, and
- Montana;

and for the federal governments of Canada and the United States. These criteria for existing or proposed air quality objectives and relevant health data have formed the basis for the ambient air quality guidelines assumed in this study (see Appendix G). Diffusion model calculations indicate that the guidelines proposed by B.C. Hydro will generally not be exceeded because of operation of the Hat Creek Project except for TSP concentrations in the Hat Creek Valley in the immediate vicinity of the mine. These levels are expected to exceed the relevant 24-hour and annual guidelines. Particulate concentrations in this area may reach a maximum 24-hour average value of 400 $\mu g/m^3$. Daily averages as high as 330 $\mu g/m^3$ are possible within a few km from the mine. Annual average TSP values greater than 100 $\mu g/m^3$ are predicted outside the mine property. Trace element concentrations that result from mining emissions are not expected to exceed the provincial guidelines.

Three air quality control strategies for the power plant were considered: (1) flue gas desulfurization (FGD) with a 366 m (1200 ft) stack; (2) meteorological control system (MCS) with a 366 m stack; and (3) MCS with a 244 m (800 ft) stack. All three systems are predicted to comply with assumed 3-hour and 24-hour ambient SO_2 criteria levels of 655 and 260 $\mu g/m^3$ respectively. Only occasional fuel switching to low-sulfur coal will be required during the winter months with the 366 m/MCS configuration. Approximately 195 hours of fuel switching in winter and 85 hours of reduced load (80%) operation would be required to meet the assumed threshold levels for 3-hour and 24-hour average concentrations with a 244 m stack and MCS. On the basis of modeling studies, it appears that the FGD system considered in this report could maintain these SO_2 levels with a shorter stack height than 366 m. Maximum annual average SO_2 concentrations are well below the B.C. Level A Guideline of 25 $\mu g/m^3$ for all three air quality control systems.

(iii) Cumulative Effects

Little interaction among effluents from the cooling towers, plant stack, and mine will occur. The mine is to be situated at an elevation about 600 m below that of the base level of the stack and cooling towers. No cumulative or additive effects between the mine and the ridge sources will occur. There will be occasional mingling of the plumes from the cooling tower and stack. Natural draft plumes have a relatively low initial vertical velocity, but by virtue of their mass, a very large buoyancy. The stack plume has a large exit velocity, but its buoyancy excess is more quickly dissipated than that of cooling tower plumes because of its smaller surface-to-volume ratio. As a result, both plumes will tend to level off at about the same height under certain infrequent meteorological conditions (this is more probable for the 244 m stack height than for 366 m). Although the orientation of the towers relative to the stack was chosen on the basis of wind direction frequencies to minimize interaction, co-mingling of the plumes will sometimes occur. The oxidation rate of atmospheric SO_2 to form sulfate is believed to proceed more rapidly (perhaps by a factor of two or more) in a saturated environment. Thus, within a distance of up to 20 km (the maximum distance with a saturated environment), the SO_2 in the cooling tower plume may produce sulfate at an accelerated rate when the plumes mix. This could lead to increased acid mist formation over this range, although no ground-level effects will be measurable.

Diffusion modeling results indicate that cumulative air quality effects due to interaction of the Hat Creek stack plume with those from other existing or known future sources are negligible. Concentration patterns in a given location are dominated by the nearest sources. The annual impact of the Hat Creek plume in Kamloops, for example, is insignificant compared with concentrations from local industries.

2.2 UNCERTAINTIES IN THE CONCLUSIONS

The air quality and climatic assessment techniques used to analyze the Hat Creek Project were the best available. A considerable effort was made to select the best and most representative computer simulation tools. A gas tracer study was conducted to develop a site-specific air quality prediction model. An extensive meteorological collection program was undertaken to understand the dispersion climatology of the region. These efforts have led to a highly credible and accurate assessment of the air quality and climatic implications of the project. Because of the obviously complex nature of atmospheric transport and chemical process and of the project itself, however, there are uncertainties in the analyses. Although uncertainties do exist, the overall conclusions and assessment are valid.

Most air quality effects addressed in this study were obtained by means of mathematical models. A simple Gaussian diffusion model can be calibrated to perform well for a given source and locale for most 'normal' weather conditions. But, for a system as complex as the atmosphere, no simple scheme for describing even one phenomenon (such as turbulent diffusion) can be expected to predict all cases with a high degree of accuracy, especially in regions with complicated terrain features. In this study, all hours of the year were categorized according to one of 1440 combinations of wind speed, wind direction, stability, and mixing depth. Because the atmosphere is a continuum, the actual number of possible combinations of these parameters is infinite.

On the basis of field studies performed at the Hat Creek site, the diffusion model employed to estimate ground-level concentrations was calibrated; i.e., its parameterization of diffusion processes was modified to provide a best fit with available data. The results show that concentration predictions made with this model should be accurate to within roughly a factor of two. Thus, while it is believed that the concentration predictions are, for the most part, valid estimates, an uncertainty still exists. The bias is generally on the conservative side for large values of ground concentration.

A second source of uncertainty arises from the relatively short record of meteorological data available for input to the modeling analysis. A 1-year period does not provide representative climatological statistics in terms of either reliable averages or extreme values. Errors can result from instrument inaccuracies (including maintenance problems for remote measurement sites) as well as during data processing and interpretation. Typical variations in annual average contaminant concentrations can be as high as 30% and in peak values as high as 50% due to the natural variability in weather conditions from year to year.

Modeling techniques to estimate emission rates for and concentrations of fugitive dust emissions are presently in a developmental stage. Very few careful measurement studies have been performed to quantify the complex parameters that govern dust emissions. In the absence of a larger data base, rather crude emission rates based on conservative premises are used to ensure that impacts are not underpredicted. It is probable that estimates of particulate concentrations due to the proposed mine are over-estimated, but there is considerable uncertainty as to the extent of this conservatism.

Finally, there is uncertainty in appraising the potential effects of a single facility on global, regional, and even local climate. In many cases of global impact assessment, scientists agree that a change in a given atmospheric variable will produce a response in another but disagree over whether the response will constitute an increase or decrease of the second variable. An example is the controversy concerning the effects of carbon dioxide emissions on global mean temperature. For this reason conclusions regarding global climatic effects are general and phrased in a semi-quantitative way in terms of orders of magnitude. Although regional and local climatic effects are also somewhat uncertain, the uncertainty is not whether the effects will occur but in the extent or magnitude of the effect. For example, it is almost certain that fogging will occur near the ash pond, but how often and to what geographical extent are uncertain.

In summary, although the best available techniques were used in the assessment, the analyses contain some uncertainties. These uncertainties can be characterized by degrees of accuracy as listed below with specific examples:

- within a factor of two - parameterization of atmospheric processes and prediction of ground-level concentrations that result from stack emissions;
- within 50% - annual variability in meteorological events;
- probable overestimations - impact of mining operations; and
- certain occurrence but small, unknown magnitude and extent - fogging near ash pond and other climatic impacts.

3.0 DESCRIPTION OF THE PROJECT

3.1 GENERATING STATION

B.C. Hydro has proposed a site near Harry Lake in the Trachyte Hills about 10 km east of Cache Creek, B.C. for installation of a coal-fired steam electric generating station. This facility will house four 500 Mw (nominal) units exhausted by a single 4-flue chimney. Determination of the stack height has not yet been made final; in this study, air quality effects of the power plant with assumed stack heights of both 366 m (1200 ft) and 244 m (800 ft) are examined.

(a) Emissions

(i) Base-Load Emissions

Table 3-1 lists estimated full-load emission characteristics for the proposed power station. Emission rates are provided for all substances examined in terms of potential health effects (see Appendix G, Epidemiology). The actual emission rates for these contaminants will depend on the nature of the air quality control system ultimately implemented. Base-load rates are provided here as reasonable (yet conservative) estimates, since not enough information is presently available to compute the effects of the various control systems on emissions for many of the substances listed in the table. The tabulated values correspond to a 2,000 Mw generating capacity, accomplished by combustion of blended coal having a mean heating value of 3500 cal/gram (6300 Btu/lb) and a mean sulfur content of 0.45% at 20% moisture. Physical stack parameters assumed in the present analysis are presented in Table 3-2.

TABLE 3-1

ESTIMATED BASE-LOAD EMISSIONS OF THE PROPOSED HAT CREEK GENERATING PLANT FOR SUBSTANCES INVESTIGATED FOR POTENTIAL PUBLIC HEALTH EFFECTS[1]

Contaminant	Symbol	Emission Rate (kg per day) Particulate	Gaseous	Total
Sulfur Dioxide	SO_2		324,768	324,768
Nitrogen Oxide	NO		82,489[2]	82,489[2]
Nitrogen Dioxide	NO_2		124,759[2]	124,759[2]
Total Particulates	TSP	40,000[3]		40,000[3]
Carbon Monoxide	CO		18,043[4]	18,043[4]
Total Hydrocarbons	HC		5,415[5]	5,415[5]
Arsenic	As	7.13[5]	11.9[5]	19.0[5]
Beryllium	Be	0.55[5]	0.11[5]	0.66[5]
Cadmium	Cd	0.195[5]		0.195[5]
Chromium	Cr	2.29[5]		2.29[5]
Copper	Cu	0.094[5]		0.094[5]
Fluorine	F	25.7[6]	265[6]	290.7[6]
Lead	Pb	2.59[6]	4.95[6]	7.54[6]
Manganese	Mn	4.4[6]		4.4[6]
Mercury	Hg	2.28[6]	3.67[6]	5.95[6]
Nickel	Ni	3.14[6]		3.14[6]
Selenium	Se	0.0337[6]	0.132	0.1657
Uranium	U		no emission	
Vanadium	V	0.12		0.12
Zinc	Zn	3.0		3.0
Sulfate	$SO_4^=$		no emission	
Nitrate	SO_3^-		no emission	
Polycyclic Organic Matter	POM		no emission	
Nitrosamines	NNA		no emission	

[1]See Appendix G

[2]Emission calculated on the basis of 600 ppm NO_x in the stack with equal parts of NO and NO_2.

[3]Emission calculated on the basis of a maximum of 0.1 grains per standard cubic foot with the use of electrostatic precipitators.

[4]Emission calculated on the basis of 0.45 kg CO per ton of coal.

[5]Emission calculated on the basis of 0.14 kg HC per ton of coal.

[6]Calculated from test burn sample analysis and coal consumption of 42,630 metric tons per day (see Appendix F).

TABLE 3-2

STACK PARAMETERS AND FLUE GAS PROPERTIES FOR BASE-LOAD EMISSIONS OF THE PROPOSED HAT CREEK GENERATING PLANT

Stack Base Elevation (MSL)	
(m)	1,418
(ft)	4,650
Stack Height	
(m)	244 or 366
(ft)	800 or 1200
Inside Diameter of Flue	
(m)	7
(ft)	23
Flue Gas Temperature	
(°C)	149
(°F)	300
Volumetric Flow Rate (per flue)	
(m^3/min)	62,204
(ACFM)	2.195×10^6

(ii) Reduced-Load Emissions

In most phases of the air quality analysis, full-load operation of the generating station is assumed to ensure that impact estimates will be conservative. However, the operating schedule for the plant includes periods of generation at reduced load. Flue gas properties and sulfur dioxide emissions for selected partial-load conditions are listed in Table 3-3. Corresponding emission rates for other contaminants may be estimated by multiplying the adjustment factor for each load by the base-load values in Table 3-1. The partial-load parameters represent uniform reductions for all four units.

(b) Control Technologies

(i) Flue Gas Desulfurization

A flue gas desulfurization (FGD) system for the power plant was examined for its capability to control ambient SO_2 levels. The system under consideration would be designed to achieve partial (54% overall) SO_2 removal from the stack gas stream. Removal would be accomplished by means of two absorber units (plus one back-up) per generating unit. Approximately 60% of the flue gas volume enters the absorber units (wet scrubbers with limestone reagent); the remainder by-passes the absorbers, and provides reheat of the scrubbed gases to enhance plume rise. The remixed effluent is discharged at a temperature of 82°C (180°F) and contains moisture (69,091 kg/hr) from the scrubbers. Redundant absorber units are installed to achieve maximum availability. Full-load power plant SO_2 emission characteristics with the operational FGD are presented in Table 3-4. The effect of the scrubbers on particulate and trace element emissions is undetermined; for purposes of this analysis, it is assumed that these emissions are the same as those listed for the uncontrolled plant in Table 3-1.

TABLE 3-3

STACK GAS PARAMETERS AND SULFUR DIOXIDE EMISSIONS FOR SELECTED PARTIAL-LOAD CONDITIONS FOR THE PROPOSED HAT CREEK GENERATING STATION

Percent of Full Load	Stack Gas Exit Temperature (°C)	Flue Gas Flow Rate (m3/min)	SO_2 Emissions Rate (kg/hr)	Adjustment Factor*
80	139	212,090	10,953	0.81
70	134	186,240	9,624	0.71
60	129	163,570	8,293	0.62
50	127	129,110	7,173	0.53
40	121	108,480	5,720	0.42

*Adjustment factor may be multiplied by emission rates in Table 3-1 to estimate partial load emissions for other contaminants.

TABLE 3-4

EMISSION CHARACTERISTICS FOR FULL-LOAD OPERATION OF THE PROPOSED HAT CREEK GENERATING STATION WITH FLUE GAS DESULFURIZATION

Sulfur Dioxide Emissions	
(kg/hr)	6,259
(lb/hr)	13,770
Flue Gas Temperature	
(°C)	82
(°F)	180
Volumetric Flow Rate	
(m^3/min)	262,189
(ACFM)	9.252×10^6

(ii) Meteorological Control Systems

A Meteorological Control System (MCS) is a systematic plan of defined procedures for the reduction of contaminant emissions in response to predicted or observed weather conditions that are conducive to high ground-level ambient concentrations. Such control programs may assume many operational forms; the MCS strategies considered in this report entail both fuel switching and load reduction as required to maintain acceptable air quality. It is assumed that low-sulfur (secondary) coal with an average sulfur content of 0.21% and a mean heating value of 4,190 cal/gm (7,560 Btu/lb) will be stockpiled for use during periods of adverse dispersion potential in the winter (November through February). Blended coal with 0.45% sulfur and 3,500 cal/gm (6,300 Btu/lb) heating value is used whenever dispersion conditions permit. During the remaining months, uniform load reduction of all units with the primary fuel is assumed to be the preferred control measure for reducing ambient concentrations. Table 3-5 lists SO_2 emission characteristics for full-load operation with the secondary fuel. Corresponding values for partial-load conditions were presented in Table 3-3. Emissions for other contaminants are assumed to be the same as those presented for full-load operation with the primary fuel (Table 3-1). Parallel MCS analyses were performed for stack heights of 366 m (1200 ft) and 244 m (800 ft).

(c) Cooling Towers

(i) Design of System

Waste heat from the Hat Creek plant will be discharged by means of evaporative (wet) cooling towers. A system of two natural draft towers has been selected as the preferred design. Physical dimensions and design conditions for the cooling towers are presented in Table 3-6.

The proposed locations of the cooling towers relative to the generating station are indicated in Figure 3-1. This deployment of the towers

TABLE 3-5

FULL-LOAD SULFUR DIOXIDE EMISSION CHARACTERISTICS FOR THE PROPOSED HAT CREEK GENERATING STATION WITH SECONDARY COAL

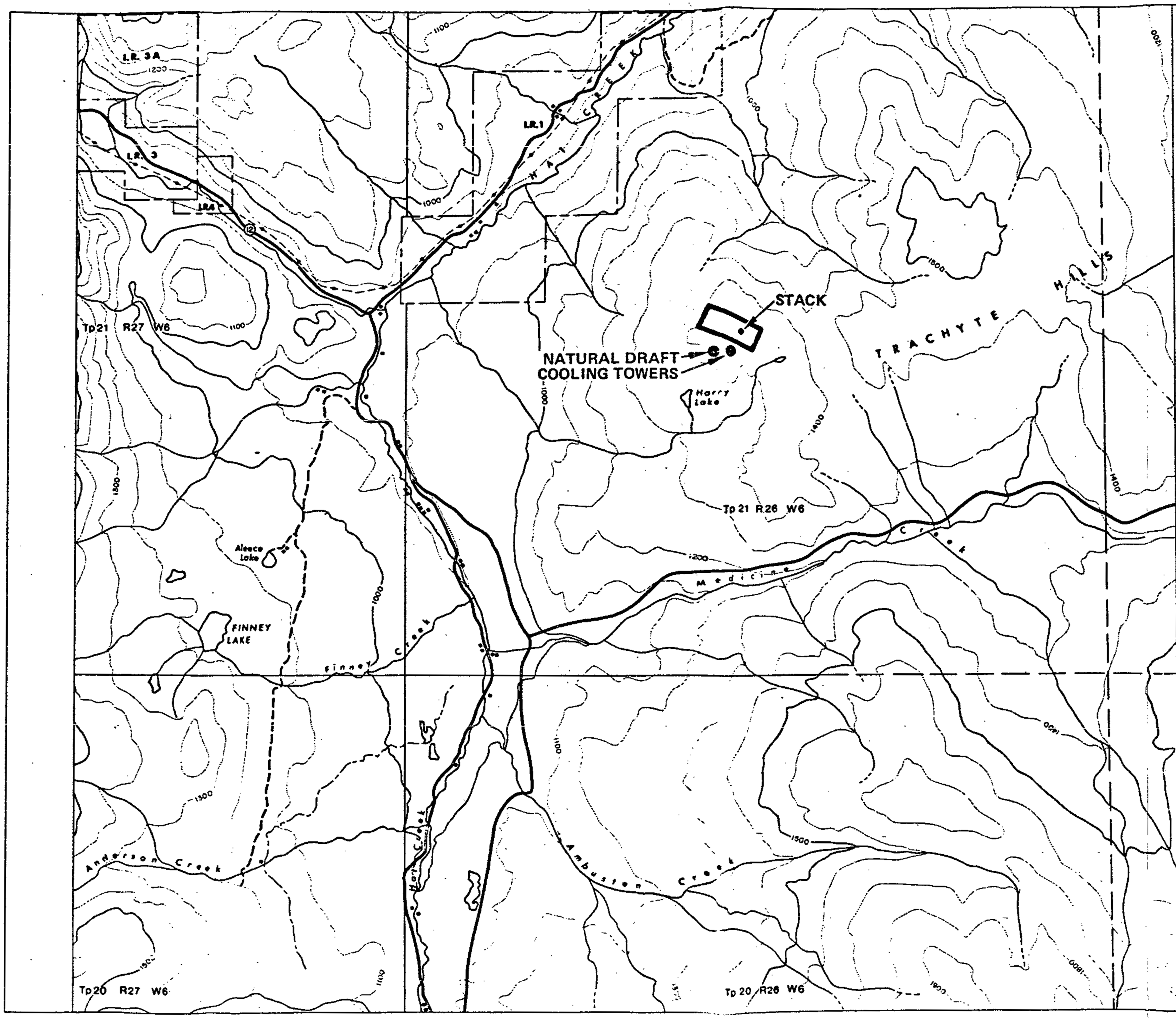
(0.21% sulfur and ~~5,500~~ 4190 cal/gm)

Sulfur Dioxide Emissions	
(kg/hr)	5,262
(lb/hr)	11,577
Flue Gas Temperature	
(°C)	149
(°F)	300
Volumetric Flow Rate	
(m^3/min)	238,384
(ACFM)	8.412×10^6

TABLE 3-6

ENGINEERING DATA FOR COOLING TOWERS

A: Design Conditions	
Ambient Wet Bulb	
(°C)	13.9
(°F)	57.0
Approach	
(°C)	12.8
(°F)	23.0
Range	
(°C)	18.7
(°F)	33.7
Circulating Water Flow Rate	
(liters/sec/tower)	20,422
(USGPM/tower)	320,000
B: Physical Dimensions	
Tower Diameter at Top	
(m)	67.1
(ft)	220.0
Tower Height	
(m)	116.4
(ft)	382.0



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DETAILED ENVIRONMENTAL STUDIES

Figure 3-1 Location of Natural Draft Cooling Towers at the Proposed Hat Creek Generating Station

804252

reflects an effort to minimize potentially adverse effects associated with the natural draft design. The placement of the towers southwest of the power plant stack is intended to take advantage of the relatively infrequent occurrence of winds from that direction, thereby minimizing the likelihood of interactions between the effluents from the stack and cooling towers. The east-west alignment of the towers was chosen to achieve maximum plume buoyancy and rise with the prevailing (westerly) winds.

(ii) Emissions

A. Evaporative Water Losses

Table 3-7 lists emission characteristics for the natural draft cooling towers. For an assumed annual average plume exit temperature of 32°C and air flow rate of 26,000 m^3/sec for two towers, the expected total evaporative moisture loss through the towers is approximately 612 kg/sec (0.67 tons/sec). Thus, approximately 5.3×10^7 kg (58,000 tons) of water will be discharged to the atmosphere per day.

B. Heat Releases

As demonstrated in Table 3-6, about 40,448 liters/sec (640,000 USGPM) of circulating water are cooled 18.7°C (33.7°F) by the cooling towers. The equivalent heat flux conveyed by the plumes to the atmosphere is approximately 2.6×10^{12} cal (1.03×10^{10} Btu) per hour of operation.[1]

C. Drift Emissions

The cooling towers will be equipped with modern drift eliminators designed to limit the percent of circulating water escaping as drift to 0.008%, or about 194 liters/min (51 gal/min). Samples of the Thompson

TABLE 3-7

EMISSION CHARACTERISTICS FOR PROPOSED NATURAL DRAFT COOLING TOWERS - SELECTED AMBIENT CONDITIONS

A: Plume Properties

Ambient Dry Bulb (°C)	Ambient Wet Bulb (°C)	Plume Exit Temperature	Air Flow Per Tower (m^3/sec)
-15.0	-16.3	28.9	13,470
-15.0	-15.0	29.4	13,508
10.0	3.3	36.7	12,393
10.0	10.0	36.7	12,393
32.2	23.9	42.2	12,006

B: Drift Properties

Percent of Circulating Water Escaping as Drift	0.008%
Recirculation Factor	14
Salt Drift Emission Rate Per Tower	2.5 g/sec

River source water indicate a dissolved solids concentration of 109 mg/liter. For an assumed cooling water recirculation factor of 14, the total emission rate of dissolved solids for two towers is about 5 gm/sec. Table 3-8 lists the results of a chemical analysis of the source water. The tabulated dissolved solids concentrations are considered to be higher than the average values for the Thompson River. Thus, their use in the analysis of cooling tower drift contributes to conservative results. Approximate emissions for individual chemicals can be estimated from the tabulated concentrations. Table 3-9 presents the assumed mass-size distribution of drift droplets.

3.2 MINE

(a) Mine Plan

The Hat Creek Valley coal deposit will be developed in conjunction with the proposed power plant to provide a local source of fuel. This deposit is located at the northern end of the Upper Hat Creek Valley. An estimated one billion tonnes of coal are contained in the two known deposits. The No. 1 deposit will be excavated first, and is expected to have a mine life of 35 years. Peak run-of-mine production is estimated at 9.8 million tonnes per year.[2]

The No. 1 deposit will be excavated as an open pit mine. The proposed method of mining is a truck/shovel/conveyor combination. With this method, overburden and coal will be loaded into 150-ton trucks by 15-cubic-yard mining shovels and transported to an in-pit conveyor transfer point. All materials will then be transported out of the pit via an inclined conveyor system to a surface interchange where they will be routed by conveyor to the appropriate areas; coal to the stockpile, waste to the waste dumps. Surficial material will be removed by scraper and delivered directly to the dump area or to a ground hopper, and from there to the waste conveyors for distribution to the dumps.

TABLE 3-8

THOMPSON RIVER WATER PROPERTIES

Property	Symbol	Amount
Bicarbonate	(HCO_3)	57 mg/l
Sulfate	(SO_4)	13
Chloride	(Cl)	7
Nitrate	(NO_3)	0.2
Silica	(SiO_2)	4
Hardness	($CaCO_3$)	42
Calcium	(Ca)	13
Magnesium	(Mg)	2
Sodium	(Na)	13
Total organic carbon		6
Dissolved solids		109
Suspended solids		6
Total solids		115 mg/l
pH		7.5

TABLE 3-9

ASSUMED COOLING TOWER DRIFT MASS-SIZE DISTRIBUTION

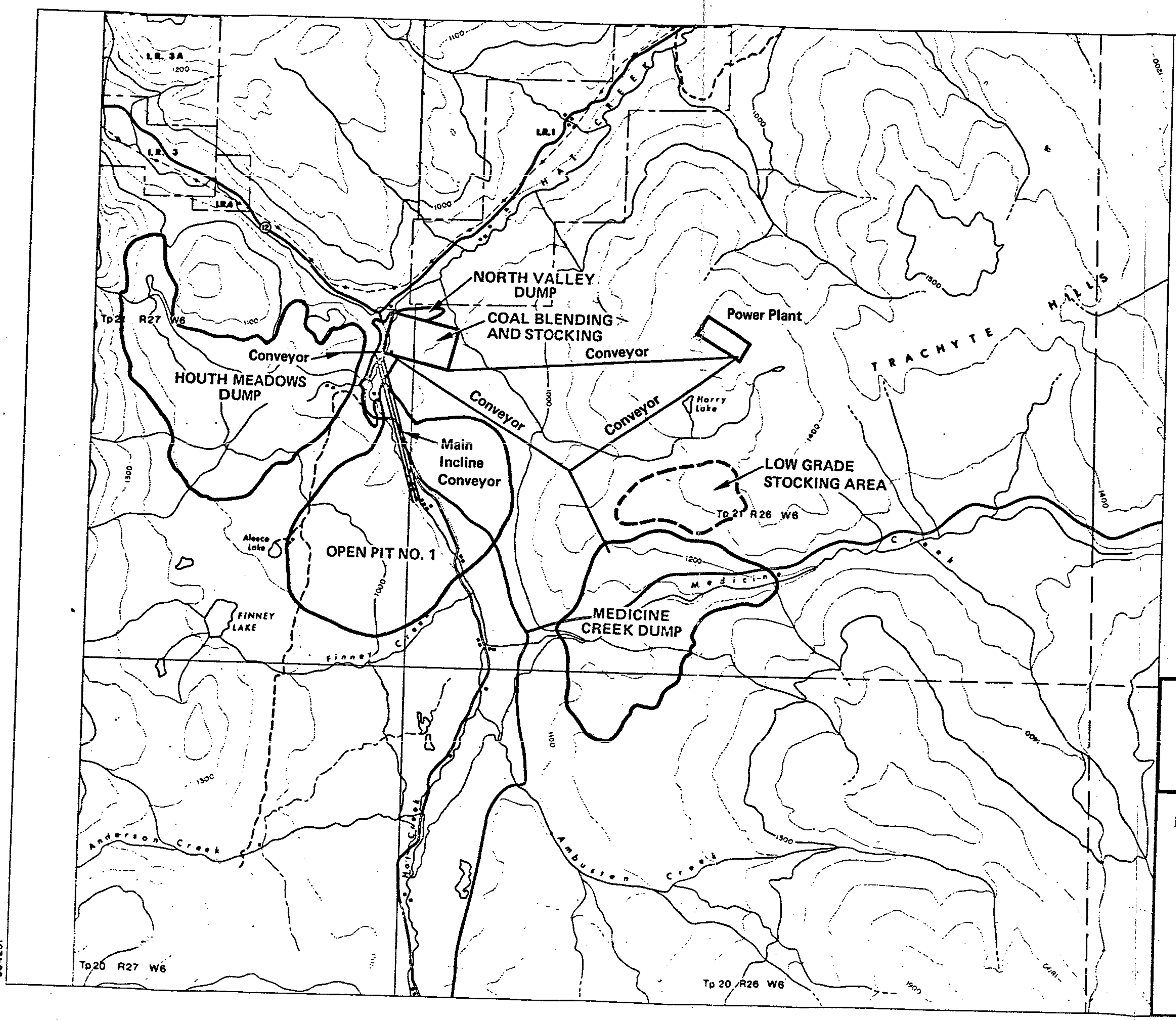
Droplet Diameter (μm)	Fraction of Drift Mass
50	0.40
75	0.24
150	0.10
275	0.07
475	0.09
600	0.10

Under the proposed mine plan, three main areas are to be set aside as waste dumps for overburden and surficial material. These include Houth Meadows, northwest of the pit; Medicine Creek, southeast of the pit; and North Valley, just north of the pit. The Houth Meadows dump will be reserved primarily for the clays and other weak materials. More stable materials will be routed to the Medicine Creek dump. Surficial material removed from the initial conveyor incline excavation, before the start of production, will be dumped in the North Valley dump. A moveable conveyor on the embankment of each dump will discharge the waste material by means of a travelling tripper and spreader. In addition to mine spoils, conditioned ash from the power station will be placed in the Medicine Creek dump. A separate dump will be maintained for the low-grade coal, in the event it should become usable at some future date. The low-grade coal dump will be located just north of the Medicine Creek waste dump. The proposed configuration of dumps, conveyors, and pit is shown in Figure 3-2.

Under the proposed plan, plant-quality coal will be stored in a mine-mouth stockpile. This stockpile will provide a blending function to enable a more consistent product to be fed to the power plant. From the surface conveyor interchange the coal will travel to the primary and secondary crushers to be reduced to the size required by the boilers. From there, it will be delivered to the coal stockpile via conveyor and crawler-mounted stacker. An average stock of one million tons will be kept in four piles. Under normal conditions two complete piles will stand idle: one pile being reclaimed, and one partial pile being built. On being reclaimed from the stockpile, the coal will be delivered to the power plant bunkers via a coal conveyor.

(b) Coal Characteristics

The Hat Creek Valley coal deposit is characterized by a high degree of variability in coal quality. There are four general mine zones or seams discernible within the deposit, but substantial variation is encountered



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 3-2 Hat Creek No. 1 Deposit. Proposed Plan of Mine Area Showing Limit of Pit, Waste Dump Areas, and Conveyor System

804251

even within localized areas and depths. Approximate average values for sulfur content, heat content, and ash content for each of the four zones are shown in Table 3-10.

The overall mean sulfur content of the deposit is estimated to be 0.45%, although sections of the deposit are expected to contain 0.21% sulfur or less. The overall mean heat content and ash content are 3,500 cal/gram (6,300 Btu/lb) and 26.0%, respectively. These values correspond to 20% moisture. The average moisture content in the coal as mined is 23%, with a range of 14% to 32%. However, the coal will dry rapidly under normal ambient conditions, and it is assumed to arrive at the plant pulverizer with 20% moisture.

(c) Emissions

Suspended particulate matter is the major contaminant resulting from open-pit mining operations. Airborne particles are produced by the mechanical disturbance of exposed earth and are termed fugitive dust because they are not discharged to the atmosphere in a defined flow stream. Fugitive dust is emitted from open sources, such as the operation of heavy, earth moving equipment or the traffic along an unpaved road.

The important mining operations in terms of suspended particulate production are:

- surficial material removal;
- overburden removal;
- coal removal;
- haul road traffic and repair; and
- coal stockpiling.

Dust-producing processes associated with these operations include scraping, shoveling, blasting, hauling, and dumping. Emissions from these activities are estimated on the basis of published factors from the literature and projected operating information from the proposed mine

TABLE 3-10

APPROXIMATE AVERAGE COAL CHARACTERISTICS FOR THE FOUR ZONES WITHIN HAT CREEK NO. 1 DEPOSIT

Zone (percentage of deposit)	Sulfur (percent*)	Heating Value (cal/kg (Btu/lb))		Ash (percent*)
A (37%)	0.58	3,300	(5,900)	28.9
B (10%)	0.66	3,500	(6,300)	26.6
C (20%)	0.35	2,500	(4,500)	38.4
D (33%)	0.22	4,200	(7,580)	19.0

*at 20% moisture.

plan.[2] The year 2017-2018 (Stage 6) with maximum production and activity was chosen for the calculation of maximum annual emissions.

Erosion of exposed surfaces and storage areas by the wind is also an important potential source of fugitive dust associated with mining activities. Emissions due to wind erosion at the Hat Creek Mine were computed to reflect local meteorological conditions, soil properties, and the orientation of the mine with respect to the prevailing wind in the manner suggested by Woodruff and Siddoway.[3]

Table 3-11 lists emission factors, source operating units, and annual controlled emission rates assumed for each mining activity. The tabulated values represent conservative estimates, based primarily on studies of the air quality effects of strip mining operations in Wyoming and Colorado. These emissions account only for the assumed fraction of disturbed material in particle sizes small enough to remain suspended beyond the mine area. As evidenced in Table 3-11, wind erosion is expected to be the major dust source for the Hat Creek Mine. The emission rate given for this source corresponds to the annual average wind speed (11 km/hr) recorded at the B.C. Hydro mechanical weather station (WS5) near the mine site. For short-term dispersion modeling applications (see Section 5.2(b) (iv)), the actual emission rate used for wind-blown dust was scaled appropriately for the meteorological condition under consideration.

After wind erosion, the major sources of fugitive dust are haul-road traffic, overburden removal, and surficial removal. However, most of these activities take place within the pit below ground level. Realistically, the depth below ground level at which a source is emitting should exert considerable influence on reducing the resulting amount of suspended particulates. However, this feature is difficult to treat quantitatively, and all sources for the Hat Creek Mine are conservatively assumed to be emitting at ground level.

TABLE 3-11

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 of Activity	Emission Factor	Source Operating Units[1]	Emissions (kg/yr)
Surficial removal (scrapers)	7.26 kg/scraper-hr[2]	26,250 scraper-hours/year[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]	$1.68 \times 10^7 m^2$	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)

(d) Control Technologies

A number of assumptions regarding dust control techniques were included in the calculation of emissions.

- Frequent watering of haul roads and exposed surfaces was assumed, resulting in 50% control of dust emissions.
- A speed limit of 6.7 mps (15 mph) was used on all haul roads to give control efficiency of 80%.
- The land reclaimed from the waste dumps midway in the life of the mine (year 2005-2006) was assumed to be the only area reclaimed at the time of the model year 2017-2018. This is a reasonable but conservative assumption for the proposed mining method; reclamation of an open pit mine and waste dumps is not possible on a large scale until mining is completed.
- The conveyor system would be completely enclosed resulting in 100% control for this source.

The emissions listed in Table 3-11 include consideration of these control measures.

3.3 OFF-SITE DEVELOPMENTS

(a) Off-Site Plans

Preliminary projections for off-site facilities to support the Hat Creek Project[9] include:

- a paved, 2-lane access road connecting the mine and power plant sites from Highway No. 1 near Ashcroft Manor, and temporary construction roads;
- a supply system to deliver water to the power plant boiler and for cooling tower make-up, as well as station and domestic service;
- a new 69 kv supply line to supply the mine substation and the power plant construction substation;
- facilities for diversion of Hat Creek and several smaller tributaries;
- an airstrip;
- construction camps;
- equipment off-loading facilities;

- ash-retaining embankments;
- permanent housing;
- tourist facilities; and
- gas transmission lines.

Many details related to the actual specifications for these facilities have not yet been made final. Air quality effects are therefore treated qualitatively in this report.

(b) Emissions

Only the new access road and airstrip are expected to produce significant emissions after construction. All facilities will create dust during construction. Temporary dust-producing activities will include traffic on unpaved roads, scraping, bulldozing, trenching, rock blasting, grading, crushing and paving.

Emissions of sulfur oxides, oxides of nitrogen, carbon monoxide, and hydrocarbons will result from self-propelled construction equipment and trucks. Temporary emissions from asphalt plants will occur during the paving of road surfaces. Passenger vehicles will make trips to and from the site throughout the life of the project. The estimated peak traffic volume during construction is 500 to 700 vehicles at the beginning and end of the work week. On the remaining weekdays, shift-change volumes of 200 to 300 vehicles are expected.

After the power plant is in operation, the volume of traffic created by employees is estimated at 200 to 300 vehicles per day in 1984, increasing to 500 to 600 by the year 2010. Since this traffic will use paved roadways, no significant incremental dust is anticipated. Vehicular emissions of carbon monoxide and hydrocarbons will be primarily restricted to short periods, and for the projected traffic volumes, the effects on air quality may be considered negligible.

4.0 DESCRIPTION OF THE ENVIRONMENT

4.1 TERRAIN FEATURES

(a) Regional Topography

The mountainous zone that parallels Canada's western coast is known as the Western Cordillera of North America. This zone comprises three major units extending into British Columbia. These are the Coast Range, Central Plateau, and Rocky Mountains. The site of the proposed Hat Creek Project is located in the southern Central Plateau region. The topography in this region is complex and varied. Several 900 m deep river valleys with generally north-south orientations cut into the low plateau, which has an average elevation of about 1200 m. Two such river valleys lie to the east and west of the project site. To the east, the Thompson River flows west out of Thompson Lake at Kamloops, turning southward at Ashcroft. To the west, the Fraser River flows south past the town of Lillooet. The Hat Creek generating station will be situated at an elevation of about 1400 m on the eastern side of the plateau rising between these major rivers. The project coal mine will be located in Upper Hat Creek Valley to the west of the power plant. Figure 4-1 is a topographical map of the regional study area.

(b) Local Topography

Detailed terrain characteristics in the immediate vicinity of the proposed site are illustrated in Figure 4-2. The Hat Creek Valley is divided into two sections, the Upper and Lower Valleys, which meet at the mouth of Marble Canyon between the Clear and Pavilion Ranges. The Lower Valley extends from the junction toward the northeast; Upper Hat Creek Valley has a north-south orientation. The floor of the Upper Valley ranges in elevation from approximately 800 m at the north end to 1200 m

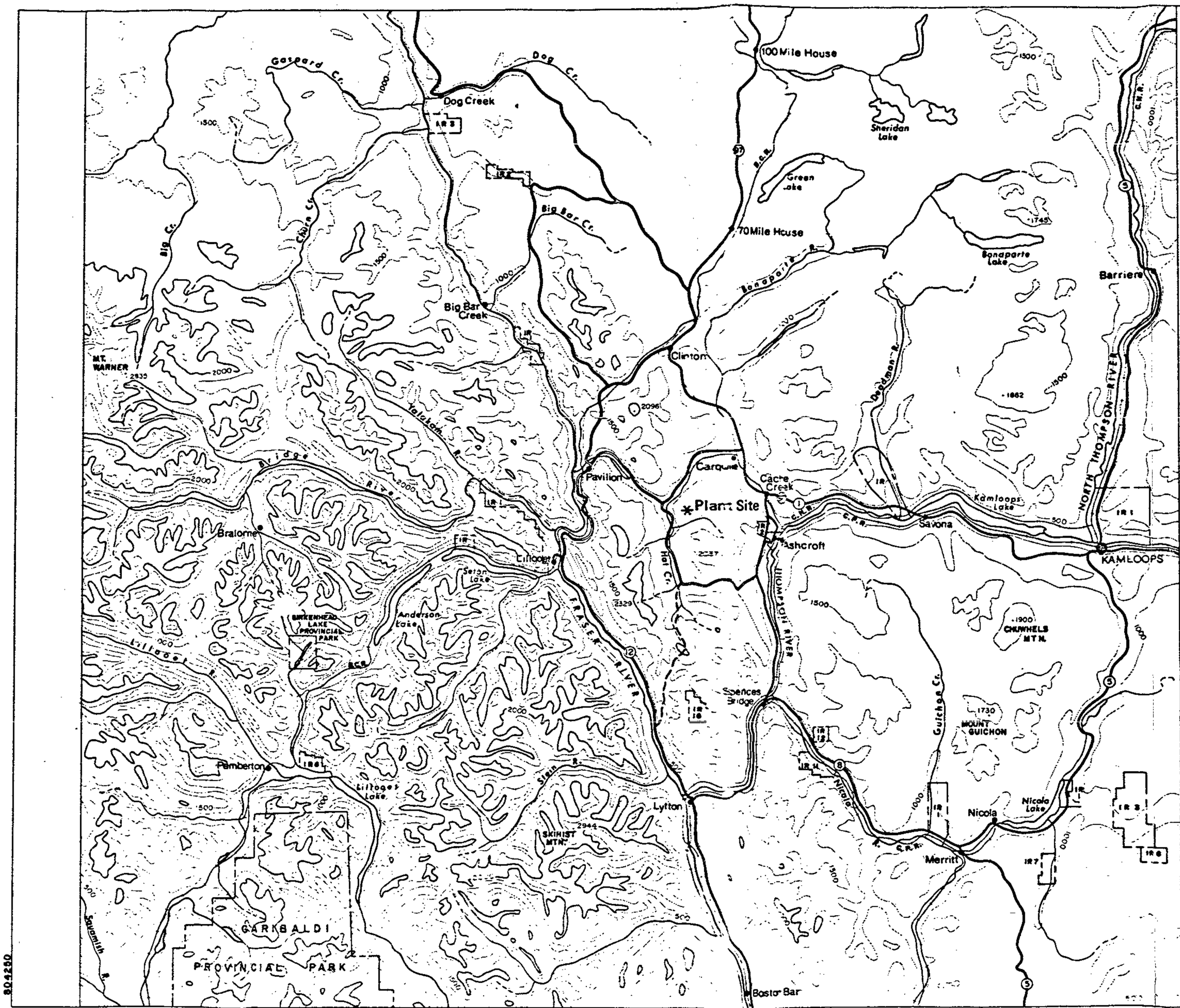
22.5 km to the south. The valley width varies from 1.5 to 5 km. The mine will be located near Hat Creek, just south of the valley junction. Marble Canyon extends to the northwest from the junction. Both Marble Canyon and Lower Hat Creek Valley are considerably narrower than the Upper Valley.

The proposed power plant site is in the Trachyte Hills. This site overlooks the Hat Creek and Bonaparte-Thompson River Valleys, as well as the hills and mountain ranges between Hat Creek and the Fraser River. Ridges in the Trachyte Hills follow a north-south pattern. Maximum elevations reach 1700 m east of the Harry Lake (power plant) site, while terrain heights in the Cornwall Hills, between Hat Creek and the Thompson River, extend to 2050 m. To the northwest of the site, Pavilion Range runs from north-northwest to south-southeast for approximately 26 km with a maximum elevation at Mount Carson (2100 m). Beyond the Pavilion Range is the parallel Marble Range. West of the Upper Hat Creek Valley, the Clear Range rises to peaks of 2150 to 2300 m.

4.2 CLIMATOLOGY/METEOROLOGY

(a) Regional Climate Characteristics

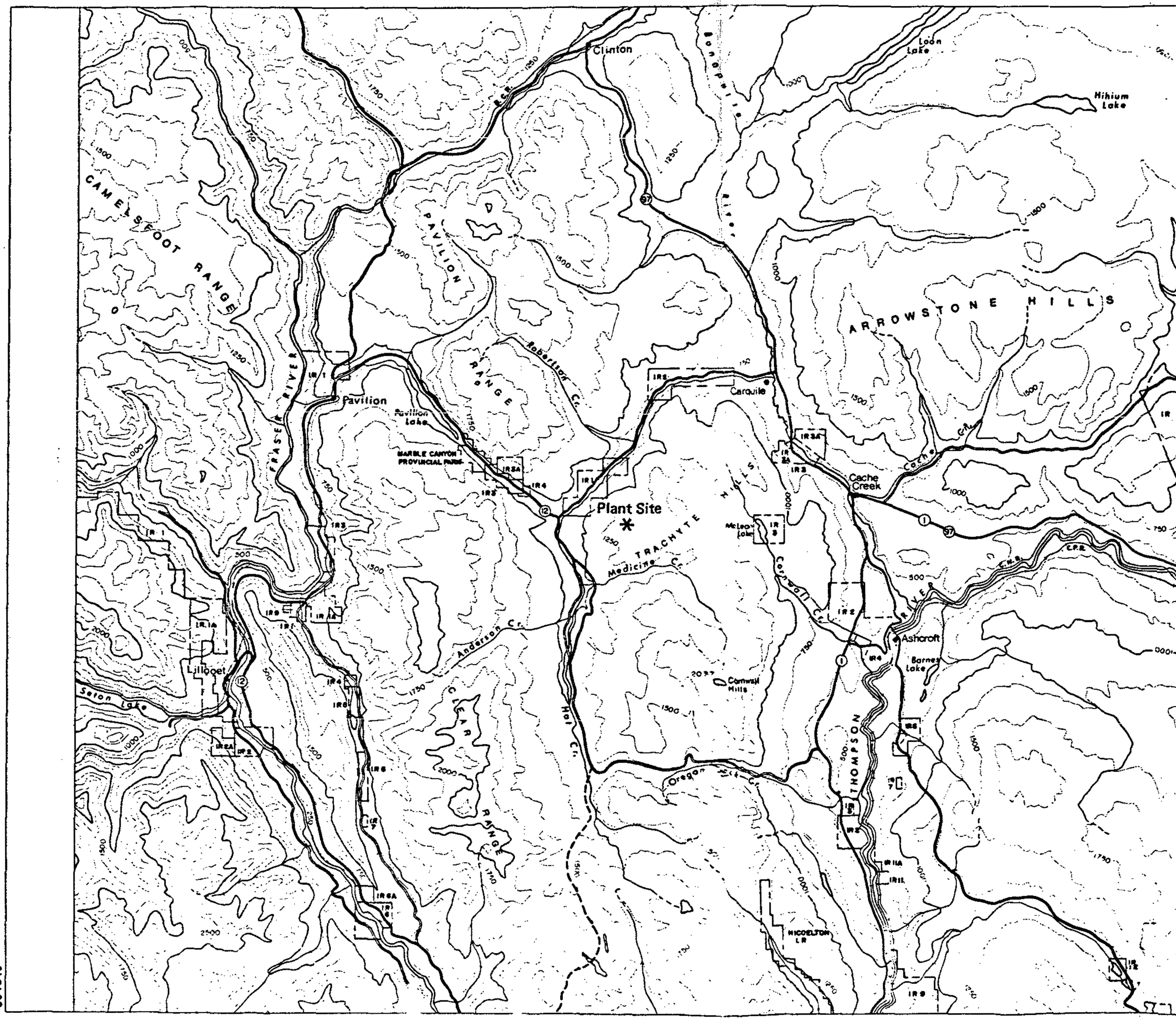
The climate of the southern interior of British Columbia is influenced by the presence of major mountain systems to the east and west. The Coast Range and Rocky Mountains serve to modify air mass properties and block low-level wind patterns associated with large-scale atmospheric circulations. The Coast Range, with peak elevations above 3,000 m, effectively limits the mild and humid ocean air to a narrow band along the Pacific Coast. As the moist air rises up the mountain slopes, it cools, resulting in condensation and precipitation. This range is responsible for the dramatic difference between the damp coastal climate and the relatively dry weather in the interior.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 4-1 Topographic Map of the Central Plateau Region of British Columbia



SCALE - 1:250,000

0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 4-2 Topographic Map of the Hat Creek Valley Area

804249

Regional air flow patterns reflect the channelling effects of the Coastal and Rocky Mountains as well as seasonal changes in the synoptic-scale wind fields. Winds aloft that drive low-level circulations are generally from west to east. However, the global scale transfer of heat between equator and pole produces north-south waves in the flow streamlines. The positions and intensity of these modulating currents are responsible for seasonal variations in the weather of south-central British Columbia.

(b) Local (Site) Meteorological Conditions

A complete analysis of meteorological data collected in the vicinity of the Hat Creek Project site is included in Appendix E, Climatic Assessment. Wind roses for stations in the area reflect large differences associated with terrain channeling and local mountain-valley effects. It is possible to infer the orientation of the topographic features near each station from the directions and speeds of the prevailing winds. Only those stations at higher elevations show consistent evidence of the frequent southerly and westerly flows associated with large-scale pressure systems over the region. Wind speeds at these stations are higher than those in the valley locations where frequent calms are recorded. Figures 4-3 and 4-4 are annual wind roses developed from measurements near the power plant site and the mine site, respectively.

Average total precipitation in the Upper Hat Creek Valley is about 30 cm per year. This total is distributed almost evenly over the year with a slight winter maximum. As is the case throughout the study region, precipitation amounts tend to reflect the effects of elevation, and, while no measurements at the plant site are currently available, a total of 40 to 50 cm is expected at that location.

Annual snowfall in the Valley averages approximately 130 cm per year; about 60% of this total is recorded in the winter months (December through February). Estimated snowfall at the Harry Lake site is about 250 cm, with somewhat larger spring and fall contributions than those recorded in the Valley.

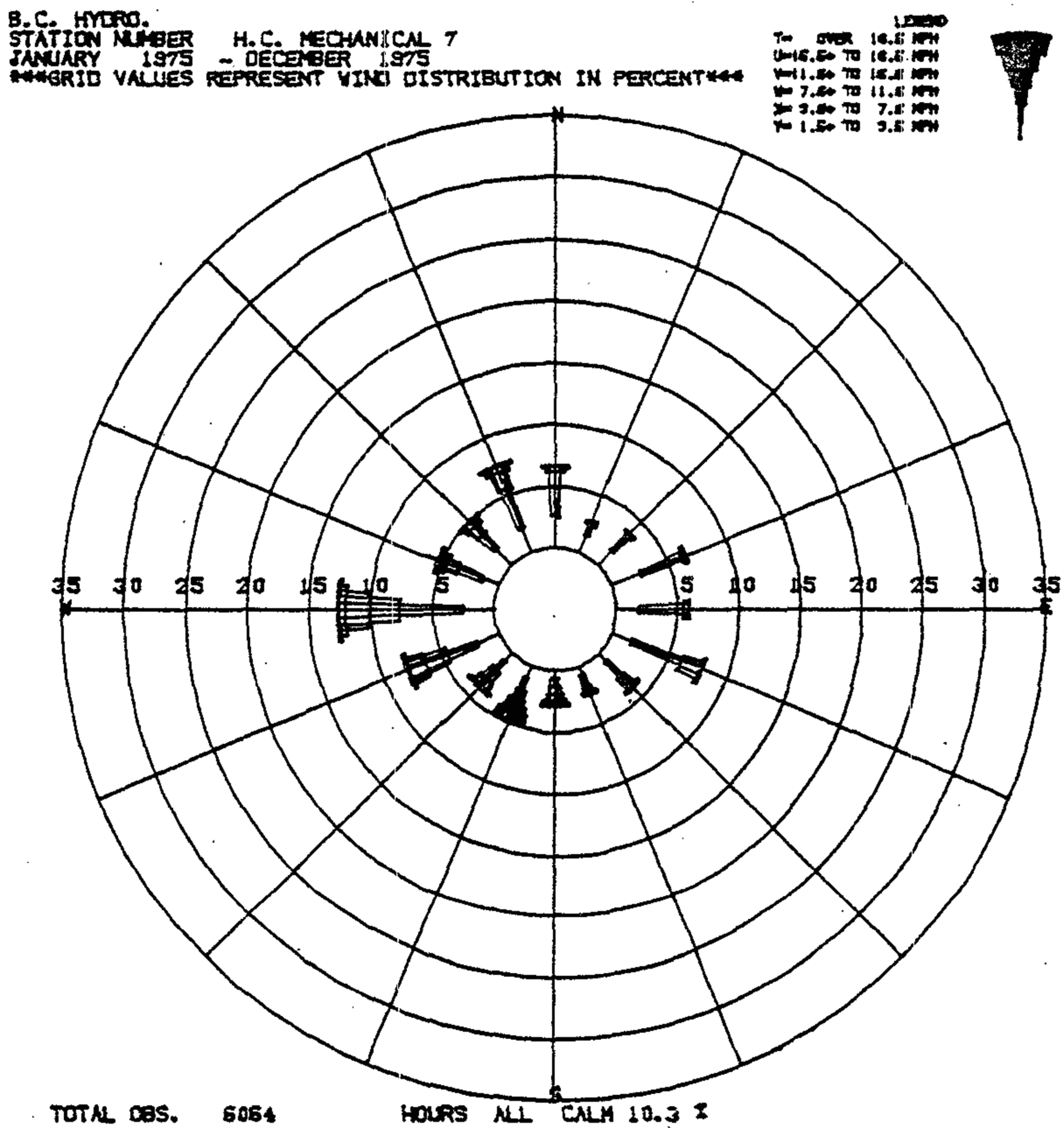


Figure 4-3 Annual Wind Rose of Measurements Near the Power Plant Site (WS7)

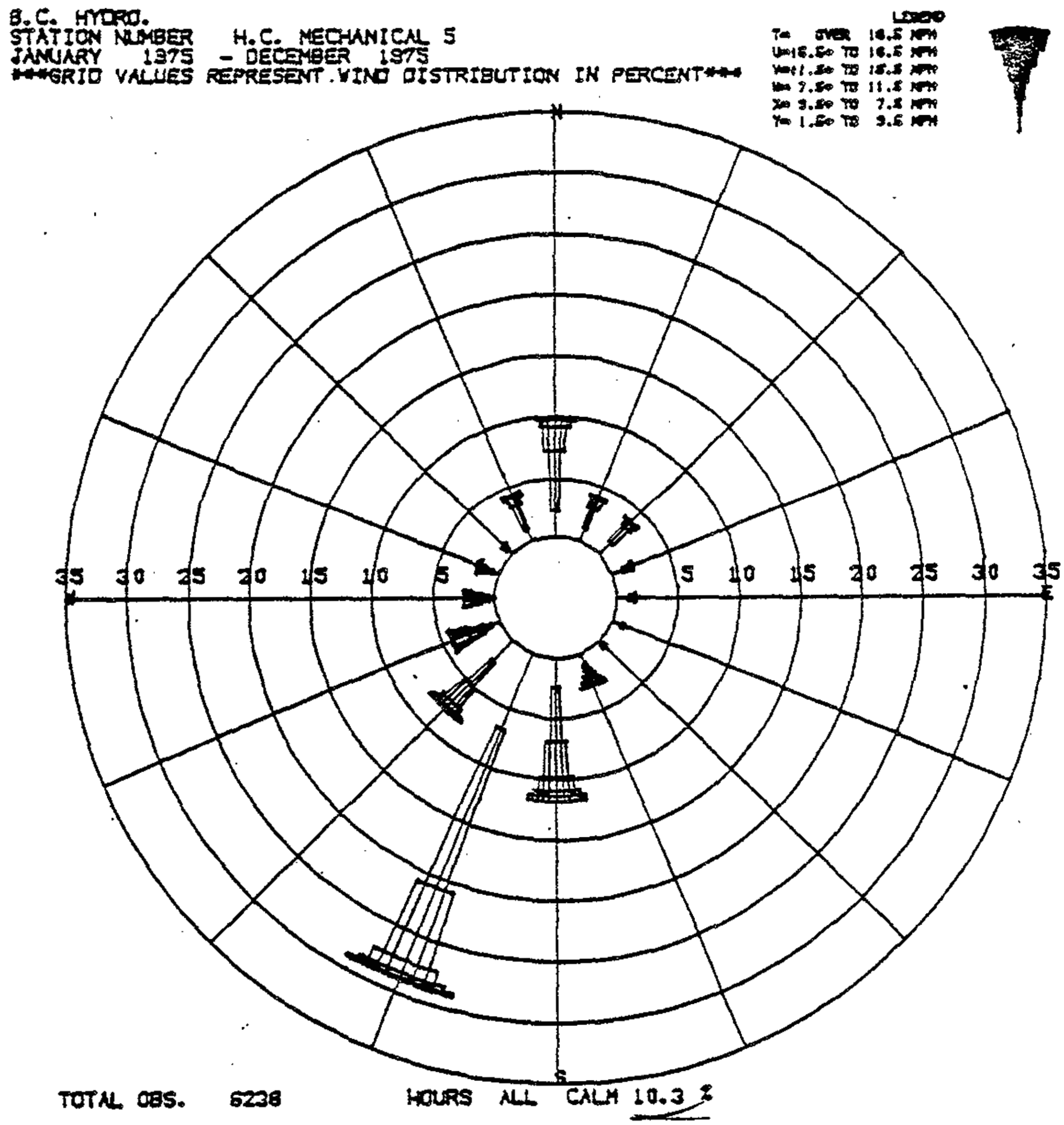


Figure 4-4 Annual Wind Rose of Measurements Near the Mine Site (WS5)

As evidenced by local temperature data, the climate of the area near the proposed project is aptly characterized as 'continental'. Mean annual temperature in the Upper Valley is 3.2°C. Absolute maximum and minimum values of 34°C and -43°C have been recorded. On the basis of comparisons with other stations in the region, a slightly warmer mean temperature is expected on the ridge near Harry Lake. Diurnal and seasonal temperature variations are large, especially in valley locations.

Extremely large diurnal relative humidity ranges are also measured in the area surrounding the project site. Nighttime humidities exceed daytime values by 20 to 40% at stations in the Lower Valley. Ridge locations are less humid at night, but similar to the Valley stations during the day.

Visibility data for the Hat Creek Valley area are presently unavailable. On the basis of other stations in the region, it can be inferred that natural restrictions to visibility occur more often in the Valley than on the ridge near the plant site. Radiation fogs during early morning hours in the winter and slash burning are the primary limitations to visibility. In general, such restrictions will be infrequent throughout the region.

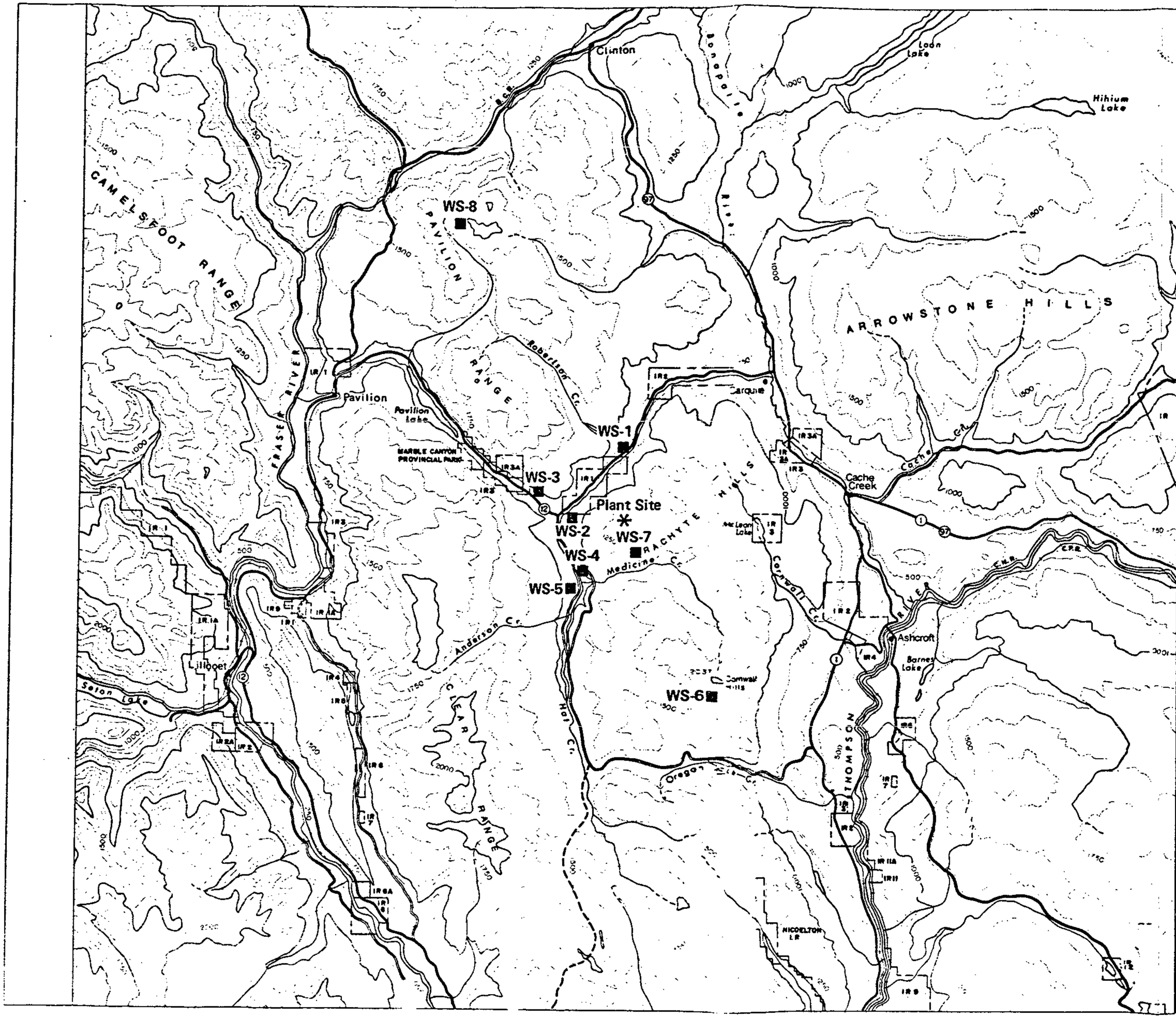
Cloudy skies occur frequently in the project area. While the region is quite dry, the presence of numerous rivers and lakes and orographic lifting of low-level flows over the mountains produce clouds covering at least half the sky about 60% of the time. Middle and high clouds occur most often; ceilings below 1800 m (6,000 ft) above the ground are reported less than 10% of the time. About 2,000 hours of bright sunshine per year are typically recorded in the study area.

The Hat Creek Valley and vicinity experience frequent ground-based inversions during early morning hours, as a result of the downward settling of cold air in association with nighttime drainage flows. When nights are cloudy or winds vigorous, such flows are weaker or absent. The ground-based inversion depth can be as deep as 500 m in the spring and up to 1,000 m in the early fall. Solar heating causes the atmospheric layer through which airborne contaminants are well mixed to grow during the late morning and early afternoon. Typically, toward late afternoon, the mixing height begins to decrease, ultimately leading to re-establishment of a ground-based inversion during the night. Depending on the degree of surface heating, the morning inversions may persist throughout the day, or may be completely eroded by the growing mixing layer.

(c) Meteorological Monitoring Programs

Since November 1974, B.C. Hydro has maintained a network of mechanical weather stations in the vicinity of the Hat Creek Project site. Stations WS1 and WS2 are located in the Lower Hat Creek Valley, WS3 is in Marble Canyon, and Stations WS4 and WS5 are in the Upper Valley near the mine site. The Harry Lake Station (WS7) provides data for the power plant site, and WS6 and WS8 document conditions at higher elevations in the Cornwall Hills and Pavilion Range respectively. Figure 4-5 indicates the locations of the eight weather stations. The mechanical weather stations record wind speed, wind direction, temperature and relative humidity at the 10 m level. An Atmospheric Environment Service/B.C. Hydro Station in the Upper Hat Creek Valley has recorded temperature and precipitation for about 15 years.

On-site meteorological field programs have been conducted by the MEP Company[10,11] and North American Weather Consultants,[12] with participation by B.C. Hydro personnel, in 1975 and 1976. These studies have provided insight into the temperature and wind structures above the Hat Creek Valley area. Constant-level balloons and instrumented aircraft were used to define local flow and dispersion characteristics in conjunction with simulated gas tracer and smoke plume releases from two potential generating station sites. Data from these programs have been analyzed by ERT to calibrate the diffusion model used to estimate air quality effects of the Hat Creek Project.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 4-5 Locations of the B.C. Hydro Mechanical Weather Stations

804276

Hourly-averaged data from WS7 (power plant site) for 1975 were used to develop a 1-year sequence of meteorological inputs for the diffusion model calculations. Correlation analyses were performed for each season to establish a system for substituting data from the other mechanical weather stations when WS7 values were missing. Details of the data set development are provided in Appendix A.

A new aerometric monitoring network is currently being installed by B.C. Hydro. This system includes sophisticated meteorological instrumentation to measure temperature, dew point, precipitation, evaporation, pressure, solar intensity, visibility, and fog occurrence. A 100 m meteorological tower will be instrumented to measure vertical temperature and wind profiles and local turbulence properties. A complete description of the monitoring program design is provided in Appendix H.

4.3 MEASURED AMBIENT AIR QUALITY

(a) Regional Air Quality

Ambient air quality data are available for only a few locations in southern British Columbia. Measurements of ambient particulate levels, dustfall, and sulfation rate by the B.C. Department of the Environment provide the only information in sufficient quantity for meaningful analysis. However, these data reflect conditions in and near the industrial communities of Kamloops and Squamish, both of which are well removed from the project site. Consequently, these data cannot be considered representative of the sparsely populated rural area surrounding the proposed project site, even for gross features, such as seasonal trends. In the interest of completeness, however, all available regional air quality data acquired in the preparation of this assessment are provided in Appendix A.

B.C. Hydro conducted snow sampling in the Cornwall Hills during the winter and spring of 1976-77 and in Wells Gray Park in June, 1977. These samples were chemically analyzed to provide baseline information for an investigation of potential effects of the power plant on precipitation acidity. The results of the analyses for samples at the two locations were similar, indicating uniform composition of the regional snowpack. Interestingly, pH values in the snow samples were about 5.5, near the 'natural' value for precipitation in equilibrium with atmospheric carbon dioxide. Samples taken from streams originating in the same snowfields showed a pH of approximately 8.0. Apparently, alkaline material in the stream beds neutralizes the acidity of the fresh snow. Results of the precipitation analyses are presented in Appendix A.

(b) Air Quality Near The Site

A limited number of high-volume filter measurements of total suspended particulates (TSP) in the Hat Creek Valley are available for the spring and summer of 1977. These data do not represent true baseline conditions, since excavation in support of a test burn of Hat Creek coal was in progress during part of the period of record. The range of measured 24-hour concentrations at the sites closest to this activity varied from less than 10 to more than 100 $\mu g/m^3$. Monitors farther from the mine site recorded maximum values of 35 to 45 $\mu g/m^3$. From the available evidence, it appears that 40 $\mu g/m^3$ represents a reasonable (but conservative) background TSP level in the vicinity of the proposed mine. A value of 20 $\mu g/m^3$ appears more reasonable for the Lower Hat Creek. The locations of the high volume samplers and complete listings of the TSP data are presented in Appendix A.

No historical record of measured ambient concentrations for other contaminants was available for the present study. In view of the project's location in a rural area with very low population density and no significant nearby industry, a sulfur dioxide background value of zero has been assumed throughout this analysis.

(c) Trace Elements

A 3-phase trace element sampling program was conducted at the site by ERT in the fall of 1976 and during the winter and spring of 1977. Samples of surface water, stream sediment, soil, airborne particulates and various species of flora and fauna were taken. In addition, samples of coal, overburden, ashes, and stack exhaust materials were collected during test burns using Hat Creek coal (see Appendix F). Leachates and cooling water were also sampled and analyzed. These efforts constituted one aspect of a comprehensive study designed to identify those trace elements in Hat Creek coals and source materials that may present hazards to the ecosystem of the project site area. In the context of this study, 'trace' elements include those found in concentrations ranging from the lowest detectable limit to 0.1% (1000 ppm).

Appendix F documents the trace element work. In addition to laboratory analyses of project source materials, other tasks included determination of existing trace element concentrations in selected ecosystem receptors and a thorough literature review of trace element ecology to evaluate and select elements of major concern. Nine elements were ascertained to be of greatest environmental importance in local ecosystems because of relatively high concentration in source materials, their mobility through ecological pathways, and/or their ready accumulation by local receptors. These elements are arsenic, cadmium, chromium, copper, fluorine, lead, mercury, vanadium, and zinc. Full quantitative analyses, with documentation of sampling techniques, laboratory methods and assumptions, and study conclusions are presented in Appendix F.

(d) Monitoring

In addition to on-site meteorological data [see Section 4.2(c)], the new B.C. Hydro aerometric monitoring network has been designed to provide continuous air quality information before and during the project's operational lifetime. Ambient sulfur dioxide (SO_2), oxides of nitrogen (NO_x), ozone (O_3), carbon monoxide (CO), and suspended particulates, as well as dustfall, sulfation, and corrosion will each be measured at one or more of the four monitoring stations located in the vicinity of the project site. These measurements will comprise an extensive data set documenting air quality before, during, and after project construction, and provide a basis for future air quality model development and validation. Complete descriptions of the monitoring program design objectives and equipment specifications are included in Appendix H.

4.4 EMISSIONS FROM OTHER INDUSTRIAL SOURCES

Although the Hat Creek area is relatively isolated from other major sources of atmospheric contaminants, several other industries within 100 km from the project site have been considered in the present study. In 1977, B.C. Hydro engaged B.H. Levelton and Associates Ltd. to prepare an inventory of sources of primary contaminants.[13] The inventory provides information regarding the nature and magnitude of emissions of particulate matter, sulfur oxides, and nitrogen oxides in the Kamloops, Cache Creek, Clinton, and Highland Valley areas.

Based on this document, estimated total emissions from existing, approved, and proposed facilities in these locales are:

- sulfur oxides (SO_x) - 102,104 kg/day (224,630 lb/day);
- nitrogen oxides (NO_x) - 20,534 kg/day (45,174 lb/day); and
- total particulates (TSP) - 22,845 kg/day (50,260 lb/day).

With the exception of a proposed 1000 ton-per-day copper smelter near Highland Valley, most of the sources are located east of Hat Creek in the Kamloops area. While these emissions are individually much smaller than those projected for Hat Creek, it is anticipated that air quality levels in Kamloops will be dominated by local sources, and that effects there due to the Hat Creek Project will be negligible [see Section 5.2(c)(iv)].

5.0 ENVIRONMENTAL EFFECTS OF THE PROJECT

5.1 EFFECTS DUE TO CONSTRUCTION ACTIVITIES

(a) The Power Plant

During the construction of the power plant, activities that produce fugitive dust emissions represent the main air quality concern. These activities include road construction, grading and excavation, erection of buildings and facilities, blasting, and concrete batching. Fugitive dust emissions could cause elevated TSP concentrations (e.g., 150 to 200 $\mu g/m^3$) within the plant site. However, the extent of the site as well as the relative lack of sensitive land-use near the site perimeters indicate that the impact of on-site construction activities would be minimal, if not negligible. Even if localized problems should arise, mitigation, e.g., watering during windy periods, is possible. Gaseous emissions from trucks, self-propelled construction equipment, and construction workers' vehicles will cause localized but insignificant increases in on-site ambient concentrations of carbon monoxide, nitrogen oxides and hydrocarbons.

(b) The Mine

Construction of the mine will consist essentially of normal mining activities, e.g., removal of surficial material and overburden, and conveying and dumping. The emissions associated with these operations are described in Section 3.2(c). The effects of mine-related dust emissions for the year of peak mine activity are described in Section 5.2(a)(iv). Elevated TSP concentrations will occur during the first few years of active mining, although they will be smaller than those expected during peak mining activities.

(c) The Off-site Facilities

Preliminary plans for off-site facilities are summarized in Section 3.3. Again, fugitive dust emissions and vehicular emissions are the primary concern. Significant dust emissions will be generated during the construction of (1) the access road from the Trans-Canada Highway to the plant site, (2) the cooling water supply system, (3) the airstrip, (4) the transshipment center, and (5) smaller facilities and during creek diversion activities.[9] B.C. Hydro has agreed to implement dust abatement and erosion control procedures. These should minimize any localized impacts. The estimated peak traffic volume during construction is 500 to 700 vehicles at the beginning and end of the work week. This volume will not produce enough gaseous pollutants to significantly alter air quality.

5.2 EFFECTS DUE TO PROJECT OPERATION

(a) Climatic Effects

Appendix E, Climatic Assessment, presents detailed results of a thorough review of literature and field studies pertaining to effects of thermal power generation on climatic phenomena for the local, regional, and global scales. A summary of that study is provided in this section.

(i) Mesoscale (Local, Regional)

A. Precipitation Enhancement

As mentioned in Sections 3.1(c)(ii)A. and 3.1(c)(ii)B., cooling towers for the proposed generating station are expected to release about 5.3×10^7 kg (58,000 tons) of evaporated water and about 6.2×10^{13} calories (25×10^{10} Btu) to the atmosphere per day of operation. The power plant stack will emit particulate matter that could act as condensation nucleii and affect precipitation. Studies of the effects of such moisture, energy and particulate releases on augmentation of precipitation have concluded that amounts resulting from such emissions are very small compared with natural rain and snowfall. On local and regional scales, this precipitation enhancement is expected to be less than 1% annually.

The precise conditions required for cooling tower-induced snowfall are not well known. Augmented precipitation due to cooling towers has been observed in the United States in Indiana, West Virginia, and Tennessee. The literature suggests that observed events of this kind occur with: (1) ambient air temperature below -12°C; (2) relatively stable atmospheric conditions at plume height; and (3) large cooling tower vapor emissions.[14] These conditions probably occur more frequently in winter in the Hat Creek area than in the states mentioned above, so small increases in snowfall by as much as 2.5 cm (1 inch) are expected to occur occasionally. Since such effects are limited to the area beneath the cooling tower plume, power plant emissions are not expected to have an appreciable regional impact.

On days characterized by natural convective instability, the cooling towers will help to initiate patches of low cumulus clouds on a local scale. On the basis of experience at other facilities with similar heat and moisture discharges, it is concluded that the Hat Creek Project will not significantly alter precipitation patterns in the surrounding area.

B. Thermal Alterations

Two mechanisms whereby project emissions might conceivably alter the local temperature structure are: (1) the release of hot stack gases and cooling tower effluent and the dispersion of these plumes, and (2) reduction of solar radiation incident at the ground by aerosols in the stack plume, visible cooling tower plumes, and fugitive dust from mining activities.

Plume material from the power plant stack and natural draft cooling towers will be dispersed slowly to the ground from substantial heights and will be in thermal equilibrium with the ambient air upon reaching surface level. A calculation performed by means of a cooling tower plume simulation model indicates that any temperature excess caused by the cooling tower plume will be effectively dissipated within a downwind distance of 500 m.

Stack plume aerosols are not expected to reduce the amount or intensity of solar radiation at the ground in any significant way. Modern electrostatic precipitators will curtail particulate emissions to a maximum value of 0.23 gram per standard cubic meter (0.1 grain per standard cubic foot) of stack gas. This concentration corresponds to a plume that is slightly visible, but the relatively narrow width of the plume and natural wind variability will preclude any appreciable decrease of visibility within about 25 km of the stack. Sulfate aerosols, slowly generated by SO_x in the plume, and the small fraction of other particulates that remain suspended for extended travel distances will cause some restriction to visibility on a regional scale. It has been estimated that these aerosols will reduce visibility by about 6% on an annual basis.

According to model calculations, maximum shadowing by visible cooling tower plumes is expected to occur within 0.5 km from the towers. Beyond a 2 km radius, not more than 20 hours of overhead plumes are predicted at any point. Considering that many of these hours will be at night during periods of natural cloudiness, the effect of these plumes on solar radiation will be insignificant.

Mining activities will generate an estimated 2.2 million kg of fugitive dust during the year of peak production. A resulting annual average particulate concentration of about 60 $\mu g/m^3$ is predicted within a small area in the Upper Hat Creek Valley. This amount of material may reduce visibility and incoming radiation in the immediate vicinity of the mine.

Local visibility degradation due to the mine will be significant on an annual basis. It is expected that the typical visual range of objects will be reduced to 25% of values representative of conditions that exist before the commencement of mining operations. A very localized cooling may result, since dust particles do not absorb long wave terrestrial radiation. However, the degree of cooling would be small compared to the natural variability of annual average temperatures and would be confined to the immediate area of the mine pit. Certainly the local growing season will not be affected.

C. Snow Cover Persistence and Depth

As discussed in Section 5.2(a)(i)A., plumes from the natural draft cooling towers are expected to enhance snowfall amounts by a few centimeters per year. This effect would normally be restricted to the immediate plant environs. Since the natural draft tower design is characterized by a release height of 116 m, downwashing plumes are not expected to reach ground-level as is frequently observed, for example, with rectangular mechanical draft towers. Thus, no decrease in the depth or persistence of the snowcover at the ground is expected from this phenomenon.

D. Ground-Level Fogging and Icing

A complete set of model calculations was performed to estimate the nature and frequency of atmospheric effects due to cooling tower operation (see Appendix D). No ground-level fogging or icing is predicted for the natural draft design. Visible plumes may impinge on peaks of surrounding hills, but such effects are not expected to impact any location more than ten hours per year. Icing due to drift water emissions from the cooling towers is shown in Appendix D to be entirely inconsequential. Evaporation of water from the ash pond and make-up water reservoir will cause instances of local fogging during the winter months.

E. Deposition of Cooling Tower Drift

Cooling tower drift consists of liquid water droplets borne with the vapor plume into the atmosphere. Most of the power plant cooling water discharged by such towers is condensed from the vapor state upon contact with the cooler ambient air. Drift droplets, however, have the chemical composition of the circulating water, in which concentrations of dissolved solids in the source water have been magnified by several cycles through the condensors. These substances are eventually deposited on the ground.

A complete modeling analysis of potential impacts due to cooling tower salt drift deposition is described in Appendix D. Seasonal and annual drift rates were computed for the natural draft towers by means of the ERT DEPOT model, using inputs of local meteorological data and emission characteristics described in Section 3.1(c)(ii)C. A maximum annual deposition rate of 4,700 kg/km^2/year (42 lb/acre/year) is predicted to occur about 1,000 meters east of the towers. Beyond about seven kilometers, annual rates of less than 112 kg/km^2/year (1 lb/acre/year) are predicted.

F. Visibility Restrictions

Fugitive emissions generated by mining activities will substantially degrade visibility in the mine environs. For example, annual concentrations of TSP will be increased from 20 μg/m^3 to approximately 80 μg/m^3 at the southern boundary of the Indian Reserve located 3 km north of the mine pit. This increase in atmospheric particulate loading is expected to reduce the visual range over which fine detail is discernible from 14.6 km to 3.6 km, moderate detail is visible from 36.0 km to 9.0 km, and coarse detail is visible from 54.0 km to 13.5 km. At other locations in the Reserve, annual average visual range will be reduced to about 45% of pre-mine values. The power plant stack emissions are not expected to noticeably alter visibility on a local scale although the plume will be somewhat opaque near the stack. On a regional scale, sulfate and other particulate concentrations will degrade visibility by about 6% on an annual basis.

(ii) Macroscale (Synoptic, Global)

A. Atmospheric Temperature Structure and Energy Balance

In recent years, concern has been expressed that man's activities will affect and have affected the earth's climate. However, global-scale impacts remain poorly understood because of the lack of understanding of the complex relationships and feedback mechanisms between atmospheric dynamics and chemistry and other factors. An additional deterrent to understanding is the scarcity of information in the current large-scale meteorological data base. Some scientists have warned that the large increases in carbon dioxide and particulate matter released to the atmosphere during the last few decades are capable of significantly altering the temperature structure of the atmosphere. However, with presently available data, it is difficult to distinguish these effects from the high degree of natural variability that has characterized mean temperatures in the past.

Four basic processes that govern the global circulation pattern[15] are: (1) the intensity of solar radiation reaching the top of the atmosphere; (2) the transmittance of the atmosphere as modified by non-internal processes; (3) the albedo (the ratio of light reflected and scattered to the amount of incident light) of the earth-atmosphere system; and (4) the greenhouse control of infrared radiation from the earth by gaseous and particulate concentrations. Significant changes in the earth's climate have been predicted should there be man-induced alterations of any of these processes. However, considerable disagreement characterizes the arguments regarding the nature and extent of any postulated effects and the magnitude of the disturbances required to produce them.

Little attention has been focused on the subject of global climatic alterations due to individual sources. Very large power generating facilities ('energy parks') have been considered as an option to meet future energy supplies. Such plants would generate 50,000 Mw or more of usable electric power, creating perhaps 100,000 Mw of waste heat. Studies of specific effects due to energy parks on local and regional scales are numerous but inconclusive. The proposed Hat Creek plant will have more than an order of magnitude less generating capacity than such an energy park. It is estimated that the B.C. Hydro facility will increase the global anthropogenic energy release by about 0.001% of its projected level in the year 2000. The approximately 4,000 Mw of waste heat expected from the Hat Creek plant is extremely small compared with the estimated 10^{11} Mw naturally emitted by the earth's surface.[16]

The emissions of gaseous and particulate matter and water vapor from the Hat Creek generating station are minute fractions of total global emissions; it is concluded that the project will have no detectable influence on the large scale climate.

B. Chemical Composition of the Stratosphere

The stratosphere extends from about 17 km to about 50 km above the earth's surface. Without the protective ozone belt of this layer, life on earth would not exist. The region between 25 and 35 km above the earth is the primary area where ozone production exceeds destruction. Man may alter stratospheric photochemical reactions (and thus the ozone concentration) by affecting either the radiation balance or the chemical equilibrium. Tremendous vertical transports are required for most surface emissions (such as oxides of nitrogen or particulates) to reach altitudes approaching 25 km. For example, updrafts and downdrafts in large thunderstorms and hurricanes have been hypothesized as possible mechanisms of mass exchange between the stratosphere and the troposphere. Other mechanisms for transport are possible, as indicated by the measurable presence of chlorofluorocarbons in the stratosphere. The extreme chemical stability of these compounds and their light atomic weights contribute to their almost indefinite residence time in the atmosphere. Very gradual diffusion is believed to cause the eventual appearance of chlorofluorocarbons at stratospheric altitudes. Such contaminants are not, of course, emitted by fossil-fuel power plants. Similarly, the upward transport of plume materials by updrafts is not expected to result in any appreciable attenuation of the radiative processes of the stratosphere.

(b) Local Air Quality

A program of diffusion modeling was designed to estimate the effects of the Hat Creek Project on local air quality (within 25 km from the site). A point source Gaussian model was employed to predict ground-level concentrations of contaminants emitted by the proposed power plant. The model simulates the rise, transport, and dispersion of buoyant stack gases. Inputs include a sequential record of local meteorological data, terrain elevations within a radial distance of 25 km, and emission characteristics corresponding to operation with FGD and MCS controls (see Section 3.1(b)). Parameterization of diffusion rates in the vicinity of the Hat Creek facility was accomplished by analysis of on-site tracer plume simulations. The basic model was thus tailored to reflect site-specific terrain and meteorological features; it is referred to as the Hat Creek Model (HCM) in this report.

The fundamental assumptions incorporated by the HCM are listed below.

- The cross-wind and vertical profiles of plume contaminant mass are well described by normal (Gaussian) distributions.
- Removal processes (chemical transformations and deposition) have little effect on the local scale.
- Steady-state meteorological conditions persist during each hour.

Model calculations were performed for each of three plant emission configurations: (1) a 366 m (1200 ft) stack with meteorological control (MCS); and (2) a 244 m (800 ft) stack with MCS, and (3) a 366 m stack with flue gas desulfurization (FGD). A 1-year (1975) record of measurements from the B.C. Hydro mechanical weather station near Harry Lake provided input for the local modeling analysis. A detailed description of the HCM is provided in Appendix B, Modeling Methodology.

Ground-level concentrations of sulfur dioxide (SO_2), oxides of nitrogen (NO, NO_2) and total suspended particulates (TSP) were computed for each hour of a 1-year period. The sequence of hourly values was used to develop 3-hour, 8-hour, 24-hour, seasonal, and annual average concentrations. The results were analyzed to determine maximum values and to develop frequency distributions for each averaging time and each contaminant. Detailed results for all averaging times and for each air quality control system are presented as an Addendum to Appendix C.

Specific guidelines regulating ambient concentrations in the vicinity of coal-fired power plants have not yet been established in British Columbia. After a review of threshold concentrations associated with effects on human health (see Appendix G), property damage, and effects on crops and wildlife, maximum allowable levels for various contaminants and averaging times were postulated. The ambient concentration guidelines assumed in this report are those recommended by B.C. Hydro in a submission to the Pollution Control Branch Public Enquiry to Review Pollution Control Objectives for the Mining, Mine-Milling, and Smelting Industries of British Columbia, January 1978. These assumed guidelines are identified in subsequent sections. Because the proposed site is located in a relatively remote area with no major sources of air contaminants, zero background levels were assumed in the modeling analyses for SO_2, NO, and NO_2. Non-zero background levels for TSP were indicated by monitoring in the Hat Creek Valley. An average value of 40 $\mu g/m^3$ in Upper Hat Creek Valley and 20 $\mu g/m^3$ in Lower Hat Creek Valley were assumed in modeling air quality effects of the mine.

(i) Flue Gas Desulfurization with 366 m (1200 ft) Stack

The Hat Creek Model was employed to evaluate the FGD system discussed in Section 3.1(b)(ii) in terms of compliance with assumed sulfur dioxide guidelines for 3-hour average (655 $\mu g/m^3$), 24-hour average (260 $\mu g/m^3$), and annual average (25 $\mu g/m^3$) concentrations. Concentration distributions for other averaging times and other stack plume constituents emitted by the proposed plant were also estimated.

A. Sulfur Dioxide

Maximum predicted SO_2 concentrations for plant operation with flue gas desulfurization are listed for various averaging times in Table 5-1. As indicated by the table, this control system, with full availability, is expected to maintain ambient levels well below the assumed criteria levels. Results of the modeling analysis suggest, in fact, that compliance could be achieved by the FGD system with a shorter stack. A detailed description of the proposed scrubber units and an evaluation in terms of air quality control and cost effectiveness is included in Appendix C.

Figure 5-1 depicts the distribution of predicted incremental annual average SO_2 concentrations within 25 km from the proposed generating station. Maximum concentrations are expected to occur at locations with the highest elevations, specifically in the Cornwall Hills, Arrowstone Hills, and Clear Range. Because the assumed stack height is 366 m, almost no measurable effect on ground-level ambient concentrations is predicted nearer than 5 km from the plant site. Terrain effects and the annual distribution of wind direction are the most important factors producing the pattern seen in Figure 5-1.

B. Oxides of Nitrogen

For purposes of computing the local-scale contribution of the power plant to ambient levels of nitrogen oxide (NO) and nitrogen dioxide (NO_2), it was assumed that a total NO_x emission rate of 600 ppm is equally divided between NO and NO_2. Due to the difference in the molecular weights of the two species, the mass emission rate of NO_2 is, therefore, about 51% greater than that for NO (see Table 3-1). In this way, the complex series of reactions that attend the conversion of NO are accounted for in a manner consistent with results of power plant plume measurements. For the local air quality analysis, plume travel times are considered insufficient to produce appreciable quantities of organic and inorganic nitrates.

TABLE S-1

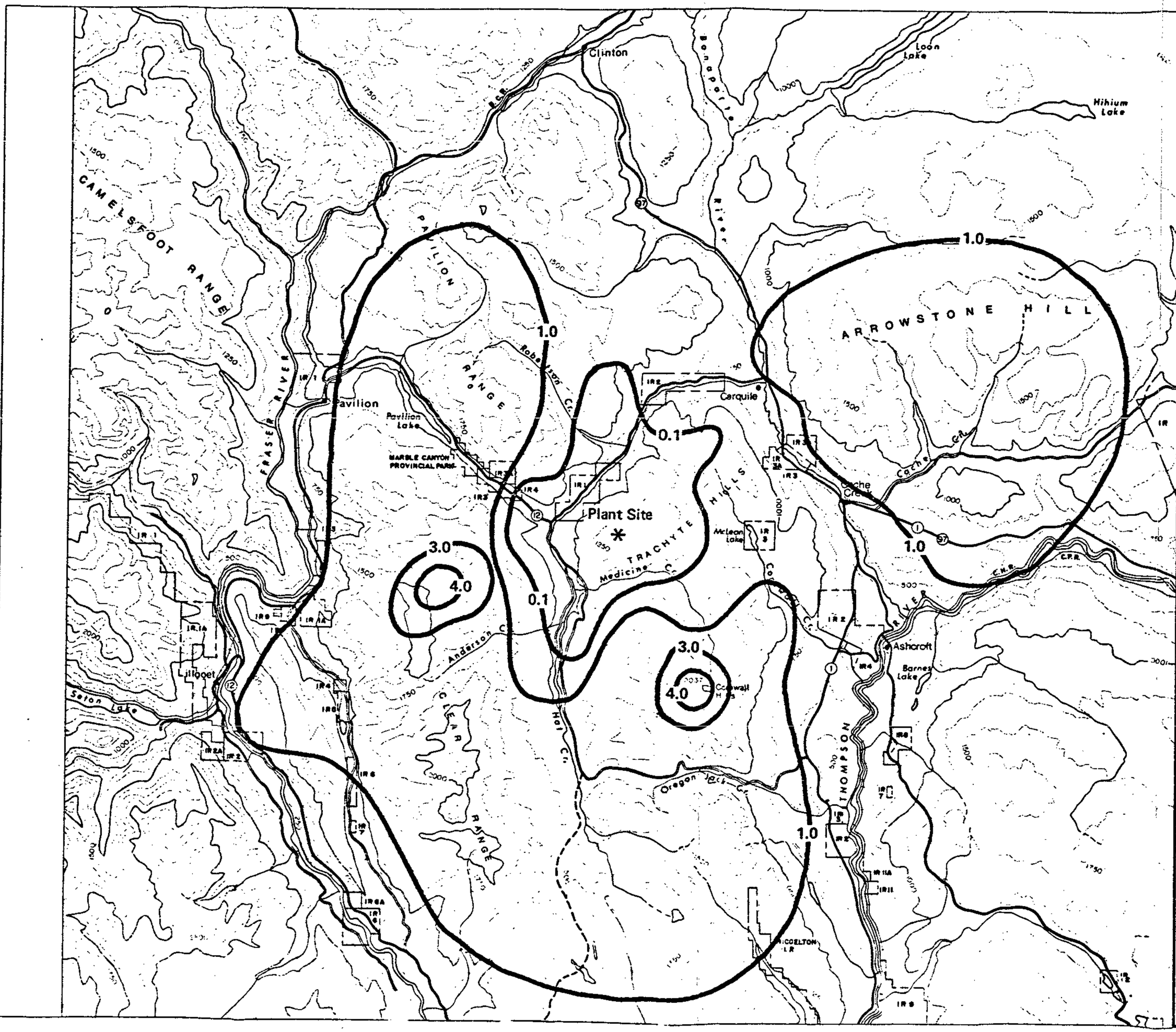
MAXIMUM PREDICTED GROUND-LEVEL AMBIENT SULFUR DIOXIDE CONCENTRATIONS WITHIN 25 KM FROM THE HAT CREEK GENERATING STATION WITH FLUE GAS DESULFURIZATION AND 366 M STACK

Averaging Time	Maximum Concentration ($\mu g/m^3$)
1-hr	729
3-hr*	366
24-hr**	208
Seasonal	
Winter	3.5
Spring	6.8
Summer	5.1
Fall	7.2
Annual***	4.5

*Assumed guideline value of 655 $\mu g/m^3$

**Assumed guideline value of 260 $\mu g/m^3$

***Assumed guideline value of 25 $\mu g/m^3$



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HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-1 Predicted Annual Averaged SO_2 Concentrations (μg/m3) within 25 km: 366 m Stack with FGD

Figures 5-2 and 5-3 indicate the distributions of computed annual average NO and NO_2 respectively. Maximum values of 1.9 $\mu g/m^3$ and 2.5 $\mu g/m^3$ are predicted for these species. The quantitative effect of the FGD on emissions of NO_x is not established. Thus, emissions corresponding to uncontrolled operation have been used in the calculations for these species. The results are considered to provide conservative estimates of concentrations for FGD operations.

No guidelines for ambient NO or NO_2 are currently in effect in British Columbia. The 600 ppm stack gas concentration assumed in the analysis corresponds to the Level A Objective for food-processing and miscellaneous industries.

C. Particulates

Isopleths of predicted local annual mean concentrations of total suspended particulates (TSP) are presented in Figure 5-4. Annual guidelines for TSP in British Columbia are expressed in terms of the geometric mean. The arithmetic mean is always greater than or equal to the geometric mean. Thus, the presentation of arithmetic mean concentrations in discussions of TSP effects in this report is inherently conservative in terms of compliance with the annual guideline. The Level A guideline for the mining, mine-milling and smelting industries in British Columbia[17] is 60 $\mu g/m^3$ (geometric mean).

A maximum annual particulate concentration of 1.2 $\mu g/m^3$ is predicted in the Cornwall Hills, 13 km south-southeast from the generating station. This value is very small in comparison with the annual guideline. Table 5-2 lists maximum predicted TSP concentrations for other averaging times.

D. Total Hydrocarbons and Carbon Monoxide

Emissions of total hydrocarbons (HC) and carbon monoxide (CO) are assumed to be about 3.6% and 12.1% of FGD-controlled SO_2 emissions

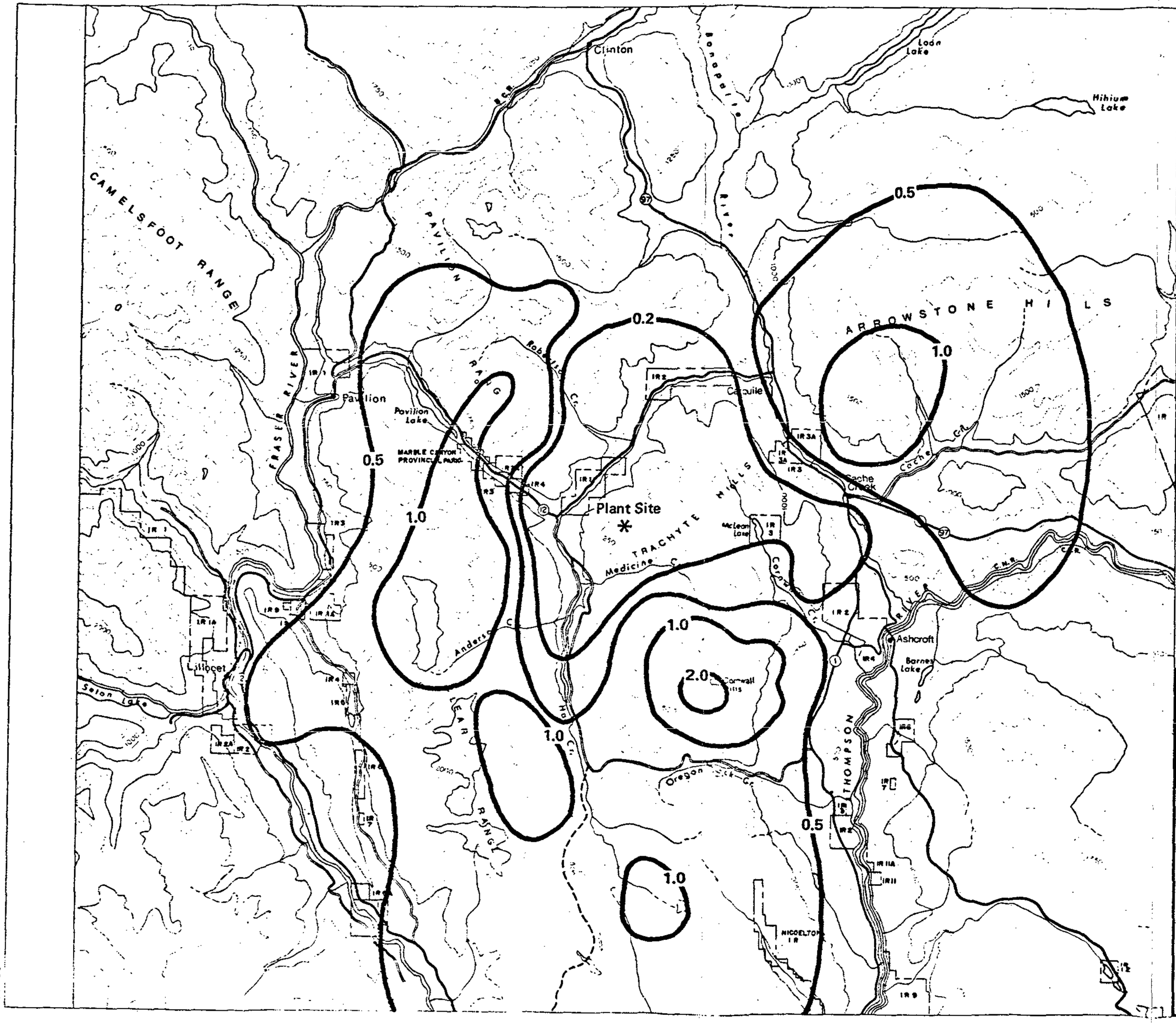

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Figure 5-2 Predicted Annual Averaged NO Concentrations ($\mu g/m^3$) within 25 km: 366 m Stack with FGD

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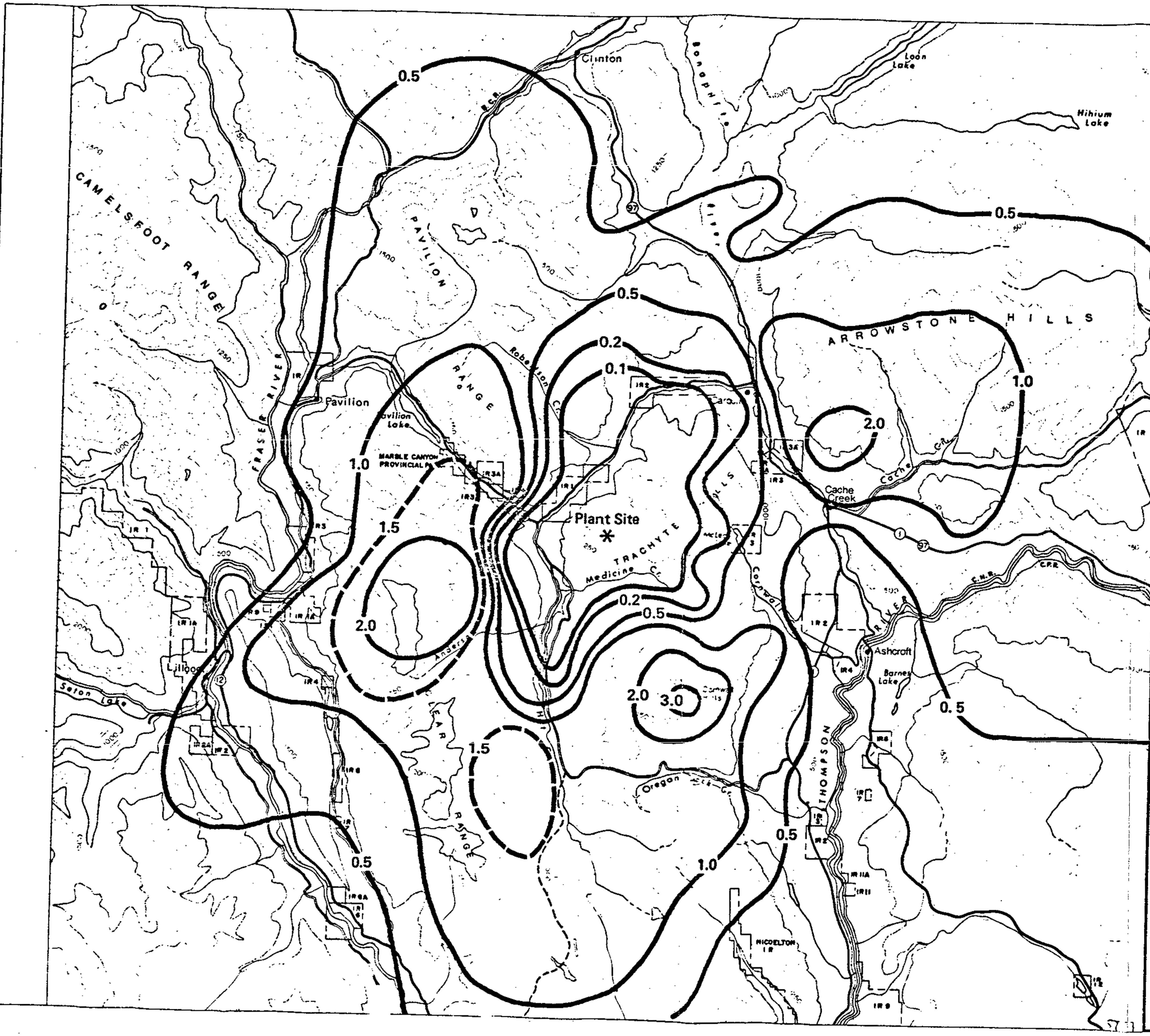

SCALE - 1:250,000

0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

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HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-3 Predicted Annual Averaged NO_2 Concentrations (μg/m3) within 25 km: 366 m Stack with FGD

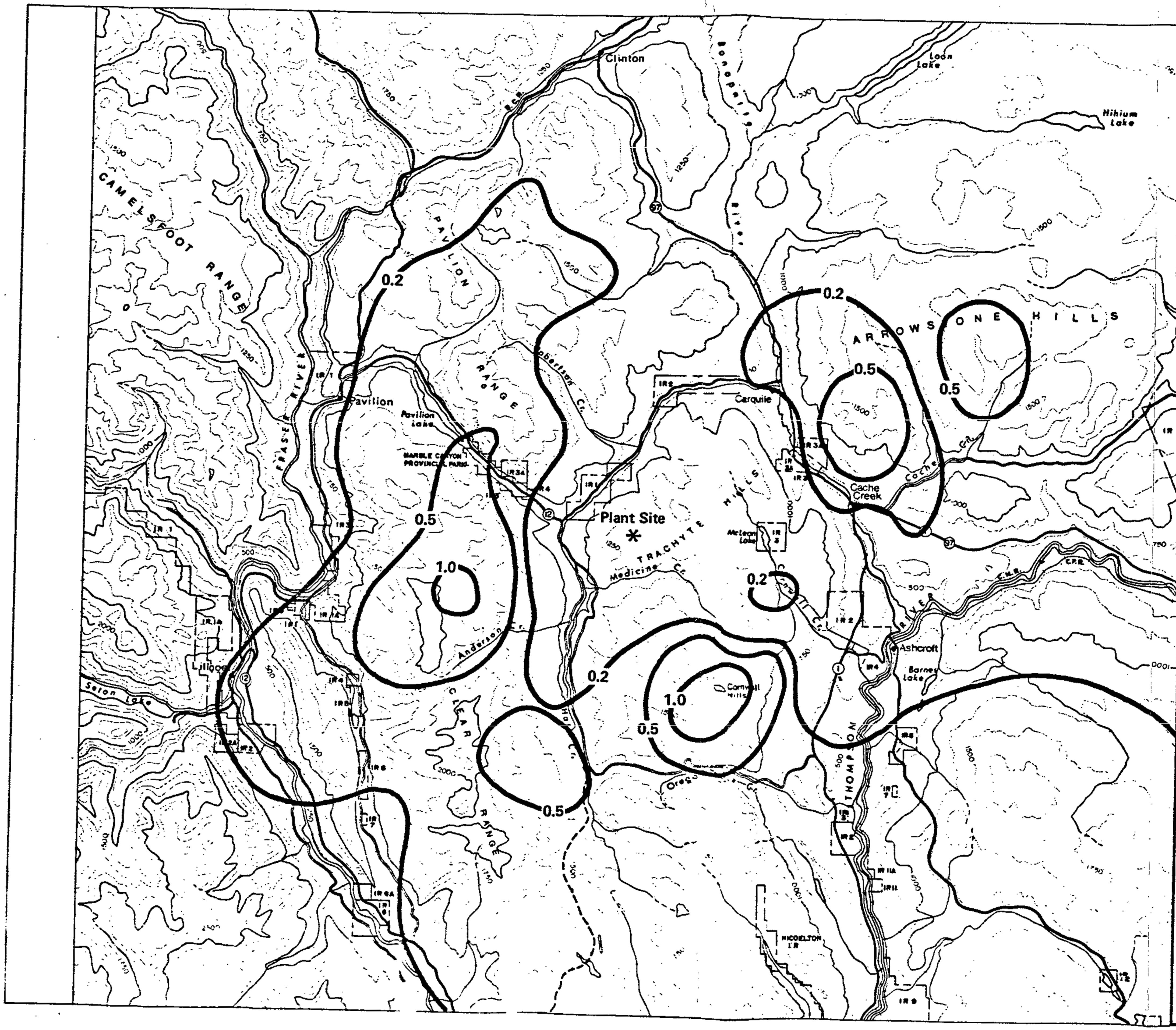

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Figure 5-4 Predicted Annual Averaged TSP Concentrations (µg/m³) within 25 km: 366 m Stack with FGD

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TABLE S-2

MAXIMUM PREDICTED GROUND-LEVEL AMBIENT TSP CONCENTRATIONS WITHIN 25 KM FROM THE HAT CREEK GENERATING STATION WITH FLUE GAS DESULFURIZATION AND A 366 M STACK

Averaging Time	Maximum Concentration ($\mu g/m^3$)
24-hr*	26
Seasonal	
Winter	0.9
Spring	1.8
Summer	1.4
Fall	1.9
Annual (Arithmetic Mean)**	1.2

*Assumed guideline value of 150 $\mu g/m^3$

**Assumed guideline value of 60 $\mu g/m^3$ (geometric mean) respectively. Estimated annual concentrations for these contaminants may be obtained from Figure 5-1 by multiplying calculated SO_2 concentrations by the appropriate emissions ratios. No applicable guidelines pertaining to ambient levels of hydrocarbons are currently in effect in British Columbia. Maximum 1-hour and 8-hour CO concentrations of 14,300 $\mu g/m^3$ and 5,500 $\mu g/m^3$, respectively, are given in the Level A guidelines for food processing, agriculturally oriented, and miscellaneous industries. Table 5-3 provides comparisons of these regulatory levels with predicted CO concentrations. Clearly, the predicted values are negligible in terms of these guidelines.

E. Trace Elements

Table 5-4 indicates predicted maximum 24-hour and annual mean concentrations for selected trace elements that will be emitted from the proposed power plant. The tabulated values correspond to those substances for which ambient guidelines are listed in the Pollution Control Objectives for the Mining, Mine-Milling, and Smelting Industries of British Columbia.[17] As seen in the table, no values approaching the assumed short-term or long-term guidelines are expected. Concentrations for other contaminants listed in Table 3-1 may be estimated by scaling predicted SO_2 concentrations by the appropriate emission ratios.

F. Commitment of the Air Resource

This section provides a quantitative estimate of the fraction of the available air resource that will be committed by operation of the Hat Creek power plant with the FGD system. Of necessity, such an estimate requires that some assumption be made regarding the definition of this resource. In this discussion the relationship between peak predicted incremental concentrations and corresponding ambient guidelines is used to define the percentage degradation attributable to the project.

TABLE 5-3

MAXIMUM PREDICTED AMBIENT CARBON MONOXIDE CONCENTRATIONS WITHIN 25 KM FROM THE HAT CREEK GENERATING STATION WITH FLUE GAS DESULFURIZATION AND A 366 M STACK

Averaging Time	Maximum Concentration (ug/m^3)
1-hr*	88.2
8-hr**	31.4
24-hr	25.2
Seasonal	
Winter	0.4
Spring	0.8
Summer	0.6
Fall	0.9
Annual	0.5

*Assumed guideline value of 14,300 μg/m^3 (13 ppm)
**Assumed guideline value of 5,500 μg/m^3 (5 ppm)

TABLE 5-4

MAXIMUM PREDICTED AMBIENT CONCENTRATIONS OF SELECTED SUBSTANCES WITHIN 25 KM FROM THE HAT CREEK GENERATING STATION WITH FLUE GAS DESULFURIZATION AND A 366 M STACK

Substance	Averaging Time	Maximum Concentration ($\mu g/m^3$)
Fluoride (gaseous)*	Annual	0.008
	24-hr	0.4
Lead (particulate)**	Annual	0.00008
	24-hr	0.004
Zinc (particulate)***	Annual	0.00009
	24-hr	0.004
Cadmium (particulate)†	Annual	0.000006
	24-hr	0.0003
Mercury††	Annual	0.0002
	24-hr	0.008
Arsenic†††	Annual	0.0006
	24-hr	0.03

*Assumed guidelines of 0.5 and 1.0 $\mu g/m^3$ for annual (arithmetic) mean and 7-day average, respectively

**Assumed guidelines of 2 and 4 $\mu g/m^3$ for annual geometric mean and maximum 24-hour average, respectively

***Assumed guidelines of 3 and 5 $\mu g/m^3$ for annual geometric mean and maximum 24-hour average, respectively

†Assumed guidelines of 0.05 and 0.1 $\mu g/m^3$ for annual geometric mean and maximum 24-hour average, respectively

††Assumed guideline of 1.0 $\mu g/m^3$ monthly average

†††Assumed guidelines of 0.2 and 1.0 $\mu g/m^3$ for annual geometric mean and maximum 24-hour average, respectively

Maximum predicted 3-hour and 24-hour SO_2 concentrations with the FGD are 366 and 208 $\mu g/m^3$ respectively. These values represent 56% and 80% of the assumed guideline levels. Care must be exercised in interpreting these percentages, since the maxima represent the highest single concentrations predicted at any point. It should be recognized that on a long-term basis, the average of 3- or 24-hour values at a particular location is, in fact, the annual average. Flue gas desulfurization is predicted to result in a maximum annual average SO_2 concentration of 4.5 $\mu g/m^3$; this is 18% of the assumed guideline, which probably represents the best overall estimate of the air quality resource commitment associated with this SO_2 control strategy. The corresponding value for particulates is about 2%. Results for other contaminants, including carbon monoxide and trace elements, indicate a negligible degradation in terms of the relevant guidelines.

(ii) Meteorological Control with 366 m Stack

This section presents modeling results corresponding to power plant operation with a meteorological control system (MCS) and a 366 m (1200 ft) stack height. The assumed mode of MCS operation is as follows.

- During periods of adequate dispersion, the plant fuel is 0.45% sulfur coal with a mean heating value of 3,500 cal/gm (6,300 Btu/lb).
- When the maximum 3-hour ambient SO_2 concentration would exceed 655 $\mu g/m^3$, or when the 24-hour maximum would exceed 260 $\mu g/m^3$, emission reductions are made by one of two methods: (1) during the months November through February, the fuel is switched to 0.21% sulfur coal with a heating value of 4,190 cal/gm (7,560 Btu/lb); or (2) during the remaining months, the generating capacity of the four 500 Mw units is uniformly reduced as required to bring ambient concentrations below the 3-hour and 24-hour criteria.
- To minimize the number of physical fuel-switch operations, it is assumed that the minimum period of low-sulfur coal use is three hours, and that the minimum interval of high sulfur coal use between switch periods is nine hours.

A modeling study based on one year of input data was performed to evaluate the feasibility of this MCS. The results, provided in detail in Appendix C, are summarized below.

- According to the model analysis, installation of a 366 m stack would ensure that the power plant could be operated virtually as a base-load facility with uncontrolled emissions. This result applies only for the 3-hour and 24-hour control guidelines assumed in the analysis.
- MCS control actions would be limited to a very few fuel switching periods during the winter. Use of 0.21% sulfur fuel on those occasions would be adequate to prevent ambient violations, even with control criteria set at 80% of the assumed guideline values.
- Load reduction requirements during the remaining months would come infrequently, if necessary at all, and the annual generating capacity loss due to any such curtailments would be negligible.

A. Sulfur Dioxide

Maximum computed SO_2 concentrations from power plant emissions with an MCS and a 366 m stack are presented for various averaging times in Table 5-5. A comparison of these values with those in Table 5-1 points out the differences between the effects of constant emission reduction technologies (such as FGD) and intermittent controls (such as MCS) designed to eliminate only peak concentrations above specified thresholds.

Figure 5-5 indicates the geographical distribution of annual average SO_2 concentrations within 25 km from the proposed generating station. Maximum values are higher than those predicted for FGD controls, but are still nearly an order of magnitude below the applicable Level A guideline (25 $\mu g/m^3$). Peak concentrations are expected to occur in remote, elevated locations, and the 366 m stack height precludes any measurable effect at ground level within 5 km from the plant site.

B. Oxides of Nitrogen

Maximum local concentrations of NO and NO_2 may be estimated from the SO_2 modeling results in Table 5-5 by scaling predicted SO_2 values by the factors 0.25 and 0.38 respectively. Distributions of annual average

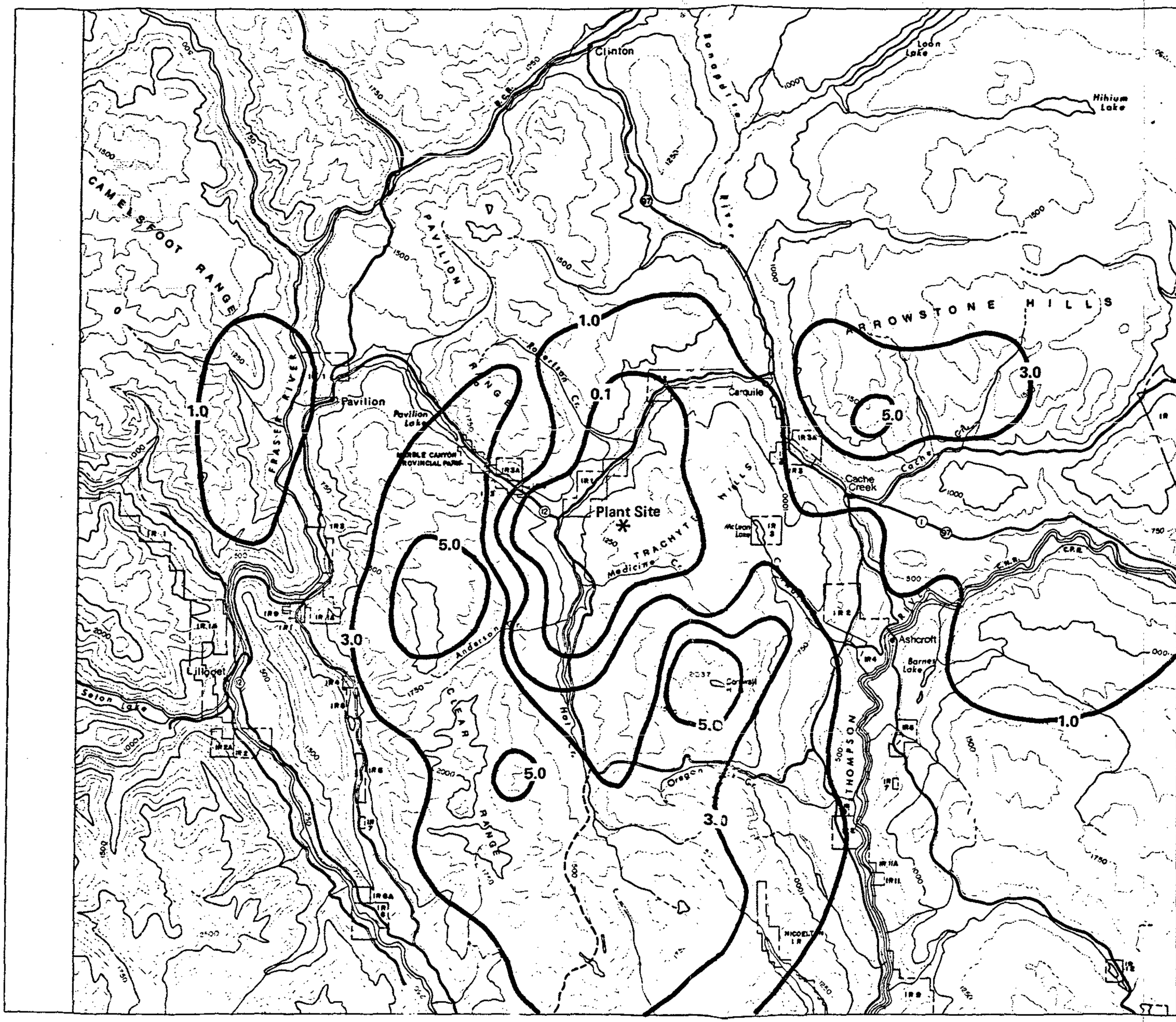
TABLE 5-5

MAXIMUM PREDICTED GROUND-LEVEL SULFUR DIOXIDE CONCENTRATIONS WITHIN 25 KM FROM THE HAT CREEK GENERATING STATION WITH METEOROLOGICAL CONTROL AND 366 M STACK

Averaging Time	Maximum Concentration ($\mu g/m^3$)
1-hr	1,644
3-hr*	647
24-hr*	260
Seasonal	
Winter	6.0
Spring	13.1
Summer	9.9
Fall	7.5
Annual	7.0

*Assumed guideline of 655 $\mu g/m^3$

**Assumed guideline of 260 $\mu g/m^3$



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DETAILED ENVIRONMENTAL STUDIES

Figure 5-5 Predicted Annual Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 366 m Stack with MCS concentrations of these species may be similarly obtained from Figure 5-5. This approach assumes that NO_x emissions are reduced by fuel switching and load reduction in the same manner as sulfur dioxide. No ambient guidelines for NO_x are currently in effect in British Columbia.

C. Particulates

Maximum computed total suspended particulate (TSP) concentrations within 25 km from the power plant are displayed in Table 5-6. Predicted concentrations are well below the assumed guidelines for 24 hours (150 $\mu g/m^3$) and one year (60 $\mu g/m^3$).

The distribution of predicted annual average TSP concentrations may be inferred from the pattern displayed in Figure 5-5, by scaling the plotted values for SO_2 by the factor 0.12.

D. Total Hydrocarbons and Carbon Monoxide

Emission ratios of total hydrocarbons and carbon monoxide to uncontrolled sulfur dioxide emissions are approximately 0.017 and 0.055 respectively. Conservative estimates of annual concentrations of these contaminants may be obtained by scaling predicted SO_2 levels given in Figure 5-5 by the appropriate ratios. Table 5-7 lists predicted CO levels for various averaging times. Calculated concentrations are seen to be well below applicable guideline values for 1 hour and 8 hours.

E. Trace Elements

Maximum 24-hour and annual (arithmetic) mean predicted concentrations of selected trace elements within 25 km of the power plant are indicated in Table 5-8. The assumed ambient guidelines for these substances are also presented for comparison with the computed values. Annual average concentration patterns for these trace elements may be estimated from

TABLE 5-6

MAXIMUM PREDICTED TSP CONCENTRATIONS WITHIN 25 KM FROM THE HAT CREEK GENERATING STATION WITH METEOROLOGICAL CONTROL AND A 366 M STACK

Averaging Time	Maximum Concentration ($\mu g/m^3$)
24-hr*	32
Seasonal	
Winter	0.7
Spring	1.6
Summer	1.2
Fall	0.9
Annual (arithmetic mean)**	0.9

*Assumed guideline 150 $\mu g/m^3$

**Assumed guideline value of 60 $\mu g/m^3$

TABLE 5-7

MAXIMUM PREDICTED CARBON MONOXIDE CONCENTRATIONS
WITHIN 25 KM FROM THE HAT CREEK GENERATING STATION WITH
METEOROLOGICAL CONTROL AND A 366 M STACK

Averaging Time	Maximum Concentration ($\mu g/m^3$)
1-hr*	91.3
8-hr**	17.9
24-hr	14.4
Seasonal	
Winter	0.3
Spring	0.7
Summer	0.6
Fall	0.4
Annual	0.4

*Assumed guideline value of 15,300 $\mu g/m^3$ (13 ppm)
**Assumed guideline value of 5,500 $\mu g/m^3$ (5 ppm)

TABLE 5-8

MAXIMUM PREDICTED AMBIENT CONCENTRATIONS§ OF SELECTED SUBSTANCES WITHIN 25 KM FROM THE HAT CREEK GENERATING STATION WITH METEOROLOGICAL CONTROL AND A 366 M STACK

Substance	Averaging Time	Maximum Concentration ($\mu g/m^3$)
Fluoride (gaseous)*	Annual	0.006
	24-hr	0.33
Lead (particulate)**	Annual	0.00007
	24-hr	0.003
Zinc (particulate)***	Annual	0.00007
	24-hr	0.004
Cadmium (particulate)†	Annual	0.000004
	24-hr	0.0002
Mercury††	Annual	0.00015
	24-hr	0.0075
Arsenic†††	Annual	0.0005
	24-hr	0.024

§Concentrations are obtained by scaling maximum predicted SO_2 concentrations for uncontrolled emissions (see Appendix C).

*Assumed guidelines of 0.5 and 1.0 $\mu g/m^3$ for annual (arithmetic) mean and 7-day average, respectively

**Assumed guidelines of 2 and 4 $\mu g/m^3$ for annual geometric mean and maximum 24-hour average, respectively

***Assumed guidelines of 3 and 5 $\mu g/m^3$ for annual geometric mean and maximum 24-hour average, respectively

†Assumed guidelines of 0.05 and 0.1 $\mu g/m^3$ for annual geometric mean and maximum 24-hour average, respectively

††Assumed guideline of 1.0 $\mu g/m^3$ monthly average

†††Assumed guidelines of 0.2 and 1.0 $\mu g/m^3$ for annual geometric mean and maximum 24-hour average, respectively.

Figure 5-5 by scaling the SO_2 concentrations in the figure by the ratio of the appropriate emission rate to that of SO_2 (see Table 5-1). As was predicted for the FGD, ambient levels of trace elements are expected to be well below the relevant guideline values.

F. Commitment of the Air Resource

By the same assumptions discussed in Section 5.2(b)(i)F., the percentage degradation of the air quality resource associated with power plant operation with MCS and a 366 m stack was examined for the major contaminant emissions. Peak predicted 3-hour, 24-hour, and annual average SO_2 concentrations are 99%, 100%, and 28% of the applicable guidelines. Short-term concentrations at or near guideline levels are expected with this form of emissions control, since MCS is designed to eliminate only those values above the guideline thresholds. Use of this control strategy, therefore, represents commitment of a larger fraction of the air resource than that associated with FGD. Model-predicted maximum concentrations for other contaminants correspond to air quality degradation of 2% or less.

(iii) Meteorological Control with 244 m Stack

This section provides results of a modeling analysis to predict local ambient concentrations resulting from operation of the proposed power plant with an MCS and a 244 m (800 ft) stack height. The assumed operating rules for the MCS are identical to those presented for the 366 m stack/MCS configuration [see Section 5.2(b)(ii)].

A complete study of the feasibility of this control strategy is included in Appendix C. In that study, it was determined that the MCS is capable of maintaining 3-hour and 24-hour concentrations below the assumed criteria level by: (1) switching to lower-sulfur fuel for about 195 hours during the months from November through February; and (2) reducing plant generating capacity to 80% load for about 80 hours and to 60% load for about 5 hours during the remaining eight months.

A. Sulfur Dioxide

Maximum predicted SO_2 concentrations within 25 km for the 244 m stack/MCS emission scenario are presented in Table 5-9. As expected, the ambient levels are highest for this control strategy, but 3-hour, 24-hour, and annual maxima are at or below the assumed guidelines. Isopleths of annual average SO_2 concentrations with the 244 m stack height and MCS are shown in Figure 5-6.

B. Oxides of Nitrogen

Maximum local concentrations of NO and NO_2 may be estimated from the SO_2 modeling results in Table 5-9 by scaling predicted SO_2 values by the factors 0.25 and 0.38 respectively. Distributions of annual average concentrations of these species may be similarly obtained from Figure 5-6. No ambient guidelines for NO_x are currently in effect for British Columbia.

C. Particulates

Table 5-10 lists local maximum computed TSP concentrations and relevant ambient guideline values for various averaging times. The distribution of annual average values for the 244 m stack/MCS configuration may be obtained from Figure 5-6 if the plotted SO_2 values are scaled by the emission ratio factor 0.12. No concentrations approaching the 24-hour and annual guideline values are expected.

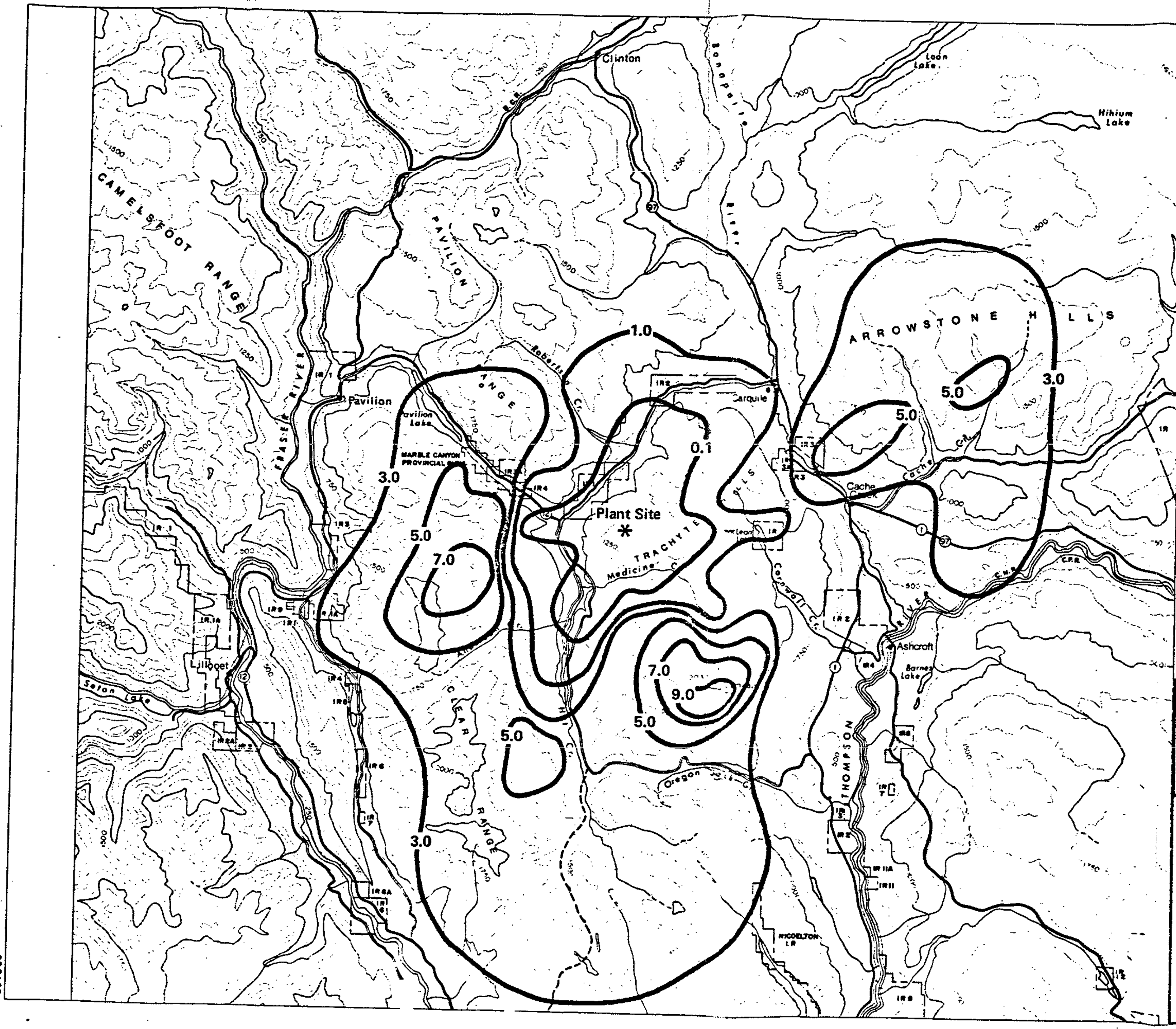
D. Total Hydrocarbons and Carbon Monoxide

Annual average concentration patterns for HC and CO may be estimated from Figure 5-6 by means of the scaling factors 0.017 and 0.055 respectively. Peak calculated CO concentrations are listed with the 1-hour and 8-hour guidelines in Table 5-11. Predicted concentration levels are insignificant by comparison with the regulatory values.

TABLE 5-9

MAXIMUM PREDICTED GROUND-LEVEL SULFUR DIOXIDE CONCENTRATIONS WITHIN 25 KM FROM THE HAT CREEK GENERATING STATION WITH METEOROLOGICAL CONTROL AND 244 M STACK

Averaging Time	Maximum Concentration ($\mu g/m^3$)
1-hr	1730
3-hr	622
24-hr	260
Seasonal	
Winter	5.8
Spring	17.2
Summer	10.9
Fall	9.2
Annual	9.3



SCALE - 1:250,000

Kilometres 5 0 5 10 15

CONTOUR INTERVAL - 250 METRES

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HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-6 Predicted Annual Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 244 m Stack with MCS

804209

TABLE 5-10

MAXIMUM PREDICTED GROUND-LEVEL TSP CONCENTRATIONS
WITHIN 25 KM FROM THE HAT CREEK GENERATING STATION
WITH METEOROLOGICAL CONTROL AND A 244 M STACK

Averaging Time	Maximum Concentration ($\mu g/m^3$)
24-hr*	32
Seasonal	
Winter	0.7
Spring	2.1
Summer	1.3
Fall	1.1
Annual**	1.1

*Assumed guideline value of 150 $\mu g/m^3$
**Assumed guideline value of 60 $\mu g/m^3$

TABLE 5-11

MAXIMUM PREDICTED GROUND-LEVEL CARBON MONOXIDE CONCENTRATIONS WITHIN 25 KM FROM THE HAT CREEK GENERATING STATION WITH METEOROLOGICAL CONTROL AND 244 M STACK

Averaging Time	Maximum Concentration ($\mu g/m^3$)
1-hr*	96.1
8-hr**	18.6
24-hr	14.4
Seasonal	
Winter	0.3
Spring	1.0
Summer	0.6
Fall	0.5
Annual	0.5

*Assumed guideline value of 14,300 $\mu g/m^3$ (13 ppm)
**Assumed guideline value of 5,500 $\mu g/m^3$ (5 ppm)

E. Trace Elements

Table 5-12 lists annual and 24-hour maximum computed concentrations for selected trace elements emitted by the power plant with the MCS and a 244 m stack. Peak values are well below assumed guideline levels. Geographical distributions of annual average concentrations may be estimated from the computed SO_2 concentrations in Figure 5-6 if the plotted values are scaled by the appropriate emission ratio factors [see Table 3-1].

F. Commitment of the Air Resource

In terms of the relationships between predicted peak concentrations and assumed ambient guidelines, SO_2 is the only significant contaminant from the standpoint of air resource commitment for power plant operation with a 244 m stack and meteorological controls. Maximum calculated values for 3-hour, 24-hour and annual averages represent 95%, 100%, and 37% of the corresponding guidelines. Of the three technologies considered in this analysis, this control strategy entails degradation of the largest fraction of the air quality resource. Fractional commitments in terms of contaminants other than SO_2, however, are expected to be negligible.

(iv) Effects of the Mine

Air quality effects of particulate emissions resulting from activities related to the Hat Creek coal mine were assessed by applications of a steady-state Gaussian diffusion model for multiple sources. A detailed description of the model is provided in Appendix B, Modeling Methodology. Suspended particulate concentrations in the vicinity of the mine site were calculated for comparison with applicable ambient guidelines. Table 5-13 lists the guideline values for particulates taken from the Pollution Control Objectives for the Mining, Mine-Milling, and Smelting Industries of British Columbia. The expected distribution of annual average concentrations as well as short-term (24-hour) averages for a number of selected weather conditions were computed.

TABLE 5-12

MAXIMUM PREDICTED GROUND-LEVEL CONCENTRATIONS§ OF SELECTED SUBSTANCES WITHIN 25 KM FROM THE HAT CREEK GENERATING STATION WITH METEOROLOGICAL CONTROL AND 244 M STACK

Substance	Averaging Time	Maximum Concentration ($\mu g/m^3$)
Fluoride (gaseous)*	Annual	0.0075
	24-hr	0.42
Lead (particulate)**	Annual	0.000085
	24-hr	0.004
Zinc (particulate)***	Annual	0.00009
	24-hr	0.005
Cadmium (particulate)†	Annual	0.000005
	24-hr	0.00025
Mercury††	Annual	0.00017
	24-hr	0.01
Arsenic†††	Annual	0.0005
	24-hr	0.03

§Concentrations are obtained by scaling maximum predicted SO_2 concentrations for uncontrolled emissions (see Appendix C).

*Assumed guidelines of 0.5 and 1.0 $\mu g/m^3$ for annual (arithmetic) mean and 7-day average, respectively

**Assumed guidelines of 2 and 4 $\mu g/m^3$ for annual (geometric) mean and maximum 24-hour average, respectively

***Assumed guidelines of 3 and 5 $\mu g/m^3$ for annual (geometric) mean and maximum 24-hour average, respectively

†Assumed guidelines of 0.05 and 0.1 $\mu g/m^3$ for annual (geometric) mean and maximum 24-hour average, respectively

††Assumed guideline of 1.0 $\mu g/m^3$ monthly average

†††Assumed guidelines of 0.2 and 1.0 $\mu g/m^3$ for annual (geometric) mean and maximum 24-hour average, respectively.

TABLE 5-13

DESIRABLE TSP CONCENTRATION GUIDELINES AND CONTROL OBJECTIVES FOR MINING IN BRITISH COLUMBIA

Averaging Time	Desirable Level (μg/m^3) Level A	Level B	Level C
Annual geometric mean (including background)*	60	70	75
(above background)**	15	20	30
Maximum 24-hour average	150	200	260

*From Reference 17 Appendix I, Table I

**From Reference 17 Appendix I, Table III

Emissions corresponding to the year of peak projected activity in the mine (2017-2018) were assumed in the model calculations. Emission factors for the various dust-producing processes in and around the mine were estimated from published factors in the literature and the projected level of activity in the test year. Section 3.2(c) describes the emission rates assumed in the model calculations. It is to be emphasized that these values represent the maximum level of activity expected during the life of the mine. Emissions during the years before 2017-2018 will gradually increase to these levels during the first years of mine operation, and gradually decrease after the test year until abandonment. Figure 5-7 indicates the geometrical representation of sources in the diffusion calculations.

Meteorological conditions at the mine site were represented in modeling analysis of annual effects by a stability wind rose (joint frequency table of wind speed, wind direction, and stability) developed from measurements at the B.C. Hydro mechanical weather station in Upper Hat Creek Valley (WS5 in Figure 4-5). Selected weather conditions taken from the stability wind rose and wind persistence statistics for WS5 to postulate typical and worst-case dispersion conditions for the simulation of 24-hour effects.

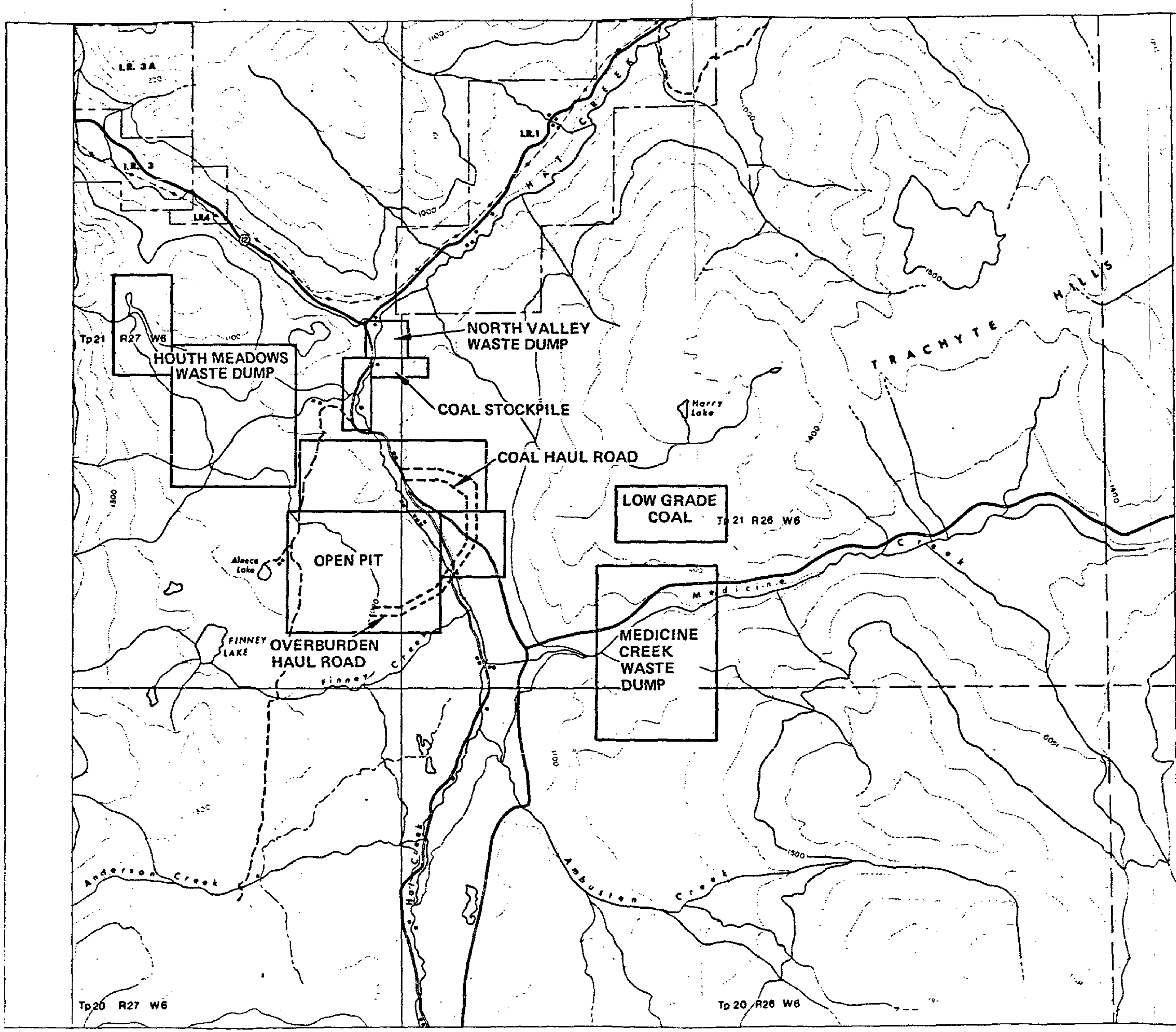
A. Total Suspended Particulates

Figure 5-8 depicts the pattern of computed (arithmetic) mean annual concentrations of TSP due to peak projected dust emissions from the Hat Creek mine. The guidelines for annual TSP concentrations are expressed in terms of geometric means. The method used to calculate long-term concentrations makes use of joint frequency statistics (stability wind rose) and cannot be used to calculate the geometric mean. However, the geometric mean can never be greater than the arithmetic mean, and it is generally smaller. Thus, the use of arithmetic means in the following discussion is conservative from the standpoint of comparison with guideline values. The dispersion model does not correct the trajectories of contaminant 'plumes' to account for topographic effects. Consequently, in the preparation of illustrations of the air quality effects of the mine, some corrections have been made to reflect the channeling of surface winds within the mountain-valley system.

Reference to Figure 5-7 indicates the relative importance of air quality contributions from specific sources. Clearly, the highest incremental concentrations are associated with emissions in the main pit area, the coal stockpile, and the coal haul road. The waste dumps in Houth Meadows and Medicine Creek contribute to smaller, isolated areas of increased TSP levels.

The high frequencies of south, south-southwest, and southwest winds seen in the wind rose for WS5 (Figure 4-4) are obviously reflected in the annual distribution. A maximum concentration of 260 $\mu g/m^3$ is predicted in a small area north of the open pit, on the east side of Hat Creek. Calculated values greater than 100 $\mu g/m^3$ are confined to the immediate vicinity of the mine pit. The 50 $\mu g/m^3$ contour extends northeastward approximately 3 km beyond the Upper-Lower junction of Hat Creek Valley, and southward to within about 1 km of Anderson Creek. Annual concentrations generally between 25 and 50 $\mu g/m^3$, with peak values of about 60 $\mu g/m^3$, are predicted for the Indian Reserve north of the mine in the Lower Valley.

The Level A, B, and C allowable increments for mining activities (15, 20, and 30 $\mu g/m^3$) are all predicted to be exceeded over an area that extends several kilometers north and south of the mine. On the basis of limited TSP measurements, average background concentrations in the Upper Valley have been estimated at 40 $\mu g/m^3$, with about 20 $\mu g/m^3$ indicated in the Lower Valley. Thus, a contour for an incremental concentration of 100 $\mu g/m^3$ should be interpreted as a total value of 140 $\mu g/m^3$ south of the main pit, and a 25 $\mu g/m^3$ contour crossing the Indian Reserve represents a total concentration of 45 $\mu g/m^3$.



SCALE - 1:50,000

0 Kilometres 1 2 3

CONTOUR INTERVAL - 100 METRES

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HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-7 Model Area and Line Sources Used in the Diffusion Modeling Study of the Hat Creek Mine

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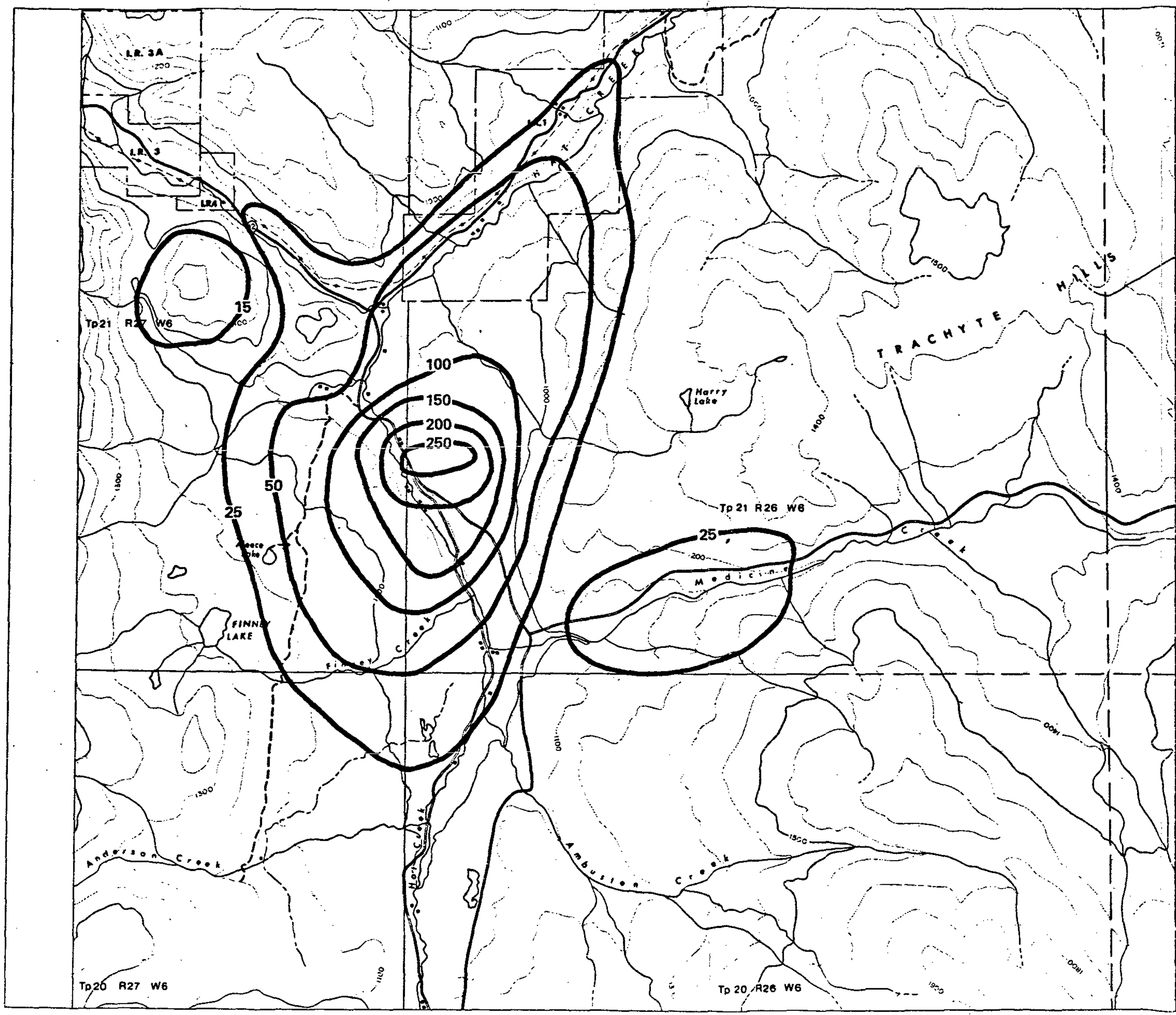

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0 Kilometres 1 2 3

CONTOUR INTERVAL - 100 METRES

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HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-8 Predicted Annual Averaged TSP Concentrations (μg/m^3) from Hat Creek Mine Emissions in Year of Peak Production

Nine separate sets of meteorological conditions were input to the model to calculate realistic worst-case and typical incremental 24-hour concentrations due to dust emissions from the mine. Table 5-14 lists the meteorological parameters assumed for each case. Distributions of computed 24-hour concentrations for each weather condition are provided in Figures 5-9 through 5-17. The following paragraphs discuss the results of these analyses.

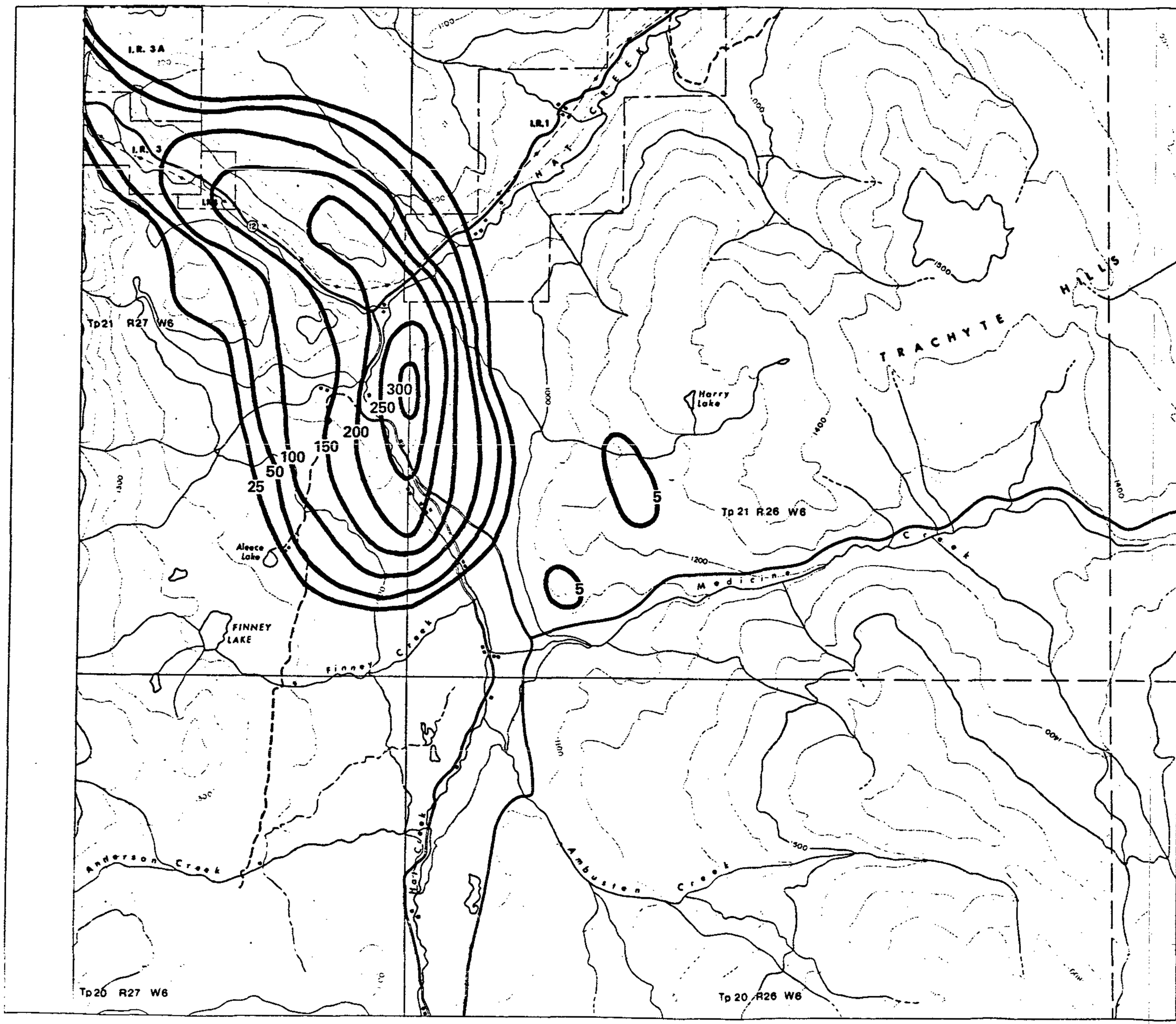
Figures 5-9, 5-10, and 5-11 illustrate the patterns of predicted 24-hour TSP values for weather Cases 1, 2, and 3. The meteorological conditions assumed for these calculations are light, directionally persistent winds with stable dispersion conditions. The model results indicate that highest local concentrations are expected for the lighest wind speeds. Thus, the Case 3 calculations for a wind speed of 0.77 mps produce the highest 24-hour TSP levels. This case probably represents a reasonable worst-case dispersion condition in Hat Creek Valley, since south-southwest flow with stable conditions occurs frequently, especially during night-time and early morning hours, when the synoptic flow is weak and circulations within the mountain-valley system are dominated by terrain effects.

The predicted concentrations for Case 3 are the highest values calculated for any of the nine meteorological situations investigated. Maximum incremental values of more than 400 $\mu g/m^3$ are expected on the eastern side of the Upper Valley below the junction. Concentrations in excess of 200 $\mu g/m^3$ are predicted for the southern section of the Indian Reserve located above the junction in the eastern branch of the Lower Valley. The 150 $\mu g/m^3$ contour extends to the northern boundary of the Reserve. Predicted effects for Case 1 and Case 2 are smaller in magnitude, with incremental concentrations above 150 $\mu g/m^3$ (the Level A Guideline) restricted to the mine site. Only the very light winds assumed in Case 3 produce off-site concentrations above 150 $\mu g/m^3$ with stable conditions. Case 2 conditions probably represent the most 'typical' meteorological situations in the Upper Valley (see wind rose for WSS in Figure 4-4).

TABLE 5-14

METEOROLOGICAL INPUT PARAMETERS FOR CALCULATION OF
INCREMENTAL 24-HOUR TSP CONCENTRATIONS DUE TO THE HAT CREEK MINE

Case #	Wind Speed (mps)	Wind Direction	Stability	Persistence (hours)	Condition
1	1.34	SSE	Stable	16	Light wind/stable
2	1.74	SE	Stable	15	
3	0.77	SSW	Stable	14	
4a	13.1	SSW	Neutral	8	High wind/neutral
4b		N			
5a	6.95	SSW	Stable	8	Moderate wind/stable
5b		N			
6a	5.0	SSW	Neutral	8	Moderate wind/neutral
6b		N			



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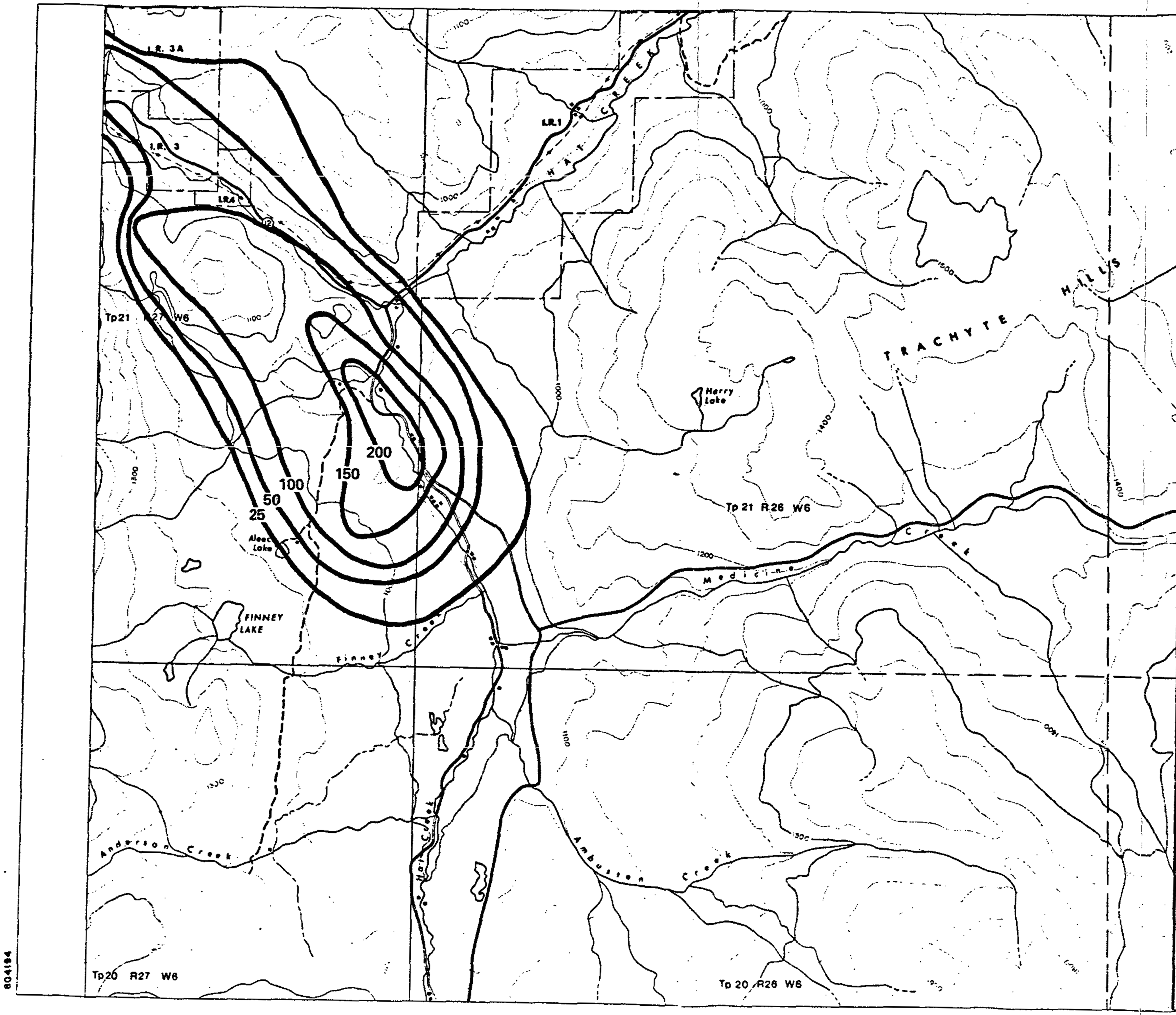
DETAILED ENVIRONMENTAL STUDIES

Figure 5-9 Distribution of Predicted 24-hr TSP Concentrations ($\mu g/m^3$) from Hat Creek Mine Emissions in Year of Peak Production: Meteorological Case 1

804192



SCALE - 1:50,000

0 Kilometres 1 2 3

CONTOUR INTERVAL - 100 METRES

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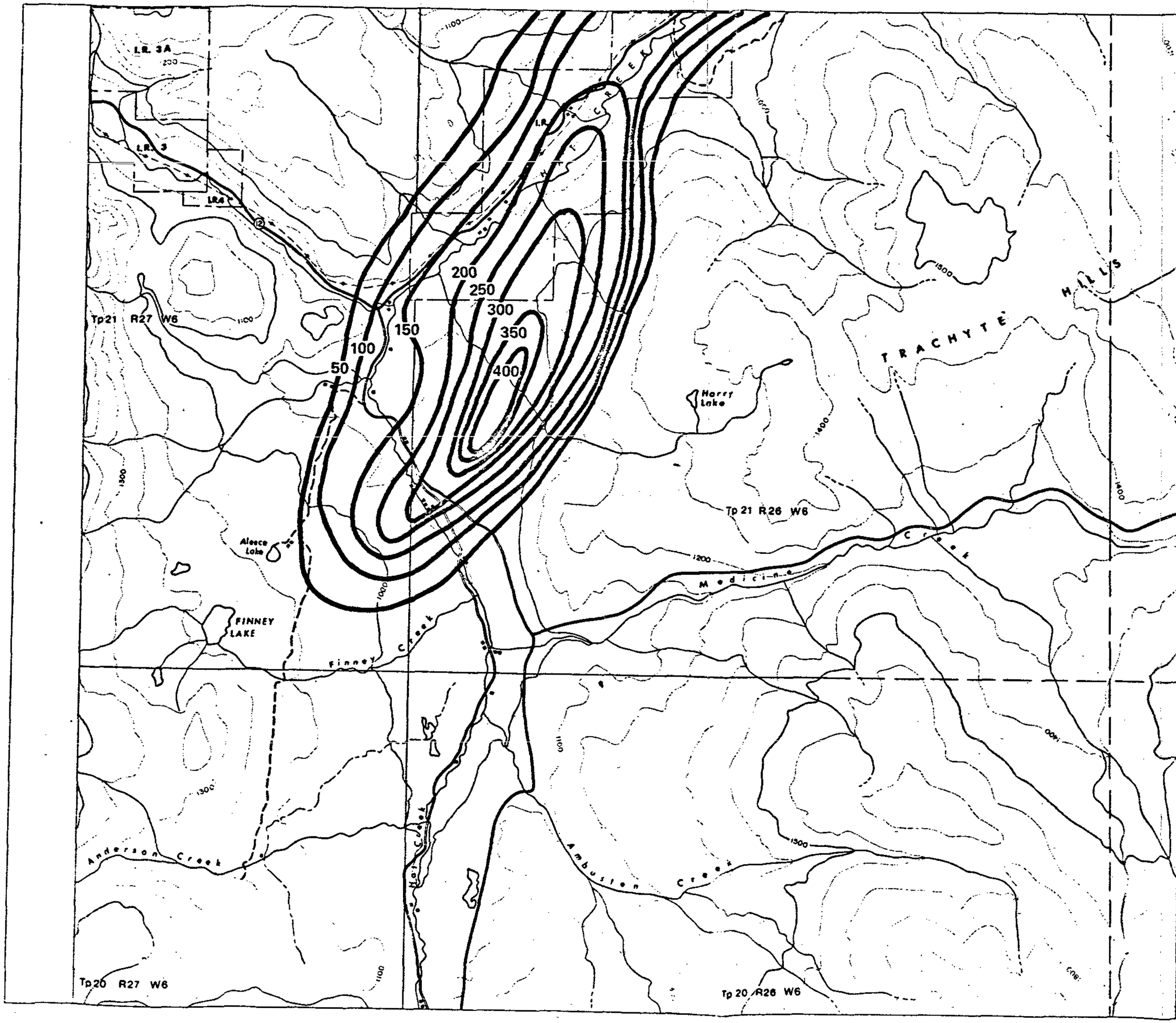
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-10 Distribution of Predicted 24-hr TSP Concentrations ($\mu g/m^3$) from Hat Creek Mine Emissions in Year of Peak Production: Meteorological Case 2



SCALE - 1:50,000

0 Kilometres 1 2 3

CONTOUR INTERVAL - 100 METRES

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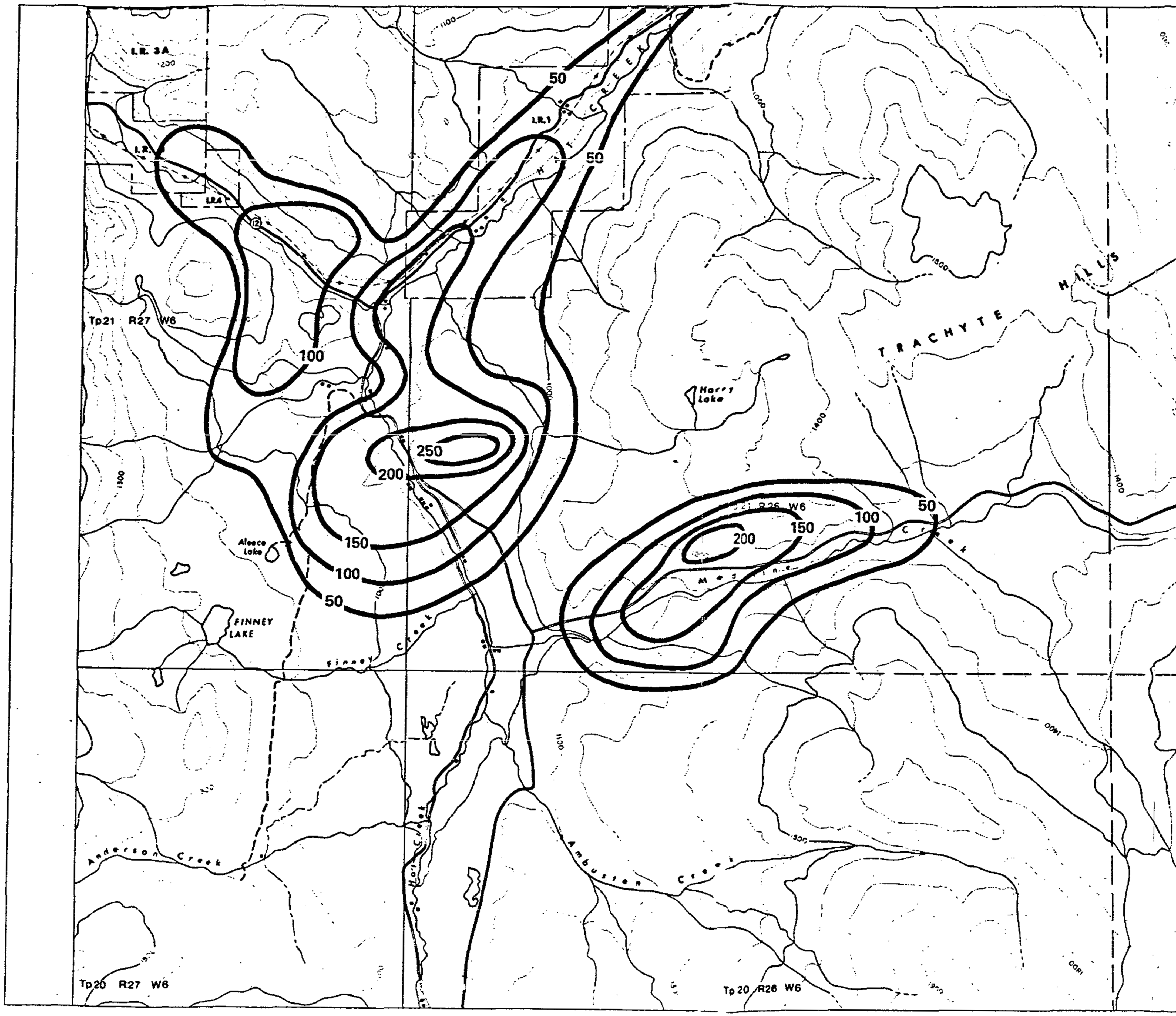
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-11 Distribution of Predicted 24-hr TSP Concentrations ($\mu g/m^3$) from Hat Creek Mine Emissions in Year of Peak Production: Meteorological Case 3

804188



SCALE - 1:50,000

0 Kilometres 1 2 3

CONTOUR INTERVAL - 100 METRES

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HAT CREEK PROJECT

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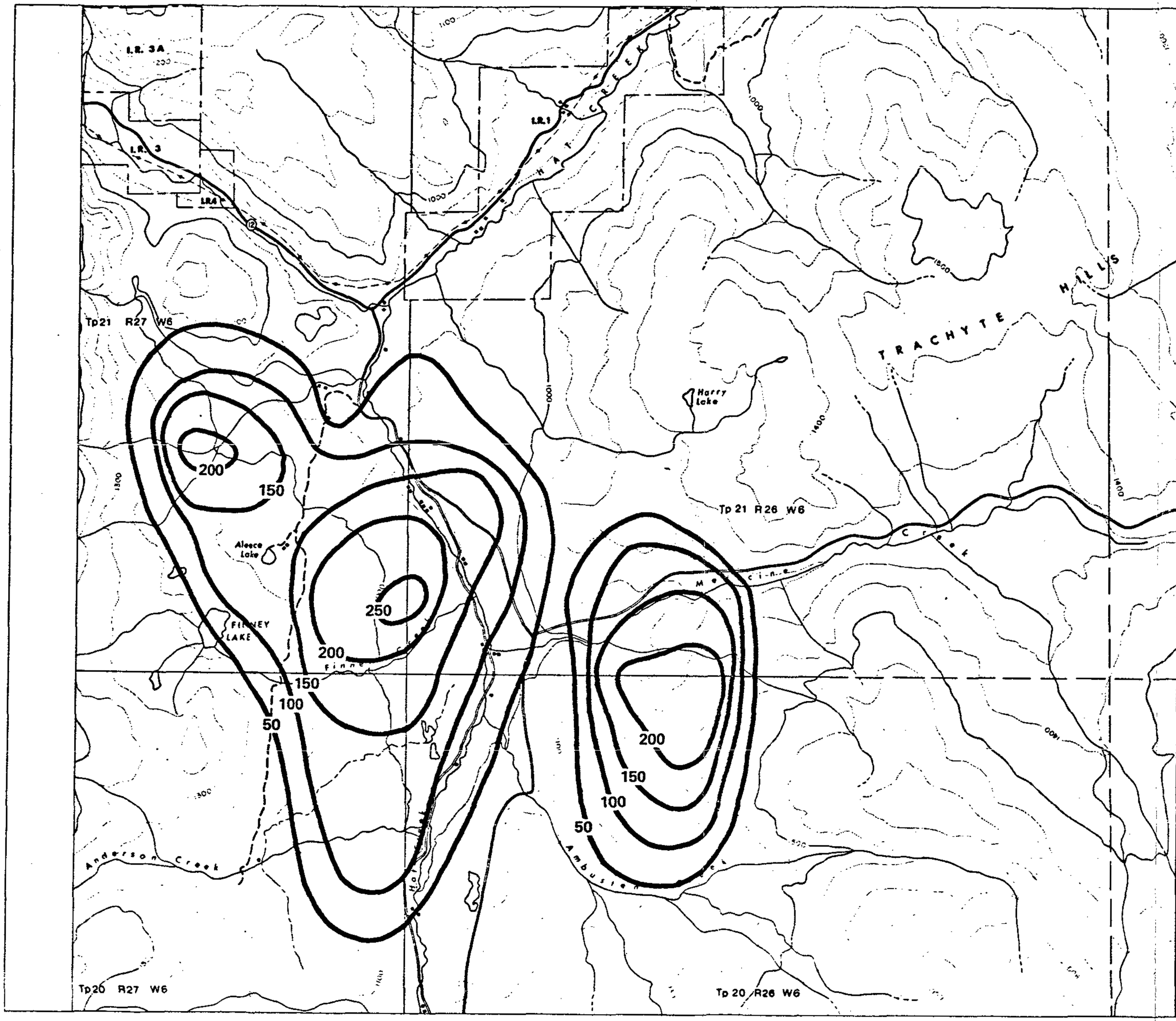
Figure 5-12 Distribution of Predicted 24-hr TSP Concentrations (µg/m^3) from Hat Creek Mine Emissions in Year of Peak Production: Meteorological Case 4a



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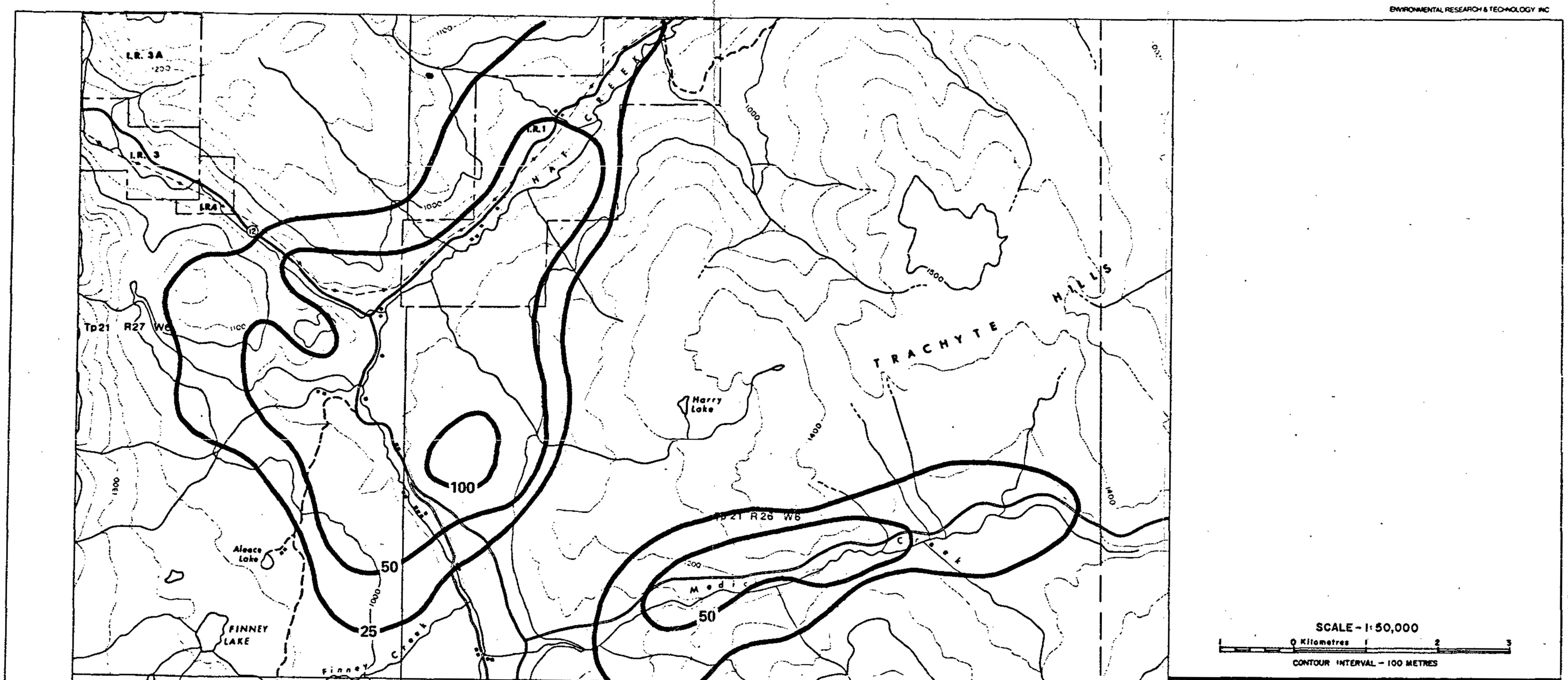
DETAILED ENVIRONMENTAL STUDIES

Figure 5-13 Distribution of Predicted 24-hr TSP Concentrations ($\mu g/m^3$) from Hat Creek Mine Emissions in Year of Peak Production: Metorological Case 4b

804195



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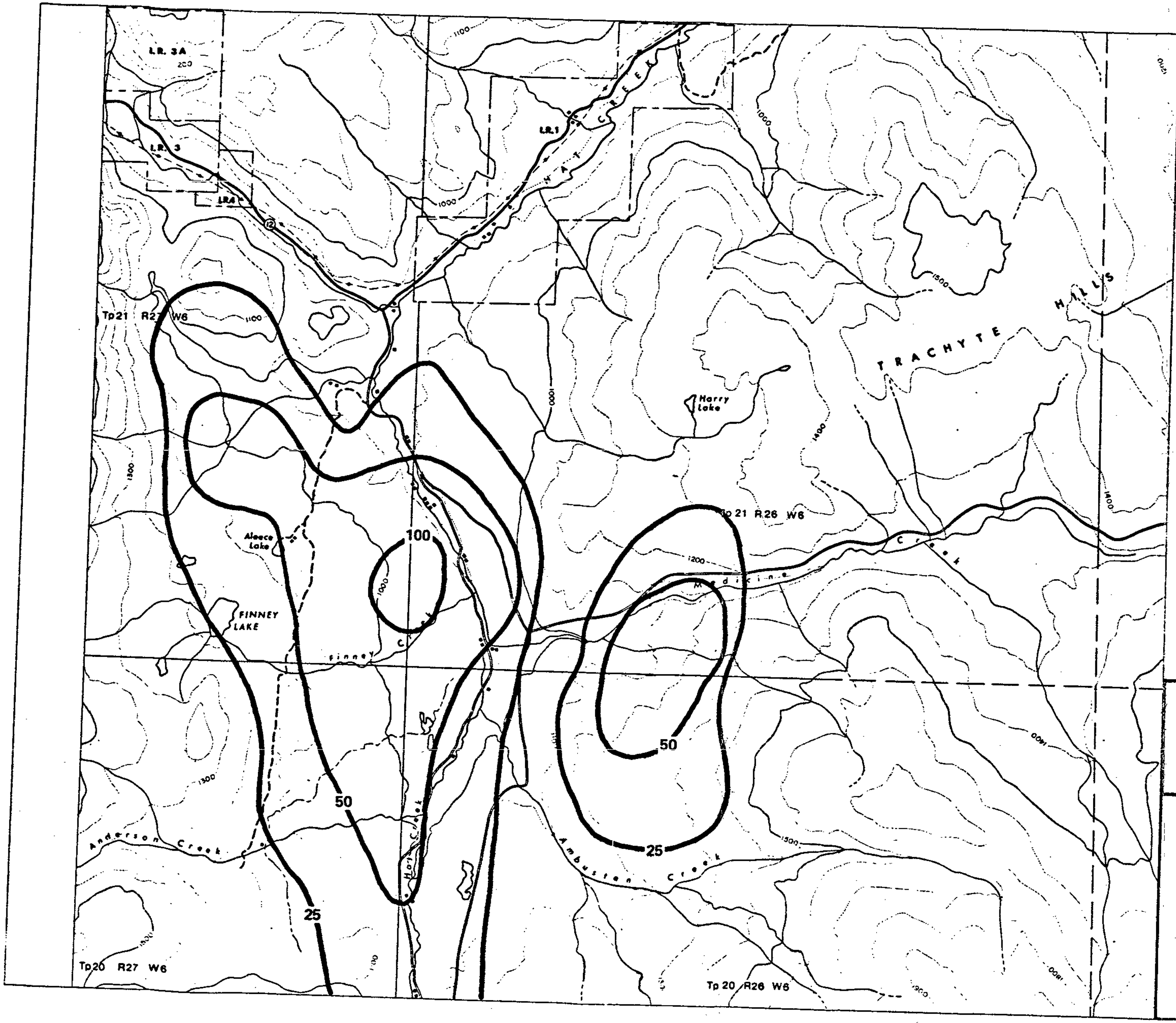
DETAILED ENVIRONMENTAL STUDIES

Figure 5-14 Distribution of Predicted 24-hr TSP Concentrations (μg/m^3) from Hat Creek Mine Emissions in Year of Peak Production: Meteorological Case 5a

804197



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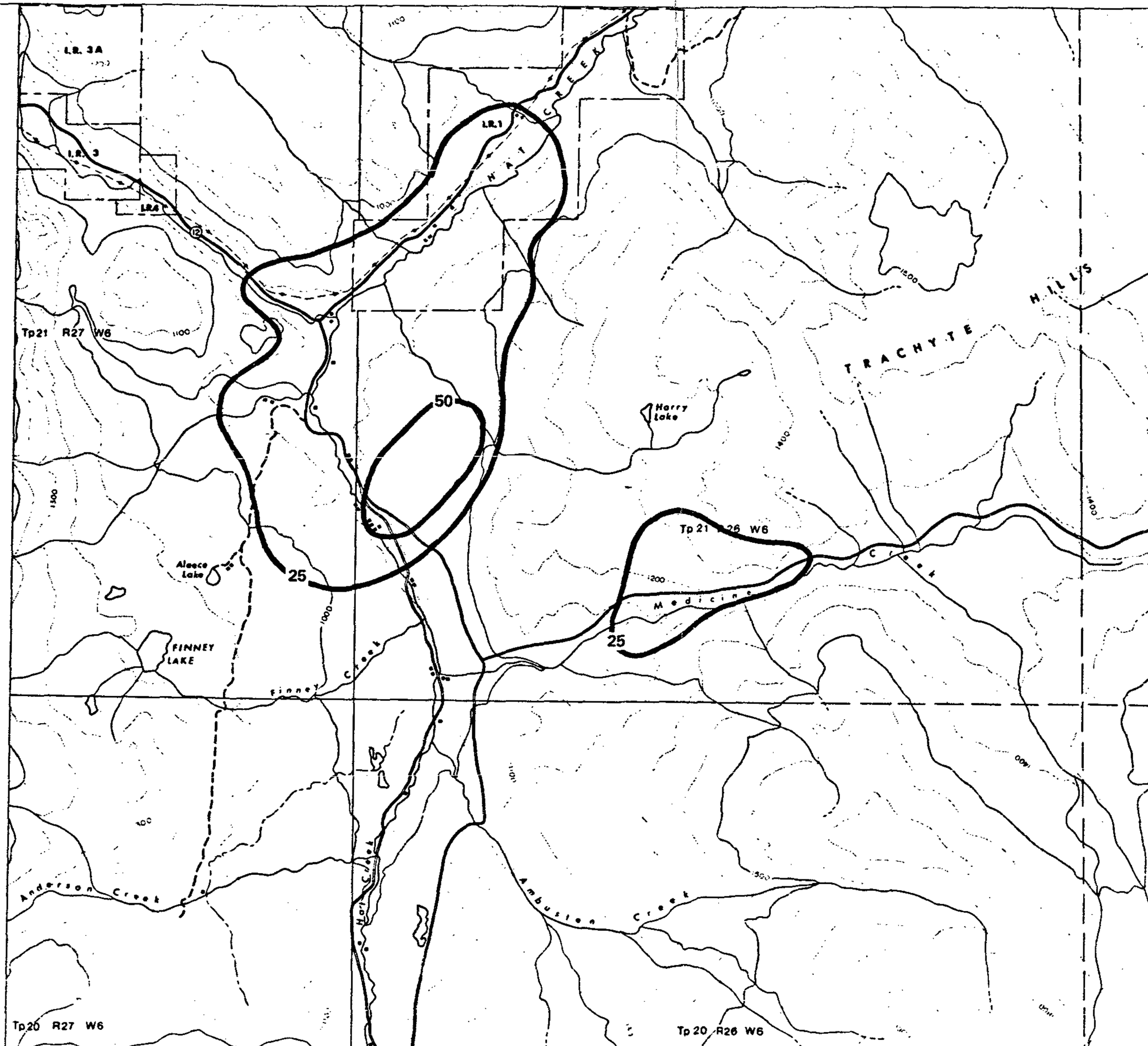
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-15 Distribution of Predicted 24-hr TSP Concentrations ($\mu g/m^3$) from Hat Creek Mine Emissions in Year of Peak Production: Metorological Case 5b



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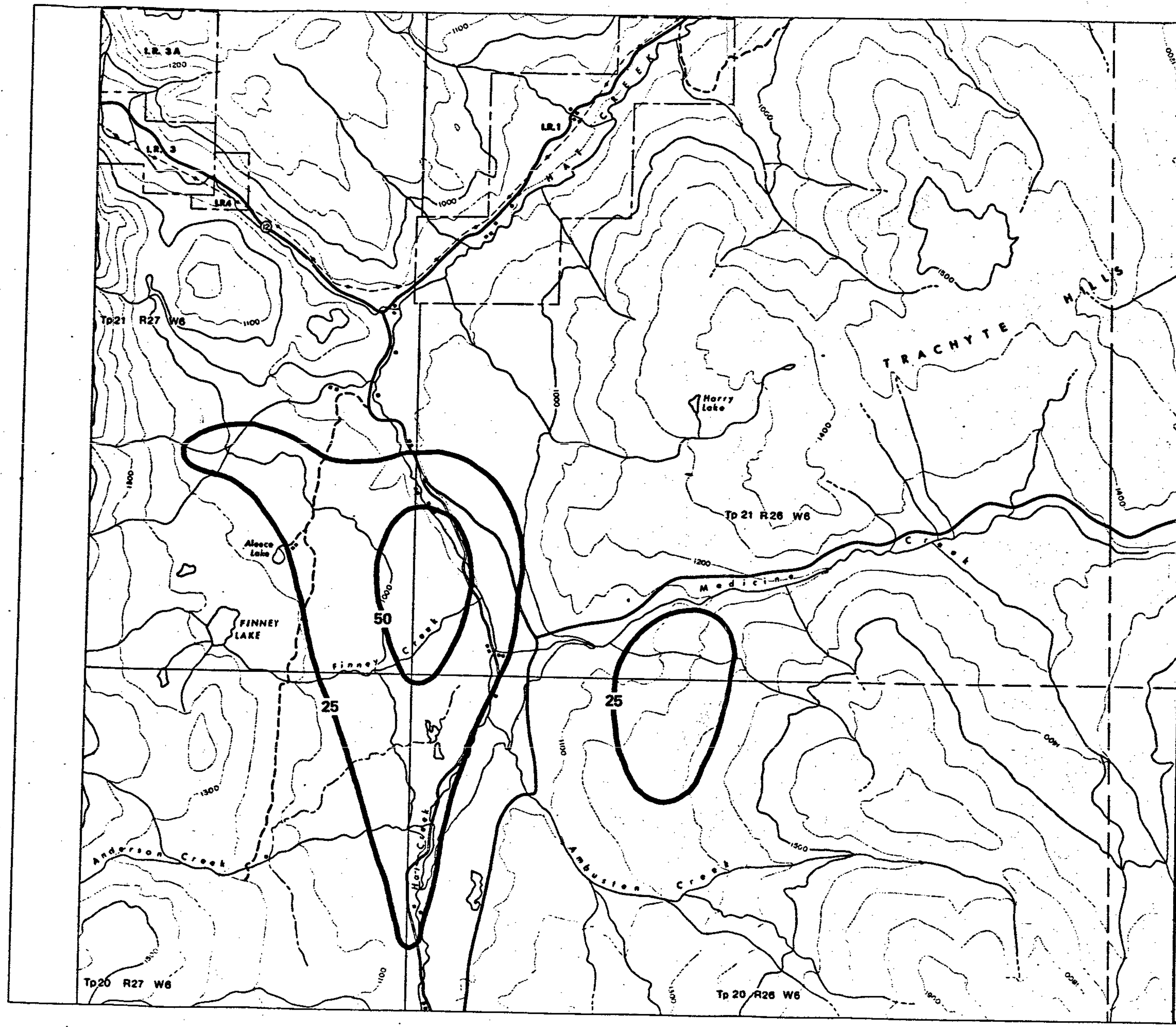
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-16 Distribution of Predicted 24-hr TSP Concentrations ($\mu g/m^3$) from Hat Creek Mine Emissions in Year of Peak Production: Meteorological Case 6a

804198



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HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-17 Distribution of Predicted 24-hr TSP Concentrations (µg/m^3) from Hat Creek Mine Emissions in Year of Peak Production: Metorological Case 6b

Figures 5-12 and 5-13 indicate the model calculation results for short-term TSP dispersion with high wind speeds (Cases 4a and 4b). The value of 13.1 mps chosen for these simulations corresponds to the highest wind speed recorded at WS5 during 1975. Both northerly and south-southwesterly wind directions were investigated to allow examination of the mine's air quality influence in the Upper and Lower Valleys.

The effects of the main pit are not significantly different from those predicted for Cases 2 and 3. The contributions of the waste dumps are greatly increased, since emissions from these sources result from erosion by the wind. In the model, such emissions are proportional to the cube of the wind speed, and during high-wind periods, erosion contributes to significant localized TSP levels near exposed surfaces. However, no off-site concentration increments greater than 50 $\mu g/m^3$ are predicted for these conditions.

Figures 5-14 and 5-15 illustrate the results of the Case 5a and 5b calculations for stable conditions and moderate wind speeds. Again, both northerly and south-southwesterly wind directions were analyzed. The wind speed value of 6.95 mps is the highest 1975 value recorded at WS5 during stable conditions. Maximum predicted incremental 24-hour TSP levels beyond the site are between 50 and 100 $\mu g/m^3$ for winds from the south-southwest. Northerly winds produce off-site maxima between 25 and 50 $\mu g/m^3$ in the Upper Valley.

Results for moderate-wind cases (6a and 6b) with neutral stability are depicted in Figures 5-16 and 5-17. These cases represent typical afternoon conditions in the Upper Valley. The results for both wind directions indicate that the dust-producing processes in the mine contribute to much lower ambient TSP levels under this meteorological condition. No incremental values greater than 100 $\mu g/m^3$ are predicted, even near the mine pit, for these cases.

According to the results described above, emissions from the mine will contribute to off-site concentrations above the Level A guideline of 150 $\mu g/m^3$ only during sustained periods of stable conditions with very light winds. During such periods, TSP values (background plus mine-related) may approach the Level B guideline (200 $\mu g/m^3$) in the Lower Valley. Annual concentrations larger than the allowable Level C increment for mining operations (30 $\mu g/m^3$) will be exceeded to the north of the mine.

B. Visibility Degradation

The effects of dust emissions from mining activities on visibility within Hat Creek Valley were estimated by means of methods proposed by Henry.[18] This author has built upon the work of Koschmieder[19] to calculate visibility reduction by atmospheric aerosols. His approach is based on the assumptions that: (1) the light-scattering efficiency of aerosols is proportional to their mass concentration; (2) the human eye-brain system is nearly linear in its response to light stimulus; and (3) all objects can be defined in terms of Fourier combinations of sinusoidal light patterns given in cycles per angular degree. This approach leads to the result that, as the integrated mass concentration of aerosols increases, the smallest discernible sinusoidal frequency of an object decreases, i.e., the visual detail of the object is obscured. The interpretation of Henry's methods to calculate visibility due to sources such as the Hat Creek project is discussed in Appendix B.

As noted in the previous section, typical background TSP concentrations on the Indian Reserve 3 km north of the mine are estimated at 20 $\mu g/m^3$. According to Henry, the eye-brain system can distinguish fine detail (e.g., the limb of a tree), moderate detail (trunk of the tree), and coarse detail (the tree itself) at distances of about 14.6 km, 36.0 km, and 54 km, respectively, with this particulate loading. The average incremental TSP concentration due to the mine at the southern border of the Indian Reserve 3 km north of the main pit was calculated to be about 60 μg/m^3 [see Section 5.2(b)(iv)A.]. Application of Henry's expression for visible range leads to the result that this increase in TSP reduces the visible ranges for fine, moderate and coarse detail to 3.6, 9.0, and 13.5 km, respectively. Thus, an observer at the southern edge of the Indian Reserve, who could distinguish fine detail of objects at 9 km without the mine emissions, could expect to see the same objects in only moderate detail during peak mining activity. A more typical incremental annual TSP value expected to occur within the Indian Reserve is 25 μg/m^3. This value added to background is expected to reduce the distances at which fine, moderate, and coarse detail are discernible to about 6.5, 16.0, and 24.0 km, respectively.

On the basis of modeling results discussed in the previous section, emissions from the mine are predicted to reduce the annual average visible range by about a factor of four near the northern boundary of the mine site, and by no more than a factor of two beyond 5 km from the mine. More severe short-term visibility reductions beyond the site limits will occasionally occur, especially with persistent, light winds and stable dispersion conditions. No such effects are expected at locations outside the Hat Creek Valley system.

C. Trace Elements

Trace elements in fugitive dust emissions were determined to be insignificant in terms of their contributions to ambient levels. A discussion of maximum predicted concentrations for selected trace elements due to coal combustion in the Hat Creek power plant is presented in Appendix F.

Concentrations of trace elements in Hat Creek coal (and similarly in the overburden) are low (see Table 5-15). Table 5-16 lists the recommended ambient levels for trace elements in suspended particulates in British Columbia. Even during worst-case episodes when TSP concentrations are expected to exceed 400 μg/m^3, ambient levels of these substances will be insignificant compared with the guideline values.

TABLE 5-15

TRACE ELEMENT LEVELS (ppm) IN VARIOUS HAT CREEK COAL SAMPLES

Element	Mine Mean Coal*	Bulk Sample Coal**
Arsenic	7.6	4.0
Boron	15	12
Cadmium	0.5	1.0
Chromium	100	46
Copper	43	MC***
Fluorine	140	170
Manganese	200	MC
Mercury	0.14	0.06
Molybdenum	1.9	4
Nickel	33	35
Selenium	0.5	15
Strontium	77	170
Zinc	25	55

*Average of 8 diamond drill cores.

**Average of only those samples of coal for which the particular element gaseous emission tests were run.

***MC = major component, >1000 ppm.

TABLE 5-16

DESIRABLE LEVELS OF AMBIENT AIR QUALITY FOR TRACE ELEMENTS IN SUSPENDED PARTICULATE MATTER ($\mu g/m^3$)*

	Level A	Level B	Level C
Lead			
Annual geometric mean	2	2	3
Maximum 24-hour	4	4	6
Zinc			
Annual geometric mean	3	3	4
Maximum 24-hour	5	5	8
Cadmium			
Annual geometric mean	0.05	0.05	0.1
Maximum 24-hour	0.1	0.1	0.3

*From Reference 17

D. Commitment of the Air Resource

Only total suspended particulates (TSP) are significant in terms of the fractional commitment of the air quality resource associated with operation of the mine. Since the predicted annual average concentration in terms of both the allowable total and the allowable increment exceeds the Level A, B, and C guideline levels, it is concluded that 100% of the air quality resource will be used. This result applies only to the areas in the Upper and Lower Hat Creek Valleys where high concentrations due to the mining operation are expected [see Section 5.2(b)(iv)A.]. The significance of mine emissions outside the valley system is expected to be negligible.

(c) Regional Air Quality

Effects of power plant emissions on air quality in the zone 25 to 100 km from the Hat Creek Project site were assessed by means of a Gaussian diffusion model adapted to include simulation of chemical transformations in the plume and depletion by dry deposition. The Hat Creek Regional Model is described in detail in Appendix B. This model was used to calculate regional ground-level ambient concentrations and average deposition rates for SO_2, $SO_4^=$ (sulfate), NO, NO_2, and TSP.

Only long-term (seasonal and annual) concentrations were computed on the regional scale. Wind data at the 700 mb level in Vernon, B.C. are considered representative of the flow governing regional transport of the Hat Creek plume. Seasonal and annual wind roses developed from these measurements are presented in Appendix A. A complete set of isopleths indicating the regional modeling results is provided in Appendix C, Addendum B. These results are summarized in the following sections. In these sections, 'maximum' concentrations are understood to be peak values between 25 and 100 km from the site, not absolute maxima.

closer than 25 km.

(i) Sulfur Dioxide and Sulfates

Figures 5-18 through 5-21 illustrate predicted annual average concentration and deposition rates of SO_2 and $SO_4^=$. Beyond 25 km, the maximum concentrations for these species are 1.7 and 0.1 $\mu g/m^3$, respectively. Peak deposition rates of less than 0.1 $\mu g/m^2/sec$ are predicted for both SO_2 and $SO_4^=$. The locations of the maxima reflect the highest terrain features and the prevailing upper-level winds over southern British Columbia.

All regional modeling was performed for an assumed stack height of 366 m (1200 ft). Since the calculated concentrations and deposition rates beyond 25 km are extremely small, the modeling was not repeated to investigate the effect of a 244 m (800 ft) stack. It is expected that concentrations and deposition rates corresponding to the lower stack would be about 50% higher than those presented in this discussion. As seen in subsequent sections, this increase would not be significant.

Annual average sulfate concentrations increase with downwind distance to a maximum at approximately 70 to 80 km from the proposed plant because of the slow chemical transformation of SO_2 and $SO_4^=$. Beyond 70 to 80 km, the ambient $SO_4^=$ concentrations begin to decrease as plume mass concentrations are depleted by diffusion, deposition, and chemical reaction processes.

The maximum 1-hour regional SO_2 concentration (388 $\mu g/m^3$) was computed to occur 40 km southwest of the Hat Creek site. The receptor elevation at the location of the peak is 2,438 m MSL or approximately 1000 m above the base of the proposed 366 m stack. This concentration was computed to occur during stable, light wind speed conditions (mean wind speed of 1.5 m/sec). The travel time required for the plume to reach this receptor is thus more than eight hours. This can occur only a few times per year. This assumption of wind persistence is inherent in all the regional modeling analyses.

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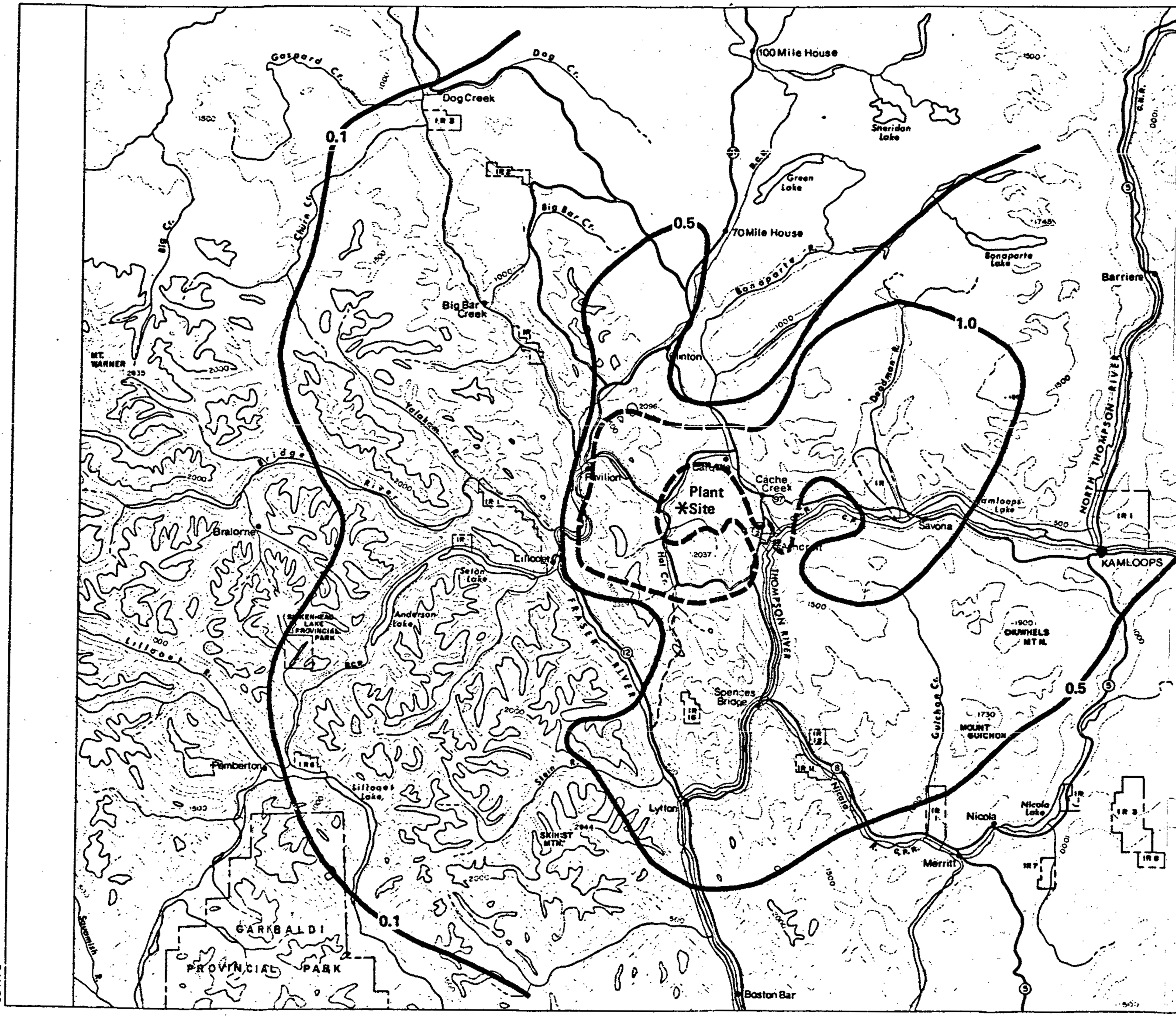
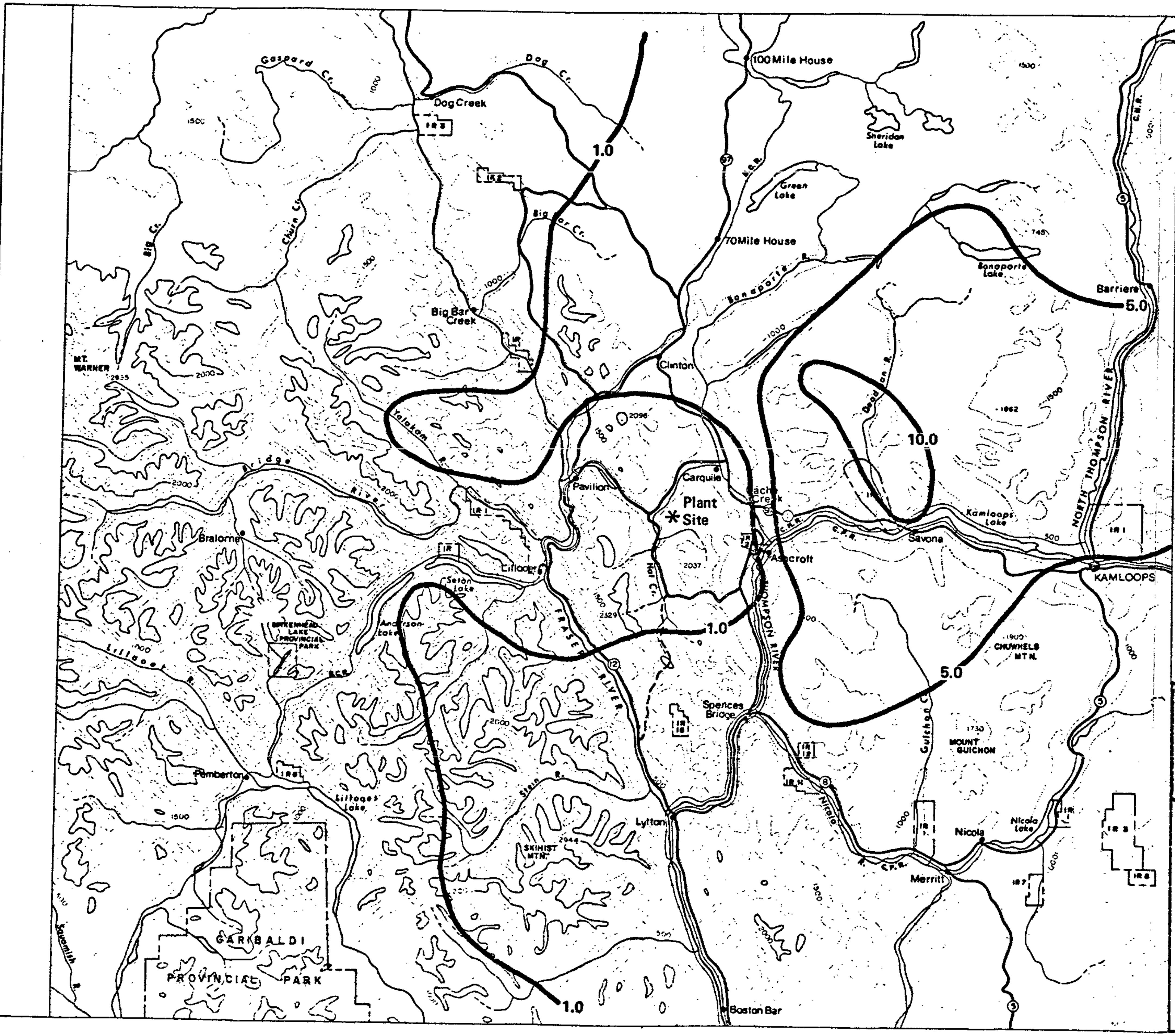


BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-18 Predicted Annual Averaged SO_2 Concentrations ($\mu g/m^3$): 366 m Stack with Uncontrolled Emissions (Regional Scale)

804170



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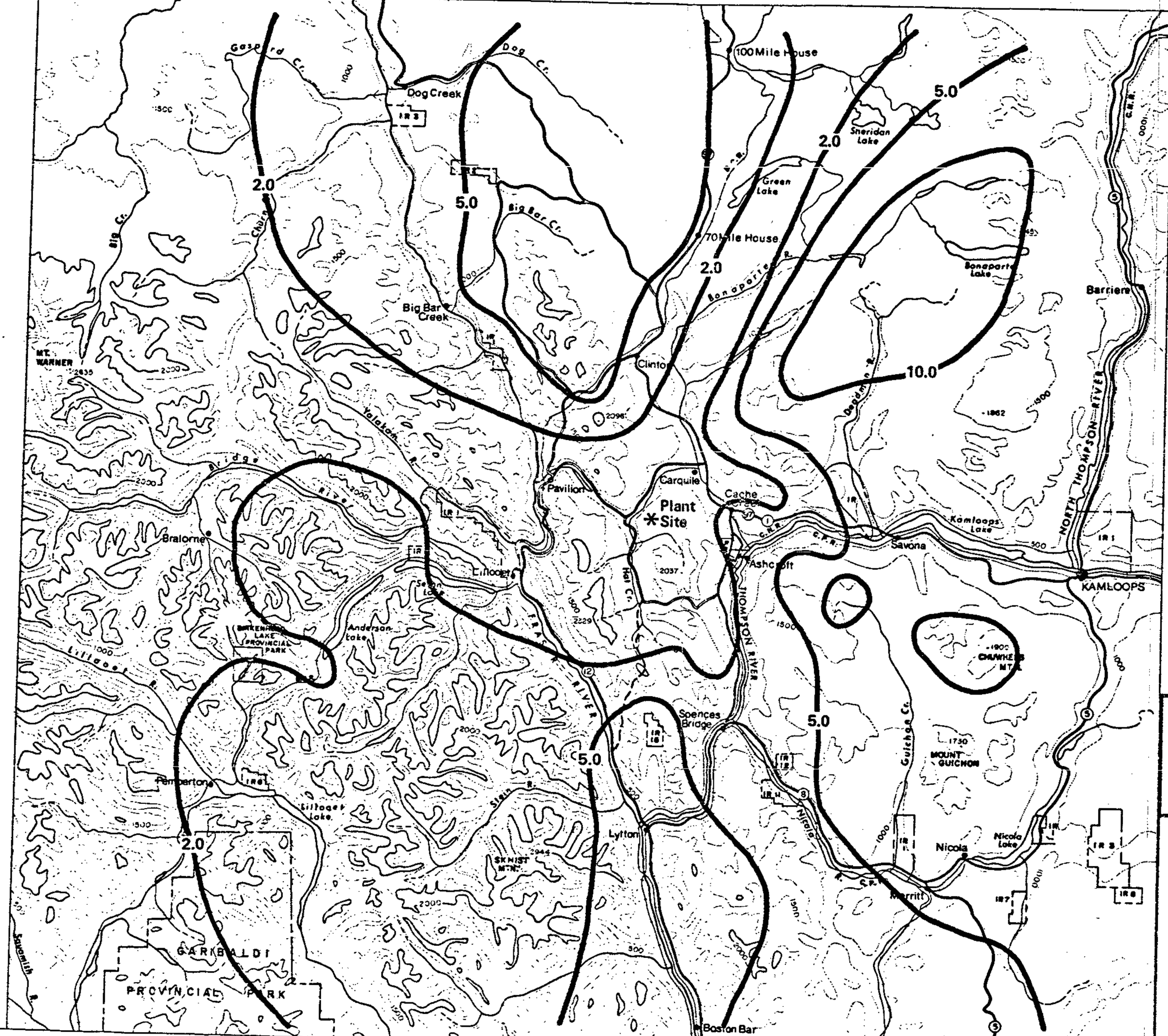
DETAILED ENVIRONMENTAL STUDIES

Figure 5-19 Predicted Annual Averaged SO_2 Deposition Rates ($10^{-3}\mu g/m^2/sec$): 366 m Stack with Uncontrolled Emissions (Regional Scale)

804171



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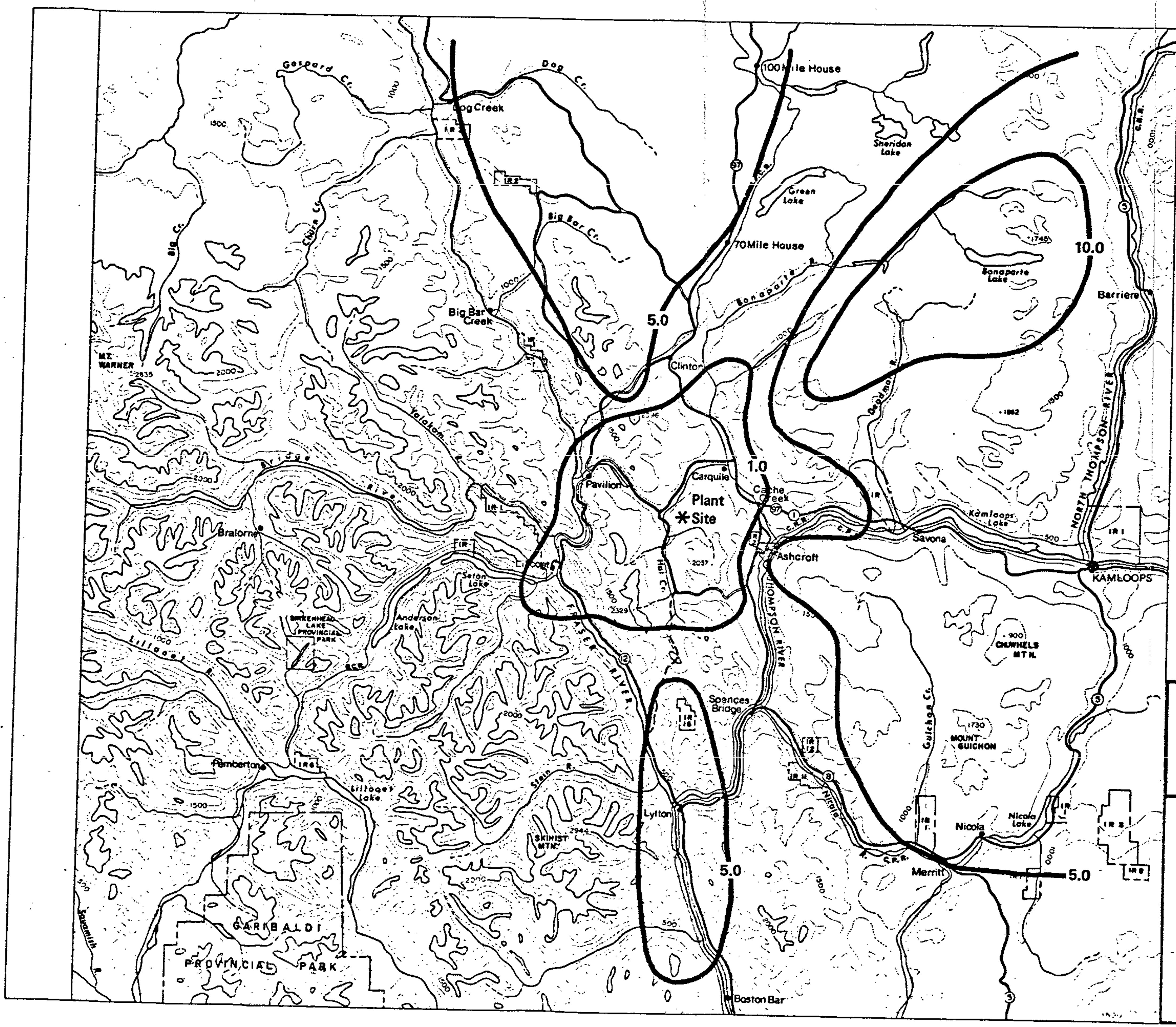
DETAILED ENVIRONMENTAL STUDIES

Figure 5-20 Predicted Annual Averaged $SO_4^{=}$ Concentrations ($10^{-2}\mu g/m^3$): 366 m Stack with Uncontrolled Emissions (Regional Scale)

604180



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-21 Predicted Annual Averaged $SO_4^{=}$ Deposition Rates ($10^{-3}\mu g/m^2/sec$): 366 m Stack with Uncontrolled Emissions (Local Scale)

(ii) Oxides of Nitrogen

The Hat Creek Regional Model was used to calculate regional NO and NO_2 concentrations that would occur because of NO_x emissions from the thermal plant (see Appendix B, Section B6.4). The model does not simulate the complicated atmospheric reactions that convert NO to NO_2. Therefore, the published results of field studies were used to adjust the emission rates in the model simulations. Because maximum NO to NO_2 ratios of about 4 are observed in power plant plumes at long downwind distances,[20] it was assumed that 80% of the NO_x emissions were in the form of NO_2. These emissions result in peak predicted annual average NO_2 and NO concentrations of 1.0 $\mu g/m^3$ and 0.1 $\mu g/m^3$, respectively. Organic and inorganic nitrate compounds will not be produced in any significant amount by the Hat Creek plume. Annual distributions of NO and NO_2 concentrations and deposition rates are presented in Figures 5-22 through 5-25.

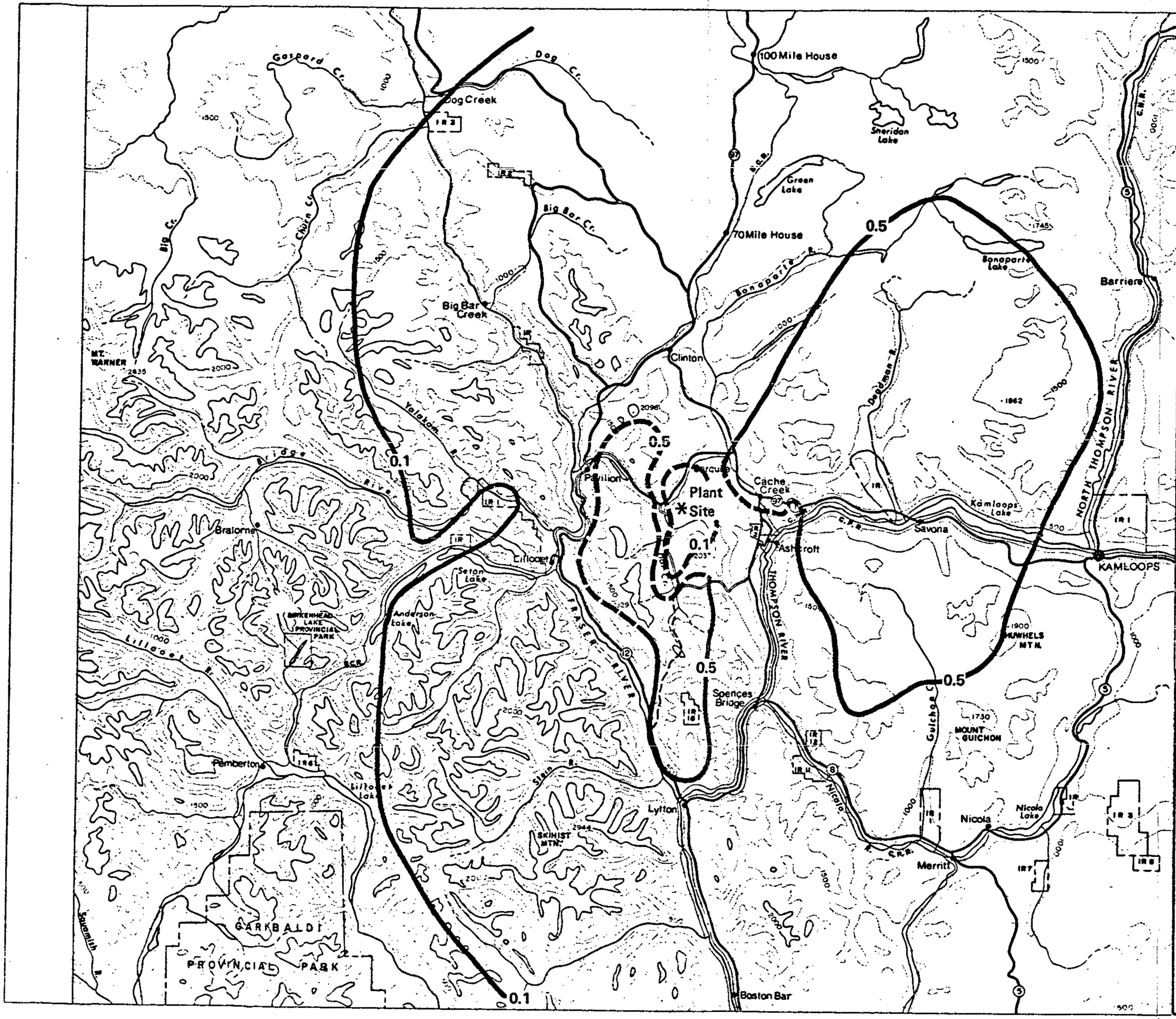
(iii) Particulates and Trace Elements

The regional effects on air quality due to the emissions of particulate fly ash and trace elements were calculated from the rates presented in Table 3-1.

Regional annual average TSP concentration and deposition rates are presented in Figures 5-26 and 5-27. The maximum concentration was calculated to be approximately 0.2 $\mu g/m^3$. Concentrations of trace elements can be calculated from the TSP isopleths by scaling predicted TSP values by the ratio of the emission rate of the trace element to the TSP emission rate.

(iv) Photochemical Oxidants

Power plant plumes have been observed to produce a net increase in photochemical oxidant concentrations only in highly polluted urban areas with significant ambient concentrations of reactive hydrocarbons.[21] These compounds are necessary precursors to the formation of photochemical



SCALE - 1:750,000

0 Kilometres 10 20 30 40 50

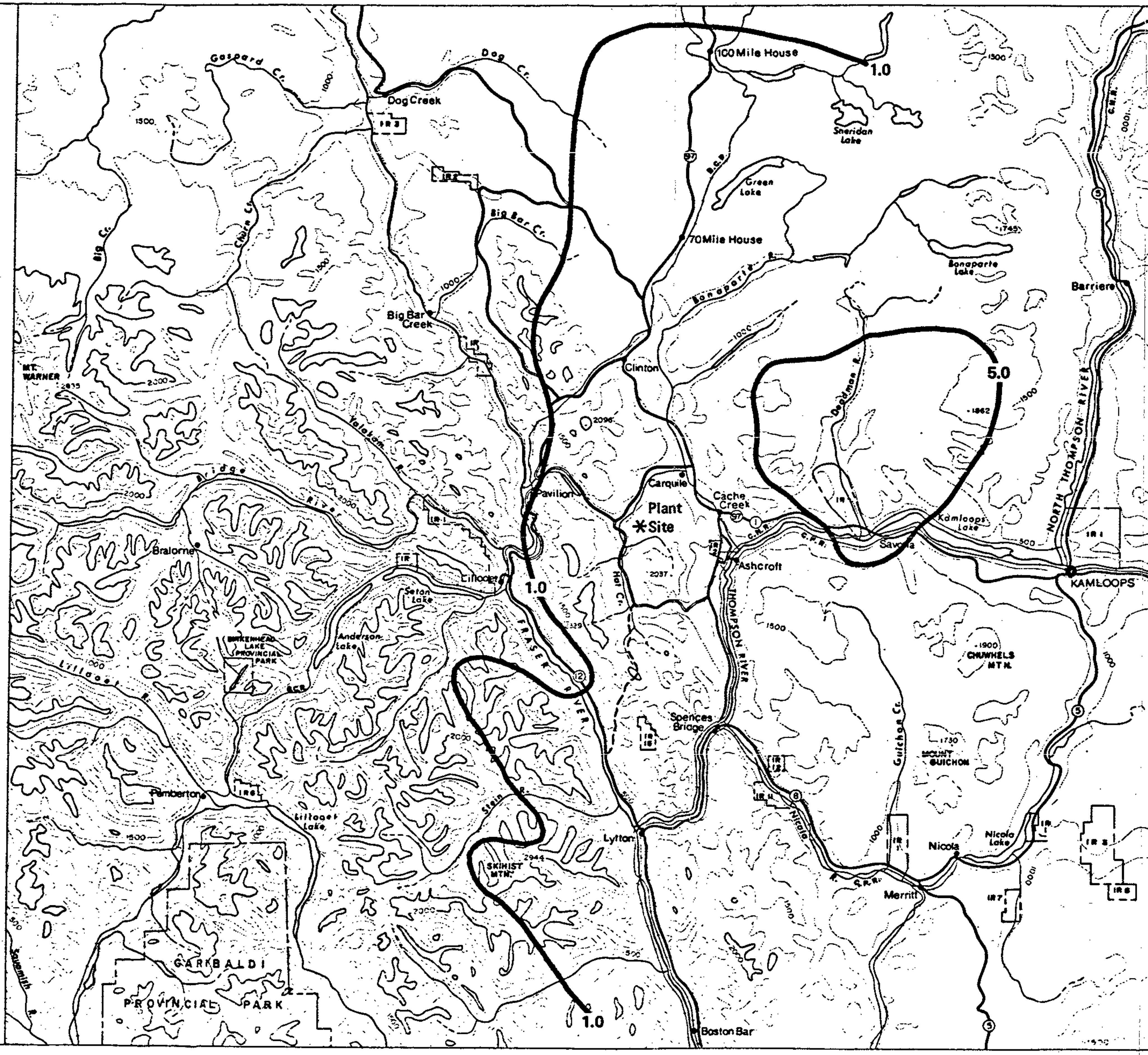
CONTOUR INTERVAL - 500 METRES

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-22 Predicted Annual Averaged NO_2 Concentrations ($\mu g/m^3$): 366 m Stack with Uncontrolled Emissions (Regional Scale)

804182

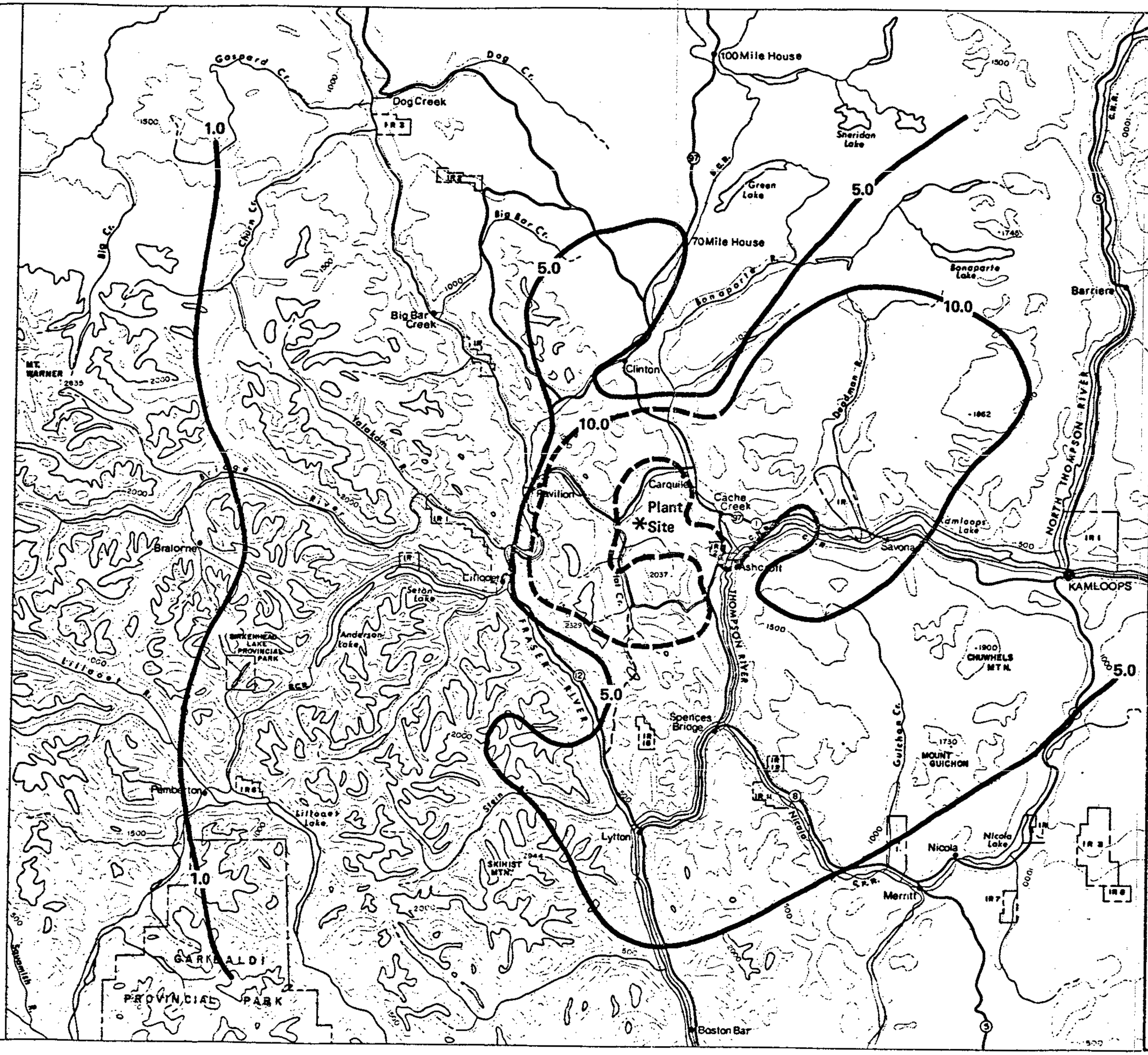


**BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT**

DETAILED ENVIRONMENTAL STUDIES

Figure 5-23 Predicted Annual Averaged NO_2 Deposition Rates ($10^{-4}\mu g/m^2/sec$): 366m Stack with Uncontrolled Emissions (Regional Scale)

804183

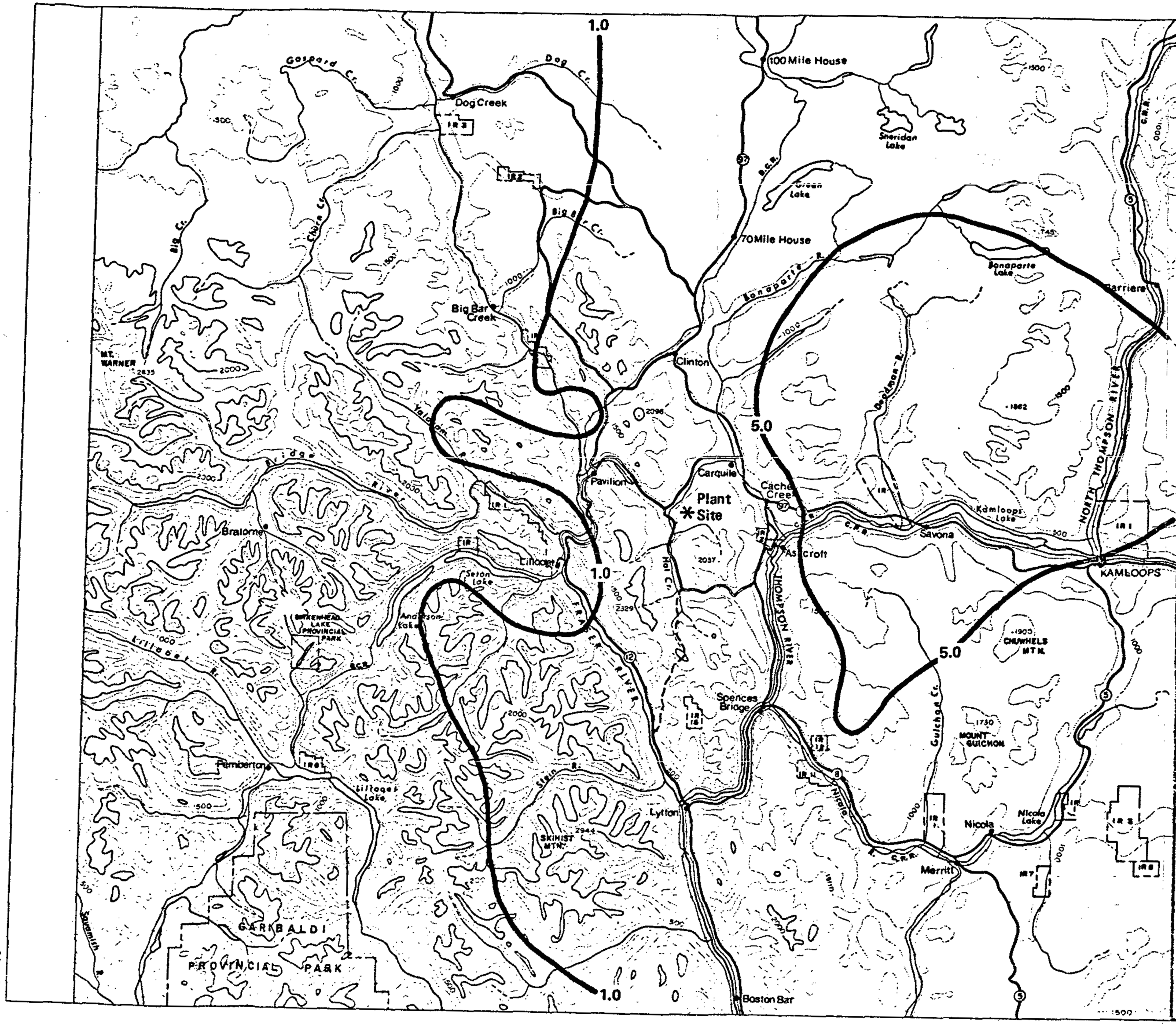


BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-24 Predicted Annual Averaged NO Concentrations ($\mu g/m^3$): 366 m Stack with Uncontrolled Emissions (Regional Scale)

804184

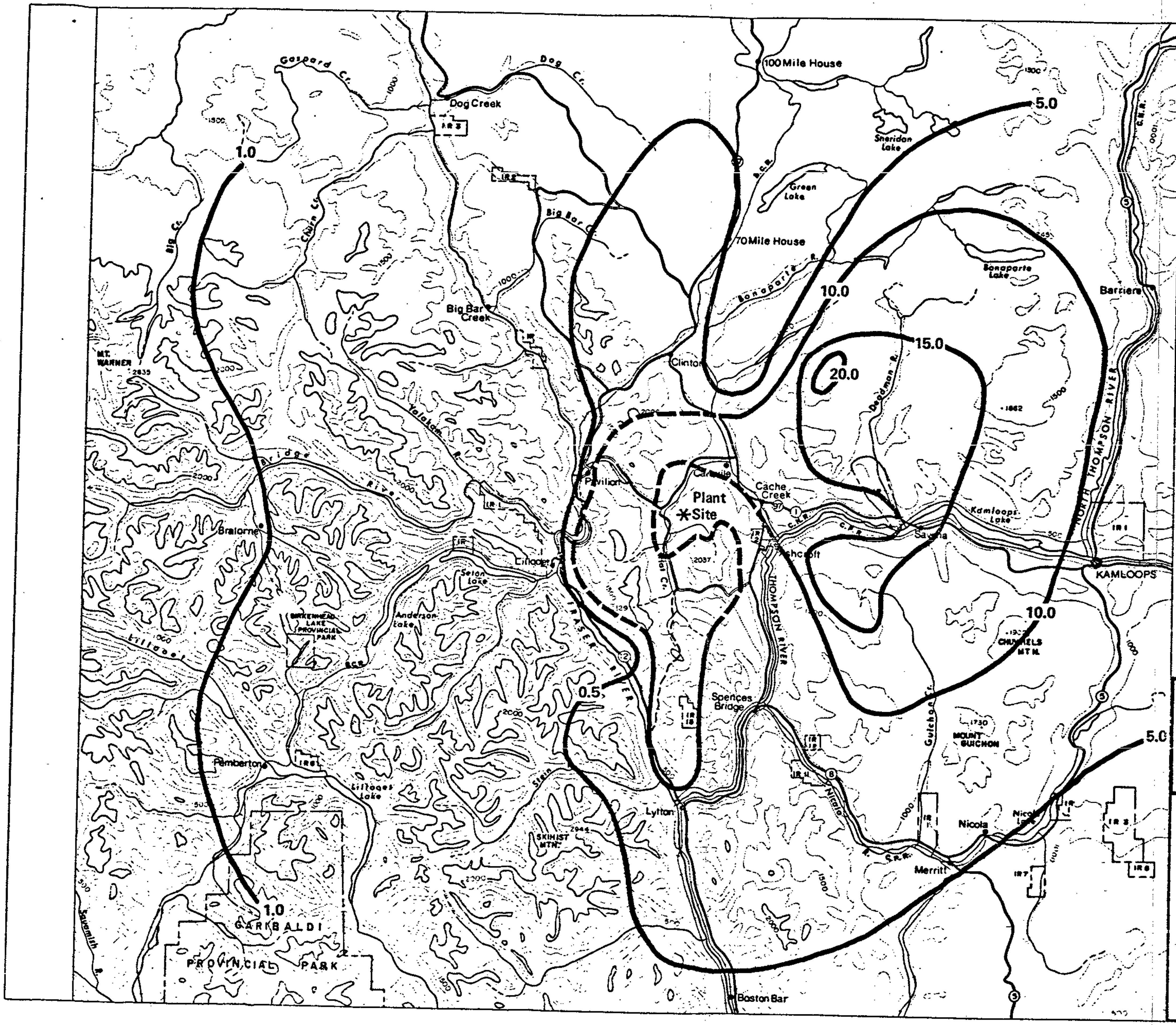


BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-25 Predicted Annual Averaged NO Deposition Rates ($10^{-5}\mu g/m^2/sec$): 366 m Stack with Uncontrolled Emissions (Regional Scale)

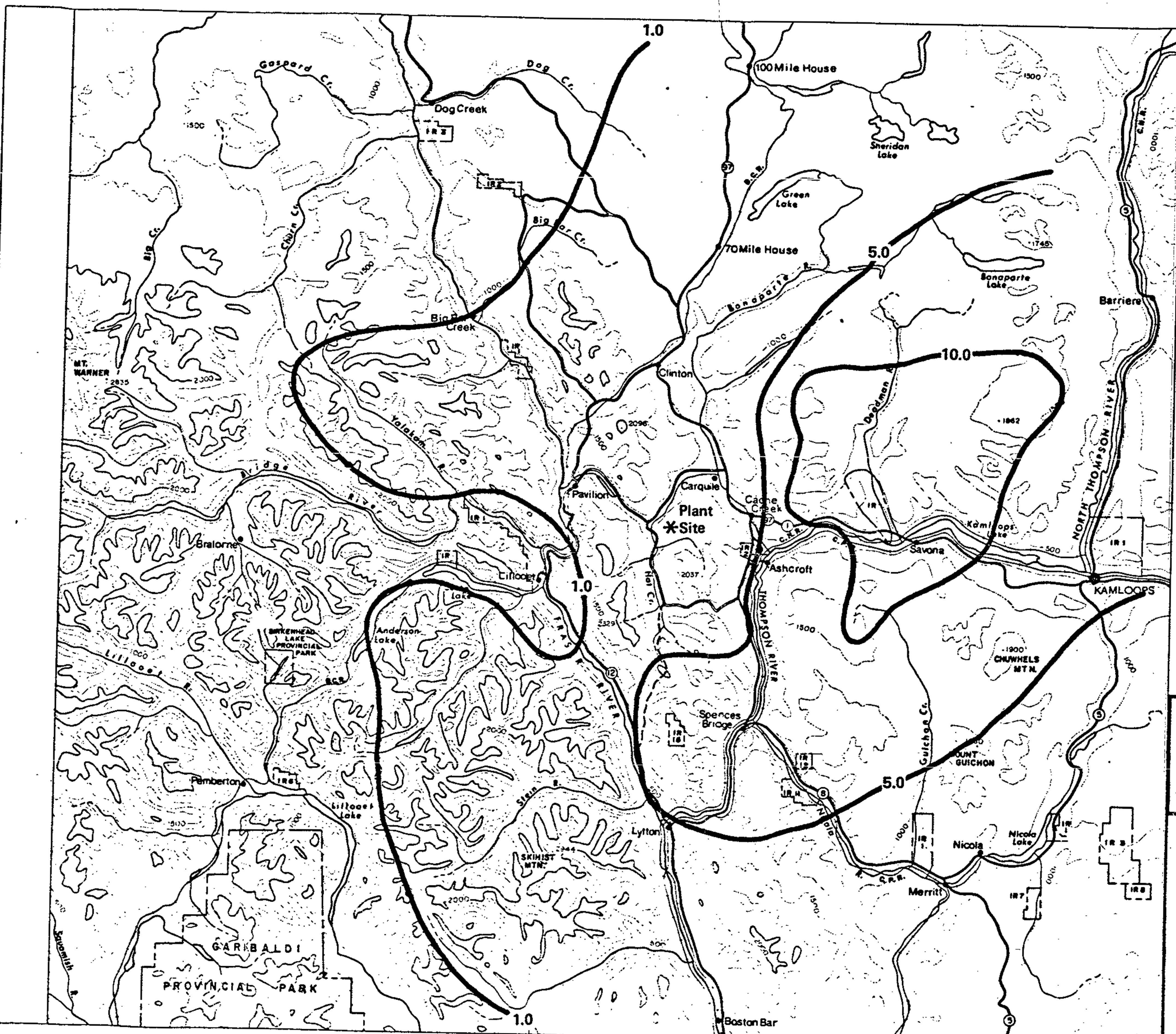
804186



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-26 Predicted Annual Averaged TSP Concentrations ($10^{-2}\mu g/m^3$): 366 m Stack with Uncontrolled Emissions (Regional Scale)



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure 5-27 Predicted Annual Averaged TSP Deposition Rates ($10^{-3}\mu g/m^2/sec$): 366 m Stack with Uncontrolled Emissions (Regional Scale) oxidants (see Appendix B, Section B6.3). Because background reactive hydrocarbon levels are expected to be very low in the Hat Creek region, the thermal plant will not produce oxidants. In fact, any oxidants in the atmosphere will be depleted by the Hat Creek plume for several tens of kilometers downwind.

(v) Acid Precipitation

Current interest in the topic of acid precipitation stems primarily from numerous published reports of steadily increased acidity in rain and snow samples collected in Scandinavia and eastern North America. Widespread precipitation pH reductions are associated primarily with long-range transport of contaminants (SO_x and NO_x) to these areas from large, highly industrialized regions. Obviously, the effects of a single stack source will produce considerably smaller effects. Only the precipitation actually passing through the Hat Creek power plant plume will experience any change in acidity, and the area affected will be small in comparison with the overall area subjected to rainfall or snowfall. In addition, most acid rain deposited at a given location occurs during limited periods or 'episodes', even in areas that are frequently downwind of major area sources.[22] It is reasonable to assume that precipitation acidification due to the Hat Creek power plant plume will occur even more intermittently.

Appendix B, Modeling Methodology, includes a discussion of published accounts on acid precipitation and the chemical and physical processes responsible for the phenomenon. On the basis of experience near other coal-fired power plants, it is concluded that pH values between 4.0 and 5.0 will occur beneath the plume within about 20 km of the plant site during typical summer showers.[23] Calculations based on: (1) conservative assumptions, i.e., complete absorption of sulfur oxides and complete dissociation of sulfuric acid within the precipitation; (2) model-predicted increases in the ambient levels of SO_x; and (3) results of chemical analyses of snow samples taken in eastern British Columbia lead to the conclusion that a minimum precipitation pH value of about 4.2 will occur in a highly limited area beneath the plume during short-term episodes between 25 and 100 km from the power plant. The long-term average precipitation pH in this region was similarly computed to be about 4.6. These results incorporate the assumption, based on experimental evidence, that present pH levels in the interior of the Province are between 5.0 and 5.5 (see Appendix A, Section A3.3).

(vi) Cumulative Effects of the Project and Other Sources

The Hat Creek Project is located in an area well isolated from major industrial sources of sulfur oxides, nitrogen oxides, and particulate matter. However, since there are industrial sources located within 100 km of the project, the potential interaction of the emissions to be produced by Hat Creek and other industrial emissions was considered. The results of the regional modeling analysis discussed in previous subsections demonstrated that Hat Creek stack emissions will produce extremely low ambient concentrations at large downwind distances. The meteorological conditions conducive to the long-range transport of the Hat Creek plume are such that the plume will be transported in elevated stable layers in the atmosphere. Under these conditions, any Hat Creek impact will therefore be confined to elevated terrain locations. Because other existing and proposed industrial sources* are located in river valleys, or at least at elevations well below the Harry Lake site, it is expected that the incremental effect of the Hat Creek plume will not produce any significant cumulative concentrations of air contaminants within the impact ranges of these sources. Local industrial sources will be the dominant contributors to ambient levels in their own environs. A discussion of emissions from other existing, scheduled and proposed facilities in the project region is included in Appendix A.

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*Based on inventory of projected developments prepared by the socio-economic consultant.

5.3 EFFECTS OF PROJECT DECOMMISSIONING

After an operational lifetime of approximately 35 years, the project will be decommissioned and the plant and mine site will be restored to natural conditions. No detailed plans concerning decommissioning or reclamation have been formulated. However, it is to be expected that significant quantities of fugitive dust emissions will be generated during demolition and disposal of the power plant facilities and reclamation of the mine. This dust will produce elevated localized TSP concentrations, although it is presumed that appropriate dust control measures will be implemented. Vehicular emissions will also produce local gaseous contaminant concentrations. The mine site and waste disposal areas will be revegetated. This will not only act to restore the site but will permanently eliminate dust problems that would occur because of wind erosion of open ground.

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