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 - Appendix C - Alternate Methods of Ambient Sulfur Dioxide Control - April 1978.

ENVIRONMENTAL IMPACT STATEMENT REFERENCE NUMBER: 14d

Document P-5074-F-C
April 1978

Prepared for
British Columbia Hydro and Power Authority

Air quality and climatic effects of the proposed Hat Creek project

Appendix C
Alternate methods of ambient sulfur dioxide control

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ERT

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C1.0 INTRODUCTION

This report documents an investigation conducted by Environmental Research & Technology, Inc. (ERT) to evaluate alternative emission control strategies for the maintenance of ambient sulfur dioxide (SO_2) concentration levels in the vicinity of British Columbia Hydro and Power Authority's proposed Hat Creek Project. The study is intended to fulfill the requirements specified in Appendix D5 of the Terms of Reference for Detailed Environmental Studies for the proposed Hat Creek Project.

C1.1 OVERVIEW OF STUDY OBJECTIVES

While a number of detailed operational control programs have been examined, a general distinction may be drawn between the two basic forms of emission control considered. These are: (1) constant emission curtailment - in particular, stack gas cleaning; and (2) intermittent controls, i.e., measures taken to reduce emissions in response to weather conditions unfavorable for dispersion of airborne contaminants. Throughout this report, systems of the first category are referenced as Flue Gas Desulfurization (FGD) strategies; programs of the second type are termed Meteorological Control Systems (MCS).

Each of several FGD and MCS options for the Hat Creek Project has been analyzed from the standpoint of feasibility in terms of:

- reliability as an effective means for maintaining ambient SO_2 concentrations at acceptable levels;
- operational aspects and constraints;
- economic implications;
- energy consumption requirements; and
- environmental costs and benefits.

Insofar as possible, the information developed in this study is presented in a form to facilitate comparisons between alternative strategies in the context of environmental cost/benefit analysis. It is to be emphasized that the results reported here represent a feasibility study. Thus, no attempt has been made to design the various components of an MCS (aerometric monitoring network, data handling procedures, air quality forecast model development, etc). Nor do the results associated with the FGD system reflect detailed equipment specifications. Rather, currently available data regarding probable operating characteristics of the proposed project; historical meteorological data; and ERT's previous experience in the evaluation, design, and operation of emission control programs have been employed to ascertain the relative merits and costs associated with several potential control strategies.

Diffusion modeling was used to simulate the effects of three selected control measures on ambient SO_2 concentrations for a one-year period. Detailed results of the model calculations are presented in the figures of Addendum B.

C1.2 SUMMARY OF EMISSION CONTROL PROGRAMS INVESTIGATED

The specific emission control programs considered in this program include one FGD system involving partial stack gas scrubbing (54% reduction of SO_2 emissions) and an MCS, which operates with both fuel switching and load reduction.

The MCS program envisioned as a control strategy for the proposed Hat Creek Project involves fuel switching during the winter months (November through February) and load reduction during the remainder of the year. When fuel switching would be the primary control strategy, blended (primary) fuel would be used when weather conditions favor atmospheric dispersion. A lower-sulfur (secondary) fuel would be burned when restricted dispersion conditions are expected.

For this analysis, sulfur contents of 0.45% and 0.21% have been assumed for the primary and secondary fuels, respectively. The sensitivity of MCS feasibility to the height of the power plant stack has been addressed; parallel analyses were performed for assumed stack heights of both 244 m (800 ft) and 366 m (1200 ft). In evaluating MCS options, only those systems requiring use of secondary fuel less than 5% of the time annually are considered to be realistic for available fuel supplies and preferred operating procedures.

Evaluation of the effectiveness of programs designed to protect ambient air quality requires that maximum allowable ground-level concentrations over specified averaging times be established. In this analysis it has been assumed that three hours is the shortest averaging time for which ambient SO_2 concentrations must be controlled. In accordance with arguments presented by B.C. Hydro in a brief submitted for consideration in the January 1978 Public Enquiry to Review Pollution Control Objectives for the Mining, Mine-Milling and Smelting Industries of British Columbia,[1] a 3-hour guideline of 655 $\mu g/m^3$ has been assumed. Also proposed in that document is a 24-hour ambient guideline of 260 $\mu g/m^3$. These suggested guidelines form the basis for evaluating alternate SO_2 control measures in this study.

For MCS operation with load curtailment to reduce emissions, a control action can usually be accomplished within a few minutes. However, a fuel-switching control program normally requires that adverse meteorological conditions be forecast some hours in advance to ensure that the secondary fuel will reach the boilers in time to reduce ambient concentrations. The lead time necessary for operation in this mode introduces uncertainty beyond that associated with atmospheric modeling techniques. One available means to compensate for this uncertainty is to set the effective or 'control guidelines' somewhat lower than actual allowable concentrations. A fuel switching program designed to maintain ambient levels imposed by these more stringent requirements is provided with a margin of safety against excursions of the actual 3-hour and 24-hour design criteria. In the present study, the implications (in terms of additional emission control requirements) associated with establishment of control guidelines at 80% and 90% of the maximum allowable concentrations are examined for each MCS option during the winter months when fuel switching is the preferred control action.

All results presented in this report reflect the assumption of continuous base-load operation for a nominal 2000 Mw generating plant whenever ambient concentrations are below acceptable thresholds. It is recognized that the operating schedule for the proposed Hat Creek Project may include scheduled periods with one or more generating units performing at reduced load or even shut down. Ambient concentrations during such periods would generally be less (given equivalent meteorological conditions) than those expected for full load generation. Thus, in this respect, the predicted number of control actions for each MCS program is considered to be conservative.

C1.3 ANALYSIS METHODS

Mathematical simulation modeling results provide the basis for quantitative evaluation of the various MCS and FGD programs. The Hat Creek Model (HCM), a point-source Gaussian diffusion model specifically adapted for applications involving air quality estimates at the proposed project site, was employed to estimate sequential hourly SO_2 concentrations attributable to the uncontrolled power plant over a one-year period for full load and selected partial loads. This procedure was repeated for the FGD option using modified inputs to reflect appropriate stack emission characteristics. Evaluation of MCS fuel switching was accomplished by means of ERT's Dynamic Emission Control Analysis (DECA) computer program. DECA processes the sequence of hourly concentrations computed by HCM to estimate the frequency and total annual hours of secondary (lower-sulfur) fuel use required to meet various sets of control guidelines. A technical description of the DECA program is included as Addendum A to this Appendix. The HCM and the procedures implemented to incorporate the results of field studies at the proposed site are described in Appendix B (Modeling Method).

C2.0 SUMMARY OF MAJOR CONCLUSIONS

The principal conclusions derived from diffusion model applications and cost evaluations of the alternative SO_2 emission control strategies for the Hat Creek Project are indicated below. The criteria by which the effectiveness of the various control measures are evaluated and the proposed guidelines for 3-hour and 24-hour ambient SO_2 concentrations are discussed in Section C1.2.

1. Provision for some form of emission control is necessary to ensure compliance with the 3-hour and 24-hour guidelines assumed in this analysis for either of the two stack heights considered. Diffusion model calculations for uncontrolled emissions from a 366 m (1200 ft) stack resulted in peak 3-hour and 24-hour concentration of 749 $\mu g/m^3$ and 408 $\mu g/m^3$, respectively. However, excesses of each guideline are predicted only once per year.

2. Uncontrolled emissions from a 244 m (800 ft) stack are predicted to cause 3-hour concentrations above 655 $\mu g/m^3$ fourteen times during a year, with a maximum ground-level value of 829 $\mu g/m^3$. Daily average values greater than 260 $\mu g/m^3$ are expected eight times per year, the highest individual concentration being 515 $\mu g/m^3$.

3. Modeling results for continuous operation with a flue gas desulfurization unit designed for 54% sulfur removal indicate that such a system, with 100% availability and a 366 m stack, could easily achieve full compliance with the assumed ambient design criteria. Peak 3-hour and 24-hour concentrations of 366 and 208 $\mu g/m^3$, respectively are predicted. On the basis of this study, it appears likely that an FGD system could be successfully operated with a somewhat shorter stack.

4. According to the model analysis, installation of a 366 m stack would ensure that the power plant with uncontrolled emissions could be operated virtually as a base-load facility within the constraints of the assumed guidelines. MCS control action

requirements would be limited to a few fuel-switching periods during winter (primarily in November). Use of 0.21% sulfur coal as secondary fuel will be adequate to prevent ambient air quality violations, even with thresholds set at 80% of the guideline values. Load reduction requirements during the remainder of the year will be infrequent, if necessary at all, and the generating capacity loss due to such curtailments will be essentially zero.

5. With a 244 m stack, an MCS is capable of maintaining SO_2 concentration levels below assumed guideline values by (1) switching to 0.21% sulfur for about 195 hours during the months from November through February; and (2) reducing plant generating capacity to 80% load for approximately 80 hours and to 60% load about 5 hours during the remainder of the year.

6. FGD will reduce the annual SO_2 emissions from the project substantially more than MCS. Both systems are considered capable of meeting the ambient guidelines assumed in this analysis. However, in terms of cost per incremental reduction in peak concentrations, the MCS is far more cost-effective.

C3.0 BASIC CONSIDERATIONS FOR SO_2 CONTROL SYSTEM ANALYSIS

C3.1 DESCRIPTION OF PROJECT SITE AREA

The proposed project will be located in the Trachyte Hills of south-central British Columbia above Upper Hat Creek Valley near Harry Lake. The project site is about 16 km (10 mi) southwest of Cache Creek and approximately 80 km (48 mi) west of Kamloops. Plant grade elevation is about 1420 m (4650 ft) above mean sea level (MSL) (see Figure C3-1).

The Hat Creek area forms part of the larger Thompson Plateau region, which separates the western Coast Range from the Monashee Range of the Rocky Mountains. Despite its characterization as a plateau region, the Thompson Plateau has significant topographic features as a result of erosion by large rivers, such as the Fraser and Thompson, and smaller ones such as Hat Creek.

The floor of the Hat Creek Valley varies in elevation from 1070 m (3500 ft) MSL at Upper Hat Creek to about 490 m (1600 ft) near the towns of Carquile and Cache Creek. Ridges to the east of the project site attain elevations up to 1555 m (5100 ft), while the Cornwall Hills to the south reach maximum heights of 2010 m (6600 ft). Peaks of the Marble Range to the north have elevations of about 2075 m (6800 ft), and maximum elevations between 2195 m (7200 ft) and 2320 m (7600 ft) are found in the Clear Range to the west. Figure C3-1 indicates the location of the proposed Hat Creek Project and the surrounding terrain features.

The rugged terrain characterizing the Hat Creek area has significant effects upon the atmospheric transport and dispersion of contaminant emissions. The presence of elevated regions within the proposed plant's immediate zone of air quality influence requires that such emissions be discharged from a tall stack. In order to ensure maintenance of air quality in populated or recreational areas, any successful strategy to control ambient SO_2 levels in the vicinity of Hat Creek must be formulated with consideration for avoiding high ground-level concentrations at elevated locations.

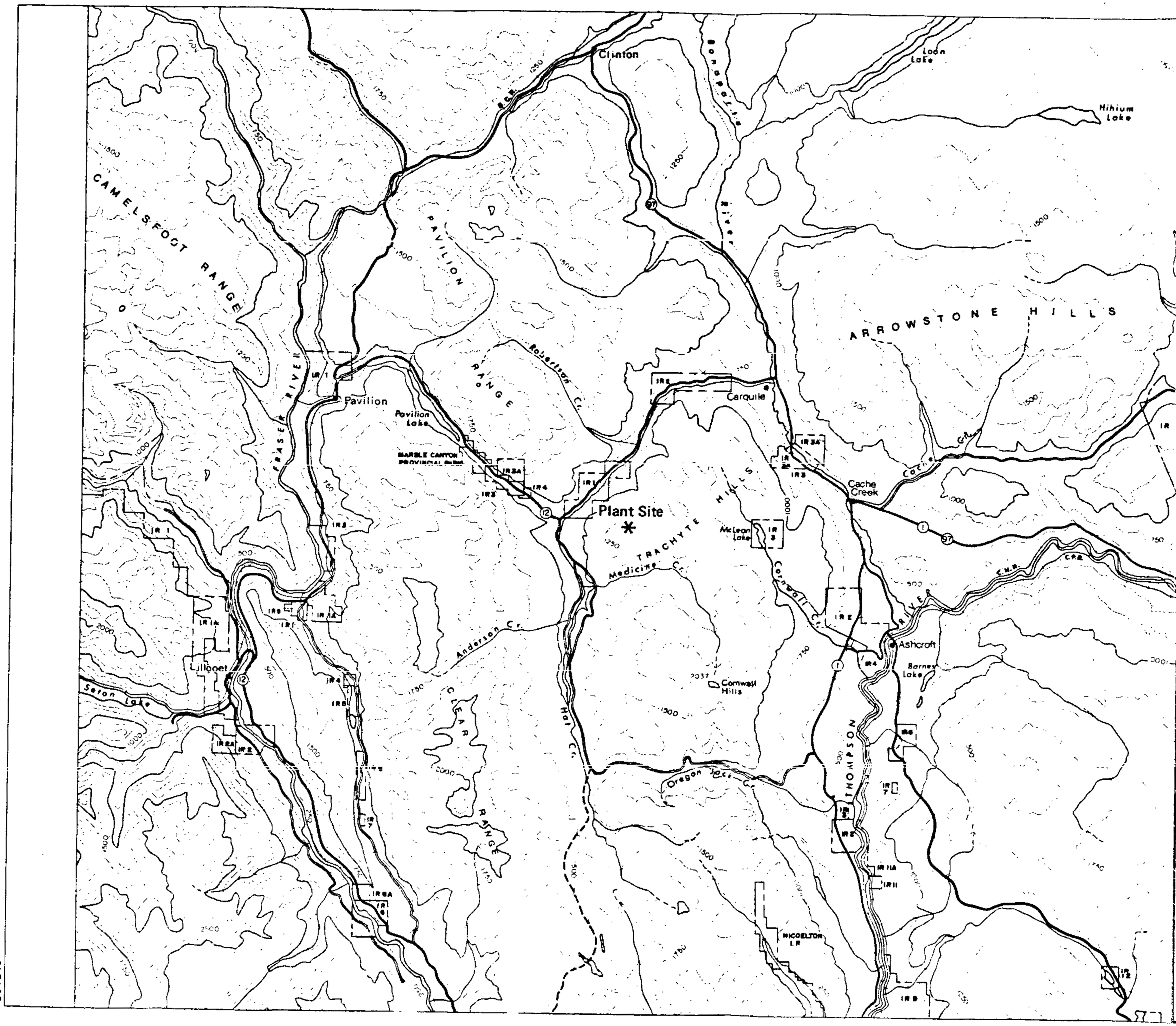
C3.2 DESCRIPTION OF THE PLANT

The proposed Hat Creek Project will consist of an open-pit coal mine and an electrical generating facility with nominal 2000 Mw capacity. In the present analysis of control measures to regulate ambient SO_2 levels, only the stack emissions from the plant have been considered. Emissions from four 500 Mw generating units will be exhausted through a single common stack.

It has been assumed in this study that coal from the mine will be blended routinely to achieve a mean sulfur content of 0.45% and an average heating value of 3500 calories/gram (6300 Btu/lb). Assumed stack dimensions and flue gas characteristics for the uncontrolled plant operating at full load are presented in Table C3-1. As depicted in the table, plume exit flow rate and temperature are considered to be identical for both a 244 m (800 ft) and a 366 m (1200 ft) stack.

C3.3 DESCRIPTION OF METEOROLOGICAL CONTROL SYSTEMS

A Meteorological Control System (MCS) is a systematic plan of defined procedures for reducing contaminant emissions to the atmosphere in response to predicted or observed meteorological conditions that are conducive to high ground-level ambient concentrations. Such control strategies may assume many operational forms; both load reduction and fuel switching programs have been evaluated quantitatively in the context of the present study. For this analysis, it has been assumed that lower-sulfur coal with average sulfur content of 0.21% and a mean heating value of 4190 cal/gm (7,560 Btu/lb) will be stockpiled for use during periods of adverse dispersion potential in the winter months (November through February). During the remaining months of the year, uniform load reduction of all generating units was assumed to be the



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DETAILED ENVIRONMENTAL STUDIES

Figure C3-1 Topographic Map of the Hat Creek Valley Area

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TABLE C3-1

ASSUMED STACK GAS PROPERTIES FOR ALTERNATIVE CONTROL CONFIGURATIONS*

Control Strategy	Stack Gas Exit Temperature (°C)	Flue Gas Flow Rate **	SO_2 Emission Rate (kgm/hr)
Uncontrolled Emissions (0.45% Sulfur Coal)	148.9	248,813	13,532
Reduced Sulfur Emissions (0.21% Sulfur Coal)	148.9	238,384	5,262
80% Load***	139.0	212,090	10,953
70% Load***	134.2	186,240	9,624
60% Load***	129.3	163,570	8,293
50% Load***	127.0	129,110	7,173
40% Load***	120.7	108,480	5,720
FGD Emissions***	82.0	262,189	6,259

* Analyses for uncontrolled emissions and MCS programs were performed for both 244m and 366m stack heights; FGD study was performed only for 366m stack.

** Flue gas flow rates are in actual cubic meters per minute.

*** Use of 0.45% sulfur coal at 3500 cal/gm (6300 Btu/lb) is assumed.

preferred control measure for reducing ground-level concentrations. Table C3-1 shows the SO_2 emission rate and flue gas characteristics corresponding to the use of this secondary coal.

In general, an MCS can be most effectively operated for a utility or industrial installation that is the dominant source of emissions within its zone of air quality influence, and that is located in a region usually characterized by conditions favorable for the dispersion of airborne contaminants to levels below ambient air quality guidelines. The first criterion met in the case of the Hat Creek Project is important to ensure that MCS control measures will produce the necessary air quality improvement. The second condition is a result of the need to minimize the frequency of required control actions and to allow for the inherent uncertainty involved in the prediction of meteorological parameters governing the behavior of atmospheric contaminants. Because of the complex terrain characterizing the Hat Creek area, control actions for the proposed plant will be required more frequently than would be necessary for a similar installation in a region of relatively flat terrain.

The fundamental requirements for successful implementation of an MCS are: a source that can effect necessary emission curtailment procedures as required; an ability to predict poor dispersion conditions in advance; an operational air quality prediction model; and a monitoring network to collect local ambient air concentration data. MCS operational requirements for the Hat Creek Project include the capability to predict threshold level concentrations for fuel switching at least eight and one-half hours in advance; moreover, it has been assumed in this analysis that a fuel switch, once enacted, will be maintained for at least three hours (the minimum averaging time corresponding to control action requirements). Load reduction procedures to decrease emissions by a given amount can normally be implemented much more rapidly than an equivalent fuel switch, since the latter involves delays associated with physically providing the secondary fuel to the boilers. Thus, for MCS applications involving load reduction, forecast lead-time requirements are less critical.

The actual response time for load curtailment depends on boiler design; according to the design engineers, a reduction of 20% generating capacity (400 Mw) could be accomplished in 10 to 20 minutes at the Hat Creek power plant. Since this interval is small in comparison with averaging times corresponding to assumed SO_2 guidelines, no correction for forecast lead time is made in estimating control action requirements for MCS with load reduction in this analysis.

For either mode of MCS operation, a plume transport lag time is inevitable. That is, a change in emission strength at the source will not begin to affect ambient concentrations at a specific downwind point until a certain time interval has elapsed. The duration of this interval depends upon wind speed. For example, with a 2 m sec^{-1} wind, the Hat Creek plume will not reach the Cornwall Hills for approximately 1.5 hours. This implies an additional forecast lead-time requirement for the operational MCS. This factor does not, however, significantly change the number of hours when fuel switching or load reduction will be required, since at the end of a control action period, the resumption to uncontrolled emissions will not be 'seen' at receptor locations for a nearly equivalent lag time.

As stipulated by B.C. Hydro, the 3-hour and 24-hour ambient SO_2 concentration criteria considered in the evaluation of MCS strategies include:

Averaging Time	SO_2 Concentration	Basis
3-hour	655 $\mu g/m^3$	B.C. Hydro submission to the Pollution Control Branch Public Inquiry to Review Pollution Control Objectives for the Mining, Mine-Milling, and Smelting Industries of British Columbia--January 1978
24-hour	260 $\mu g/m^3$	

In practice, because of uncertainty in meteorological forecasting and imperfections in air quality model prediction techniques, fuel-switching threshold concentration values somewhat lower than those corresponding to maximum allowable levels should be chosen as the actual criteria for initiation of emission controls during the winter months. Thus, in all calculations related to MCS strategies, additional results have been developed on the basis of control guidelines set at 80% and 90% of the actual design criteria tabulated above.

Experience with an operational MCS generally leads to improved forecasting, modifications of the air quality prediction model to reflect local effects, and greater skill in the interpretation of available onsite data. Accordingly, increased documentation of system performance will identify those ambient concentration levels and corresponding averaging times which prove most reliable as indicators for potential control action requirements to protect MCS program objectives for specific weather conditions. The predicted and observed concentrations used as MCS thresholds may thus be modified to reflect accumulated experience throughout the lifetime of the program.

C3.4 FLUE GAS DESULFURIZATION

A flue gas desulfurization (FGD) system was examined for its ability to control ambient SO_2 levels in the vicinity of the proposed Hat Creek Project. Detailed emission properties associated with operation of the emission controls are presented in Table C3-1.

A system designed to achieve partial (54% overall) SO_2 removal would consist of two absorbers (plus one back-up) for each generating unit. Approximately 60% of the flue gas will enter the wet scrubbers; the remainder will by-pass the absorbers and be used to provide reheat for the saturated gas from the scrubbers. The remixed effluent will be discharged at a temperature of 82°C (180°F) and will contain moisture (69,091 kgm/hr) picked up in the scrubbers. The addition of large amounts of water to the stack effluent will produce extended visible saturated plumes when ambient temperature is low and/or relative humidity is high.

C4.0 CONCENTRATIONS OF SO_2 WITHOUT EMISSION CONTROLS

The Hat Creek Model (HCM) was employed to estimate ground-level SO_2 concentrations attributable to the uncontrolled plant for each hour of an annual period. Three-hour, 24-hour, and annual average concentrations were calculated from the time sequence of hourly values computed by HCM. Due to the remoteness of the project area, background SO_2 concentrations were considered negligible. Separate model calculations were performed for assumed stack heights of 244 m (800 ft) and 366 m (1200 ft).

C4.1 DIFFUSION MODEL INPUT DATA

Surface meteorological data used in the diffusion calculations were derived from measurements taken at the B.C. Hydro Weather Station near Harry Lake from 1 January through 31 December, 1975. For periods when data were missing from this station, values recorded at other stations in the Hat Creek network were substituted to develop a nearly complete annual set of sequential hourly wind speed and direction data. Concurrent cloud ceiling and cloud cover observations made at the Atmospheric Environment Service (AES) station in Kamloops were used with the wind speed data to estimate atmospheric stability at the plant site according to the scheme developed by Turner.[2] The Turner stability typing scheme was modified to incorporate the effects of the rural nature of the area and the ruggedness of the terrain. Afternoon stabilities on days with strong insolation and light to moderate wind speeds were designated as unstable. Periods of overcast skies and/or strong wind speeds were considered neutral. Finally, night and early morning hours characterized by clear skies and low wind speeds were all classified as stable.

Mixing depths were calculated on the basis of rawinsonde data from Vernon, B.C., in the manner recommended by Holzworth[3] and applied to Canadian weather stations by Portelli.[4] Interpolation to determine hourly mixing depths was accomplished by a method described by Busse and Zimmerman.[5] Emission characteristics presented in Table C3-1 were assumed. Terrain elevations within a 25-km radial area from the proposed plant site were input directly into the model. As explained in Appendix B (Modeling Method), the assumptions of negligible chemical transformation and deposition incorporated by the HCM are not considered valid beyond a travel distance of 25 km.

Diffusion modeling techniques, properly tailored for use in specific applications, have become a recognized tool to estimate air quality impacts of future sources, and to augment information derived from measurement data in the vicinity of existing installations. The HCM is described in Appendix B (Modeling Method). Certain meteorological events capable of producing high concentrations due to tall-stack emissions in the project area have been identified in the course of field studies. Since the HCM cannot accurately simulate some of these conditions, their implications with regard to maintenance of acceptable air quality by various control strategies are discussed separately in Section C4.3.

C4.2 RESULTS OF MODEL SIMULATIONS

For this study, estimates of 3-hour averaged ground-level SO_2 concentrations attributable to the Hat Creek Plant were calculated by averaging successive 1-hour centerline concentrations during periods of neutral and/or unstable conditions. For hours during which stable, light-wind conditions prevailed, the hourly concentrations were recalculated from the centerline values by assuming that the plume mass contained within a 22.5° sector (the precision to which the wind direction is specified in the model) is uniformly distributed across this sector at each downwind distance. Simple arithmetic averaging was then applied to compute 3-hour concentrations from the adjusted hourly values. Twenty-four-hour concentrations were calculated from sector averaged hourly values for all weather conditions. Experimental justification for the assumption of greater directional variability of a plume under light-wind, stable conditions is given by Wilson _et al._[6] and Lague.[7]

Table C4-1 summarizes the results of the diffusion model calculations for the uncontrolled plant. Maximum SO_2 concentrations within 25 km from the proposed generating facility for various averaging times, as well as predicted frequencies of values above the assumed 3-hour and 24-hour ambient criteria are presented for stack heights of 244 m (800 ft) and 366 m (1200 ft). Continuous, baseload operation of the plant is assumed.

Examination of the table reveals that for both stack heights, maximum annual average concentrations are well below the Provincial Level-A ambient guideline of 25 $\mu g/m^3$ without SO_2 controls. It is apparent that the design of emission control strategies for the protection of ambient SO_2 levels must emphasize regulation for shorter averaging periods. Maximum predicted concentrations for each averaging time are only slightly lower with a 366 m (1200 ft) stack than with a 244 m (800 ft) stack. This result reflects the fact that, even under the most adverse weather conditions, plume rise is sufficient in either case to place the plume centerline well above local terrain features. It is also evident from Table C4-1 that for both stack heights, a control strategy which focuses on the protection of the 3-hour ambient guideline will not necessarily be sufficient to achieve the 24-hour concentration threshold. Therefore, any control strategy must be stringent enough to ensure that both guideline concentrations will be met.

C4.3 SPECIAL METEOROLOGICAL EVENTS

The diffusion calculations performed in the context of this analysis used a mathematical model, the HCM. Insofar as possible, the parameterization of the HCM was modified by calibration procedures to increase its applicability to the specific meteorology and terrain of the proposed power plant site (see Appendix B, Modeling Method). It is believed that the model, so calibrated, provides an accurate representation of stack plume behavior for most weather conditions likely to occur. However, when on-site measurements are available, it is prudent

TABLE C4-1

ESTIMATED EFFECTS OF THE UNCONTROLLED HAT CREEK PLANT ON AMBIENT SO_2 LEVELS

Maximum Concentrations ($\mu g/m^3$)

Averaging Time	Season	244 m stack	366 m stack
3-hour	winter	780	749
	spring	753	644
	summer	829	645
	autumn	829	648
24-hour	winter	312	253
	spring	116	108
	summer	205	159
	autumn	513	408
annual		0.9	8

Percent Frequency

	244 m stack	366 m stack
3-hour concentrations $\geq$ 655 $\mu g/m^3$	0.4 (14 3-hr periods)	0.03 (1 3-hr period)
24-hour concentrations $\geq$ 260 $\mu g/m^3$	2.2 (8 24-hr periods)	0.3 (1 24-hr period)

to use this information to identify situations which the modeling techniques are incapable of treating to ensure a thorough analysis of air quality effects. This subsection is devoted to an examination of such conditions. In the course of field experiments designed to characterize the dispersion meteorology in the vicinity of the Hat Creek site, certain weather conditions have been observed which, by reason of their association with potentially high ground-level concentrations, merit special consideration. Since these conditions are transient and occur primarily as a result of the particular topography of the project area, they cannot be accurately simulated by means of a steady-state Gaussian model such as the HCM. The two such meteorological events identified during the field studies are: fumigation due to breakup of nocturnal inversion, and fumigation on the valley slopes induced by formation of cross-valley circulation cells created by uneven solar heating of the ground. In the context of control strategy analysis it is important to evaluate the existing data to determine whether, and to what extent, control requirements will be altered by the occurrence of such meteorological events not treated in the model calculations.

The term 'fumigation' is used to describe rapid downward mixing of contaminants from an elevated source. The most familiar process by which fumigation may occur is the early morning breakup of a nighttime surface inversion by solar heating. As the ground warms, the stable layer is eroded from below, such that the lowest levels are characterized by instability, i.e., vigorous vertical eddy motions. As this unstable layer grows, it can reach the height of stack effluents and cause them to be mixed to the ground in relatively high concentration. This phenomenon is transient in time and location, generally persisting for only a few minutes at a given receptor. Whether and how frequently inversion breakup fumigation will produce elevated ground-level concentrations in the vicinity of a particular source depends upon the characteristic depth of the morning inversion versus the effective height of plume release.

Table C4-2 indicates composite morning inversion depth statistics developed from two meteorological measurement programs conducted in the Hat Creek Valley.[8,9,10,11] Tabulated inversion depths are measured from the valley floor. For reference, a depth of about 680 m is required to reach the top of a 244 m (800 ft) stack located at the Harry Lake site; about 800 m corresponds to the top of a 366 m (1200 ft) stack.

Inversion depths as high as the 244 m stack were observed six times during the 26 days of field measurements (see Table C4-2). An indication of whether stack plumes could have experienced fumigation is afforded by a comparison of calculated plume heights with concurrent inversion depths. Table C4-3 indicates that on two occasions (the experiments of 11 March and 6 November), computed plume heights for a 244 m stack are nearly at the inversion top elevation, so that downward mixing of some portion of these plumes might have occurred. The expected duration of this fumigation condition is only a few minutes. Furthermore, downward mixing would have to take place through a layer at least 1000 m deep to have an appreciable effect on ground-level concentrations. Finally, plume transport toward Hat Creek Valley would be necessary for this type of fumigation to occur at all.

The observed inversion depths reached the level of the 366 m stack top four times. However, as demonstrated in Table C4-3, plume rise would place the plume from such a stack well above any inversions. Thus, it appears unlikely that fumigation conditions for the 366 m stack would ever exist.

Based on the available evidence, then, there is no indication that an emission control strategy designed to protect 3-hour and 24-hour ambient levels would entail special control actions for inversion breakup fumigation. For a 366 m stack, it appears unlikely that this condition would even occur. The data from the field studies includes two cases with marginal fumigation potential for plumes from a 244 m stack, but for the reasons stated above, it is doubtful that fumigation due to

TABLE C4-2

NOCTURNAL INVERSION STATISTICS DEVELOPED FROM MEP AND NAWC TEMPERATURE SOUNDINGS

Inversion Depth* (m)	February and March Occurrences	August and September Occurrences
0 to 100	2	3
100 to 200	2	1
200 to 300	4	1
300 to 400	2	3
400 to 500	0	1
500 to 600	0	1
600 to 700	0	1
700 to 800	0	1
800 to 900	0	1
900 to 1.000	1	1
> 1000	0	1
TOTAL	11	15

*Inversion depths derived from references 5, 6, 7, and 8.

TABLE C4-3

COMPARISON OF CALCULATED FINAL PLUME HEIGHT TO HEIGHT OF INVERSION TOP (METERS ABOVE VALLEY FLOOR)*

Day	Plume Height for 366 m stack (m)	Plume Height for 244 m stack (m)	Inversion Height (m)
March 11, 1975	1110	990	970
September 4, 1975	1270	1150	800
September 5, 1975	1210	1090	900
September 6, 1975	1230	1110	1100

*Inversion heights derived from references 9, 9, 10, and 11.

inversion breakup would produce ground-level concentrations in excess of the 3-hour and 24-hour criteria assumed in this study.

Another type of fumigation was observed during the gas tracer study conducted by North American Weather Consultants (NAWC).[8,9] Oil fog and sulfur hexafluoride (SF_6) releases were made from an aircraft at the calculated effective stack height for alternate power plant sites. On one occasion, with a simulated 183 m stack located near the Harry Lake site, fumigation of the tracer plume was noted to occur on the western slopes of Hat Creek Valley as it drifted slowly southward. Concurrent meteorological data indicate that this phenomenon is apparently caused by the formation of vigorous cross-valley circulation cells created by uneven heating of the ground at different elevations. While this condition occurs as a direct result of morning insolation, it is not properly classified as a case of inversion breakup fumigation of the type discussed above.

During this experiment the maximum 3-hour equivalent SO_2 concentration at the ground that would have resulted from a continuous source, was estimated at 435 $\mu g/m^3$. This value is well below the assumed guideline of 655 $\mu g/m^3$. Subsequent discussions with NAWC personnel indicated that, in performing the field tests, the height of tracer releases above the assumed physical stack height was conservatively calculated by means of the formulae recommended by Briggs,[12] but limited to 400 m so that the plume would remain within the influence of the valley circulation and within initial plume rise guidelines. The actual plume rise calculated on the basis of expected flue gas properties and meteorological conditions during the field test is four times the limit imposed by NAWC for this case. Since the maximum ground-level concentration may not have been measured, it is of interest that a concentration 50% higher than that observed would be required to reach the assumed 3-hour guideline. Since this experiment was performed for a simulated 183 m stack release with an extremely conservative assumed plume rise estimate, it is considered extremely improbable that this type of fumigation would occur for a plume released from a 244 m or 366 m stack. Therefore, no control action requirements in response to such conditions are anticipated for an emission control program designed to protect the assumed 3-hour and 24-hour ambient guidelines.

C5.0 CONCENTRATIONS OF SO_2 WITH METEOROLOGICAL CONTROLS

For this analysis it has been assumed that MCS programs with either a 244 m (800 ft) or 366 m (1200 ft) stack would be operated according to the following three criteria.

- Whenever predicted ambient concentrations are below the 3-hour and 24-hour guidelines, the power plant will operate at full load (2,000 Mw) with 0.45% sulfur coal.
- Whenever a control action is required to avert an excess of the guidelines during the months from November through February, the preferred action is fuel switching to 0.21% sulfur coal with no load reduction.
- Whenever a control action is required during the remainder of the year, the preferred action is uniform load reduction of the four generating units as required to avert an excess of the guidelines.

Results of the dispersion model (HCM) calculations described in the previous section provide the basic input to the MCS analysis. Evaluation of fuel switching during the winter months was accomplished using ERT's computer program DECA (Dynamic Emission Control Analysis). Load curtailment requirements were identified by additional applications of the HCM using input parameters corresponding to various discrete load levels.

C5.1 THE DECA PROGRAM

The DECA program is an analysis tool designed specifically to extend the applicability of conventional diffusion model calculations to permit detailed evaluation of selected two-fuel MCS switching strategies. A detailed description of this program is included as Addendum A to this Appendix. The basic input data requirement is a time series of hourly ground-level concentrations in the vicinity of the MCS source.

Additional input information used in DECA program is presented in Table C5-1. For each set of postulated 3-hour and 24-hour control guidelines (switching thresholds), the DECA model was used to provide the following output information:

- total hours during each month (November through February) when use of the secondary fuel (0.21% sulfur coal) is required. This total reflects the frequency of atmospheric conditions that would produce concentrations in excess of applicable thresholds with the Hat Creek Plant burning the primary fuel, as well as the specified minimum switch length and interval criteria. The duration of the longest single switch period required during each month is also provided to facilitate an estimate of the size of the secondary (lower-sulfur) coal pile required to support MCS operation.
- a frequency distribution indicating the number of times per month when required switch lengths correspond to various prespecified time intervals.
- the number of 3-hour and 24-hour periods, if any, when operation of the Hat Creek Plant according to the MCS procedures would produce concentrations above threshold values.
- the 'complying fuel' sulfur contents, i.e., the maximum percent sulfur fuel that could be used continuously by the Hat Creek Plant each month with no resultant excess of any SO_2 threshold value in the vicinity of the site.

C5.2 LOAD REDUCTION ANALYSIS METHODS

For the nonwinter months (March through October) MCS operation was assumed to entail uniform load reduction of all four generating units in response to anticipated violations of the 3-hour and 24-hour ambient guidelines with full load. Emission rates and stack gas properties corresponding to a range of reduced loads were used as input to the HCM to calculate 3-hour and 24-hour concentrations for each configuration shown in Table C3-1. For periods when full-load operation was predicted to cause an excess of the guidelines, the concentrations corresponding to 80% load during these periods were tested for compliance. If reduction to 80% load was sufficient to avoid an excess, this fact was

TABLE C5-1

MCS PARAMETERS ASSUMED IN THE DECA STUDY

(a) Primary Fuel

Fuel Type	coal
Sulfur Content (%)	0.45
Heating Value (Btu/lb)	6,300

(b) Secondary Fuel

Fuel Type	coal
Sulfur Content (%)	0.21
Heating Value (Btu/lb)	7,560

(c) Ambient Control Criteria*

3-hour averaging time	655 $\mu g/m^3$
24-hour averaging time	260 $\mu g/m^3$

(d) Operational Constraints**

Minimum switch length (hrs)	3 hrs
Minimum uncontrolled interval between switches	9 hrs

*Calculations also performed for control criteria set at 80 and 90% of tabulated values.

**Determined by the fuel types involved and the expected facilities for their storage and handling.

noted; otherwise the 70% load case was examined, etc. Finally, the frequency distribution of required curtailment to each reduced load was developed.

Unlike fuel-switching, the response time to accomplish load reductions is quite rapid. In practice, this form of MCS can be operated in response to measured as well as predicted ambient concentrations. The lag time associated with plume transport to distant receptors (see Section C3.3) does require that some form of meteorological/air quality forecasting be included in the design of a load reduction MCS. However, the lag-time effect is a relatively minor one, and does not require that ambient control criteria be set below the assumed quidelines.

C5.3 RESULTS OF MCS ANALYSIS FOR A 366 m STACK HEIGHT

Tables C5-2(a) through C5-2(d) present the results calculated by the DECA program for fuel-switch MCS operation with an assumed stack height of 366 m (1200 ft). Each table represents output for one of the four months (November through February) when fuel switching was assumed as the preferred control action. The information provided includes total hours when use of the secondary fuel (0.21% sulfur) would be required to maintain SO_2 concentrations below control guidelines set at 80%, 90%, and 100% of the 3-hour and 24-hour ambient design criteria. In addition, the distribution of required switch durations and the maximum single switch length are indicated for each set of fuel-switching thresholds.

The complying fuel values listed in each table for the various control guidelines represent maximum sulfur contents for hypothetical fuels that could be used continuously without producing ambient SO_2 concentrations higher than the corresponding 3-hour and 24-hour thresholds. Thus, for example, Table C5-2(a) shows that a coal sulfur content of 0.21% (the assumed secondary fuel) is adequate to prevent concentrations greater than 80%, 90%, or 100% of the 655 $\mu g/m^3$ or 260 $\mu g/m^3$ levels with

TABLE C5-2(a)

NOVEMBER RESULTS OF MCS ANALYSIS FOR
366 METER STACK
HAT CREEK PLANT

FREQUENCY DISTRIBUTION OF LENGTHS OF SWITCHING PERIODS AS A FUNCTION OF PERCENT OF STANDARDS USED AS SWITCHING TRIGGER AND SULFUR CONTENT OF HIGH SULFUR FUEL

MINIMUM SWITCHING PERIOD 3 HOURS; MINIMUM INTERVAL BETWEEN SWITCHES 9 HRS

OPTION 1: 0.45% COAL SWITCHING TO 0.21% COAL

PERCENT OF AMBIENT STANDARDS USED AS SWITCH CRITERION	SWITCH LENGTH CATEGORIES (HOURS) 3- 6	7- 9	10-12	13-15	16-18	19-21	22-24	25-36	37-48	49-	TOTAL HOURS SWITCHED	LONGEST SWITCH (HOURS)
80 %	2	0	0	0	0	0	0	1	0	0	34	28
90 %	1	0	0	0	1	0	0	0	0	0	20	17
100 %	0	0	0	0	1	0	0	0	0	0	17	17

NO. OF PERIODS OF EXCESS OF STANDARDS 1-HR	3-HR	24-HR	NO. OF PERIODS WITH BKGD. IN EXCESS OF STANDARDS 1-HR	3-HR	24-HR
0	0	0	0	0	0

COMPLYING FUEL CALCULATED

0.23% SULFUR FOR 80% OF AMBIENT STANDARDS (0.74 LBS SO2/MILLION BTU INPUT)

0.26% SULFUR FOR 90% OF AMBIENT STANDARDS (0.84 LBS SO2/MILLION BTU INPUT)

0.29% SULFUR FOR 100% OF AMBIENT STANDARDS (0.93 LBS SO2/MILLION BTU INPUT)

TABLE C5-2(b)

DECEMBER RESULTS OF MCS ANALYSIS FOR

366 METER STACK

HAT CREEK PLANT

FREQUENCY DISTRIBUTION OF LENGTHS OF SWITCHING PERIODS AS A FUNCTION OF PERCENT OF STANDARDS USED AS SWITCHING TRIGGER AND SULFUR CONTENT OF HIGH SULFUR FUEL

MINIMUM SWITCHING PERIOD 3 HOURS; MINIMUM INTERVAL BETWEEN SWITCHES 9 HRS

OPTION 1: 0.45% COAL SWITCHING TO 0.21% COAL

PERCENT OF AMBIENT STANDARDS USED AS SWITCH CRITERION	SWITCH LENGTH CATEGORIES (HOURS) 3- 6	7- 9	10-12	13-15	16-18	19-21	22-24	25-36	37-48	49-	TOTAL HOURS SWITCHED	LONGEST SWITCH (HOURS)
80 %	2	0	0	0	0	0	0	0	0	0	8	5
90 %	2	0	0	0	0	0	0	0	0	0	6	3
100 %	1	0	0	0	0	0	0	0	0	0	3	3

NO. OF PERIODS OF EXCESS OF STANDARDS 1-HR	3-HR	24-HR	NO. OF PERIODS WITH BKGD. IN EXCESS OF STANDARDS 1-HR	3-HR	24-HR
0	0	0	0	0	0

COMPLYING FUEL CALCULATED

0.32% SULFUR FOR 80% OF AMBIENT STANDARDS (1.02 LBS SO2/MILLION BTU INPUT)

0.36% SULFUR FOR 90% OF AMBIENT STANDARDS (1.15 LBS SO2/MILLION BTU INPUT)

0.40% SULFUR FOR 100% OF AMBIENT STANDARDS (1.28 LBS SO2/MILLION BTU INPUT)

TABLE C5-2(c)

JANUARY RESULTS OF MCS ANALYSIS FOR

366 METER STACK

HAT CREEK PLANT

FREQUENCY DISTRIBUTION OF LENGTHS OF SWITCHING PERIODS AS A FUNCTION OF PERCENT OF STANDARDS USED AS SWITCHING TRIGGER AND SULFUR CONTENT OF HIGH SULFUR FUEL

MINIMUM SWITCHING PERIOD 3 HOURS; MINIMUM INTERVAL BETWEEN SWITCHES 9 HRS

OPTION 1: 0.45% COAL SWITCHING TO 0.21% COAL

PERCENT OF AMBIENT STANDARDS USED AS SWITCH CRITERION	SWITCH LENGTH CATEGORIES (HOURS) 5- 6	7- 9	10-12	13-15	16-18	19-21	22-24	25-36	37-48	49-	TOTAL HOURS SWITCHED	LONGEST SWITCH (HOURS)
80 %	3	0	0	0	0	0	0	0	0	0	9	3
90 %	0	0	0	0	0	0	0	0	0	0	0	0
100 %	0	0	0	0	0	0	0	0	0	0	0	0

NO. OF PERIODS OF EXCESS OF STANDARDS 1-HR	3-HR	24-HR	NO. OF PERIODS WITH BKGD. IN EXCESS OF STANDARDS 1-HR	3-HR	24-HR
0	0	0	0	0	0

COMPLYING FUEL CALCULATED

0.42% SULFUR FOR 80% OF AMBIENT STANDARDS (1.34 LBS SO2/MILLION BTU INPUT)

0.48% SULFUR FOR 90% OF AMBIENT STANDARDS (1.51 LBS SO2/MILLION BTU INPUT)

0.53% SULFUR FOR 100% OF AMBIENT STANDARDS (1.68 LBS SO2/MILLION BTU INPUT)

TABLE C5-2(d)

FEBRUARY RESULTS OF MCS ANALYSIS FOR
366 METER STACK
HAT CREEK PLANT

FREQUENCY DISTRIBUTION OF LENGTHS OF SWITCHING PERIODS AS A FUNCTION OF PERCENT OF STANDARDS USED AS SWITCHING TRIGGER AND SULFUR CONTENT OF HIGH SULFUR FUEL

MINIMUM SWITCHING PERIOD 3 HOURS; MINIMUM INTERVAL BETWEEN SWITCHES 9 HRS

OPTION 1: 0.45% COAL SWITCHING TO 0.21% COAL

PERCENT OF AMBIENT STANDARDS USED AS SWITCH CRITERION	SWITCH LENGTH CATEGORIES (HOURS) 3- 6	7- 9	10-12	13-15	16-18	19-21	22-24	25-36	37-48	49-	TOTAL HOURS SWITCHED	LONGEST SWITCH (HOURS)
80 %	0	0	0	0	0	0	0	0	0	0	0	0
90 %	0	0	0	0	0	0	0	0	0	0	0	0
100 %	0	0	0	0	0	0	0	0	0	0	0	0

NO. OF PERIODS OF EXCESS OF STANDARDS 1-HR	3-HR	24-HR	NO. OF PERIODS WITH BKGD. IN EXCESS OF STANDARDS 1-HR	3-HR	24-HR
0	0	0	0	0	0

COMPLYING FUEL CALCULATED

0.51% SULFUR FOR 80% OF AMBIENT STANDARDS (1.62 LBS SO2/MILLION BTU INPUT)

0.57% SULFUR FOR 90% OF AMBIENT STANDARDS (1.82 LBS SO2/MILLION BTU INPUT)

0.64% SULFUR FOR 100% OF AMBIENT STANDARDS (2.02 LBS SO2/MILLION BTU INPUT)

a 366 m stack during the month of November. This result is true for each of the four months.

Quite naturally, the number of hours when fuel switching is required increases as the control guidelines become more stringent. Total switch hours during the 4-month period for 80%, 90%, and 100% of the assumed air quality critieria are 51, 26, and 20, respectively. The corresponding longest single switch periods are 34, 20, and 17 hours. Clearly, adverse dispersion conditions occurred most frequently during the month of November.

For the months March through October load reduction was designated as the preferred MCS control action. Analysis of HCM results during this period indicates that for a 366 m stack height, no contraventions of either the 3-hour or 24-hour air quality criteria were predicted. The maximum calculated values for three hours and 24 hours, respectively, are 644 $\mu g/m^3$ and 215 $\mu g/m^3$. Both maxima are close to the assumed regulatory values, reflecting that MCS programs are designed only to protect against peak concentrations in excess of the guidelines. These results correspond to only one year of meteorological input data. However, they do provide evidence that required load reductions during the nonwinter months will be infrequent, and that the magnitude of any such reductions will be small.

The combined results for the full year demonstrate that installation of a 366 m stack ensures, for practical purposes, that the Hat Creek Plant could virtually be operated as a base-load facility. Meteorological control of plant emissions would involve very few control actions, most of them in the form of fuel switches during the winter months.

C5.4 RESULTS OF MCS ANALYSIS FOR A 244 m STACK HEIGHT

Results of the DECA calculations during the winter months of MCS operation with a 244 m (800 ft) stack are presented in Tables C5-3(a) through C5-3(d).

TABLE CS-3(a)

NOVEMBER RESULTS OF MCS ANALYSIS FOR
244 METER STACK
HAT CREEK PLANT

FREQUENCY DISTRIBUTION OF LENGTHS OF SWITCHING PERIODS AS A FUNCTION OF PERCENT OF STANDARDS USED AS SWITCHING TRIGGER AND SULFUR CONTENT OF HIGH SULFUR FUEL

MINIMUM SWITCHING PERIOD 3 HOURS; MINIMUM INTERVAL BETWEEN SWITCHES 9 HRS

OPTION 1: 0.45% COAL SWITCHING TO 0.21% COAL

SWITCH LENGTH CATEGORIES (HOURS)

PERCENT OF AMBIENT STANDARDS USED AS SWITCH CRITERION	3- 6	7- 9	10-12	13-15	16-18	19-21	22-24	25-36	37-48	49-	TOTAL HOURS SWITCHED	LONGEST SWITCH (HOURS)
80 %	3	0	0	0	1	0	0	0	1	0	75	45
90 %	1	0	1	0	0	0	0	0	1	0	56	42
100 %	0	1	0	0	0	0	0	0	1	0	51	42

NO. OF PERIODS OF EXCESS OF STANDARDS			NO. OF PERIODS WITH BKGD. IN EXCESS OF STANDARDS		
1-HR	3-HR	24-HR	1-HR	3-HR	24-HR
0	0	0	0	0	0

COMPLYING FUEL CALCULATED

0.19% SULFUR FOR 80% OF AMBIENT STANDARDS (0.59 LBS SO2/MILLION BTU INPUT)

0.21% SULFUR FOR 90% OF AMBIENT STANDARDS (0.66 LBS SO2/MILLION BTU INPUT)

0.23% SULFUR FOR 100% OF AMBIENT STANDARDS (0.74 LBS SO2/MILLION BTU INPUT)

TABLE C5-3(b)

DECEMBER RESULTS OF MCS ANALYSIS FOR
244 METER STACK
HAT CREEK PLANT

FREQUENCY DISTRIBUTION OF LENGTHS OF SWITCHING PERIODS AS A FUNCTION OF PERCENT OF STANDARDS USED AS SWITCHING TRIGGER AND SULFUR CONTENT OF HIGH SULFUR FUEL

MINIMUM SWITCHING PERIOD 3 HOURS; MINIMUM INTERVAL BETWEEN SWITCHES 9 HRS

OPTION 1: 0.45% COAL SWITCHING TO 0.21% COAL

SWITCH LENGTH CATEGORIES (HOURS)

PERCENT OF AMBIENT STANDARDS USED AS SWITCH CRITERION	3- 6	7- 9	10-12	13-15	16-18	19-21	22-24	25-36	37-48	49-	TOTAL HOURS SWITCHED	LONGEST SWITCH (HOURS)
80 %	3	0	0	0	0	0	0	1	0	0	39	27
90 %	3	0	0	0	1	0	0	0	0	0	25	16
100 %	3	0	0	1	0	0	0	0	0	0	22	13

NO. OF PERIODS OF EXCESS OF STANDARDS			NO. OF PERIODS WITH BKGD. IN EXCESS OF STANDARDS		
1-HR	3-HR	24-HR	1-HR	3-HR	24-HR
0	0	0	0	0	0

COMPLYING FUEL CALCULATED

0.31% SULFUR FOR 80% OF AMBIENT STANDARDS (0.97 LBS SO2/MILLION BTU INPUT)

0.35% SULFUR FOR 90% OF AMBIENT STANDARDS (1.10 LBS SO2/MILLION BTU INPUT)

0.38% SULFUR FOR 100% OF AMBIENT STANDARDS (1.22 LBS SO2/MILLION BTU INPUT)

TABLE C5-3(c)

JANUARY RESULTS OF MCS ANALYSIS FOR
244 METER STACK
HAT CREEK PLANT

FREQUENCY DISTRIBUTION OF LENGTHS OF SWITCHING PERIODS AS A FUNCTION OF PERCENT OF STANDARDS USED AS SWITCHING TRIGGER AND SULFUR CONTENT OF HIGH SULFUR FUEL

MINIMUM SWITCHING PERIOD 3 HOURS; MINIMUM INTERVAL BETWEEN SWITCHES 9 HRS

OPTION 1: 0.45% COAL SWITCHING TO 0.21% COAL

PERCENT OF AMBIENT STANDARDS USED AS SWITCH CRITERION	SWITCH LENGTH CATEGORIES (HOURS) 3- 6	7- 9	10-12	13-15	16-18	19-21	22-24	25-36	37-48	49-	TOTAL HOURS SWITCHED	LONGEST SWITCH (HOURS)
80 %	3	1	0	0	0	0	0	0	0	0	18	9
90 %	3	0	0	0	0	0	0	0	0	0	9	3
100 %	2	0	0	0	0	0	0	0	0	0	6	3

NO. OF PERIODS OF EXCESS OF STANDARDS 1-HR	3-HR	24-HR	NO. OF PERIODS WITH BKGD. IN EXCESS OF STANDARDS 1-HR	3-HR	24-HR
0	0	0	0	0	0

COMPLYING FUEL CALCULATED

0.33% SULFUR FOR 80% OF AMBIENT STANDARDS (1.05 LBS SO2/MILLION BTU INPUT)

0.37% SULFUR FOR 90% OF AMBIENT STANDARDS (1.18 LBS SO2/MILLION BTU INPUT)

0.41% SULFUR FOR 100% OF AMBIENT STANDARDS (1.31 LBS SO2/MILLION BTU INPUT)

TABLE C5-3(d)

FEBRUARY RESULTS OF MCS ANALYSIS FOR

244 METER STACK

HAT CREEK PLANT

FREQUENCY DISTRIBUTION OF LENGTHS OF SWITCHING PERIODS AS A FUNCTION OF PERCENT OF STANDARDS USED AS SWITCHING TRIGGER AND SULFUR CONTENT OF HIGH SULFUR FUEL

MINIMUM SWITCHING PERIOD 3 HOURS; MINIMUM INTERVAL BETWEEN SWITCHES 9 HRS

OPTION 1: 0.45% COAL SWITCHING TO 0.21% COAL

PERCENT OF AMBIENT STANDARDS USED AS SWITCH CRITERION	SWITCH LENGTH CATEGORIES (HOURS) 3- 6	7- 9	10-12	13-15	16-18	19-21	22-24	25-36	37-48	49-	TOTAL HOURS SWITCHED	LONGEST SWITCH (HOURS)
80 %	0	0	0	0	0	0	0	0	0	0	0	0
90 %	0	0	0	0	0	0	0	0	0	0	0	0
100 %	0	0	0	0	0	0	0	0	0	0	0	0

NO. OF PERIODS OF EXCESS OF STANDARDS 1-HR	3-HR	24-HR	NO. OF PERIODS WITH BKGD. IN EXCESS OF STANDARDS 1-HR	3-HR	24-HR
0	0	0	0	0	0

COMPLYING FUEL CALCULATED

0.61% SULFUR FOR 80% OF AMBIENT STANDARDS (1.95 LBS SO2/MILLION BTU INPUT)

0.69% SULFUR FOR 90% OF AMBIENT STANDARDS (2.19 LBS SO2/MILLION BTU INPUT)

0.77% SULFUR FOR 100% OF AMBIENT STANDARDS (2.44 LBS SO2/MILLION BTU INPUT)

Except in November, the complying fuel sulfur content calculations again indicate that 0.21% sulfur coal is adequate to achieve ambient thresholds set at 80%, 90%, and 100% of the assumed 3-hour and 24-hour criteria. During November this secondary fuel would not always ensure compliance at the 80% level.

As expected, more frequent switching is required with the 244 m stack height. However, MCS operation to maintain SO_2 levels below 80% and 100% of the ambient criteria would entail switching for only 130 and 79 hours, respectively. These values correspond to about 3.2% and 2.7% of the hours during the 4-month period. More than half of secondary fuel use is required during November. The longest single switches for control guidelines set at 80%, 90%, and 100% of the ambient criteria are 45, 42, and 42 hours, respectively.

For the remainder of the year (March through October) the required frequency and magnitude of load reductions necessary to maintain air quality levels were calculated. The diffusion model results indicate that emission reductions to levels below those for full-load operation will be required eight times to avoid an excess of the 3-hour guideline and three times to prevent violations of the 24-hour guideline. The minimum number of hours when reduced load operation would be necessary to achieve compliance for these periods was determined to be about 55 (in general, reduction for a full 24 hours is not necessary to meet the daily guideline).

Concentrations were next calculated for these periods with emissions and stack gas properties appropriate for 80% generating capacity. It was found that all 24-hour excesses and all but one 3-hour excess were eliminated by curtailment to this load. The remaining 3-hour violation was predicted to occur late in October at a receptor located in elevated terrain (1889 m MSL) 10 km west of the power plant. For this period, the 3-hour concentration actually increased from 690 $\mu g/m^3$ to 760 $\mu g/m^3$ for a simulated load reduction from 100% to 80%. This result reflects the decreased plume rise associated with partial load operation.

Analysis of the model predictions shows that concentrations at high-elevation receptors are particularly sensitive to plume height, such that the effects of reduced emissions at partial load are sometimes outweighed by the closer approach of the plume to the underlying surface.

Additional model calculations were performed to determine the load reduction necessary to decrease the maximum 3-hour concentration below 655 μg. Further reduction to 60% load resulted in a concentration of 626 $\mu g/m^3$, below the assumed guideline. Use of a secondary fuel (0.21% sulfur) during this period would decrease the predicted concentration to a value of 271 $\mu g/m^3$ at full load.

Although results based on model calculations with one year of data are not conclusive, MCS operation with a stack height of 244 m appears viable as an effective air quality control strategy for the ambient SO_2 guidelines assumed in this study. In the event that B.C. Hydro selects a 244 m stack, it is recommended that a modeling study based on a longer data period (e.g. three years) be performed. As discussed in Section C5.5, difficulty in forecasting the meteorological conditions associated with high ambient concentrations will probably lead to enactment of control measures about 25% to 50% more frequently than is indicated by the model calculations. Thus, assuming the higher (50%) value, about 195 hours of fuel switching and 85 hours of load reduction may be expected for MCS with a 244 m stack.

C5.5 METEOROLOGICAL AND AIR QUALITY FORECASTING REQUIREMENTS

The purpose of an MCS is to reduce the occurrence of ambient concentrations above acceptable levels by reducing emissions during periods of poor atmospheric dispersion capability. Identification of such periods must be accomplished with some advance notice since there are practical limits to the speed with which emission reduction orders can result in lower stack gas concentrations. Furthermore, there is a significant 'ventilation time' before the effects of reduced emissions are detectable at ground-level locations away from the source. The requirement for advance warning of impending poor dispersion conditions means that, in practice, an MCS must include some form of meteorological forecasting. Certain local weather events, e.g., wind shifts, particularly demand prior recognition, since measured air quality levels alone would not generally provide a warning of such changes. Without forecasting, contaminant concentrations could rise rapidly in these situations, leading to values in excess of the control guidelines before any curtailment action could be effective.

The principal role of meteorological forecasting in the context of MCS programs is in support of air quality predictions. Actual MCS operation should include routine analysis of measured contaminant concentrations and concurrent meteorological conditions. Such continuous review procedures will improve forecasting methods to reflect accumulated experience.

In general, the essential requirements of meteorological forecasting for MCS are as follows.

- The forecast lead time and updating intervals must be appropriate to the methods of emission reduction and their associated practical time constraints.
- The relationship between synoptic-scale weather patterns and critical meteorological parameters at the site must be understood, as well as the consequences of forecast uncertainties in the prediction of air quality levels.
- Forecast verification procedures must be included as part of the MCS.

For the Hat Creek Plant, a lead time of approximately nine hours will be required for lower-sulfur coal to reach the boilers. During the months when load reduction is the preferred control action, a 20% curtailment could be effected within minutes. It is assumed that the MCS must be operated to protect ambient guidelines for 3- and 24-hours. Thus, forecasts must be prepared for a period of at least 33 hours during the winter. Based on this requirement continuous meteorological support would be advantageous. Periodic updating (e.g., every eight hours) of the meteorological and air quality forecasts would compensate for the natural increase in uncertainty that accompanies extended predictions. Such revisions can greatly improve control system reliability.

The weather variables that the MCS meteorologist must forecast are those that influence or are closely related to the dispersive capacity of the lower atmosphere. These include wind speed, wind direction, stability, mixing depth, and, to a lesser extent, cloudiness and precipitation. In general, the most important parameters are those required as input to the MCS air quality prediction model.

Predictability of wind direction is generally good, especially when well-defined synoptic pressure systems are present in the vicinity of the MCS source. Accuracy of forecasts decreases with increased lead time and is generally more difficult for regions of complex terrain. Large high-pressure systems over the area of interest are often associated with light and variable winds; wind direction predictions are least reliable under these conditions.

Wind speed is more difficult to forecast. It varies diurnally, with generally higher values during daylight hours. Wind speeds also depend on the strength of the synoptic pressure gradient, surface roughness, and terrain channeling effects. Forecast reliability for this parameter also decreases with length of forecast time.

The stability in the lowest kilometers of the atmosphere is broadly related to its turbulence characteristics. An unstable condition is characterized by thermal convection, vertical eddy motions, and good dispersion. A stable atmosphere is one with suppressed turbulence and weak mixing capacity. Vertical profiles of wind speed and temperature are good indicators of atmospheric stability. These are most reliably predicted with assistance from monitoring instruments placed at different levels (e.g., on a meteorological tower).

The atmospheric mixing depth is defined as the height of the atmosphere through which vertical mixing readily occurs. Its predictability depends on the predictability of the maximum temperature, the vertical distribution of temperature in the lowest few kilometers, and the presence or absence of subsidence inversions associated with synoptic scale anticyclones (high-pressure systems). The prediction of maximum temperature is routine and generally quite reliable. The reliability of a temperature forecast decreases with increased lead time and is affected by cloud cover, wind speed and direction, time of year, and local effects. Like atmospheric stability, the mixing depth depends on the vertical temperature structure of the atmospheric boundary layer. Temperature sounding data from Vernon presently provide the best means for estimating the mixing height near the Hat Creek Project. The planned installation of a 100 m meteorological tower at the plant site (see Appendix H, Aerometric Monitoring) will provide additional information. The mixing height is limited by the elevation of the base of a subsidence inversion; the mixing height is intrinsically lower than or equal to the inversion base height. Successful prediction of an inversion base height is thus determined in part by the reliability of forecasting the movement and locations of anticyclones.

The determination of model input parameters is strongly related to the predictability of synoptic scale weather systems. The prediction of the growth and movement of cyclones and anticyclones is routinely performed by the forecasters from the Atmospheric Environment Service (AES). Meteorological forecasts can often be improved by the use of relevant real-time data gathered at the site. Pilot balloons, radiosondes, and on-site wind and temperature sensors are important sources of forecast inputs. It is obvious that the mix of AES guidance, on-site data collection, and forecasting experience and skill are important for MCS forecasting reliability. The reliability of these predictions varies with experience, forecasting lead-time requirements, and the positions of large-scale weather patterns.

Meteorological forecasting in the context of an air quality prediction program requires a basic understanding of the relationship between local weather conditions and contaminant concentrations. This knowledge should be gained by an extensive diffusion analysis and aerometric monitoring programs.

An investigation of the synoptic weather conditions that are associated with relatively high predicted contaminant concentrations (3-hour average SO_2 concentrations greater than 655 $\mu g/m^3$) in the Hat Creek region was performed in an attempt to identify the meteorological conditions leading to these levels. From the cases examined for 1975, several synoptic-scale patterns emerge:

- weak pressure gradient in the Hat Creek area, resulting from the absence of strong pressure systems or from a high pressure system centered over the area; or
- a large Pacific high pressure cell to the West and/or a well-developed low over Alberta; or
- a cyclonic storm system approaching the area from the West;
- wind directions between northwest, clockwise through south-southeast; and
- light surface wind speeds, less than 2 m sec^{-1}.

In general, the problem situations are created by stable conditions with persistent critical wind directions and light speeds. This condition is relatively simple to forecast, since stable conditions usually occur during the evening or morning hours, and persistent wind conditions are generally associated with the approach of cyclonic or anticyclonic cells. This was the situation in 12 of the 15 cases examined. The remaining days involved a more difficult forecasting situation, since the corresponding winds were very light and variable. Wind direction under such circumstances is difficult to predict, despite the tendency for flow to be channeled along the orientation of the mountain-valley system. In terms of an MCS, the greatest danger of exceeding criteria will occur during these meteorological conditions. From detailed examination of weather maps during 1975, it is estimated that forecast uncertainties associated with such difficult-to-forecast cases will require that MCS controls be enacted 25% to 50% more often then indicated by modeling results to ensure protection of the assumed ambient thresholds.

In the beginning stages of an MCS, forecasts of critical meteorological conditions should be conservative in order to account for the inherent inaccuracies in both air quality and meteorological prediction, since even a very small number of underpredictions will limit the success of the MCS. With a 244 m stack and control thresholds set at 80% of the assumed 3- and 24-hour guidelines, fuel-switching to 0.21% sulfur coal would be required about 195 hours during the 4-month winter period. The use of this more restrictive set of control guidelines is recommended at least during initial MCS operation as a measure to compensate for forecast uncertainties.

An additional means for improving air quality and meteorological forecasts for an MCS at the Hat Creek Plant would be provided by commencing system operation at the same time as startup for the first 500 Mw generating unit. The construction schedule calls for staggered installation with one new unit called into service each year. This provides an important advantage in that the relationships between plant emissions, meteorological conditions, and ambient air quality can be studied and forecasting procedures refined for several years before emissions reach the levels assumed in this analysis.

C5.6 MCS RELIABILITY

As noted in the previous section, incorporation of certain design features in the MCS program for the Hat Creek Plant will substantially improve the reliability of meteorological and air quality predictions, thereby minimizing the number of system failures, i.e., excursions of applicable ambient guidelines. These may be summarized as follows.

1. For fuel-switch mode, the control guidelines should be set at 80% of the assumed 3-hour and 24-hour regulatory guidelines to compensate for errors incurred due to forecast lead-time requirements.

2. MCS operation should commence concurrently with startup of the first 500 Mw generating unit to develop of skill in recognizing adverse dispersion conditions, to tailor the air quality forecast model, and to streamline system operations during the period when total emissions are substantially below those assumed in this analysis.

3. Conservative forecasting methods should be used, especially during the early phases of the MCS. It is estimated that control actions will be necessary about 25% to 50% more frequently than indicated by the modeling results to compensate for the difficulty in predicting certain meteorological events associated with relatively high ground-level concentrations.

4. Staffing for the MCS should include provision for continuous forecasting service by professional meteorologists. This is especially important during the months when fuel switching is the preferred control action, due to the large forecast lead-time requirement imposed by this emission reduction technique. Periodic updating and refinement of the meteorological forecasts is particularly helpful for improving 24-hour concentration estimates.

5. All aspects of the MCS program should be routinely evaluated to identify problems and suggest methods to improve reliability of site-specific meteorological forecasting and air quality predictions, and to enhance understanding of the effects of control actions on ambient concentration levels.

6. The facility design should include a stack with a height of 244 m (800 ft) or greater to protect against plume impacts on elevated terrain, and to avoid high ambient levels associated with 'special' meteorological events (see Section C4.3).

If these features are included in the design and operation of the MCS, it is reasonable to expect excellent reliability, i.e., few if any SO_2 concentrations greater than the assumed guideline criteria.

An example of reliability for an operational MCS serves to illustrate the improvement of air quality control with accumulated experience. Since the summer of 1974, ERT has operated a system for a major chemical manufacturer in the midwestern United States. The program is intended to provide the chemical company with recommended plant operating conditions (emissions) for maintenance of Federal 3-hour and 24-hour SO_2 standards on the basis of predicted dispersion conditions.[13]

The manufacturing plant has two separate power houses approximately 2 km apart. Each power house has five boilers. Emissions are exhausted through a total of eight stacks. The MCS procedures are complicated in that 10 boilers can operate at variable loads, and some are capable of operation with different fuels. Control actions are required relatively frequently. During the summer, emission curtailment orders are in effect about 5% of the time, during the spring and fall 10% to 20%, and from 25% to 45% of the time during winter. Table C5-4 documents the performance of the MCS with regard to maintaining SO_2 levels below the 365 $\mu g/m^3$ (0.14 ppm) standard for 24 hours and the 1300 $\mu g/m^3$ (0.5 ppm) standard for three hours. During the 'shakedown' year, the number of excesses dropped dramatically, and continual improvement is evidenced during the ensuing operational years. A similar reduction in measured 3-hour concentrations above the Federal secondary standard (1300 $\mu g/m^3$ or 0.50 ppm) has occurred since implementation of MCS. In 1972, measured maxima above this threshold were recorded on 23 occasions; only one such value occurred in each of the years 1975, 1976, and 1977.

Considerable effort has been expended to refine meteorological forecasting for the plant area by systematic verification procedures. Experience with the MCS has identified the specific weather situations that previously resulted in unexpectedly high ground-level concentrations. Three model upgrade studies have been performed since system startup to incorporate realistic methods for simulating these conditions.

In addition, results of physical modeling experiments conducted in a wind tunnel have substantially improved air quality predictions for high wind speed conditions that produce plume downwash from the relatively low stacks. The statistics presented in Table C5-4 demonstrate the effectiveness of such studies in improving system reliability and reflect the accumulation of site-specific operational experience.

Interestingly, forecast verification records have shown that accuracy in forecasting weather parameters for this MCS has been consistently good throughout the program. Thus, the dramatic reduction in air quality violations with MCS is primarily related to an improved ability to simulate dispersion processes associated with particular meteorological events.

TABLE CS-4

PERFORMANCE STATISTICS FOR ERT MCS AT A MAJOR MIDWESTERN CHEMICAL MANUFACTURING PLANT

Standard	Before MCS		MCS 'Shakedown'	Operationl MCS		
	1972	1973	1974	1975	1976	1977
3-hour secondary (1300 $\mu g/m^3$ or 0.5 ppm)	23	8	7	1	1	1
24-hour primary (365 $\mu g/m^3$ or 0.14 ppm)	22	11	6	2	1	0

6. CONCENTRATIONS OF SO_2 WITH FGD

The HCM was used with appropriate emission parameters to calculate ground-level SO_2 concentrations corresponding to operation of the Hat Creek Plant with the FGD system described in Section C3.4. This system involves wet scrubbing with limestone reagent to clean part of the flue gas stream, achieving a 54% overall sulfur removal efficiency. Reheat is accomplished by remixing the scrubbed and unscrubbed gases to enhance stack plume buoyancy. To achieve full availability, redundant absorber units will be installed for backup use. For this analysis, continuous full-load operation of the generating station and 100% scrubber availability were assumed. Emission characteristics corresponding to this system are presented in Table C3-1. A stack height of 366 m (1200 ft) was assumed.

Maximum predicted ground-level concentrations for averaging times of 3 hours, 24 hours, and 1 year are 366, 208, and 4 $\mu g/m^3$, respectively. Background SO_2 concentrations in the vicinity of the proposed Hat Creek Project were considered to be near zero for all averaging periods.

The maximum annual average concentration for the partial scrubbing configuration is 4 $\mu g/m^3$. This value is negligible in comparison with any applicable Provincial Guideline. The peak 24-hour concentration prediction is 208 $\mu g/m^3$, 52 $\mu g/m^3$ below the assumed criterion. The highest expected 3-hour concentration during the year is 366 $\mu g/m^3$.

Constant emission control devices such as scrubbers reduce emissions and, consequently, ambient concentrations during all weather conditions, whereas MCS procedures are formulated to require emissions reductions only when the potential exists for poor atmospheric dispersion conditions. In view of the results presented for uncontrolled emissions in Section C4.0, it is apparent that with the 366 m stack height, scrubber outages would only infrequently result in ambient levels above the assumed guidelines. However, if FGD malfunctions occur randomly with respect to the weather, it must be assumed that some occasional violations are to be expected. The provision for back-up absorbers on each generating unit will reduce the frequency of such events, but probably will not eliminate them completely. On the other hand, normal FGD operation will improve air quality substantially over that associated with uncontrolled emissions.

For the ambient guidelines assumed in this analysis, the role of the FGD with a 366 m (1200 ft) stack is limited to the prevention of a small number of potential violations during the year. The results presented here strongly suggest that if an FGD system is chosen, a shorter stack might be acceptable. It is probable that ambient air quality could be maintained with a 244 m (800 ft) stack if: (1) the scrubber design is modified to provide cleaning of a larger part of the flue gas; or (2) the scrubber system described here is used in conjunction with back-up MCS procedures.

C7.0 COMPARISONS OF MCS AND FGD

The preceding sections have discussed the capabilities of selected air quality control methods for calculated ground-level concentrations. While the effectiveness of a given system is properly evaluated for such criteria, other important factors must be considered in the comparison of those programs able to meet a given set of control objectives. For each such strategy these factors include:

1) technical feasibility and reliability
2) capital and operating costs
3) energy expenditures
4) availability of required raw materials
5) environmental degradation potential

The following sections provide comparative information for the two basic types of SO_2 control systems considered in this analysis - MCS and FGD.

C7.1 OPERATION CONSTRAINTS

It is important that the Hat Creek Plant be capable of providing uninterrupted service as required by future load demands. While electrical generation requirements may change from those presently anticipated, B.C. Hydro will benefit from the selection of an air quality control program that allows operational flexibility, with minimum reliance on variable external factors such as atmospheric dispersion conditions. A successful SO_2 control system will incorporate features to compensate for meteorological variability. To accomplish the parallel goals of acceptable air quality and operational freedom, it is essential that the strategy selected be highly reliable and of a proven, commercially available type.

MCS reliability was discussed in Section C5.6. By its nature, an MCS is an active as well as reactive control system and, properly managed, can operate continously except for failure of aerometric monitoring and/or communications equipment. Due to the remoteness of the project area, the design of an MCS for the proposed facility must make special provisions for system maintenance and backup instrumentation.

Otherwise the reliability of an MCS depends mainly on the degree of conservatism in its use and the skill of its operators. Operational history at other facilities indicates that air quality prediction accuracy improves with time after program initiation. Thus, the frequencies of unnecessary control actions and of unanticipated air quality excursions are both diminished by accumulated experience with the program. The construction and startup schedule for the project includes a planned increase of generating capacity from 500 to 2000 Mw over a 3-year period. The plan for a gradual increase to the emission levels assumed in this study offers an excellent opportunity to gain experience during the interval when the air quality consequences of operational mistakes will be less serious. It is highly recommended that any MCS program be operated from the onset of electric power generation. Such a system, conscientiously operated with routine evaluation and improvement, should be capable of extremely high reliability for the 2000 Mw plant.

Flue gas desulfurization is as yet a developing technology. Scrubbers of the type described in this report have been operated effectively at other coal-fired generating plants. Technical problems are common during the initial operating phase, but can be overcome with intense manpower and economic commitments.[14] The opportunity to gain operational experience while individual 500 Mw units at the Hat Creek Project are gradually brought into service is again an important assurance for successful air quality control with the completed facility. Reliability will also be achieved by means of equipment redundancy, since any individual scrubber unit will have an availability considerably below 100% during the lifetime of the plant. FGD downtime is independent of meteorological conditions; thus, failures occurring in all or part of the scrubber system could eventually lead to high ambient SO_2 concentrations. In addition, load variations and associated scrubber inefficiencies add to the potential for ambient air quality violations during startup and shutdown periods. However, as noted in Section C6.0, modeling results indicate that an FGD system used with a 366 m stack will limit the frequency of such events to a very small number per year.

The reliability of an FGD system or MCS also depends on the technical and commercial feasibility of the program. An MCS must be tailored to account for site-specific terrain, meteorology, and plant load scheduling. Operation of this type of emission control program requires more effort in certain locations, e.g., areas with complex topography or where weather systems associated with high ambient concentrations are difficult to forecast. Similarly, technical problems are to be expected with installation of scrubbers at a given facility. FGD operation for the proposed project will necessarily involve special 'custom-fitting' to accomodate the particular qualities (high ash and moisture, low sulfur, and heating value) of the Hat Creek coal.

C7.2 ECONOMICS

An MCS can be designed to prevent 3-hour and 24-hour SO_2 concentrations from exceeding the respective air quality criteria. On the other hand, an FGD system with full flue gas scrubbing is expected to maintain SO_2 concentrations at levels well below the air quality criteria continuously. A consideration of the costs of MCS versus FGD is useful to assess the overall differences between the two control strategies.

Table C7-1 lists estimated total MCS capitalized owning and operating costs. They include the necessary lower-sulfur coal storage and equipment costs and annual charges for operation, maintenance, and electric power based on the firing of lower-sulfur coal for approximately 195 hours per year (366 m stack, 80% control guidelines). The expected costs also include those for the MCS itself, including the necessary air quality and meteorological instrumentation, as well as the meteorological/air quality forecasting and analysis services.

The MCS cost figures in Table C7-1 for the generating station have been supplied by Ebasco.[14] MCS implementation would require a stockpile of lower-sulfur coal that would have to be separately mined and segregated from the normal blended coal feed. Otherwise, the MCS needs no raw materials and has no significant energy consumption.

Table C7-2 summarizes the economics and energy consumption of FGD for the Hat Creek Project. All the costs were obtained from Ebasco.[14] The values listed in the tables show that capitalized costs for FGD systems are about 37 times higher than for an MCS. Obviously from an economic point of view, installation and operation of an FGD system is a major undertaking. A significant part of the cost is the energy needed to operate the system. Approximately 2% of the energy produced by the plant would be consumed to support partial scrubbing. This does not include the energy costs of reagent procurement and transport or of sludge disposal.

Cost effectiveness of MCS and FGD may be examined from the standpoint of dollars per incremental reduction in maximum SO_2 concentrations for various averaging times. Table C7-3 lists the highest predicted annual, 24-hour, and 3-hour SO_2 concentrations for uncontrolled (coal blending) emissions with both a 244 m and a 366 m stack, for an MCS with a 244 m stack, and for FGD with a 366 m stack.

An MCS will reduce the maximum annual average SO_2 concentration by 2 $\mu g/m^3$ for about $9 million, while FGD will provide a 4 $\mu g/m^3$ reduction for approximately $341 million. Similarly, the MCS is predicted to lower the highest 24-hour level by 255 $\mu g/m^3$, the FGD by 200 $\mu g/m^3$. Corresponding reductions of maximum predicted 3-hour concentrations are 174 $\mu g/m^3$ and 383 $\mu g/m^3$, respectively. Thus, in terms of expenditures per incremental air quality improvement, the FGD system is about 19 times more expensive than MCS for reducing the maximum annual average, 48 times costlier for reducing the peak 24-hour average, and 17 times higher in cost per unit reduction of the 3-hour average concentration.

TABLE C7-1

ECONOMICS FOR IMPLEMENTATION OF AN MCS

1977 Capital Cost of Coal Handling Equipment	$ 2,000,000
Inflated to 1984 dollars @ 1.46 factor	2,920,000
1984 Capital Cost of Monitoring Equipment	2,450,000
Total Capitalized Cost	$ 5,370,000
Annual Capitalized Cost @ 3% of Capital Cost	$ 88,000
Operating Cost of Monitoring Equipment	500,000
Total Capitalized and Operating Cost Per Year	$ 1,404,000
Total Capitalized Owning and Operating Cost	$ 9,236,000

- For the overall emissions burden of SO_2, FGD systems would result in the lowest annual emissions. There is considerable uncertainty in quantifying costs associated with the effects of SO_2 emissions on the environment, especially if the ambient concentrations are below reported thresholds of significance. The long-range transport of sulfur oxides and the subsequent potential for subtle effects on the environment are potentially important considerations, but very difficult to evaluate in the context of economic analysis. Thus, the benefits (if any) resulting from continuously reduced emissions cannot be readily calculated in the Hat Creek Project case.

  On the other hand, the long-term environmental effects of sludge disposal are potentially adverse. In particular, an FGD system would result in a heavier particulate burden to the atmosphere, since fugitive emissions from the spent slurry and from storage and transfer of limestone may adversely affect local air quality. Since the SO_2 levels that would result from the Hat Creek Project with the operation of an MCS are below those levels that are considered necessary for the protection of human health and welfare (see Appendix G, Epidemiology) it appears that an MCS is an acceptable, cost effective, and preferable way to maintain air quality below ambient guidelines assumed in this study.

TABLE C7-2

ECONOMICS FOR IMPLEMENTATION OF A PARTIAL FGD*

Total Investment Costs	$252,540,000
Annual Owning and Operating Costs	
Fixed Charge on Investment at 0.152 Fixed Charge Rate	38,386,000
Capacity and Replacement Energy Charge	4,056,497
Water Consumption	506,000
Reagent Consumption	1,172,000
Operating Labor Costs	2,236,000
Maintenance Material and Labor	5,523,000
Total Owning and Operating Costs	$ 51,829,497
Total Capitalized Owning and Operating Costs	$340,983,533

*Designed for 54% sulfur removal.

TABLE C7-3

PREDICTED MAXIMUM SO_2 CONCENTRATIONS ($\mu g/m^3$) FOR SELECTED EMISSION CONFIGURATIONS

	Annual	24-Hour	3-Hour
Uncontrolled base plant With 244m Stack	9.1	515	829
Uncontrolled Base Plant With 366m Stack	8	408	749
MCS with 244m Stack	7.1	260	655
Partial FGD with 366m Stack	4.1	208	366

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ADDENDUM A
DESCRIPTION OF ERT DYNAMIC EMISSION CONTROL ANALYSIS (DECA) PROGRAM

ADDENDUM A

(A) 1.0 DESCRIPTION OF ERT DYNAMIC EMISSION CONTROL ANALYSIS (DECA) PROGRAM

This addendum describes the ERT computer program DECA (Dynamic Emission Control Analysis), which was used to assess the feasibility of a meteorological control system (MCS) in the Hat Creek area. Each DECA application simulates a series of alternative two-fuel MCS strategies corresponding to the various combinations of candidate source primary fuel and control threshold specified by the user. For simplicity, the model description presented here demonstrates the analysis procedures for a single such MCS. It is assumed for purposes of this discussion that ambient standards for 1-, 3-, and 24-hour periods are in effect, although only the 3-hour and 24-hour switching thresholds were considered in this study.

Sequential hourly centerline concentrations attributable to switching units of the candidate source and concurrent background values are read for each 24-hour period of the data record. For each hour of the day, the program scans downwind receptors to determine the minimum value of $P^*(j)$, that is, the fuel sulfur content of the switching source that just results in a total concentration (switching source plus background contributions) equal to the one hour threshold at the j^{th} receptor. This quantity may be computed on the premise that concentrations due to the switching source vary in direct proportion to its emissions. $P^*(j)$ is thus defined by the relationship

$$C(j) \times \frac{P^*(j)}{P_{Nom}} + C_B(j) = rC_s \qquad (A-1)$$

where:

$C(j)$ is the SO_2 concentration due to switching units at j^{th} receptor;

P_{Nom} is the fuel sulfur content for switching units assumed in the HCM calculations;

$C_b(j)$ is the background SO_2 concentrations at j^{th} receptor;

r is the fraction of hourly standard specified as the threshold concentration for initiation of a switch

C_s is the applicable hourly ambient SO_2 standard

The primary (high sulfur) fuel content P_H is compared with the minimum P^* (j) for each hour. If $P^* (j)_{min} \geq P_H$, no switch is necessary, and the value of C (j) is multiplied by P_H/P_{Nom}. If $P^* (j)_{min} > P_H$, a switch to the secondary fuel P_L is required to avoid an excess of the threshold concentration at one or more receptors. The values of C(j) are then scaled by $P_L/P_{Nom.}$ If $P^* (j)_{min} < P_L$, the switch to the secondary fuel will not prevent the excess(es) for this hour. For such cases, the values of C(j) are scaled to simulate a switch to P_L, but the resulting violations are recorded.

Centerline (peak) concentrations due to source emissions are considered appropriate for evaluation of compliance with 1-hour average objectives. However, since wind direction inputs for each hour are specified according to 22.5° sectors only, the use of hourly plume centerline peaks to calculate long term averages at specific receptors may introduce unrealistic conservatism in the 3-hour and 24-hour analyses. A more appropriate hourly value for use in determining mean values for these time periods in some suitable average value expected to occur at the receptor over an hour. If a uniform distribution of pollutant mass contained in the portion of a Gaussian profile confined to a 22.5° sector is assumed, the expression for this hourly average concentration $\overline{C}(j)$ is given by:

$$\overline{C}\ (j) = C\ (j)\ \frac{\sqrt{2\pi}\ \sigma_y}{\pi x/8}\ \text{erf}\ \frac{\pi x/16}{\sqrt{2}\ \sigma_y} \qquad \text{(A-2)}$$

where C(j) is the centerline (peak) concentration at downwind distance x, and σ depends upon atmospheric stability. The DECA model incorporates these averaged hourly source contributions for purposes of computing 24-hour concentrations. In addition, since natural wind variability is great for certain weather conditions, namely light wind/stable situations, the user may specify that this sector averaging be employed selectively in forming 3-hour average concentrations.

For each 3-hour period, averages of the $\overline{C}(j)$ and corresponding average background concentrations (considered to be 0 in this study) are calculated. Values of P* (j) for each 3-hour period are then determined by an expression analogous to Equation A-1. For multiple-hour averaging periods, however, the term corresponding to P_{Nom} in Equation 1 must be adjusted to reflect scaling of the hourly concentrations as discussed below.

Assume that the 3-hour average contribution of the switching source may be expressed as follows:

$$\overline{C}_3\ (j) = \overline{M}_3\ (j) \cdot \overline{P}_3\ (j) \qquad \text{(A-3)}$$

where P_i is either P_H or P_L as determined in the hourly analysis.

$\overline{P}_3$, the 3-hour equivalent fuel sulfur content, may thus be written

$$\overline{P}_3\ (j) = \frac{\sum_{i=1}^{3} C_i\ (j)}{\sum_{i=1}^{3} \frac{C_i\ (j)}{P_i}} \qquad \text{(A-4)}$$

This quality corresponds to P_{Nom} in Equation 1.

Three-hour values of $P^*\ (j)_{min}$ are compared with P_H and P_L to determine whether fuel-switching is required to maintain total concentrations below the corresponding threshold value. If a switch to P_L is necessary, it is assumed to take effect for the full three hours. If use of the secondary fuel during this period does not prevent an excess of the applicable 3-hour threshold, this fact is noted and recorded.

Daily average concentrations due to the switching source $\overline{C}_{24}$ (j) are calculated from the 3-hour averages. Twenty-four hour average background values (considered to be 0 in this study) are computed for each receptor. The 24-hour P* (j) are computed similarly to the 3-hour values, using

$$\overline{P}_{24}(j) = \frac{\sum_{i=1}^{24} C_i(j)}{\sum_{i=1}^{24} \frac{C_i(j)}{P_i}}$$

It is obviously desirable to minimize the number of physical switches required during the analysis period. Thus, if further switching is necessary to achieve the daily threshold, the program checks to see whether the previous daily period ended with use of the secondary fuel. If so, additional hour-by-hour switches proceeding from the beginning of the day under investigation are required. If the previous day did not end in switch mode, any hourly adjustments to achieve the daily threshold are assumed to proceed in backward steps from the 24^{th} hour of the present day.

After a daily record of input data has been analyzed in terms of compliance with the 1-, 3-, and 24-hour thresholds, the constraints of minimum switch length and interval are imposed before each completed switch is categorized by length and added to the total number of hours of secondary fuel use. Tables summarizing the required SCS operational procedures are generated for each year of the analysis period. Total annual average concentrations as well as the contribution of the switching source to the average values are calculated to document the performance of the SCS in terms of the annual SO_2 standard.

ADDENDUM B

(B)1.0 DETAILED RESULTS OF AIR QUALITY MODELING STUDIES FOR ALTERNATE SO_2 CONTROL STRATEGIES

(B)1.1 INTRODUCTION

This Addendum consists of pictorial representations of the results of air quality modeling studies performed to estimate air quality effects of the proposed Hat Creek Project. This form of presentation is designed primarily to provide information for use in evaluating potential impacts of plant emissions on vegetation, wildlife, recreational facilities, and population centers in the project area. Results for both the local (within 25 km) and regional (between 25 and 100 km) are presented.

Two types of figures are provided: (1) isopleths of annual and seasonal average contaminant concentrations; and (2) isopleths representing percent frequencies of predicted short-term concentrations above pre-specified thresholds. Figures of the latter type were prepared for averaging times of 1-, 3-, 8-, and 24-hour averaging periods.

Local modeling results are presented separately for the three air quality control systems considered in the simulations: FGD (366 m stack); MCS with a 366 m stack; and MCS with a 244 m stack.

With the exception of the annual average concentration isopleths, all results are presented for SO_2. Seasonal average concentration estimates for other contaminants may be estimated by scaling the plotted SO_2 values by emission factors provided in Table (B)-1. Similarly, the frequencies corresponding to predicted short-term excesses of various SO_2 thresholds may be interpreted to represent the frequencies of exceeding thresholds for other contaminants, as calculated by multiplying the SO_2 values by the emission ratios.

TABLE (B)-1

DESCRIPTION OF AIR QUALITY MODEL RESULTS

Figure No.	Study Area	Figure Type[1]	Control Strategy[2]	Stack Height (m)	Averaging Time	Contaminant	Threshold ($\mu g/m^3$)[3]	Emission Factor Type[4]
(B)-1	Local	Conc.	FGD	366	Annual	SO_2		A
(B)-2	Local	Conc.	FGD	366	Winter	SO_2		A
(B)-3	Local	Conc.	FGD	366	Spring	SO_2		A
(B)-4	Local	Conc.	FGD	366	Summer	SO_2		A
(B)-5	Local	Conc.	FGD	366	Fall	SO_2		A
(B)-6	Local	Freq.	FGD	366	1-hr	SO_2	100	A
(B)-7	Local	Freq.	FGD	366	1-hr	SO_2	225	A
(B)-8	Local	Freq.	FGD	366	1-hr	SO_2	450	A
(B)-9	Local	Freq.	FGD	366	3-hr	SO_2	150	A
(B)-10	Local	Freq.	FGD	366	3-hr	SO_2	300	A
(B)-11	Local	Freq.	FGD	366	8-hr	SO_2	150	A
(B)-12	Local	Freq.	FGD	366	8-hr	SO_2	300	A
(B)-13	Local	Freq.	FGD	366	24-hr	SO_2	160	A
(B)-14	Local	Conc.	FGD	366	Annual	NO		
(B)-15	Local	Conc.	FGD	366	Annual	NO_2		
(B)-16	Local	Conc.	FGD	366	Annual	TSP		
(B)-17	Local	Conc.	MCS	366	Annual	SO_2		B
(B)-18	Local	Conc.	MCS	366	Winter	SO_2		B
(B)-19	Local	Conc.	MCS	366	Spring	SO_2		B
(B)-20	Local	Conc.	MCS	366	Summer	SO_2		B
(B)-21	Local	Conc.	MCS	366	Fall	SO_2		B
(B)-22	Local	Freq.	MCS	366	1-hr	SO_2	100	B
(B)-23	Local	Freq.	MCS	366	1-hr	SO_2	225	B
(B)-24	Local	Freq.	MCS	366	1-hr	SO_2	450	B
(B)-25	Local	Freq.	MCS	366	1-hr	SO_2	900	B
(B)-26	Local	Freq.	MCS	366	1-hr	SO_2	1300	B
(B)-27	Local	Freq.	MCS	366	3-hr	SO_2	150	B
(B)-28	Local	Freq.	MCS	366	3-hr	SO_2	300	B
(B)-29	Local	Freq.	MCS	366	8-hr	SO_2	150	B
(B)-30	Local	Freq.	MCS	366	8-hr	SO_2	300	B
(B)-31	Local	Freq.	MCS	366	24-hr	SO_2	160	B
(B)-32	Local	Conc.	MCS	244	Annual	SO_2		B
(B)-33	Local	Conc.	MCS	244	Winter	SO_2		B
(B)-34	Local	Conc.	MCS	244	Spring	SO_2		B
(B)-35	Local	Conc.	MCS	244	Summer	SO_2		B
(B)-36	Local	Conc.	MCS	244	Fall	SO_2		B
(B)-37	Local	Freq.	MCS	244	1-hr	SO_2	100	B
(B)-38	Local	Freq.	MCS	244	1-hr	SO_2	225	B
(B)-39	Local	Freq.	MCS	244	1-hr	SO_2	450	B

TABLE (B)-1 (continued)

Figure No.	Study Area	Figure Type[1]	Control Strategy[2]	Stack Height (m)	Averaging Time	Contaminant	Threshold ($\mu g/m^3$)[3]	Emission Factor Type[4]
(B)-40	Local	Freq.	MCS	244	1-hr	SO_2	900	B
(B)-41	Local	Freq.	MCS	244	1-hr	SO_2	1300	B
(B)-42	Local	Freq.	MCS	244	3-hr	SO_2	150	B
(B)-43	Local	Freq.	MCS	244	3-hr	SO_2	300	B
(B)-44	Local	Freq.	MCS	244	8-hr	SO_2	150	B
(B)-45	Local	Freq.	MCS	244	8-hr	SO_2	300	B
(B)-46	Local	Freq.	MCS	244	24-hr	SO_2	160	B
(B)-47	Regional	Conc.	UNC	366	Annual	SO_2		B
(B)-48	Regional	Dep.	UNC	366	Annual	SO_2		
(B)-49	Regional	Conc.	UNC	366	Winter	SO_2		B
(B)-50	Regional	Dep.	UNC	366	Winter	SO_2		
(B)-51	Regional	Conc.	UNC	366	Spring	SO_2		B
(B)-52	Regional	Dep.	UNC	366	Spring	SO_2		
(B)-53	Regional	Conc.	UNC	366	Summer	SO_2		B
(B)-54	Regional	Dep.	UNC	366	Summer	SO_2		
(B)-55	Regional	Conc.	UNC	366	Fall	SO_2		B
(B)-56	Regional	Dep.	UNC	366	Fall	SO_2		
(B)-57	Regional	Conc.	UNC	366	Annual	$SO_4^=$		
(B)-58	Regional	Dep.	UNC	366	Annual	$SO_4^=$		
(B)-59	Regional	Conc.	UNC	366	Annual	NO_2		
(B)-60	Regional	Dep.	UNC	366	Annual	NO_2		
(B)-61	Regional	Conc.	UNC	366	Annual	NO		
(B)-62	Regional	Dep.	UNC	366	Annual	NO		
(B)-63	Regional	Conc.	UNC	366	Annual	TSP		
(B)-64	Regional	Dep.	UNC	366	Annual	TSP		

[1]Figure Type:

Conc. - Average Ambient Concentration for Corresponding Averaging Time
Dep. - Average Deposition Rate
Freq. - Frequency of Predicted Concentrations Greater than Threshold Value

[2]Control Strategy:

FGD - Flue Gas Desulfurization
MCS - Meteorological Control System
UNC - Uncontrolled Emissions

[3]Threshold:

Concentration ($\mu g/m^3$) corresponding to frequency of excesses.

[4]Emission Factor Type:

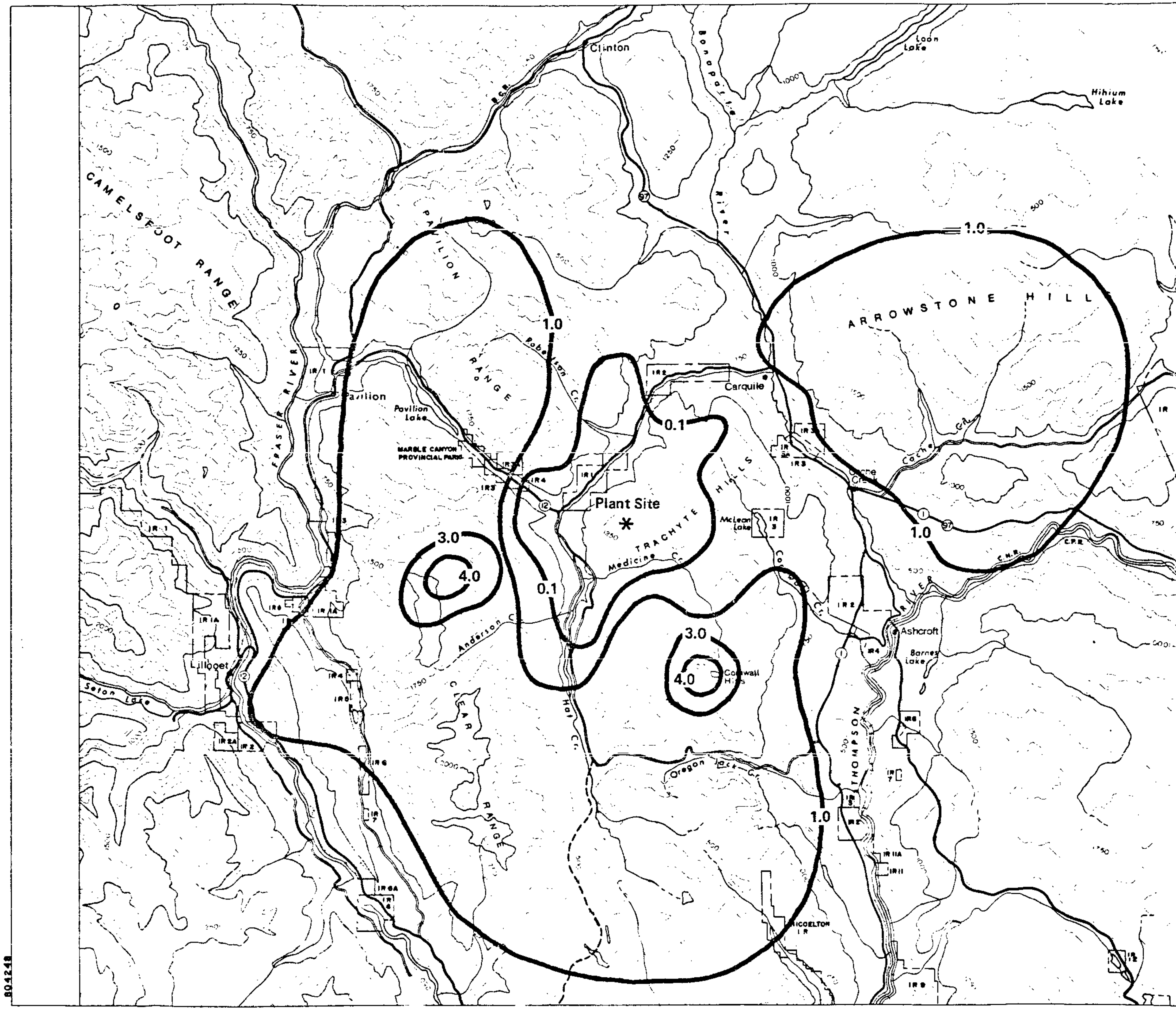
Factors used to estimate concentrations of other contaminants from plotted SO_2 values in the figures.

A - Factors for NO, NO_2, CO, HC, TSP are 0.55, 0.84, 0.12, 0.04, 0.27.

Factors for Fluoride, Lead, Zinc, Cadmium, Mercury, and Arsenic are 0.0017, 0.000017, 0.00002, 0.000001, 0.00004, 0.00013, respectively.

B - Factors for NO, NO_2, CO, HC, TSP are 0.13, 0.61, 0.06, 0.02, 0.12.

Factors for Fluoride, Lead, Zinc, Cadmium, Mercury, and Arsenic are 0.0008, 0.000008, 0.00001, 0.0000005, 0.00002, 0.00007, respectively.



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HYDRO AND POWER AUTHORITY
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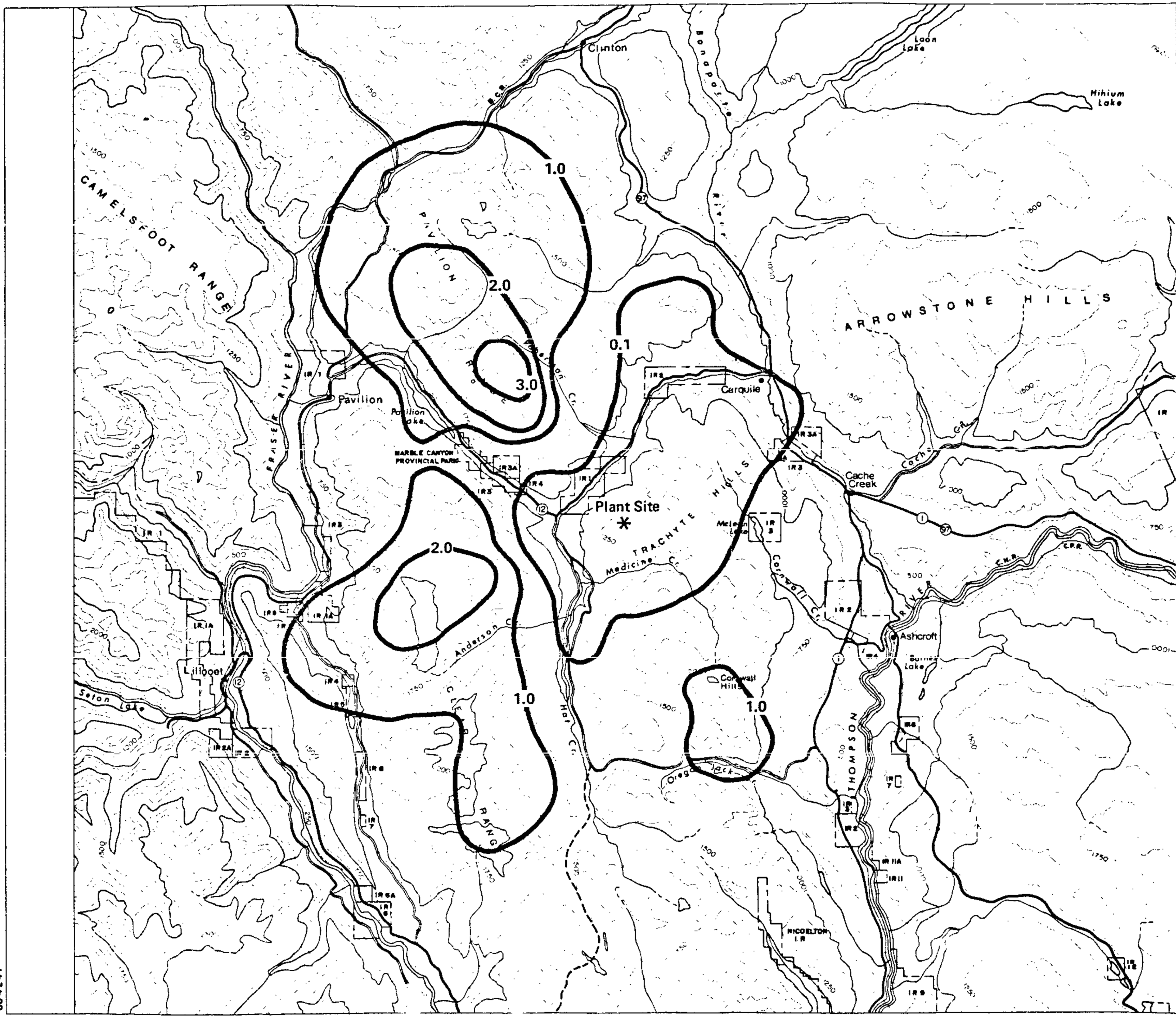
DETAILED ENVIRONMENTAL STUDIES

Figure (B)-1

Predicted Annual Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 366 m Stack with FGD

804248



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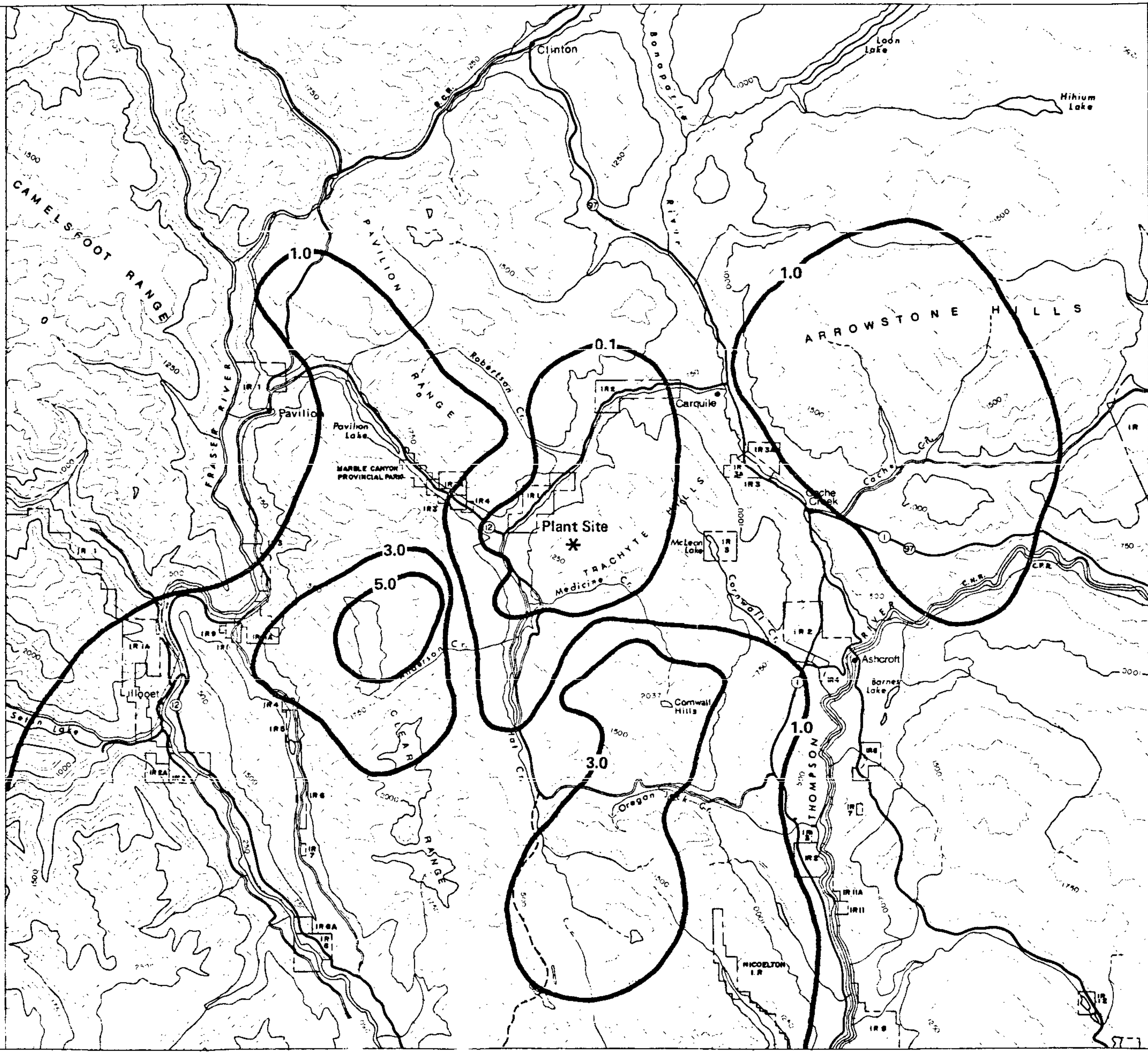
DETAILED ENVIRONMENTAL STUDIES

Figure (B)-2

Predicted Seasonal (Winter) Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 366 m Stack with FGD

804247



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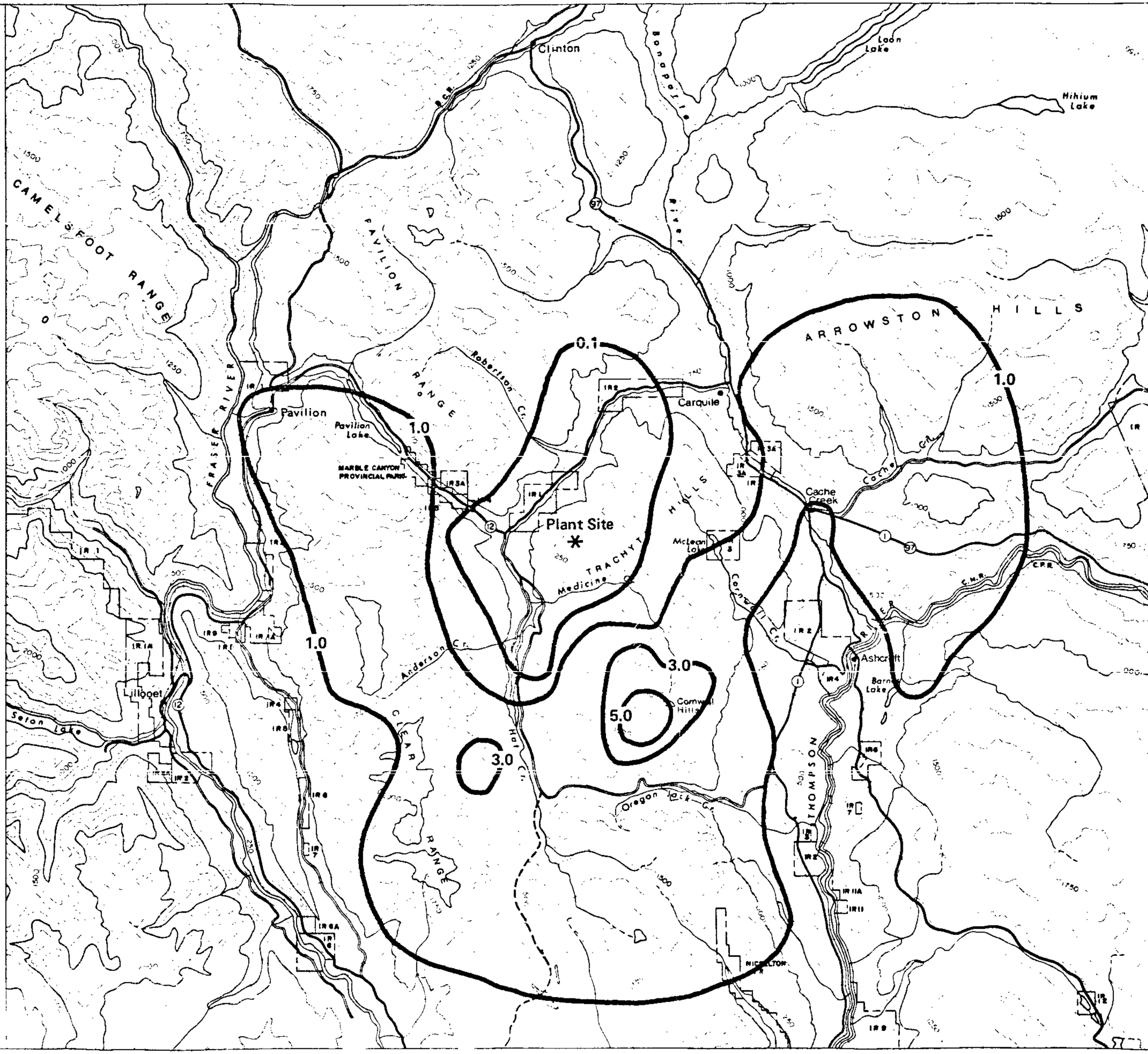
DETAILED ENVIRONMENTAL STUDIES

Figure (B)-3

Predicted Seasonal (Spring) Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 366 m Stack with FGD

804245



BRITISH COLUMBIA
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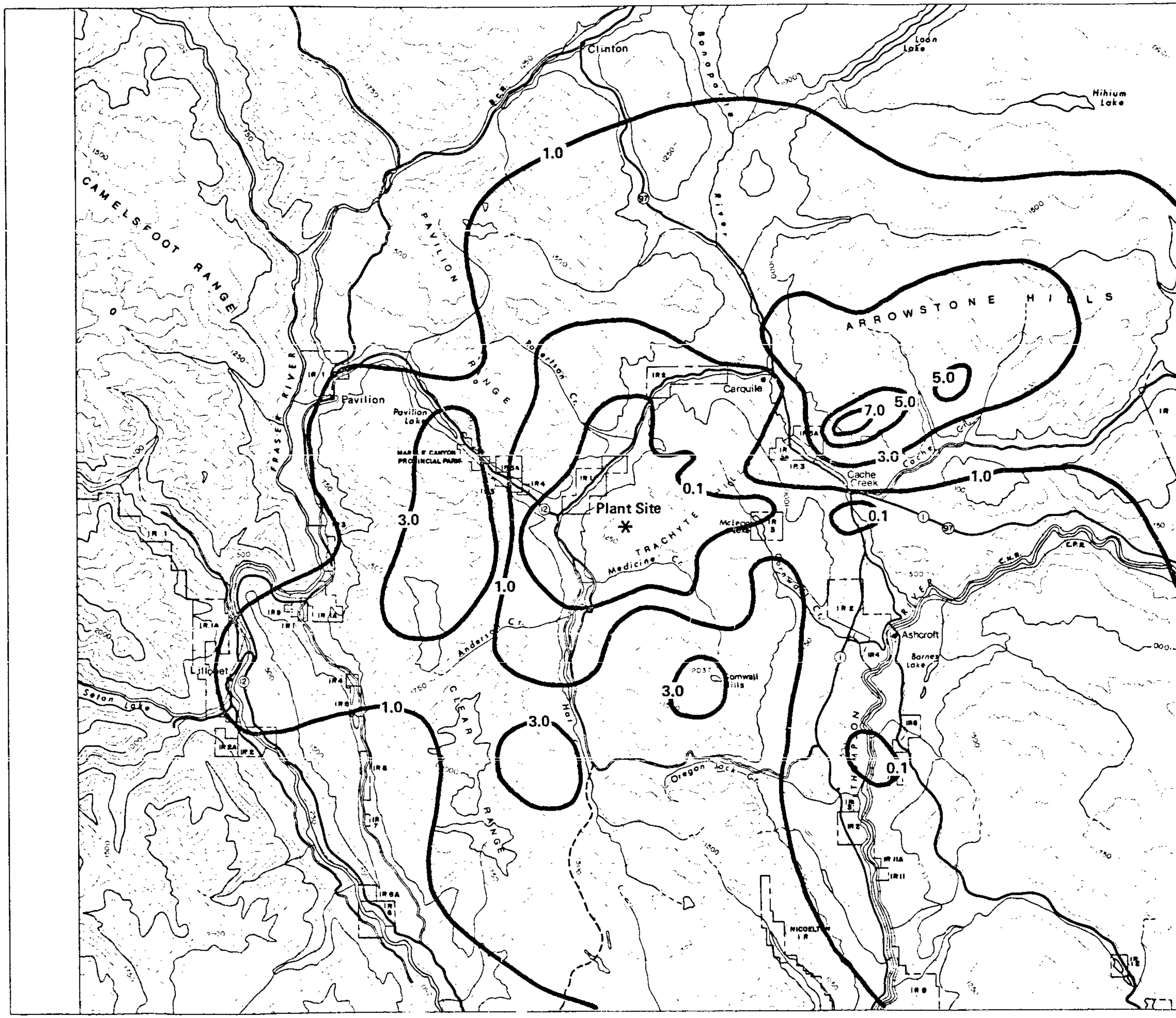
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-4

Predicted Seasonal (Summer) Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 366 m Stack with FGD

804244



SCALE - 1:250,000

Kilometres 5 0 5 10 15

CONTOUR INTERVAL - 250 METRES

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DETAILED ENVIRONMENTAL STUDIES

Figure (B)-5

Predicted Seasonal (Fall) Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 366 m Stack with FGD

604243

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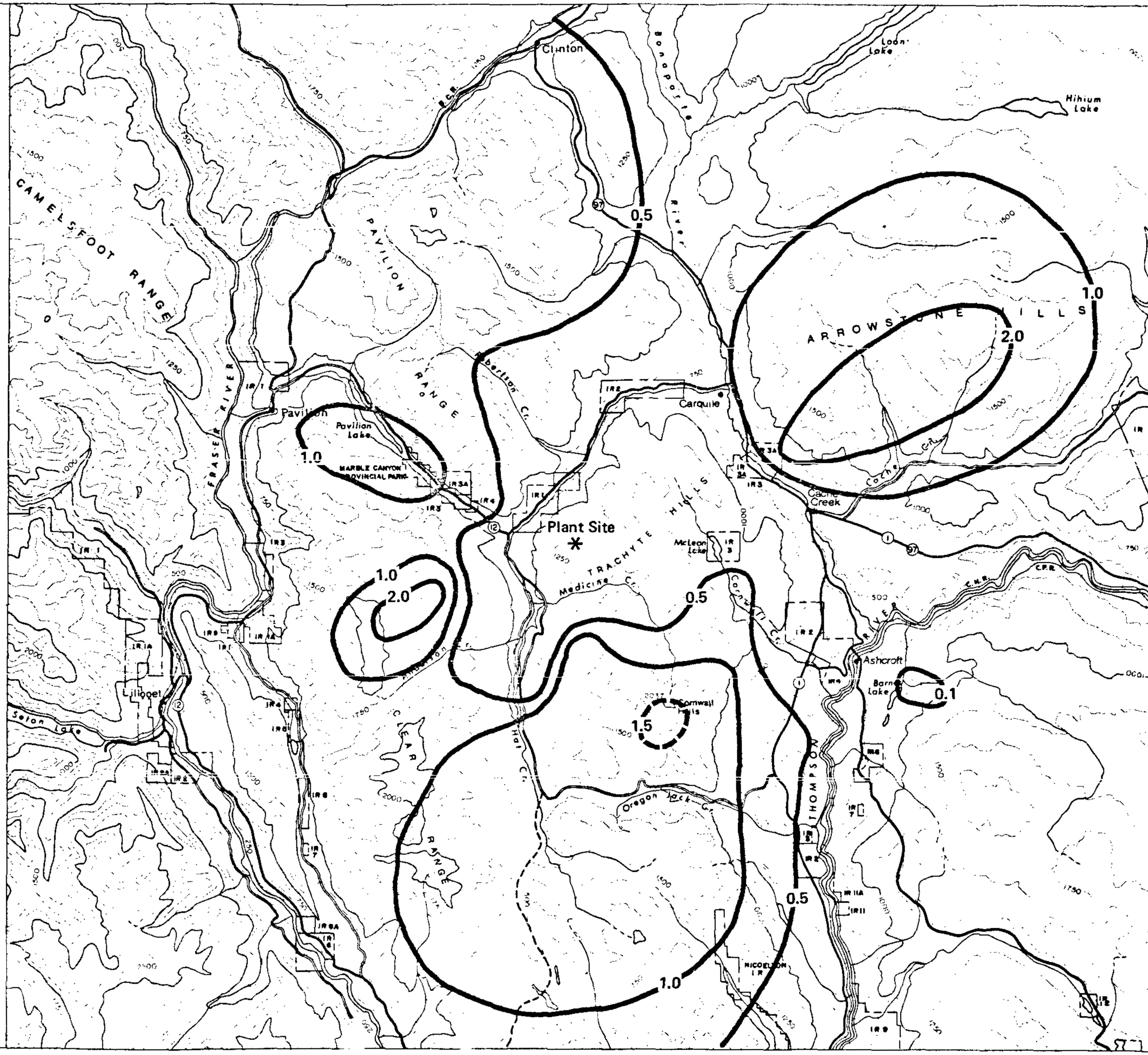

SCALE - 1:250,000

CONTOUR INTERVAL - 250 METRES

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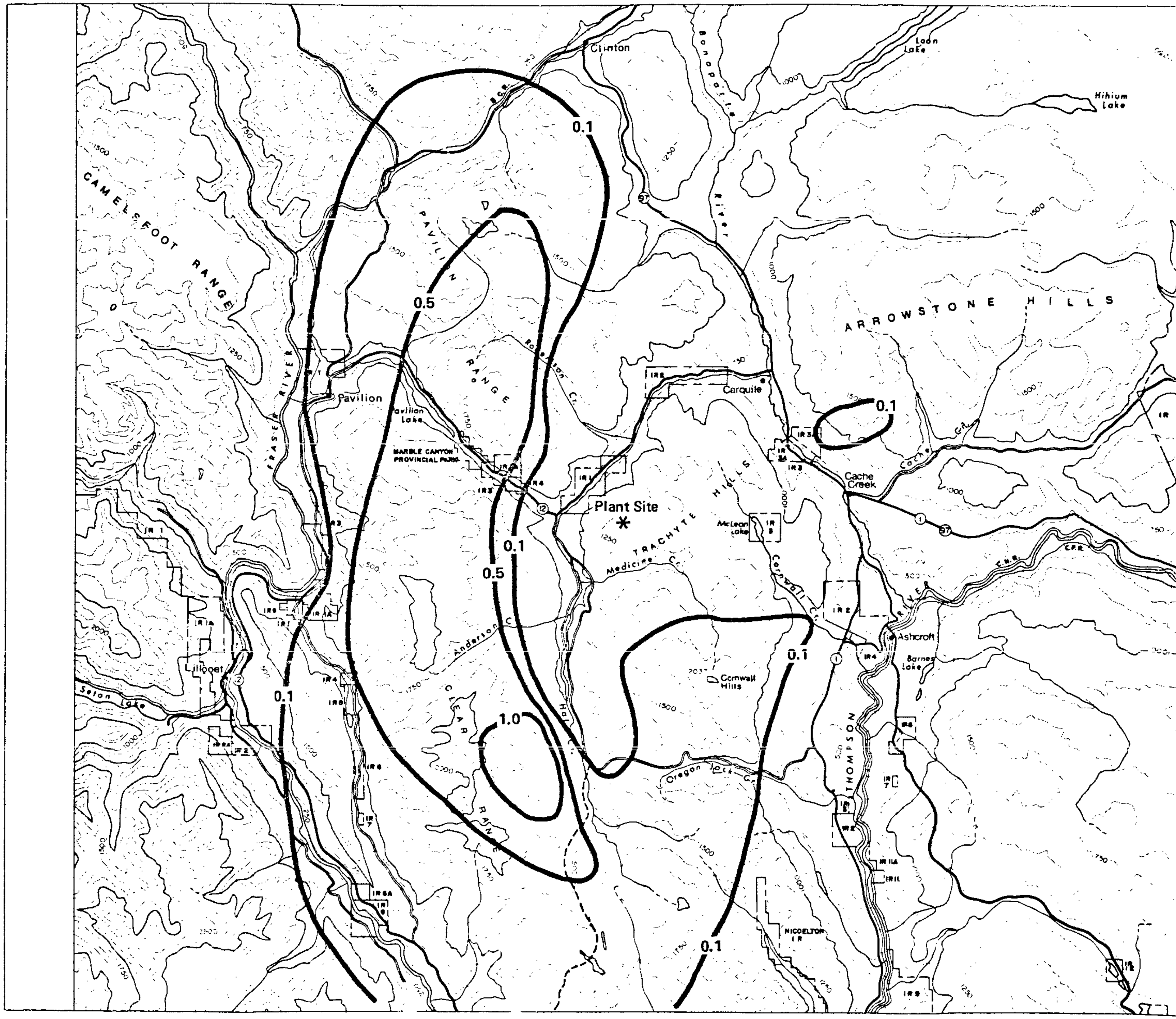
Figure (B)-6

Predicted Frequencies (%) of 1-Hour SO_2 Concentrations Greater than 100 $\mu g/m^3$: 366 m Stack with FGD (Local Scale)

804242



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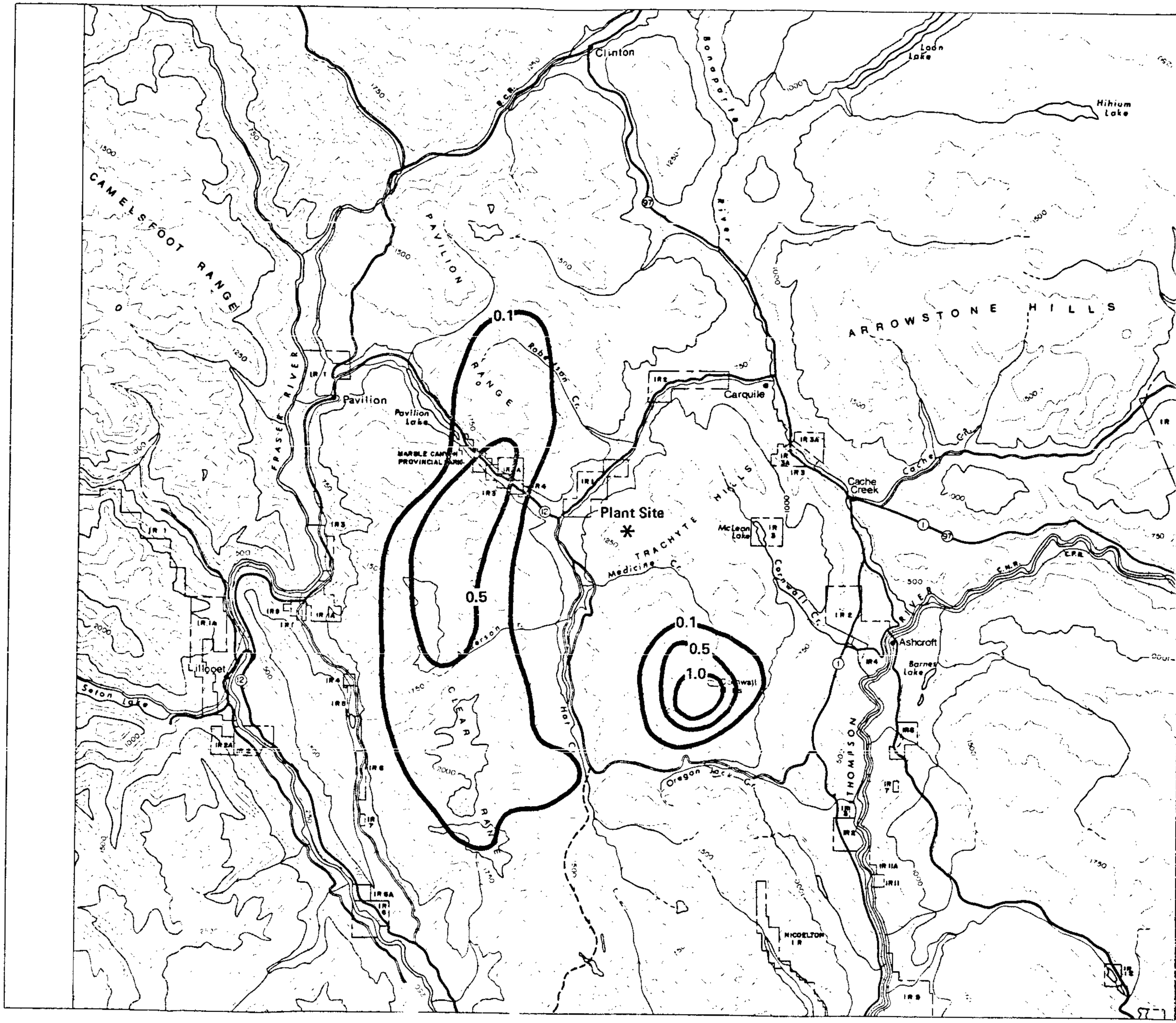
DETAILED ENVIRONMENTAL STUDIES

Figure (B)-7

Predicted Frequencies (%) of 1-Hour SO_2 Concentrations Greater than 225 $\mu g/m^3$: 366 m Stack with FGD (Local Scale)

804241



SCALE - 1:250,000

0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

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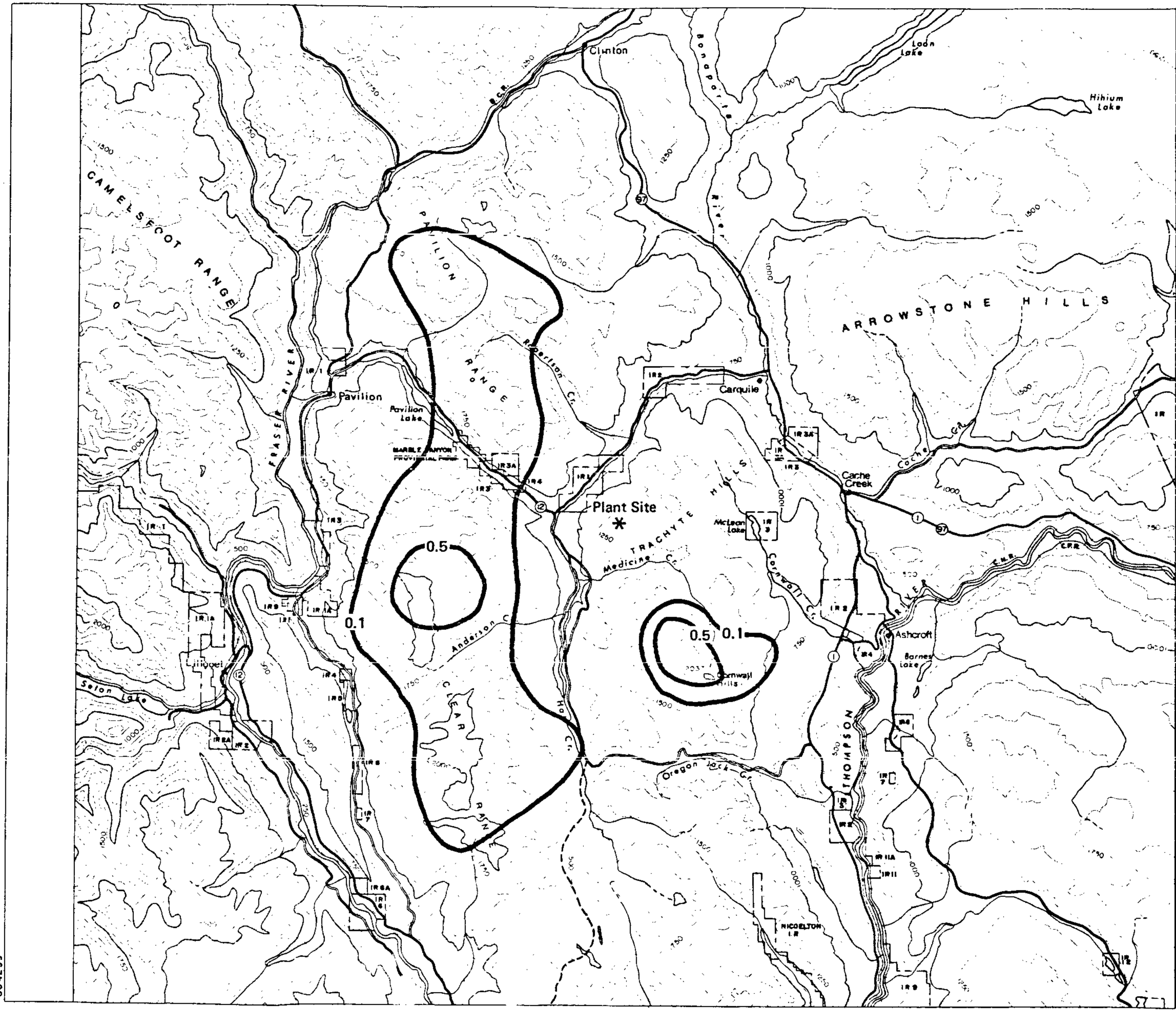
Figure (B)-8

Predicted Frequencies (%) of 1-Hour SO_2 Concentrations Greater than 450 $\mu g/m^3$: 366 m Stack with FGD (Local Scale)

604240



SCALE - 1:250,000

Kilometres

CONTOUR INTERVAL - 250 METRES

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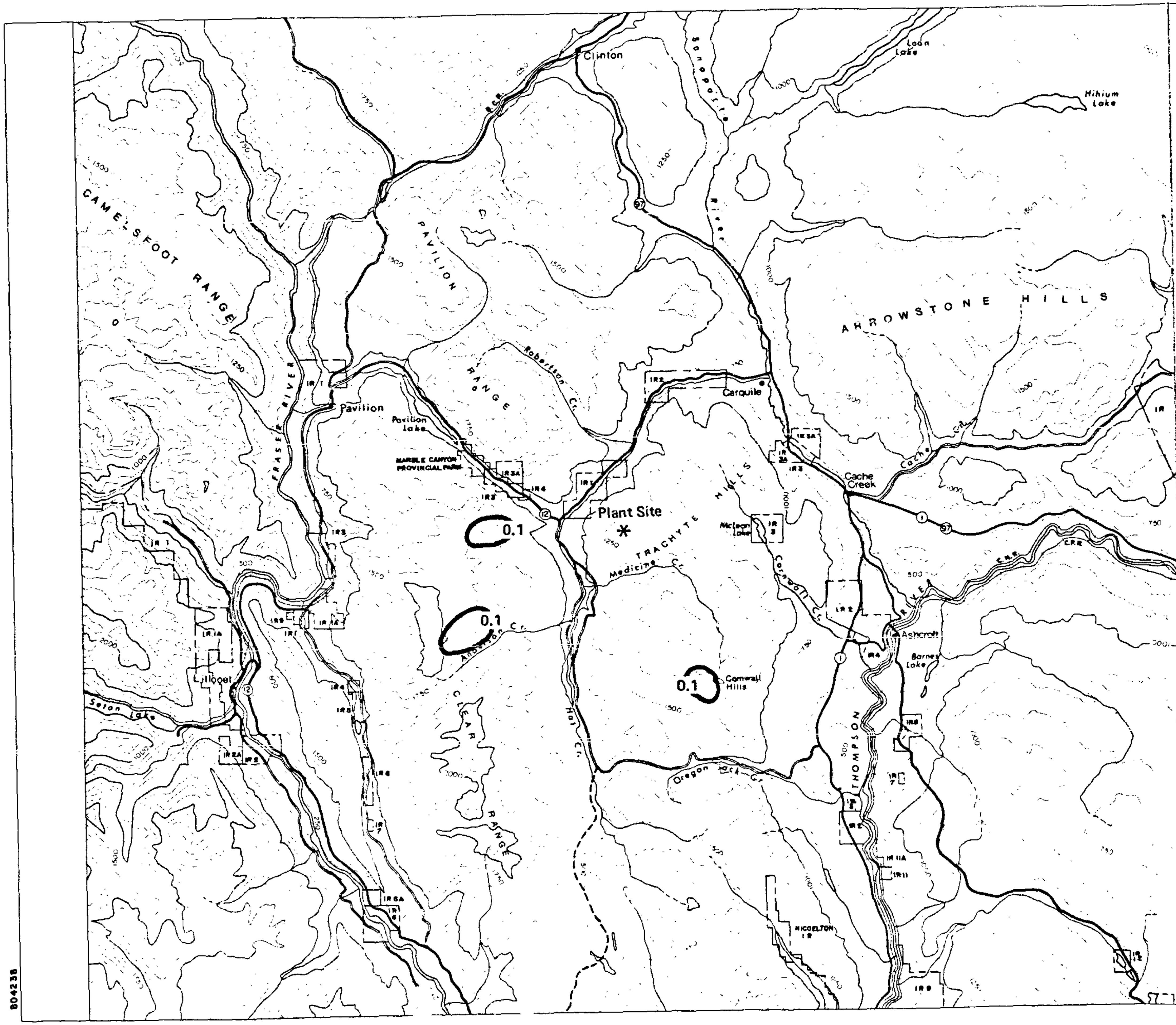
DETAILED ENVIRONMENTAL STUDIES

Figure (B)-9

Predicted Frequencies (%) of 3-Hour SO_2 Concentrations Greater than 150 $\mu g/m^3$: 366 m Stack with FGD (Local Scale)

804239



SCALE - 1:250,000

0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

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Figure (B)-10

Predicted Frequencies (%) of 3-Hour SO_2 Concentrations Greater than 300 $\mu g/m^3$: 366 m Stack with FGD (Local Scale)

804238

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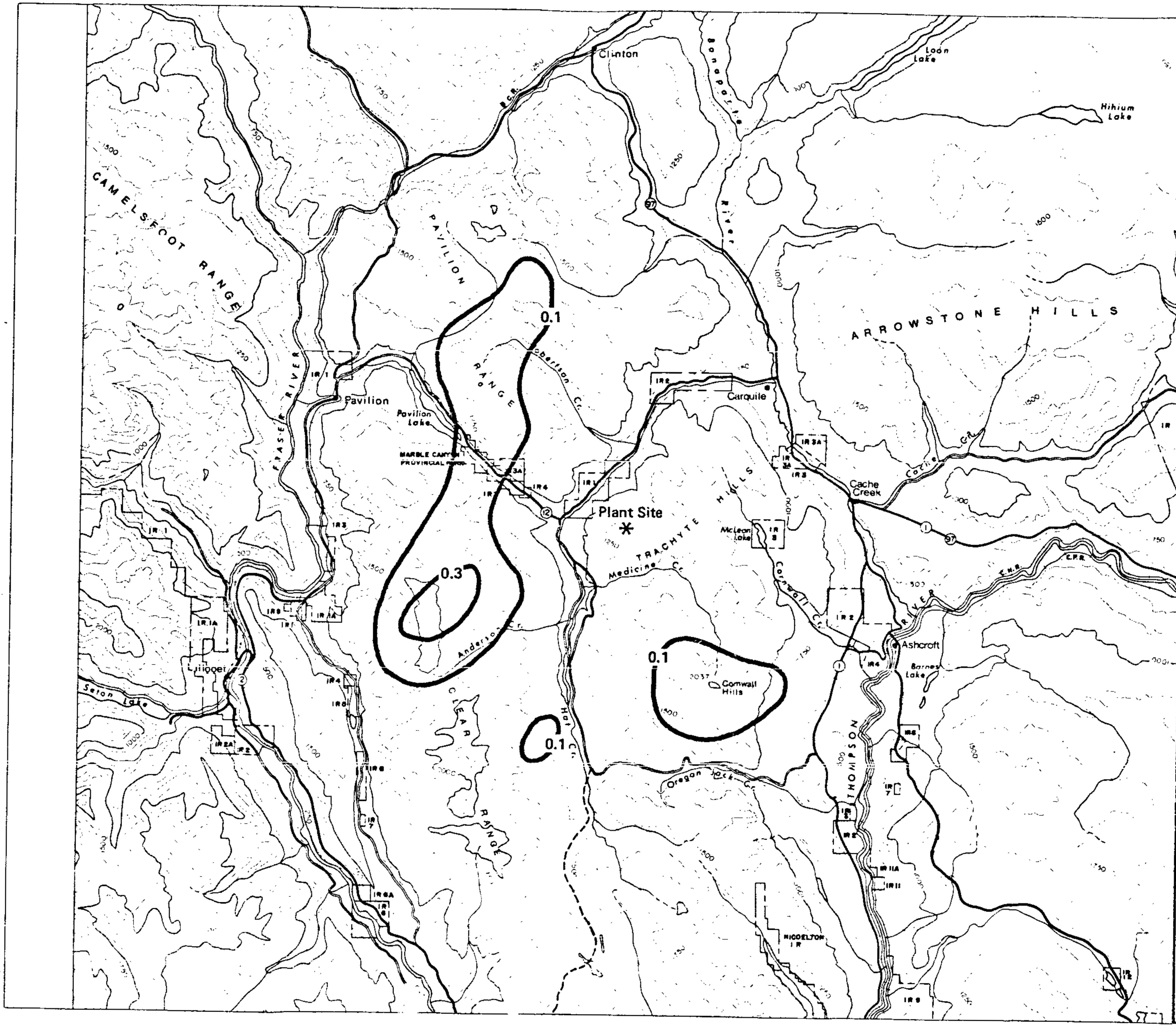

SCALE - 1:250,000

0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

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DETAILED ENVIRONMENTAL STUDIES

Figure (B)-11

Predicted Frequencies (%) of 8-Hour SO_2 Concentrations Greater than 150 $\mu g/m^3$: 366 m Stack with FGD (Local Scale)

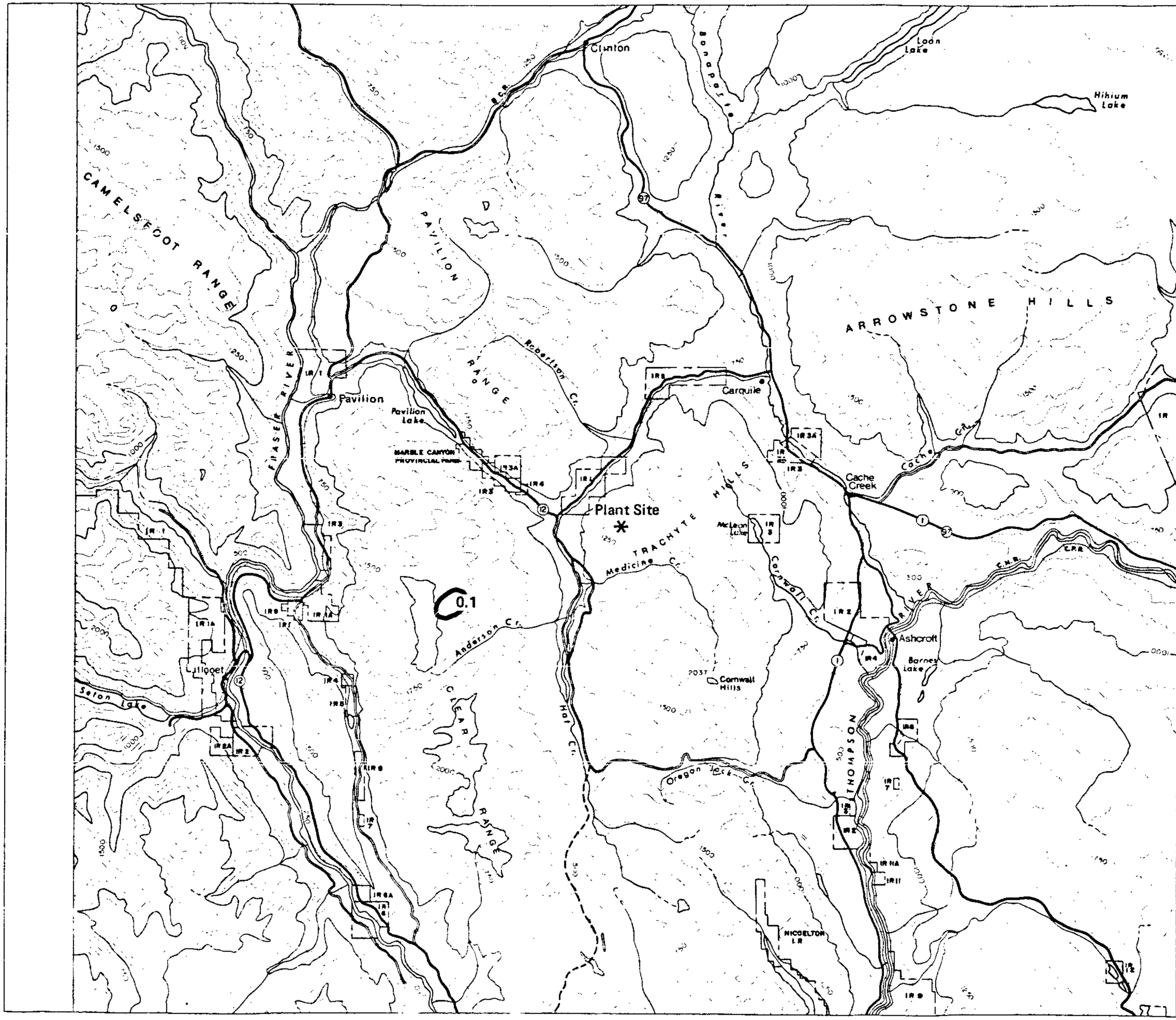

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Figure (B)-12

Predicted Frequencies (%) of 8-Hour SO_2 Concentrations Greater than 300 $\mu g/m^3$: 366 m Stack with FGD (Local Scale)

804236

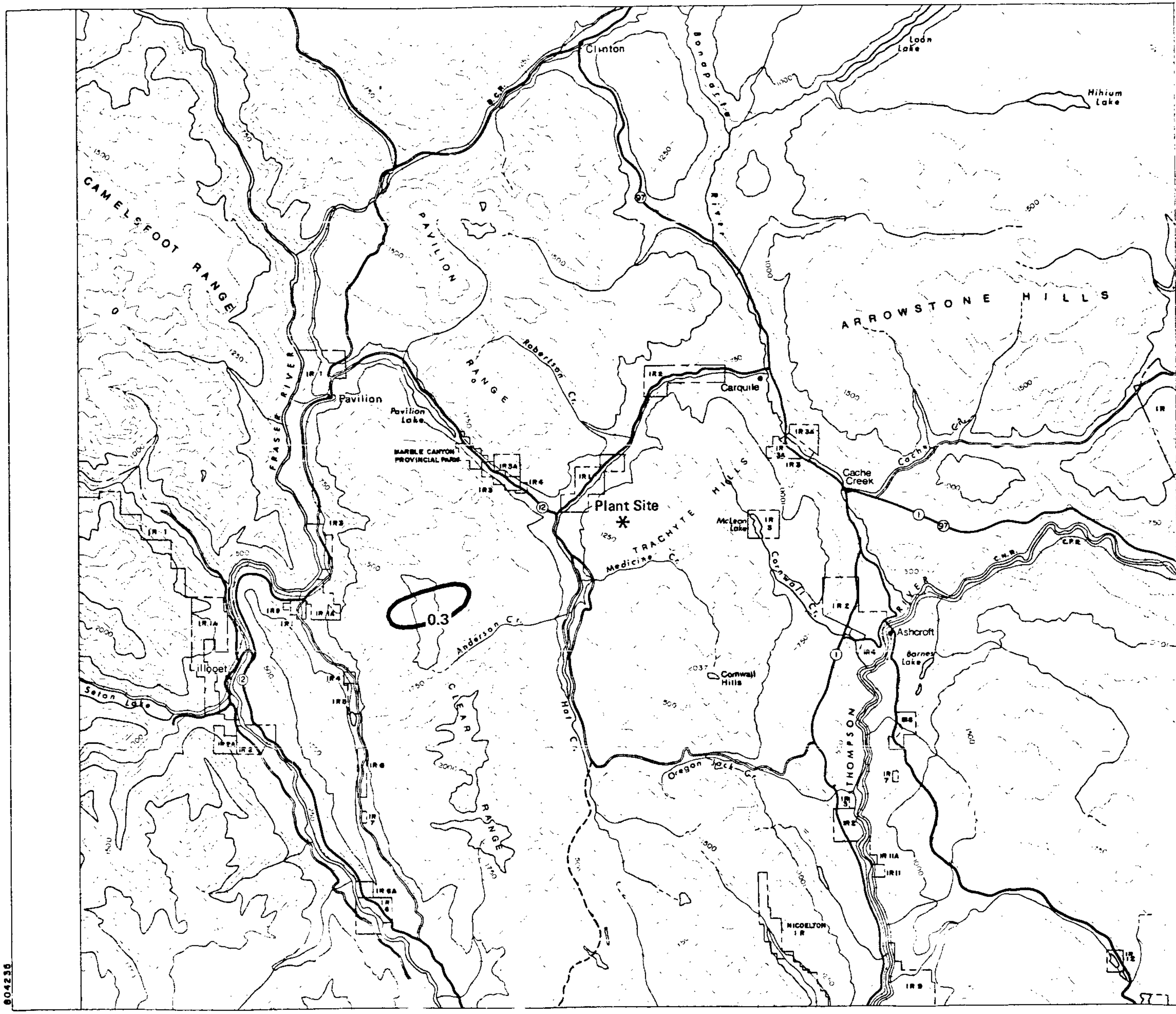

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Figure (B)-13

Predicted Frequencies (%) of 24-Hour SO_2 Concentrations Greater than 160 $\mu g/m^3$: 366 m Stack with FGD (Local Scale)

804235

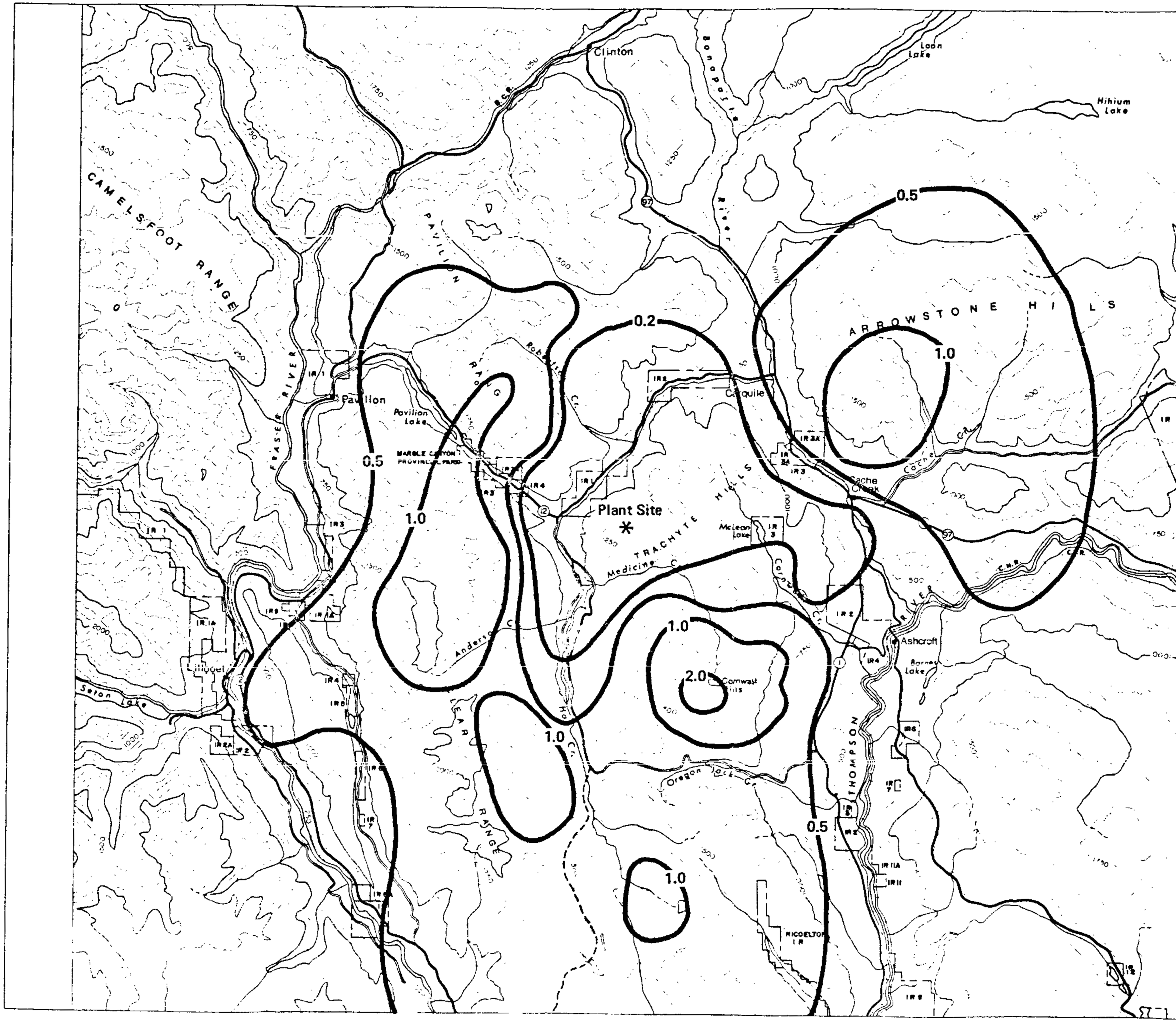

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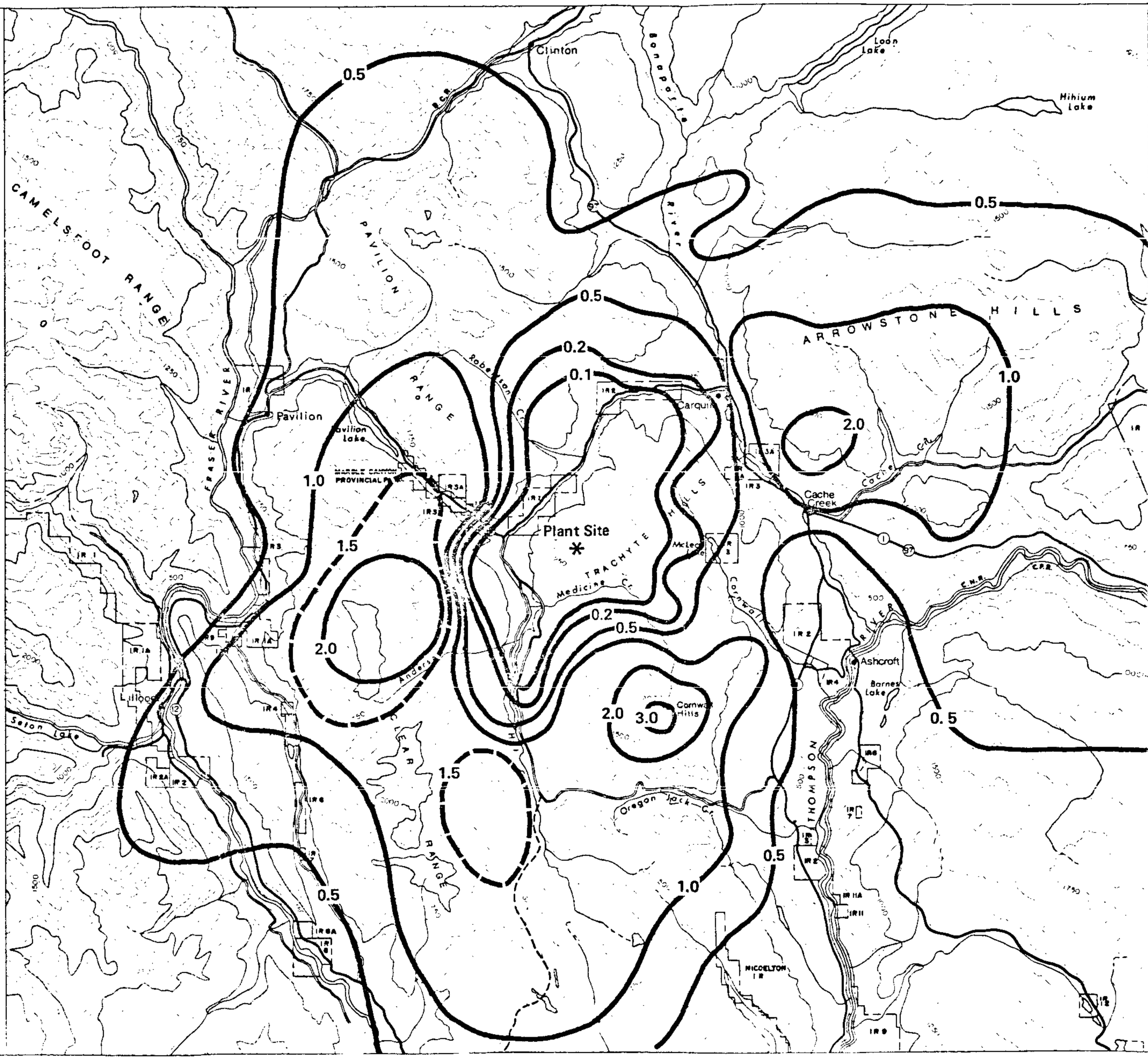
Figure (B)-14

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

804234



SCALE - 1:250,000

Kilometres 5 0 5 10 15

CONTOUR INTERVAL - 250 METRES

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DETAILED ENVIRONMENTAL STUDIES

Figure (B)-15

Predicted Annual Averaged NO_2 Concentrations ($\mu g/m^3$) within 25 km: 366 m Stack with FGD

804233

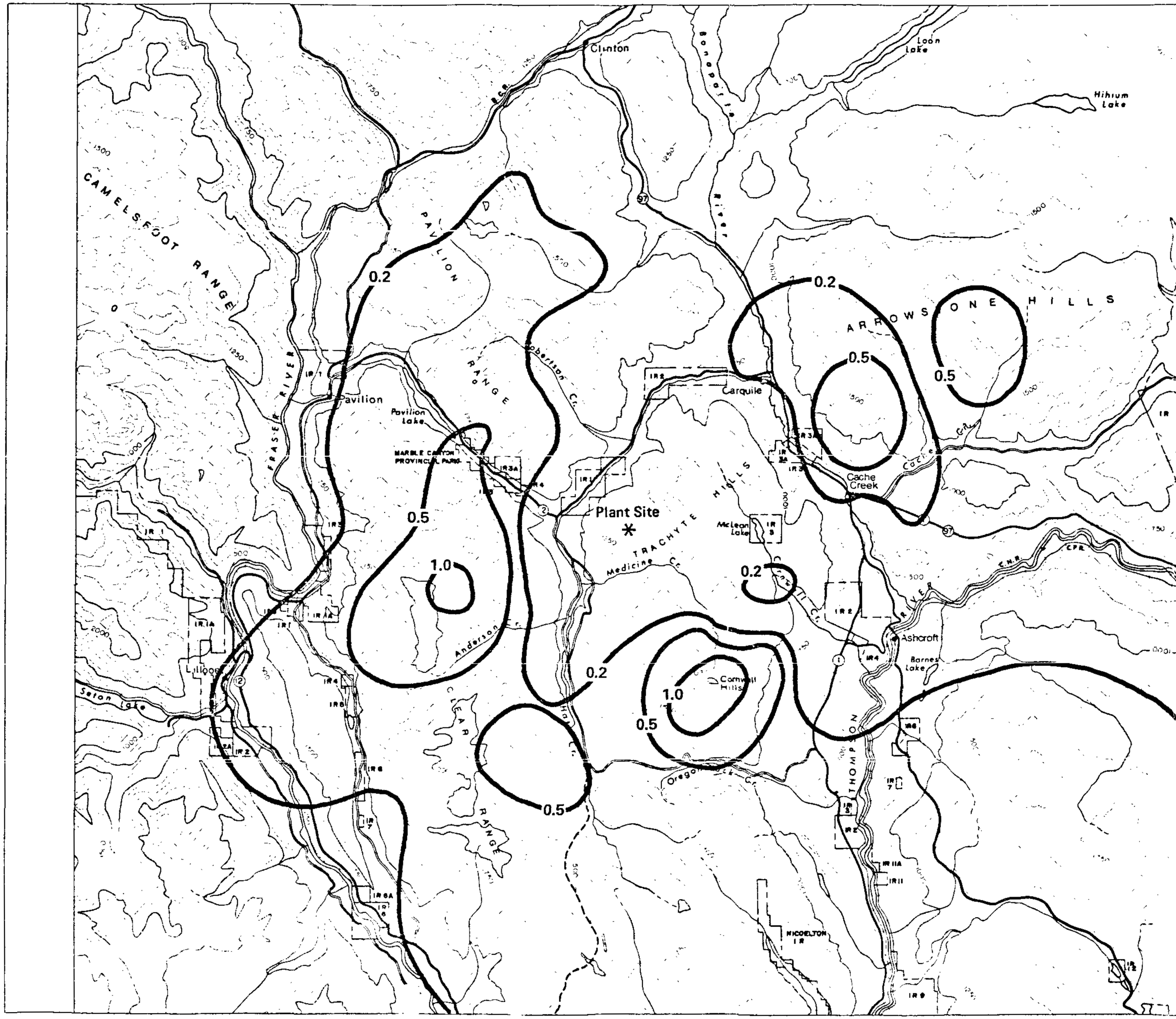

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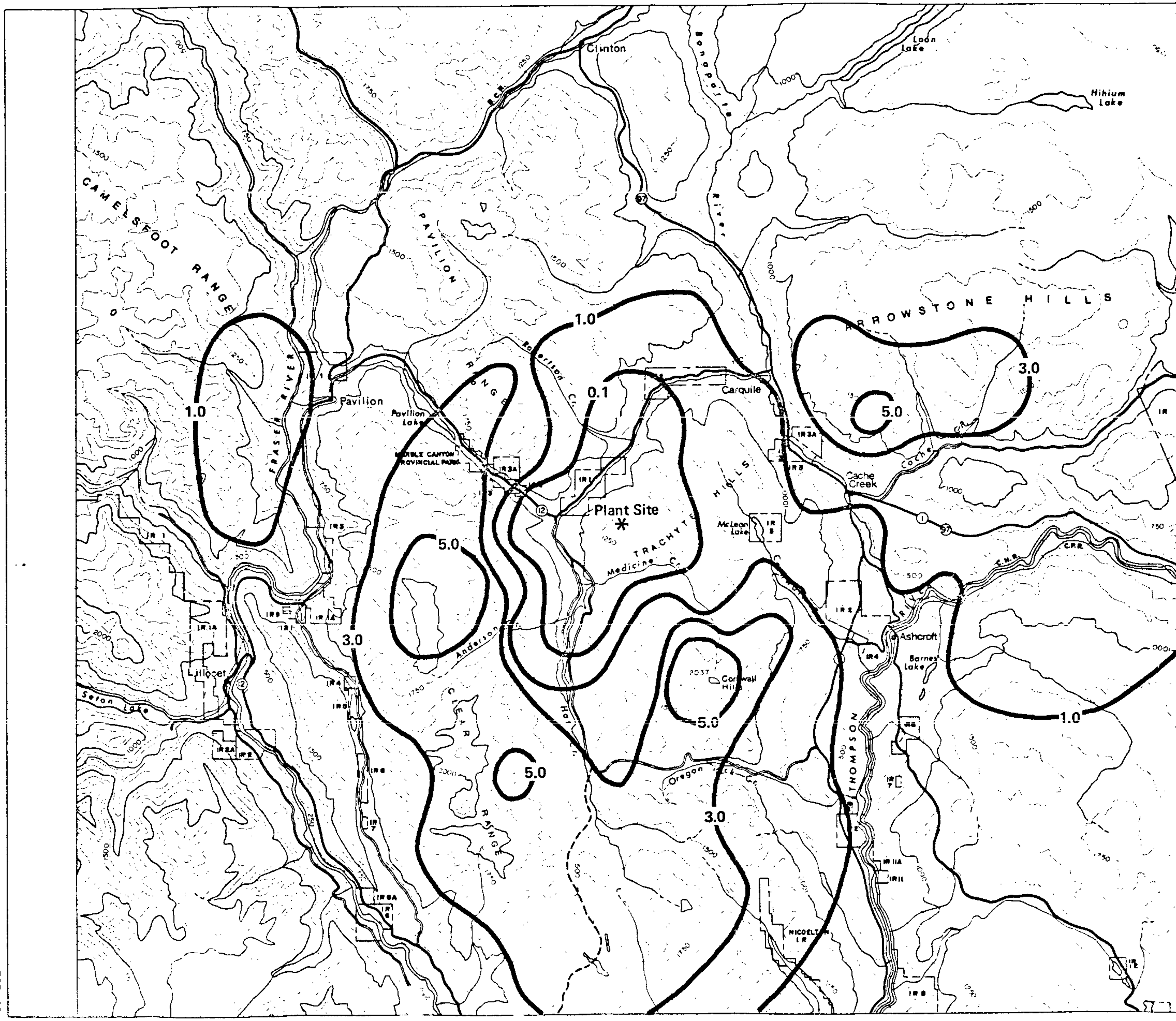
Figure (B)-16

Predicted Annual Average TSP Concentrations ($\mu g/m^3$) within 25km: 366 m Stack with FGD

804202



SCALE - 1:250,000

CONTOUR INTERVAL - 250 METRES

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Figure (B)-17

Predicted Annual Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 366 m Stack with MCS

804232

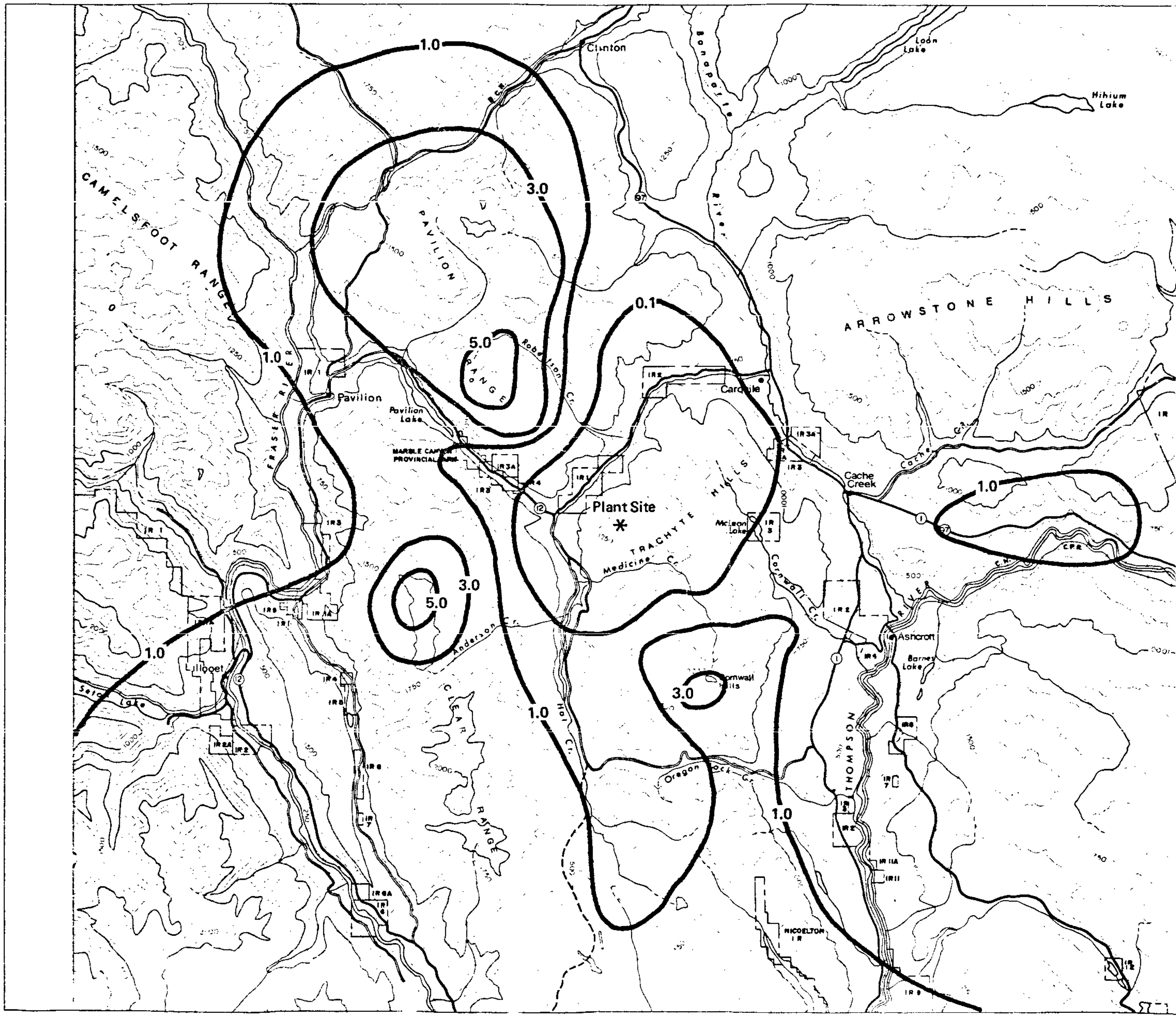

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Figure (B)-18

Predicted Seasonal (Winter) Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 366 m Stack with MCS

804231

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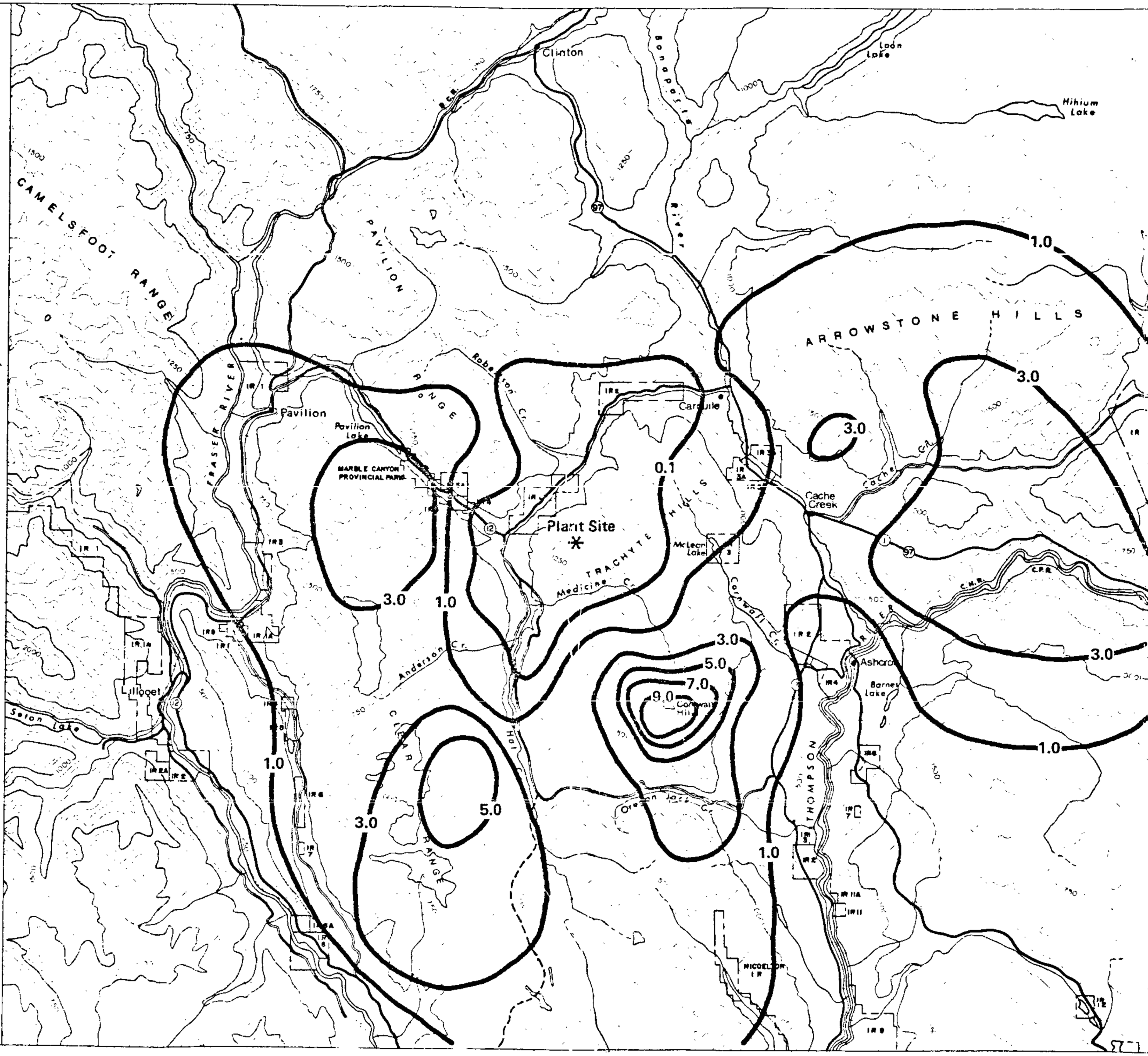
Figure (B)-19

Predicted Seasonal (Spring) Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 366 m Stack with MCS



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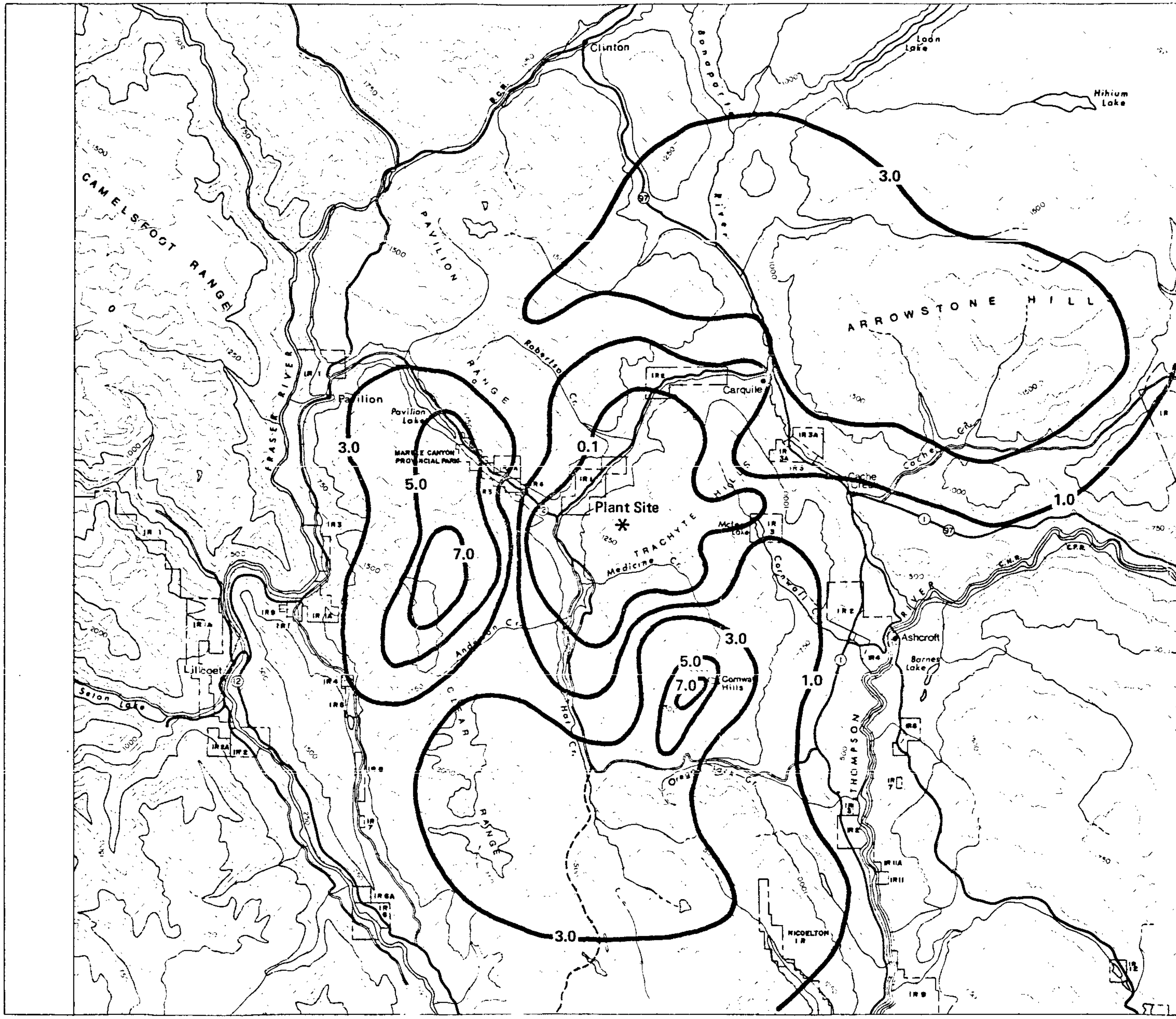
DETAILED ENVIRONMENTAL STUDIES

Figure (B)-20

Predicted Seasonal (Summer) Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 366 m Stack with MCS

804229



SCALE - 1:250,000

Kilometres

CONTOUR INTERVAL - 250 METRES

BRITISH COLUMBIA
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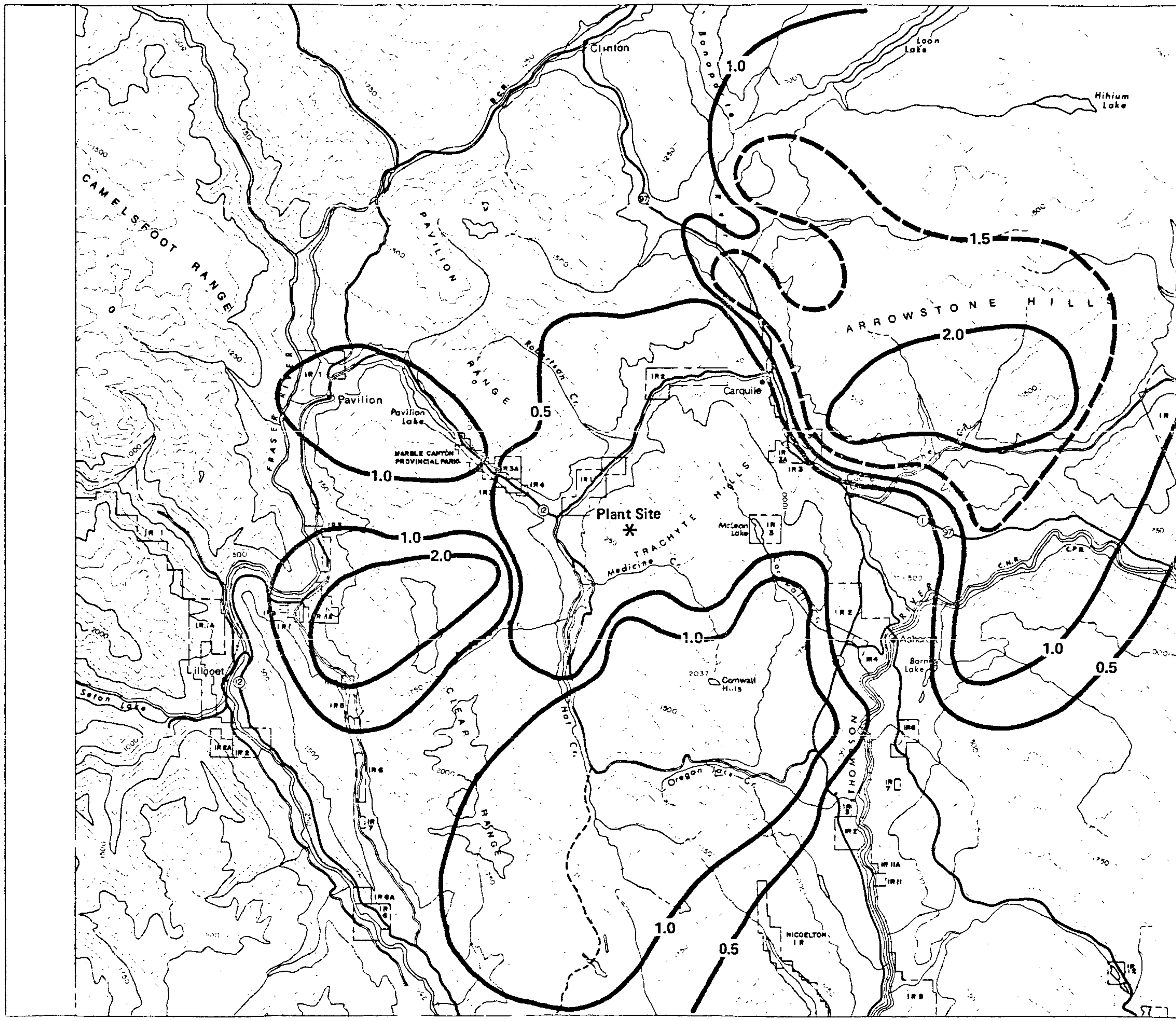
DETAILED ENVIRONMENTAL STUDIES

Figure (B)-21

Predicted Seasonal (Fall) Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 366 m Stack with MCS

804228



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DETAILED ENVIRONMENTAL STUDIES

Figure (B)-22

Predicted Frequencies (%) of 1-Hour SO_2 Concentrations Greater than 100 $\mu g/m^3$: 366 m Stack with MCS (Local Scale)

804227

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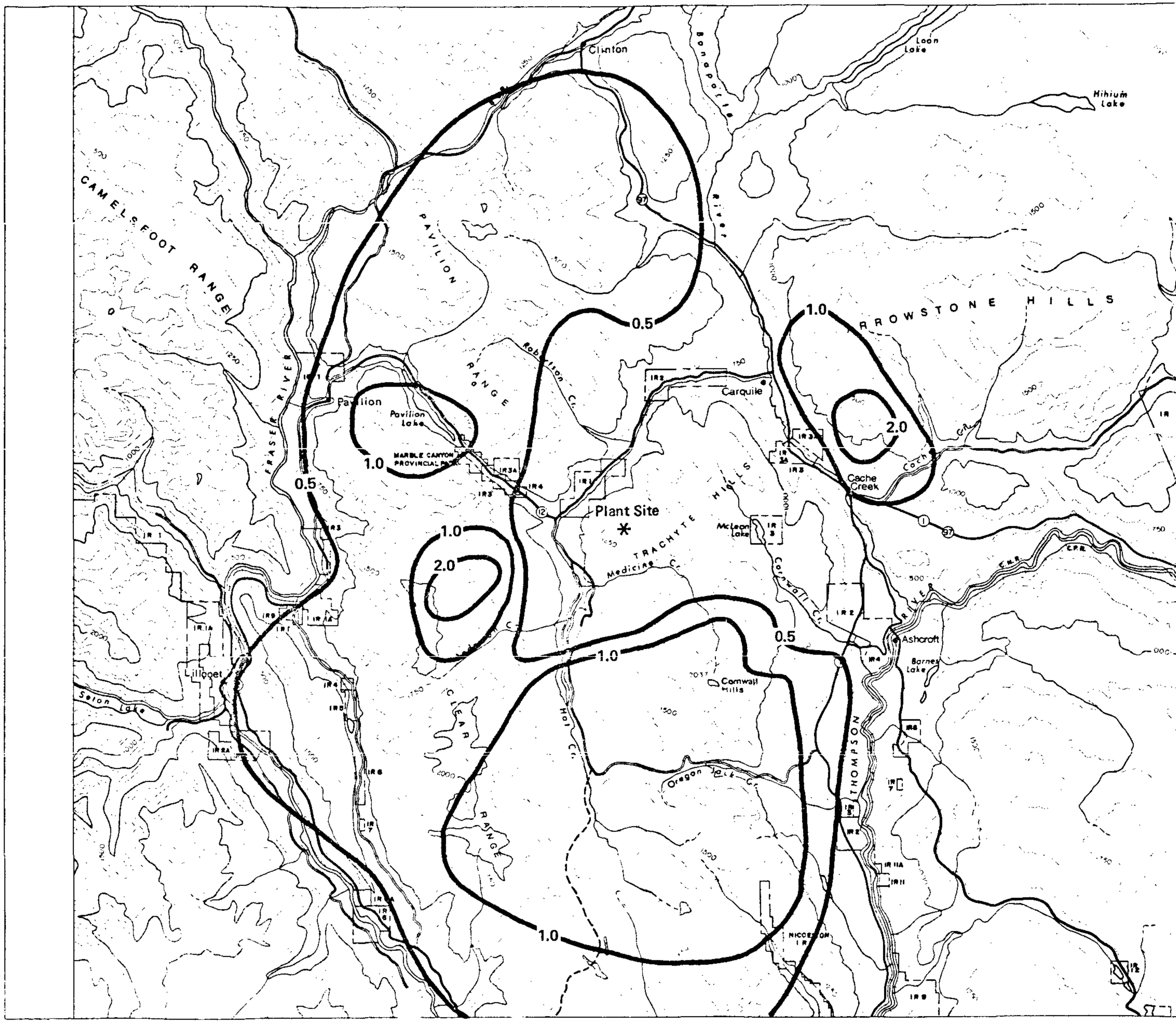

SCALE - 1:250,000

Kilometres

CONTOUR INTERVAL - 250 METRES

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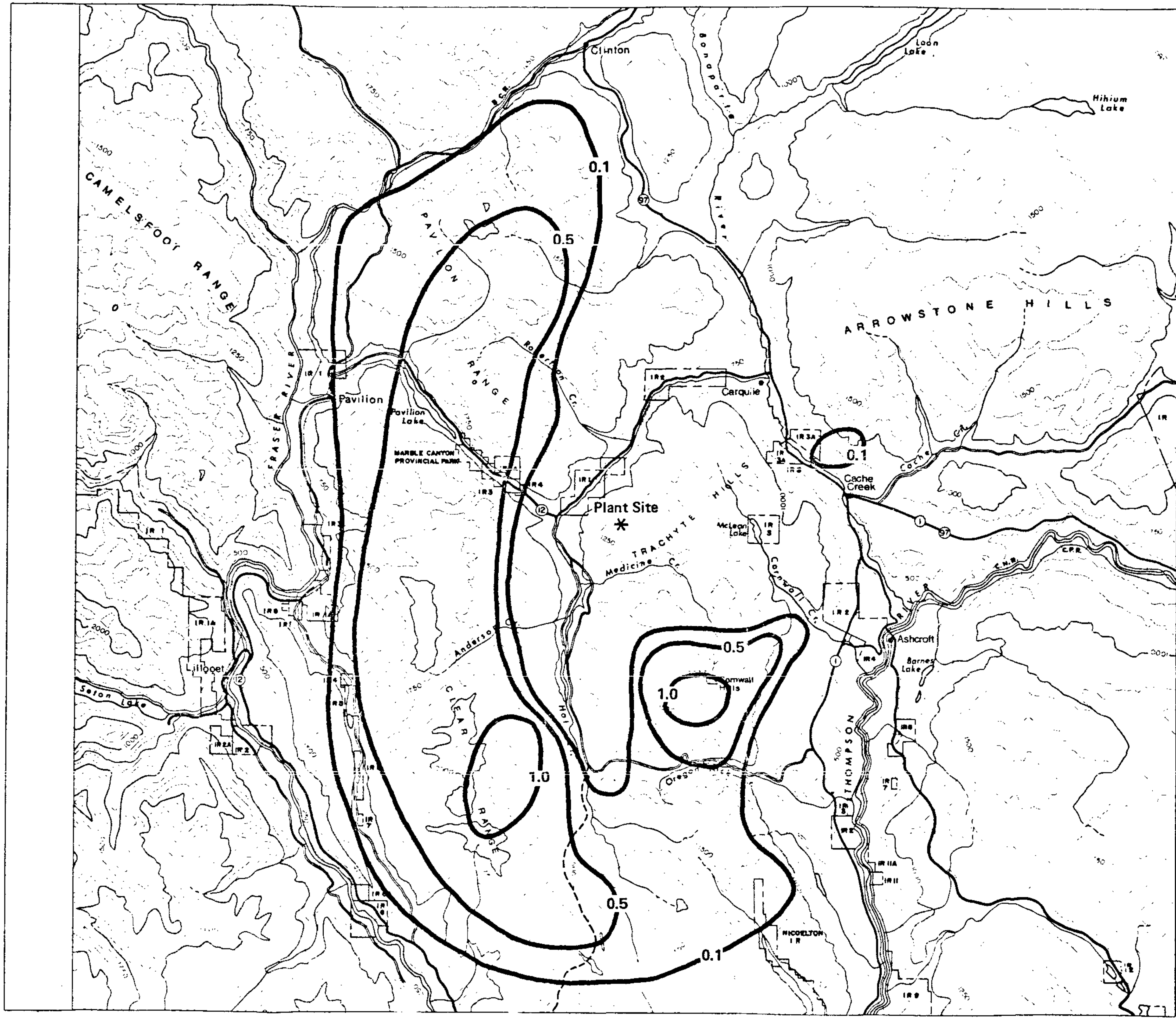
Figure (B)-23

Predicted Frequencies (%) of 1-Hour SO_2 Concentrations Greater than 225 $\mu g/m^3$: 366 m Stack with MCS (Local Scale)

804236



SCALE - 1:250,000

0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

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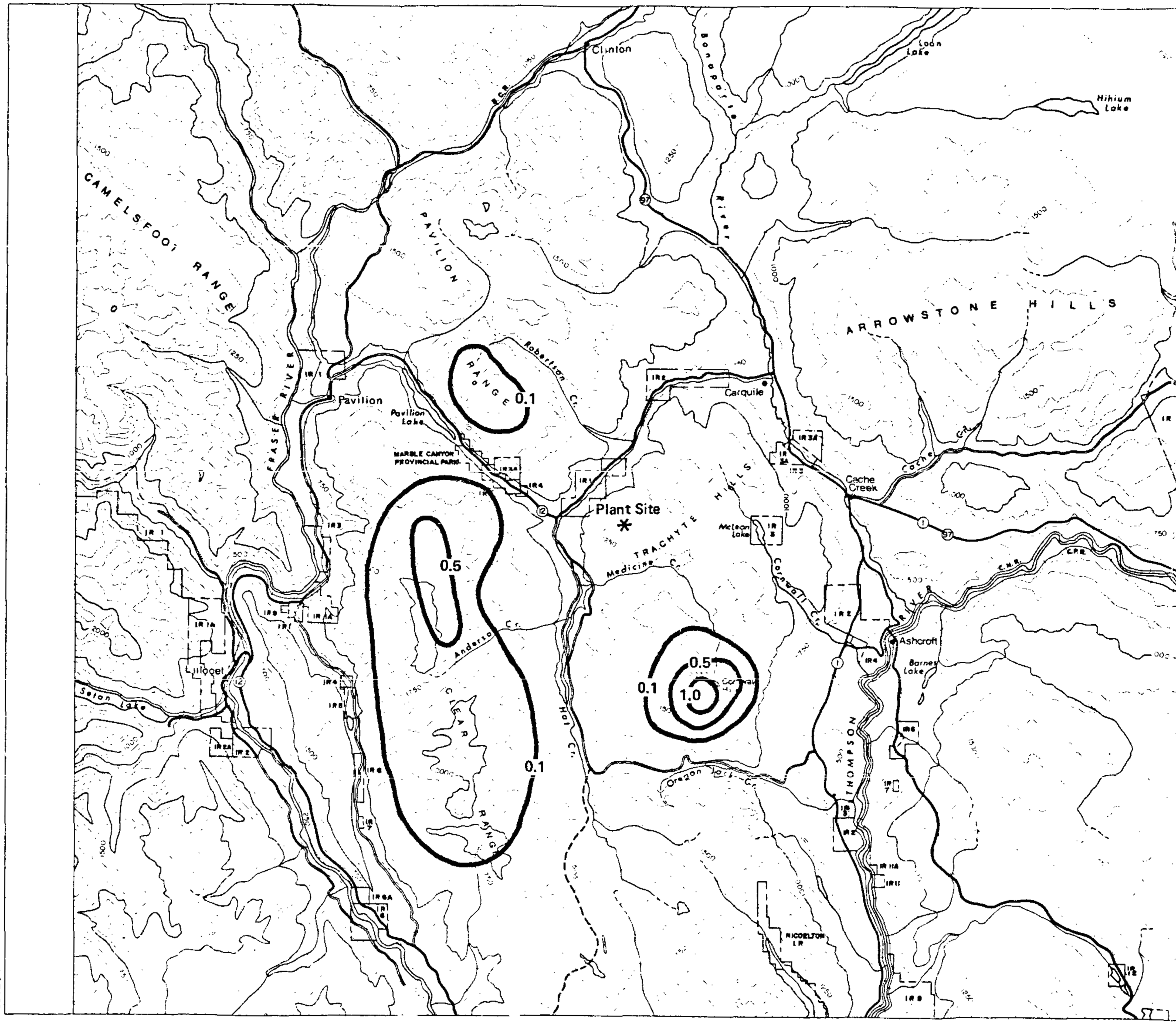
DETAILED ENVIRONMENTAL STUDIES

Figure (B)-24
Predicted Frequencies (%) of 1-Hour SO_2 Concentrations Greater than 450 $\mu g/m^3$: 366 m Stack with MCS (Local Scale)

804235



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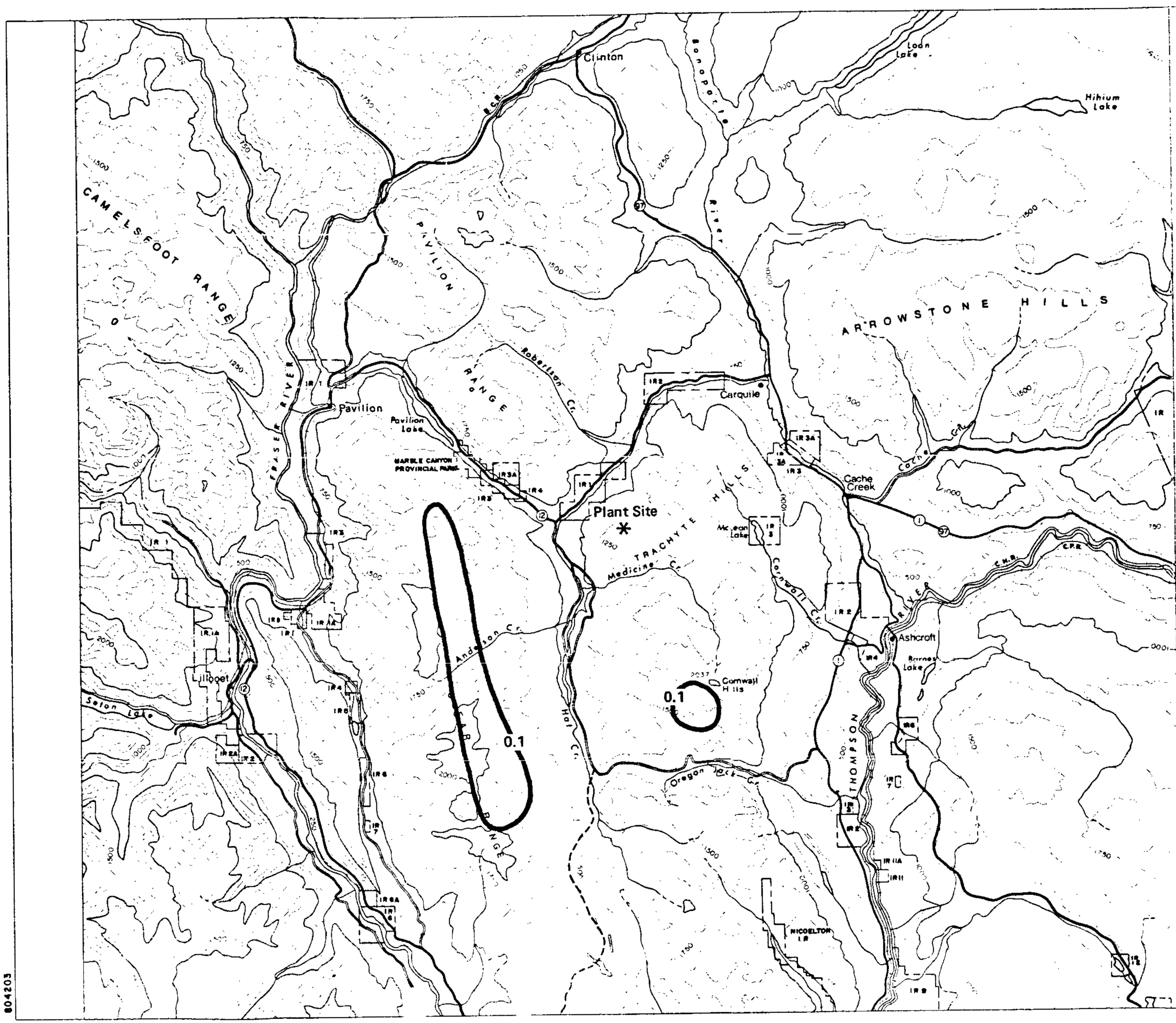
DETAILED ENVIRONMENTAL STUDIES

Figure (B)-25

Predicted Frequencies (%) of 1-Hour SO_2 Concentrations Greater than 900 $\mu g/m^3$: 366 m Stack with MCS (Local Scale)

804234



SCALE - 1:250,000

0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

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Figure (B)-26

Predicted Frequencies (%) of 1-Hour SO_2 Concentrations Greater than 1300 $\mu g/m^3$: 366 m Stack with MCS (Local Scale)

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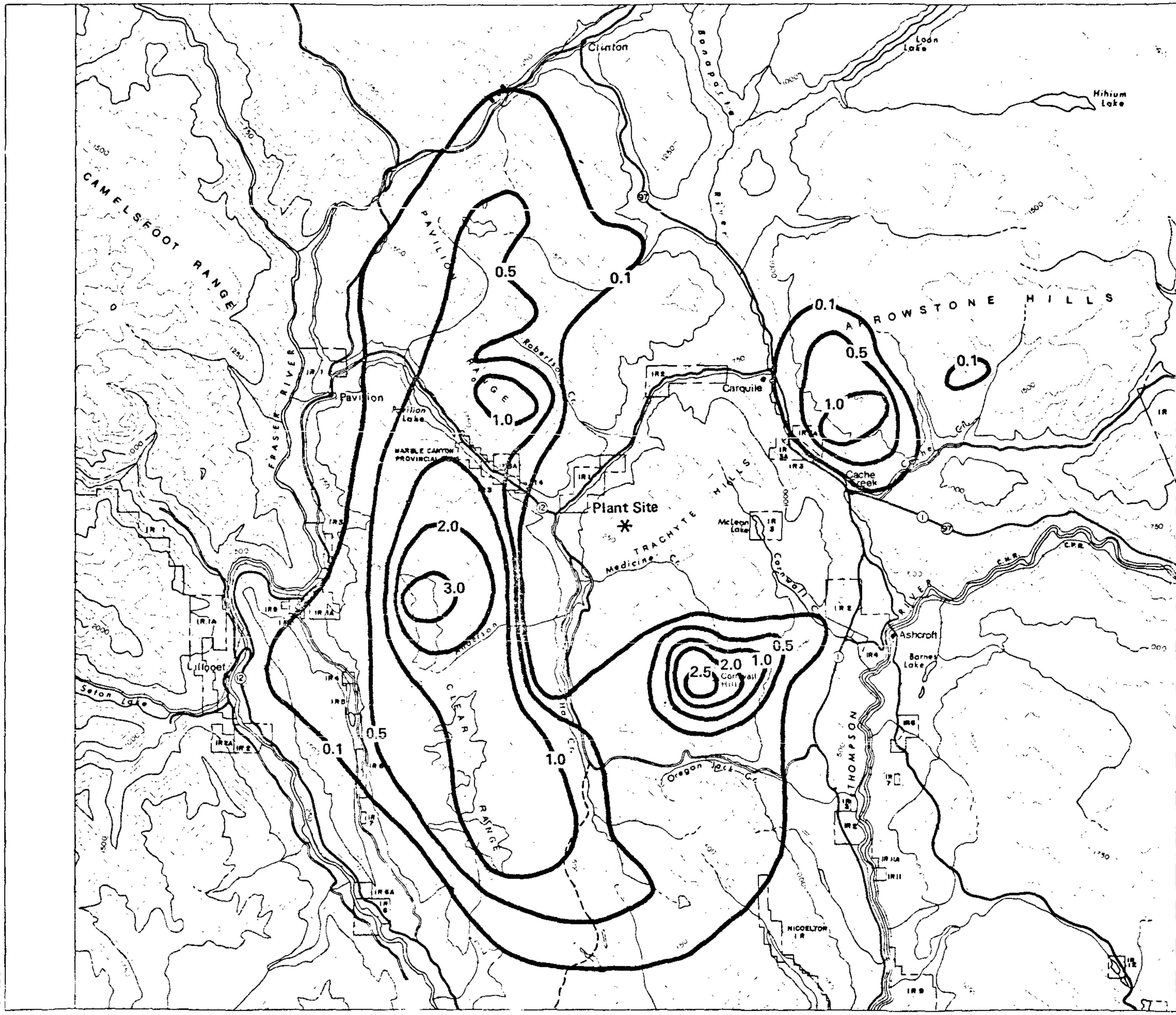

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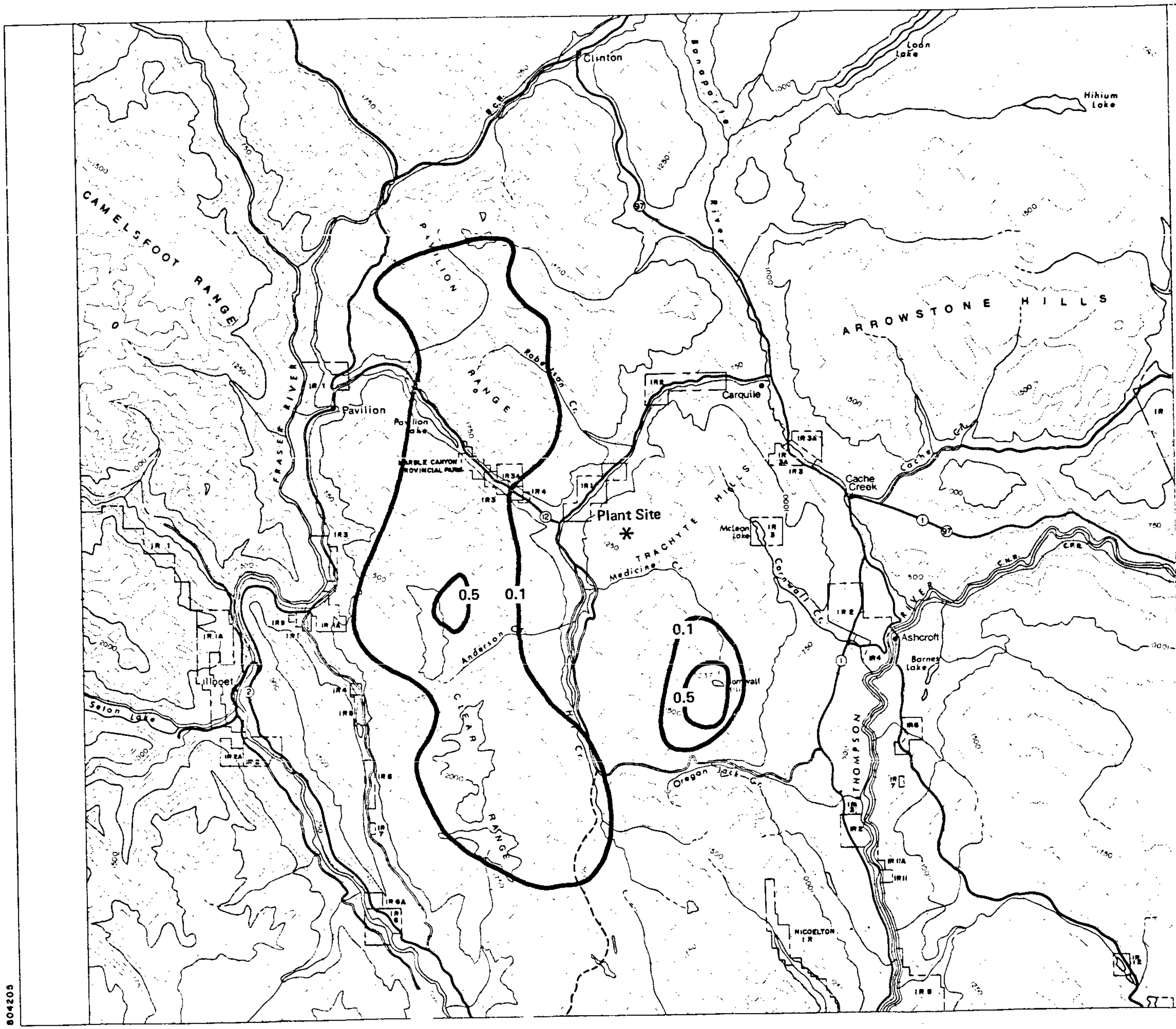
Figure (B)-27

Predicted Frequencies (%) of 3-Hour SO_2 Concentrations Greater than 150 $\mu g/m^3$: 366 m Stack with MCS (Local Scale)

804204



SCALE - 1:250,000

Kilometres 0 5 10 15

CONTOUR INTERVAL - 250 METRES

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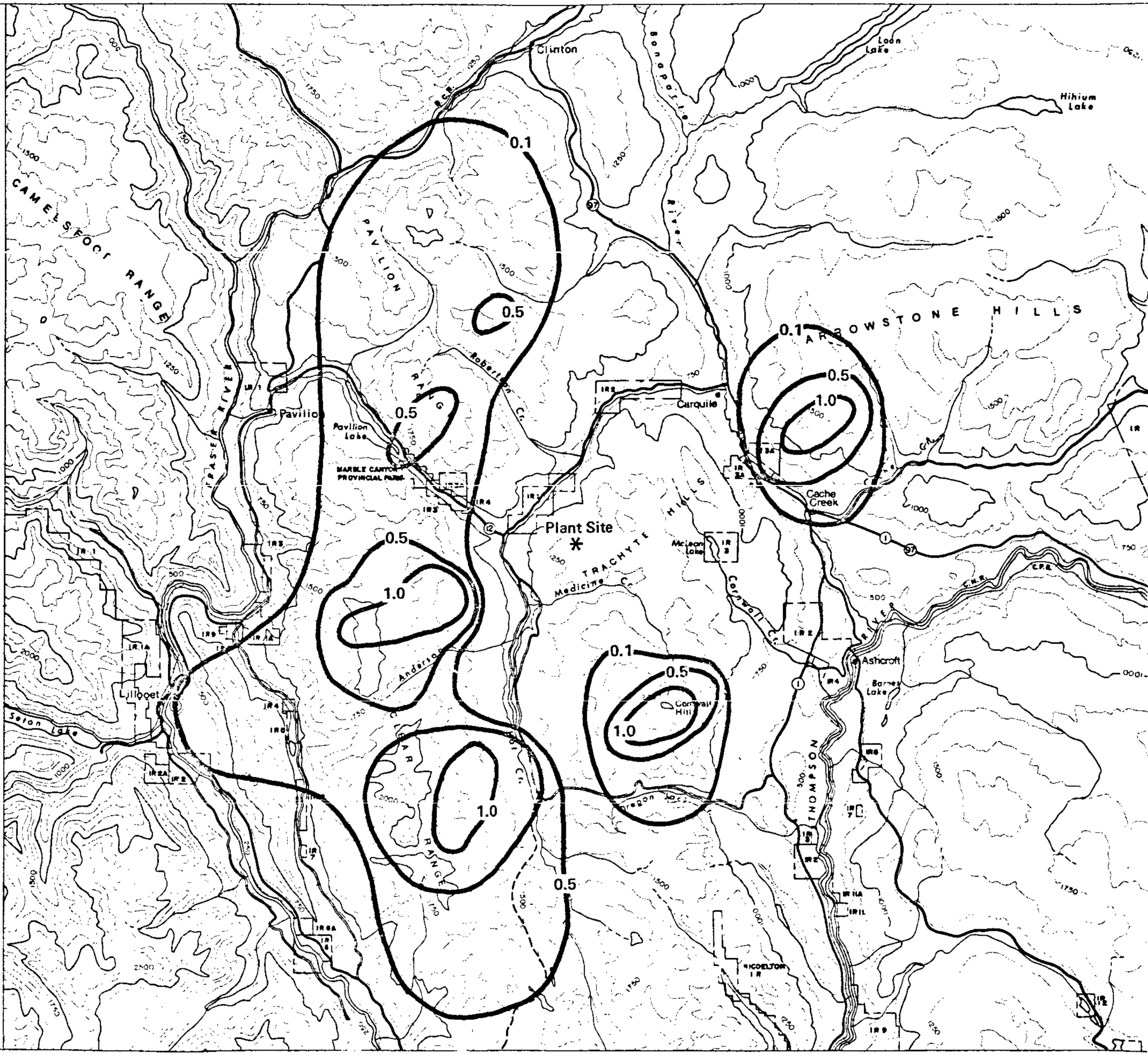
DETAILED ENVIRONMENTAL STUDIES

Figure (B)-28

Predicted Frequencies (%) of 3-Hour SO_2 Concentrations Greater than 300 $\mu g/m^3$: 366 m Stack with MCS (Local Scale)

604205



SCALE - 1:250,000

0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

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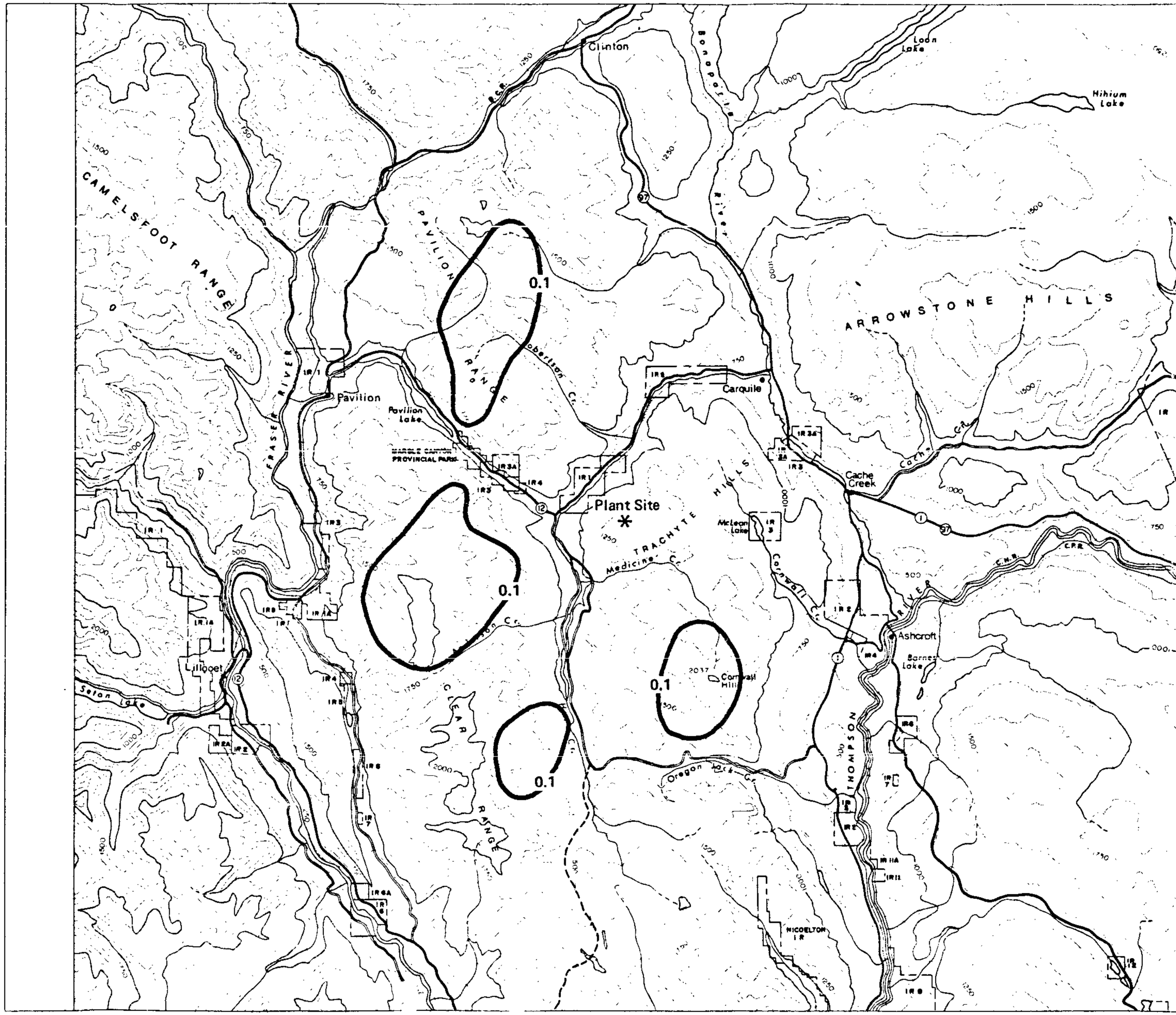
DETAILED ENVIRONMENTAL STUDIES

Figure (B)-29

Predicted Frequencies (%) of 8-Hour SO_2 Concentrations Greater than 150 $\mu g/m^3$: 366 m Stack with MCS (Local Scale)

804206



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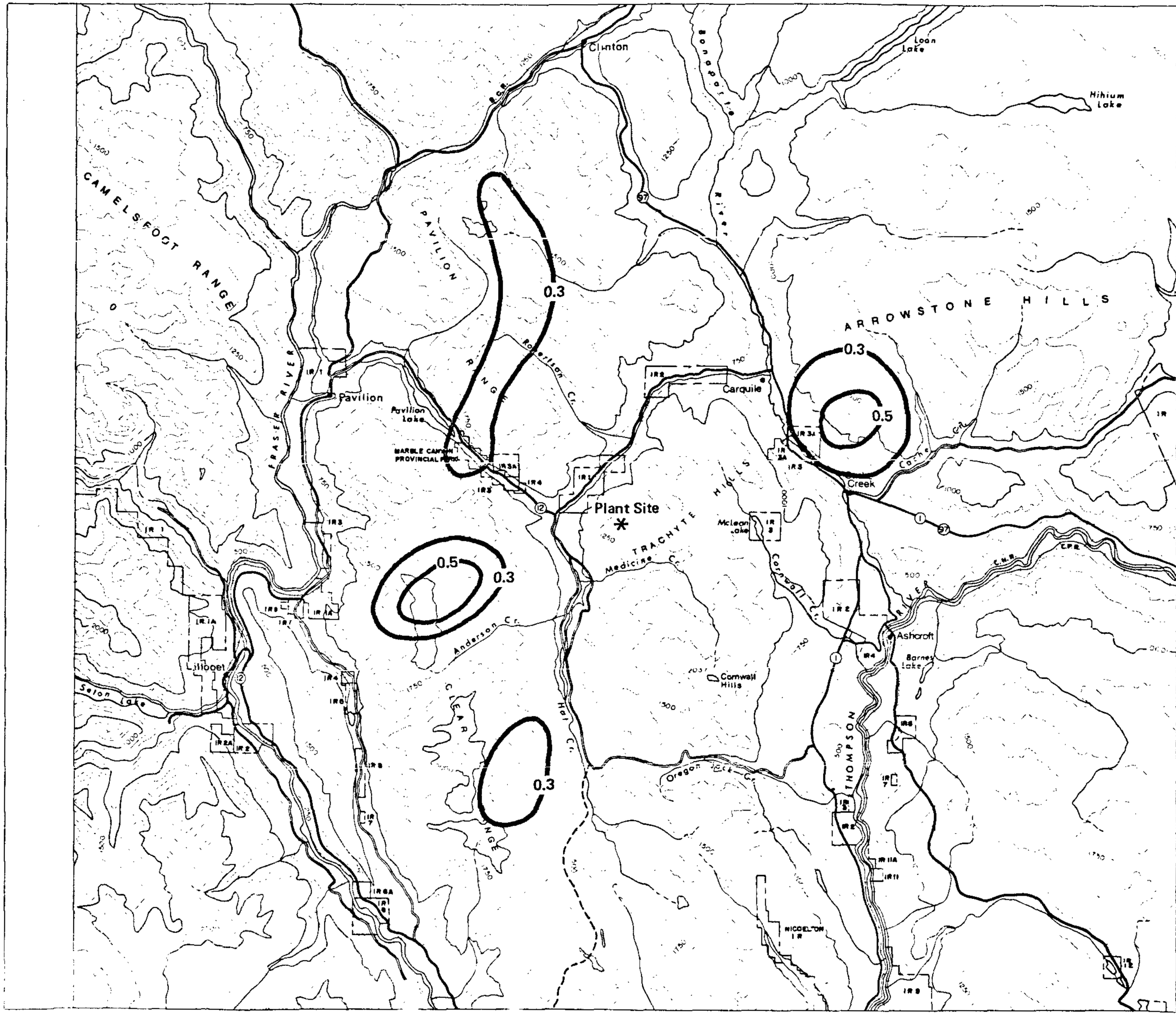
DETAILED ENVIRONMENTAL STUDIES

Figure (B)-30
Predicted Frequencies of 8-Hour SO_2 Concentrations Greater than 300 $\mu g/m^3$: 366 m Stack with MCS (Local Scale)

804207



SCALE - 1:250,000

0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

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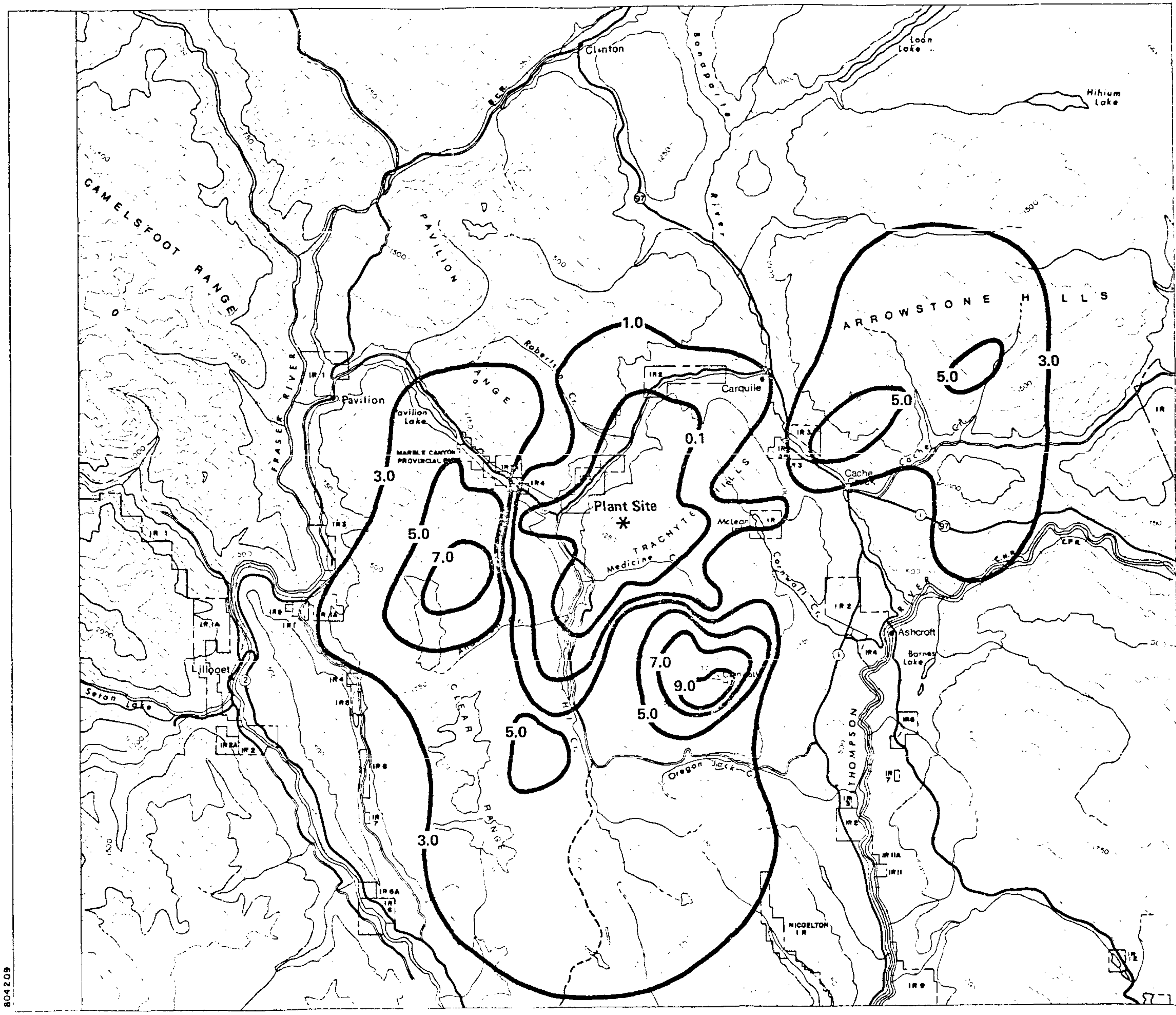
DETAILED ENVIRONMENTAL STUDIES

Figure (B)-31

Predicted Frequencies of 24-Hour SO_2 Concentrations Greater than 160 $\mu g/m^3$: 366 m Stack with MCS (Local Scale)

804208



SCALE - 1:250,000

0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

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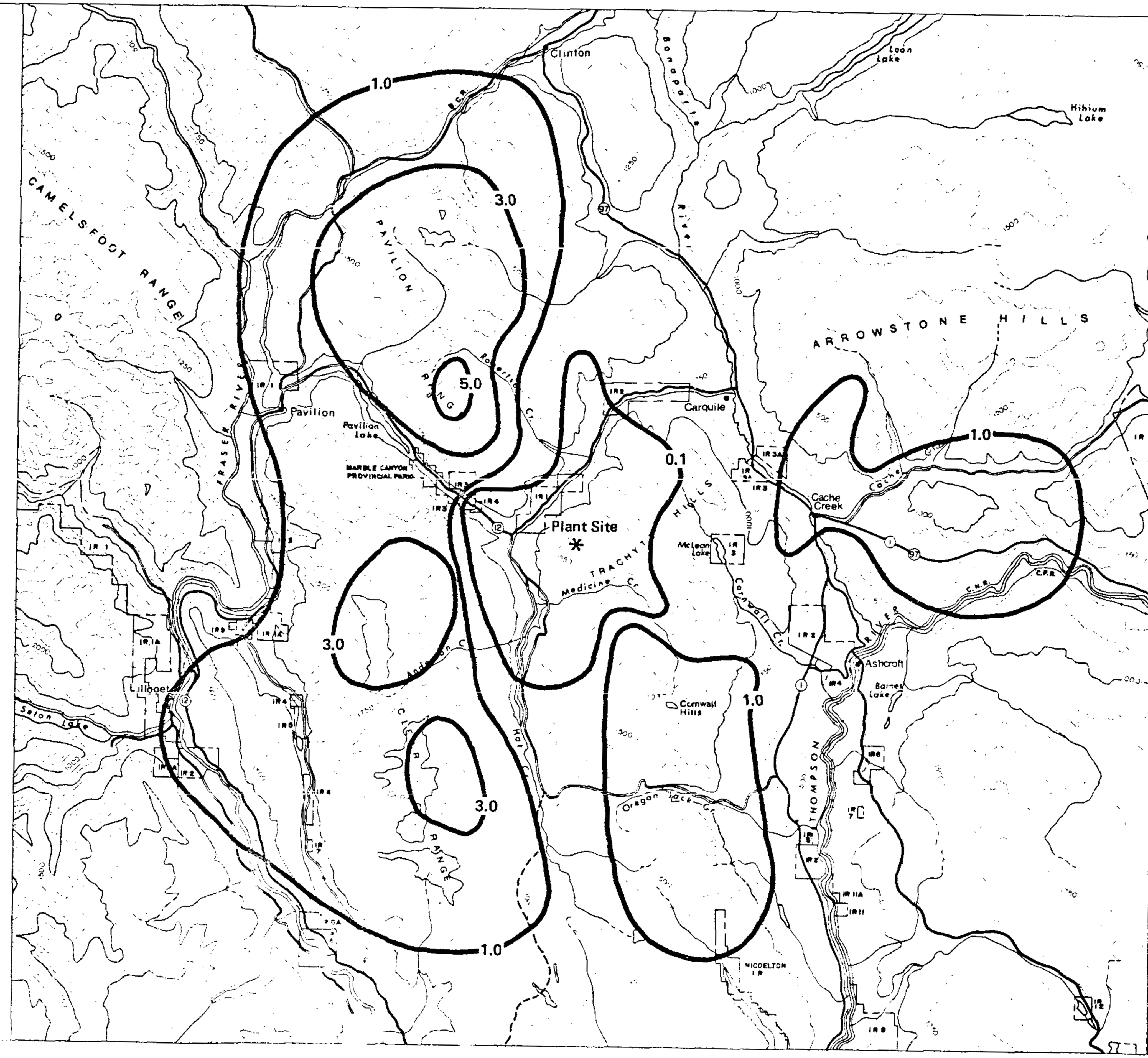
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-32

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

804209



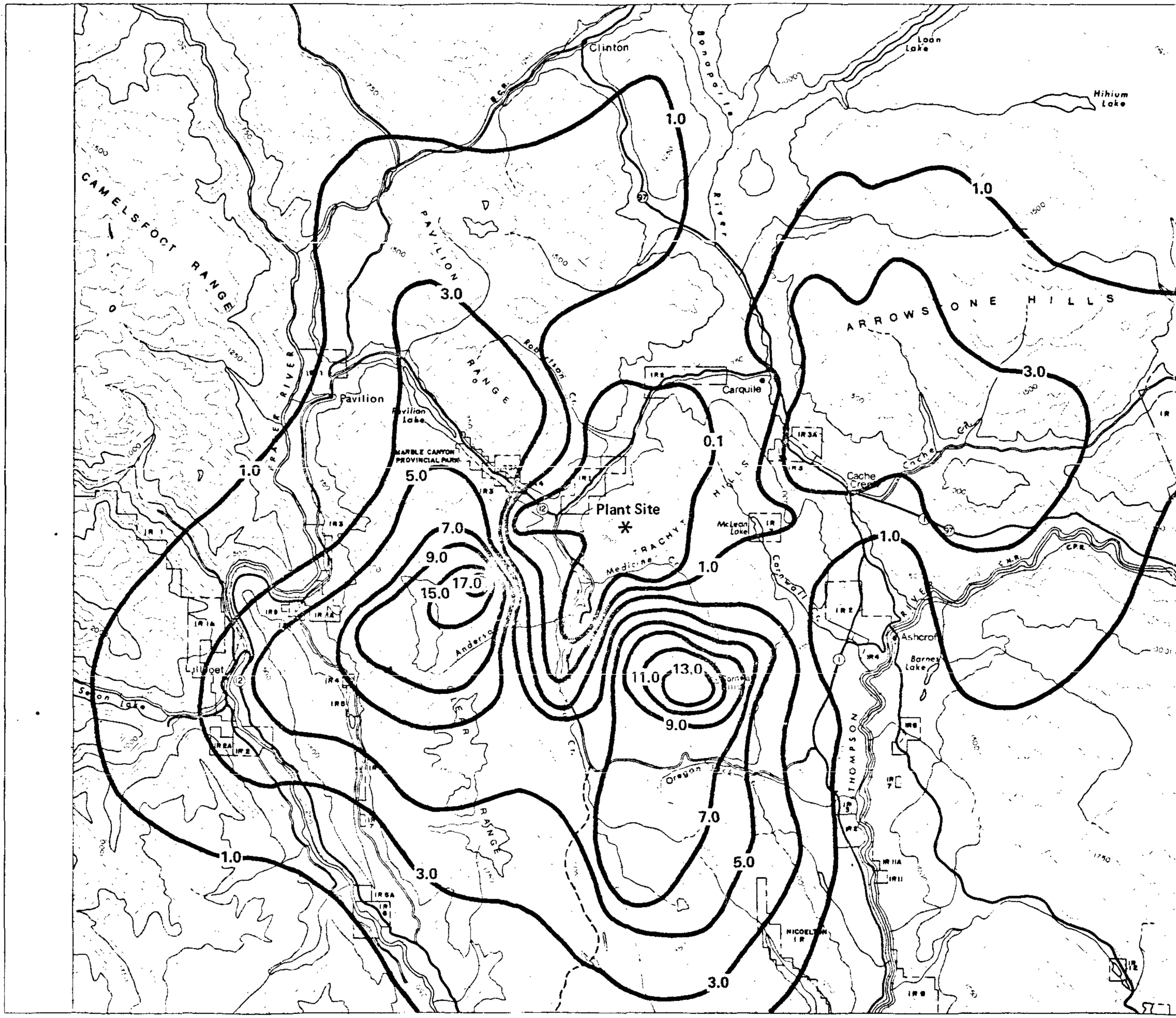
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-33

Predicted Seasonal (Winter) Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 244 m Stack with MCS

804210



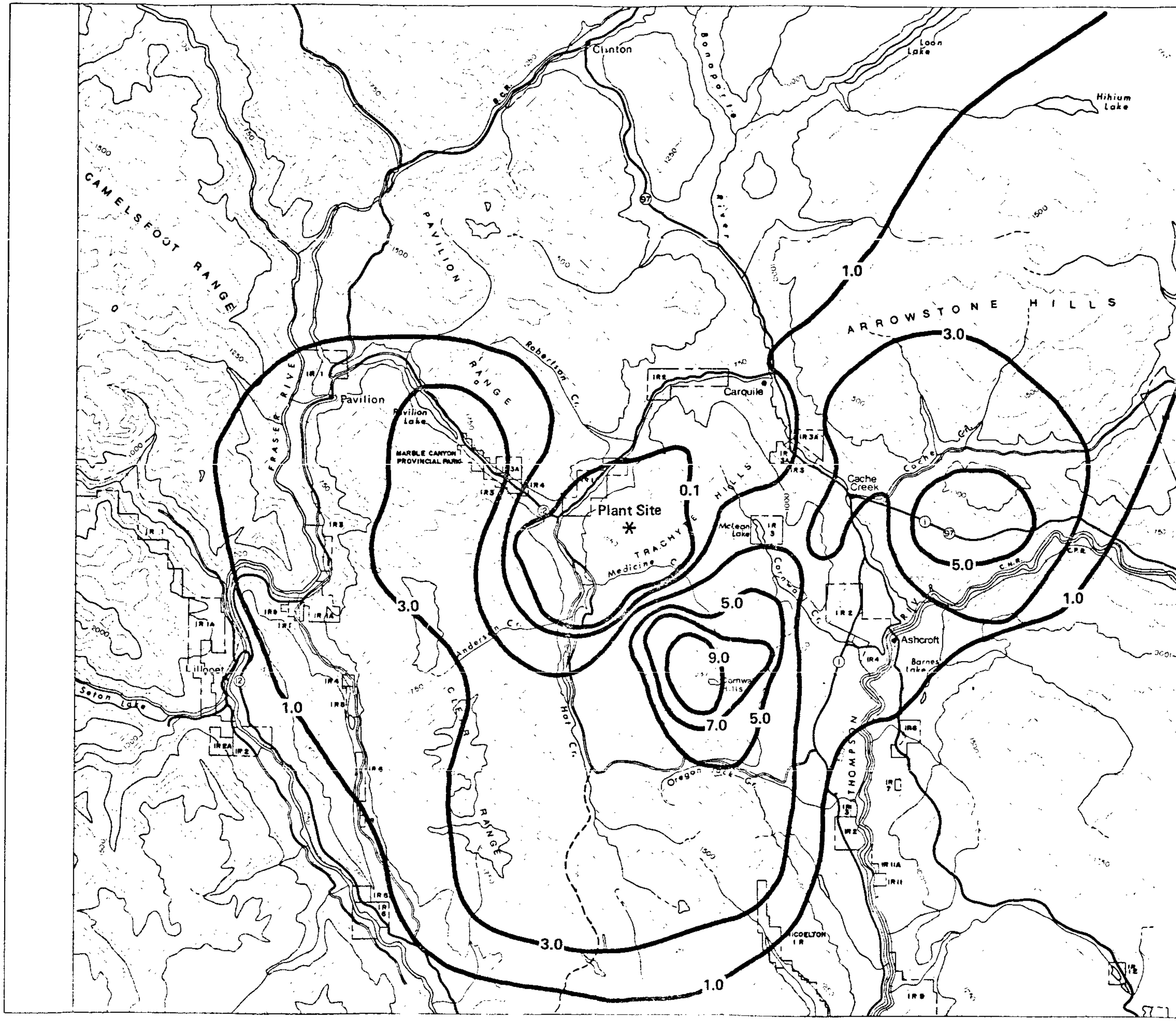
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-34

Predicted Seasonal (Spring) Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 244 m Stack with MCS

804211



SCALE - 1:250,000

Kilometres 5 0 5 10 15

CONTOUR INTERVAL - 250 METRES

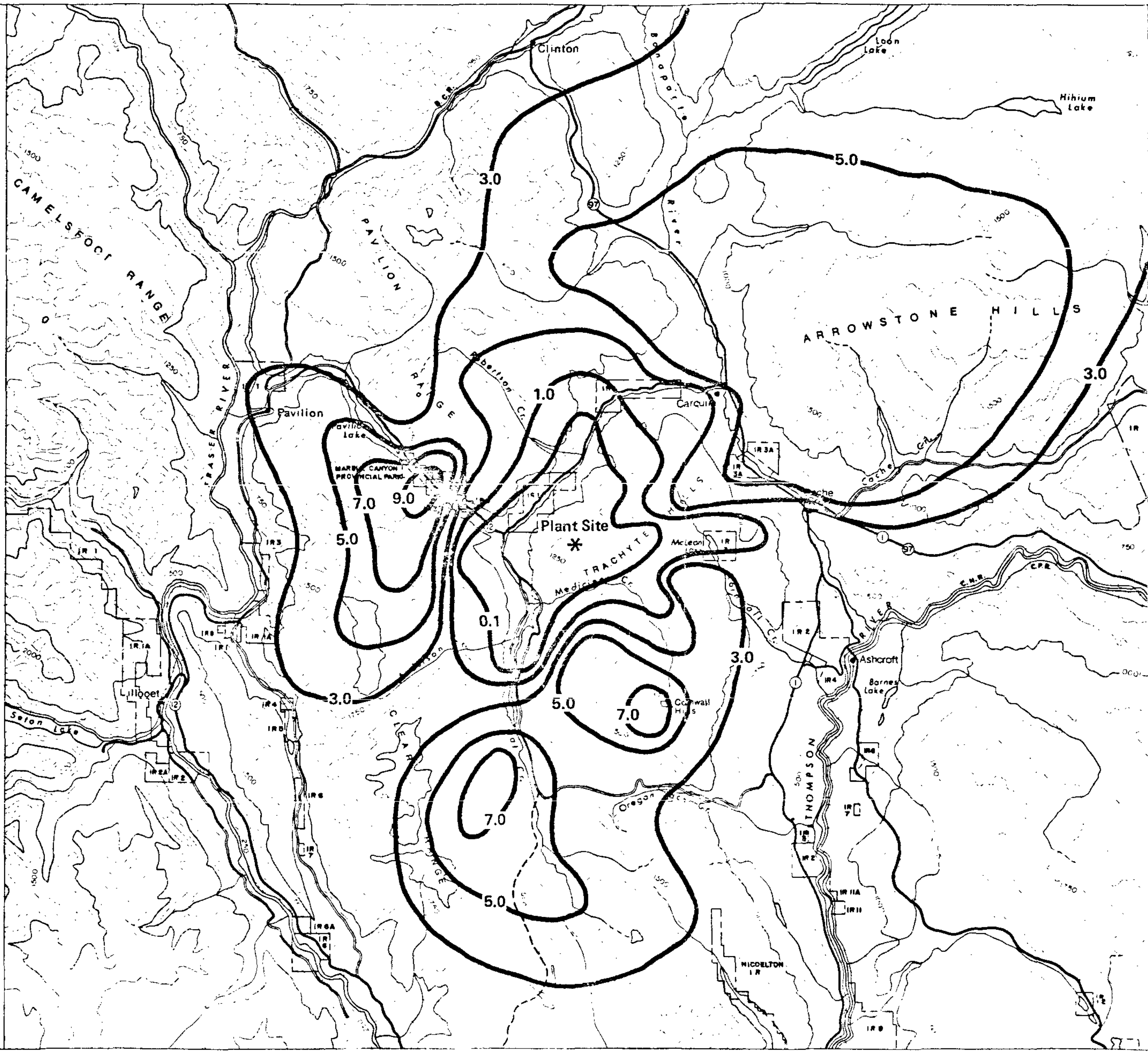
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-35

Predicted Seasonal (Summer) Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 244 m Stack with MCS

804212



SCALE - 1:250,000

Kilometres 0 5 10 15

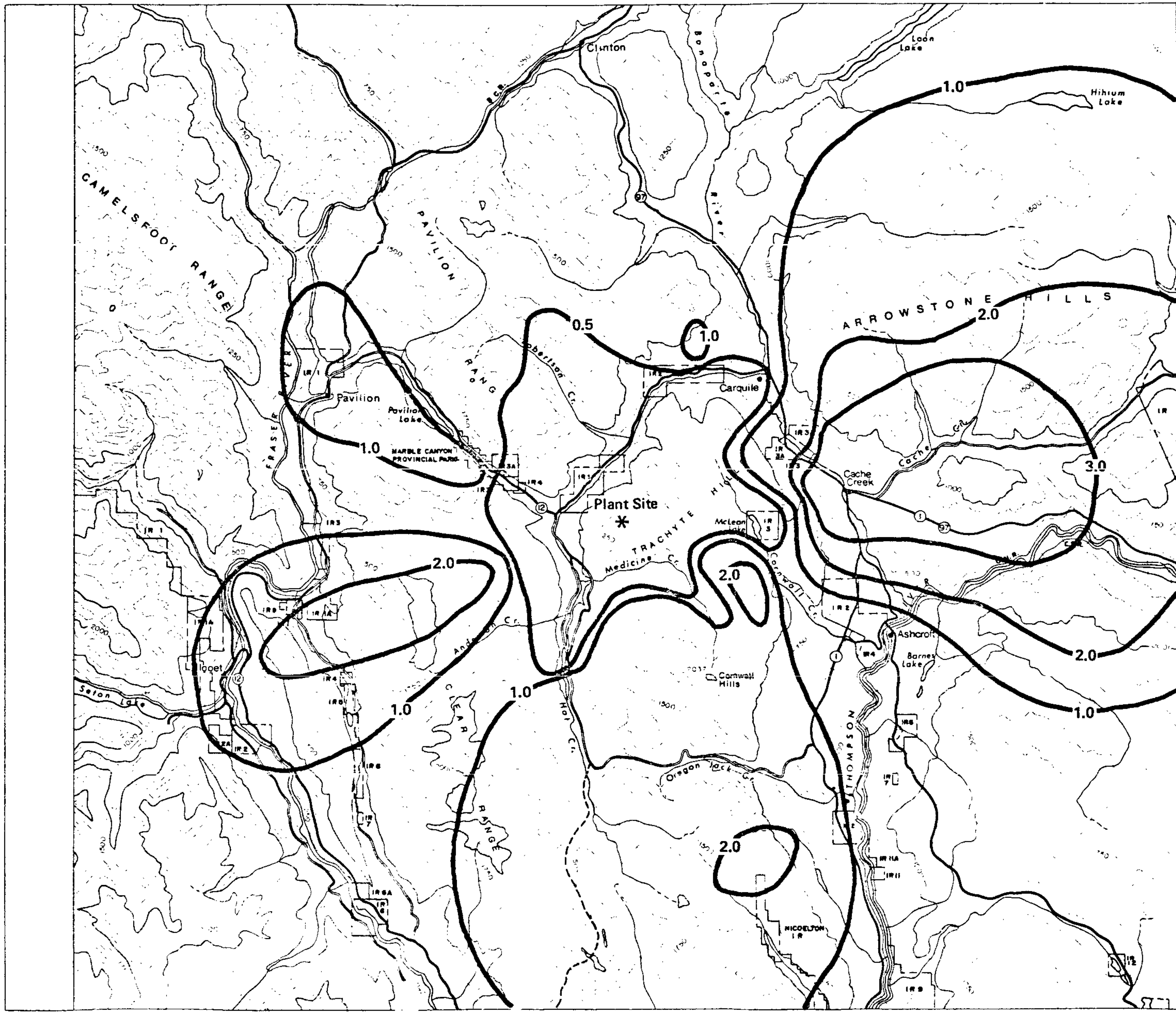
CONTOUR INTERVAL - 250 METRES

BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-36

Predicted Seasonal (Fall) Averaged SO_2 Concentrations ($\mu g/m^3$) within 25 km: 244 m Stack with MCS



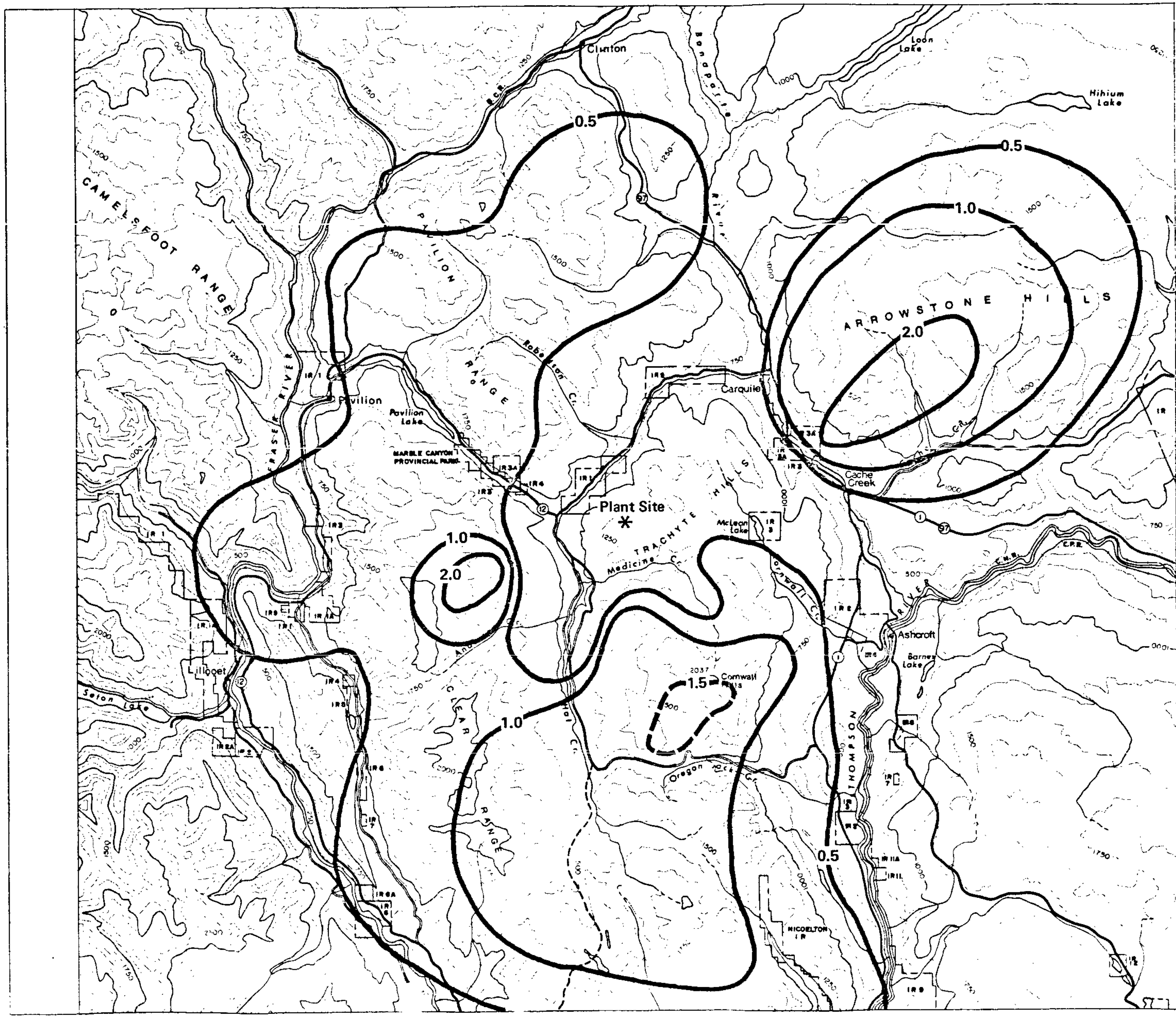
BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-37

Predicted Frequencies (%) of 1-Hour SO_2 Concentrations Greater than 100 $\mu g/m^3$: 244 m Stack with MCS (Local Scale)

604214



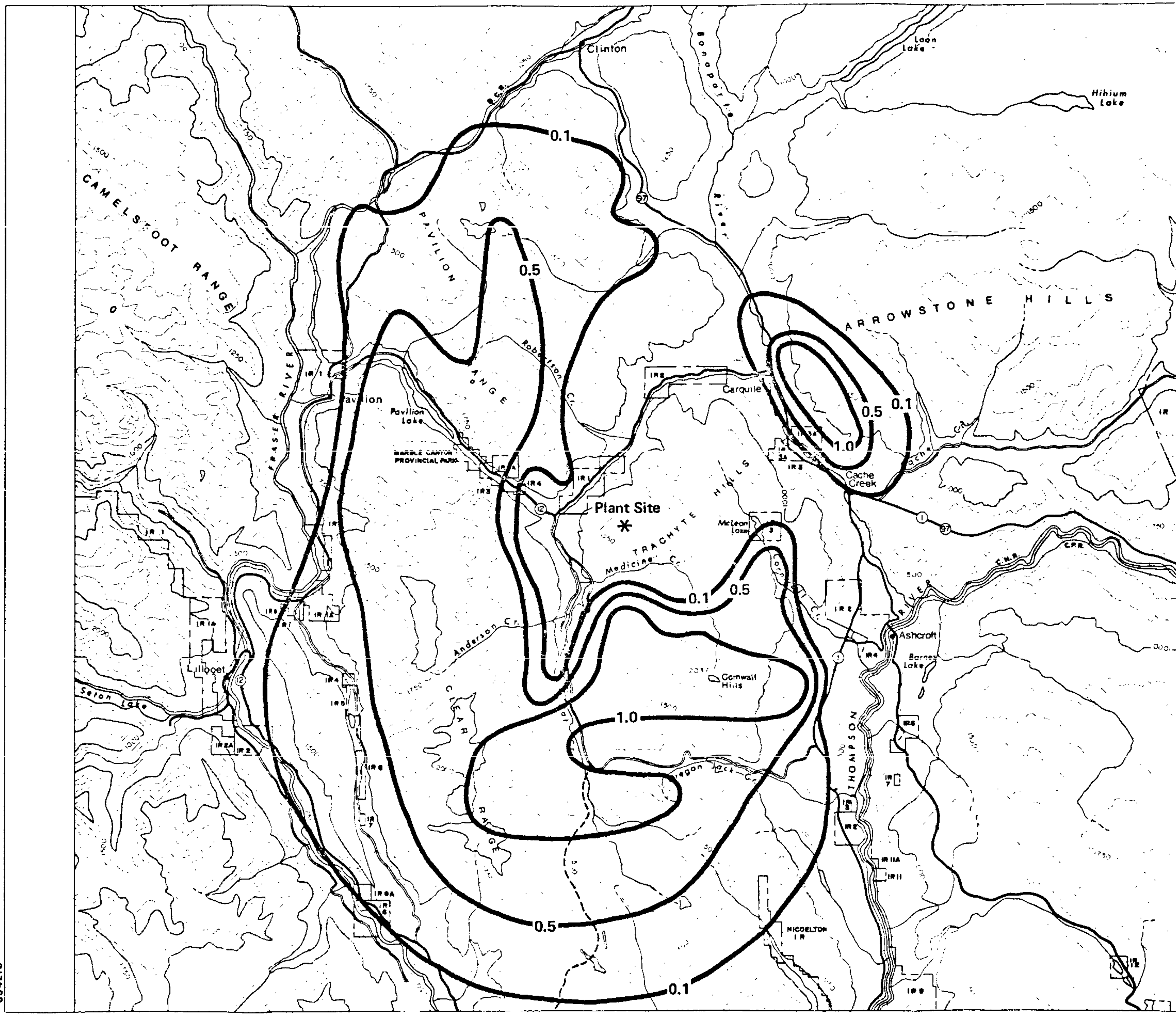
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-38

Predicted Frequencies (%) of 1-Hour SO_2 Concentrations Greater than 225 $\mu g/m^3$: 244 m Stack with MCS (Local Scale)

804215



SCALE - 1:250,000

0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

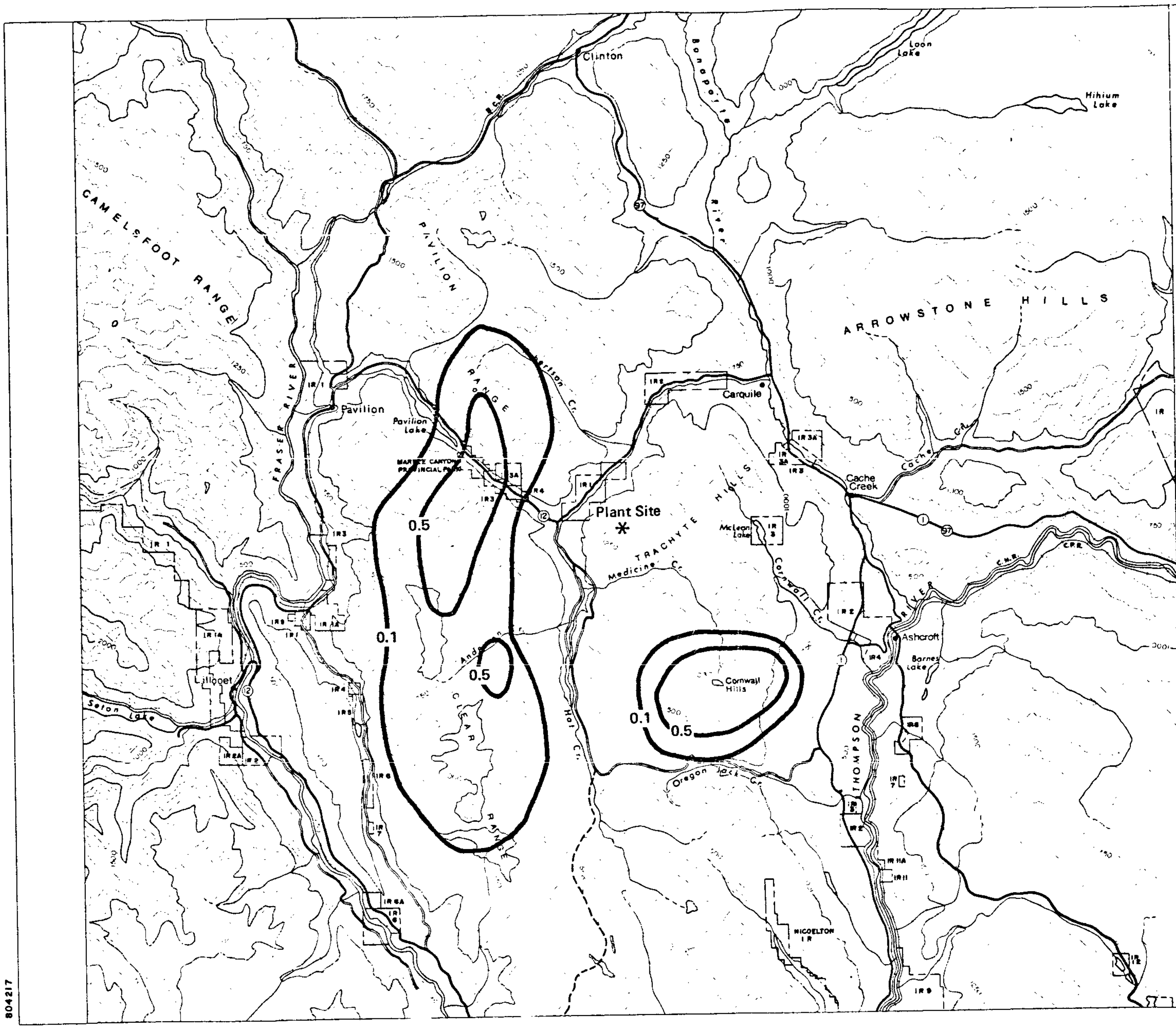
BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-39

Predicted Frequencies (%) of 1-Hour SO_2 Concentrations Greater than 450 $\mu g/m^3$: 244 m Stack with MCS (Local Scale)

804216



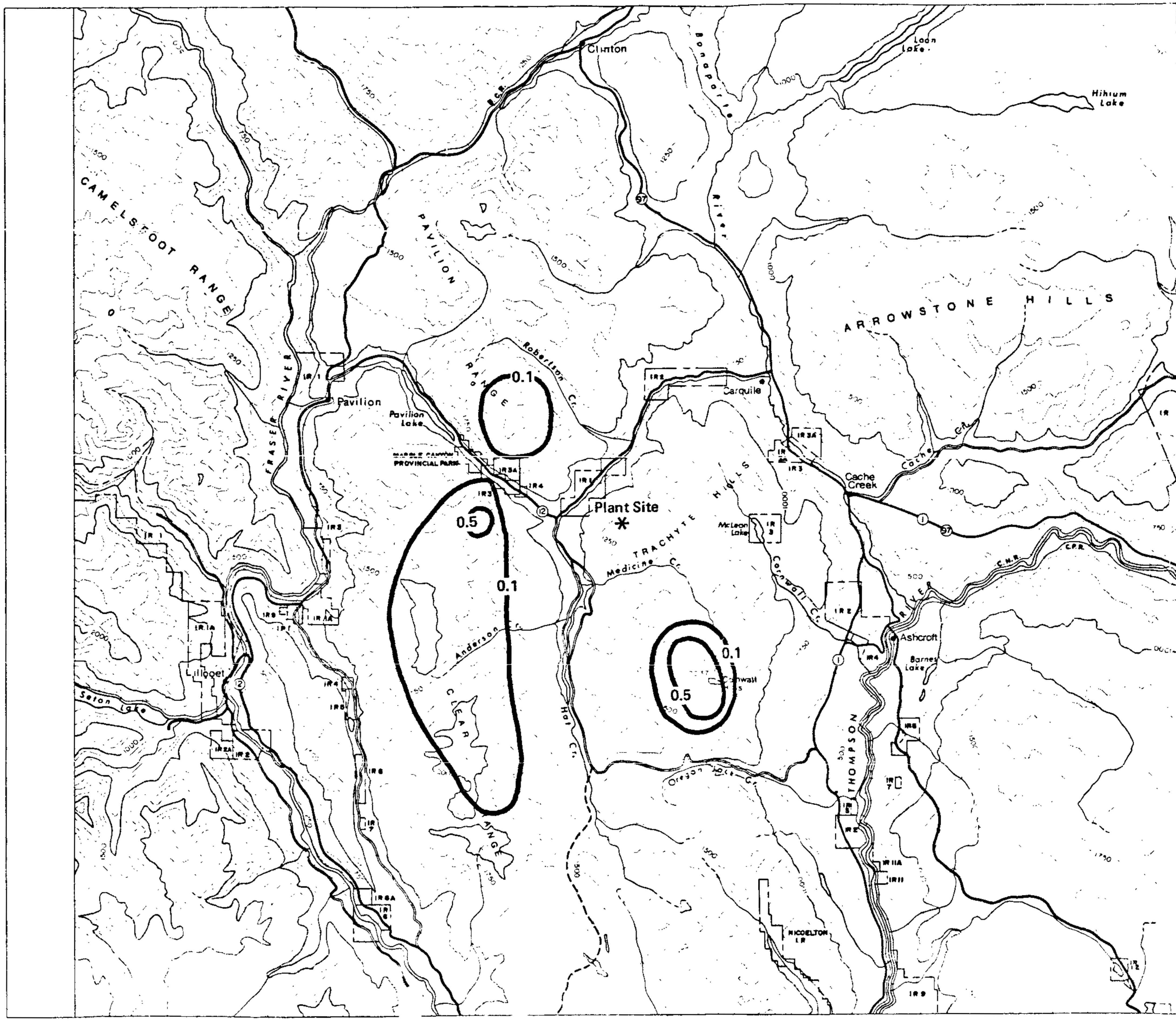
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-40

Predicted Frequencies (%) of 1-Hour SO_2 Concentrations Greater than 900 μg/m^3: 244 m Stack with MCS (Local Scale)

804217



SCALE - 1:250,000

5 0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

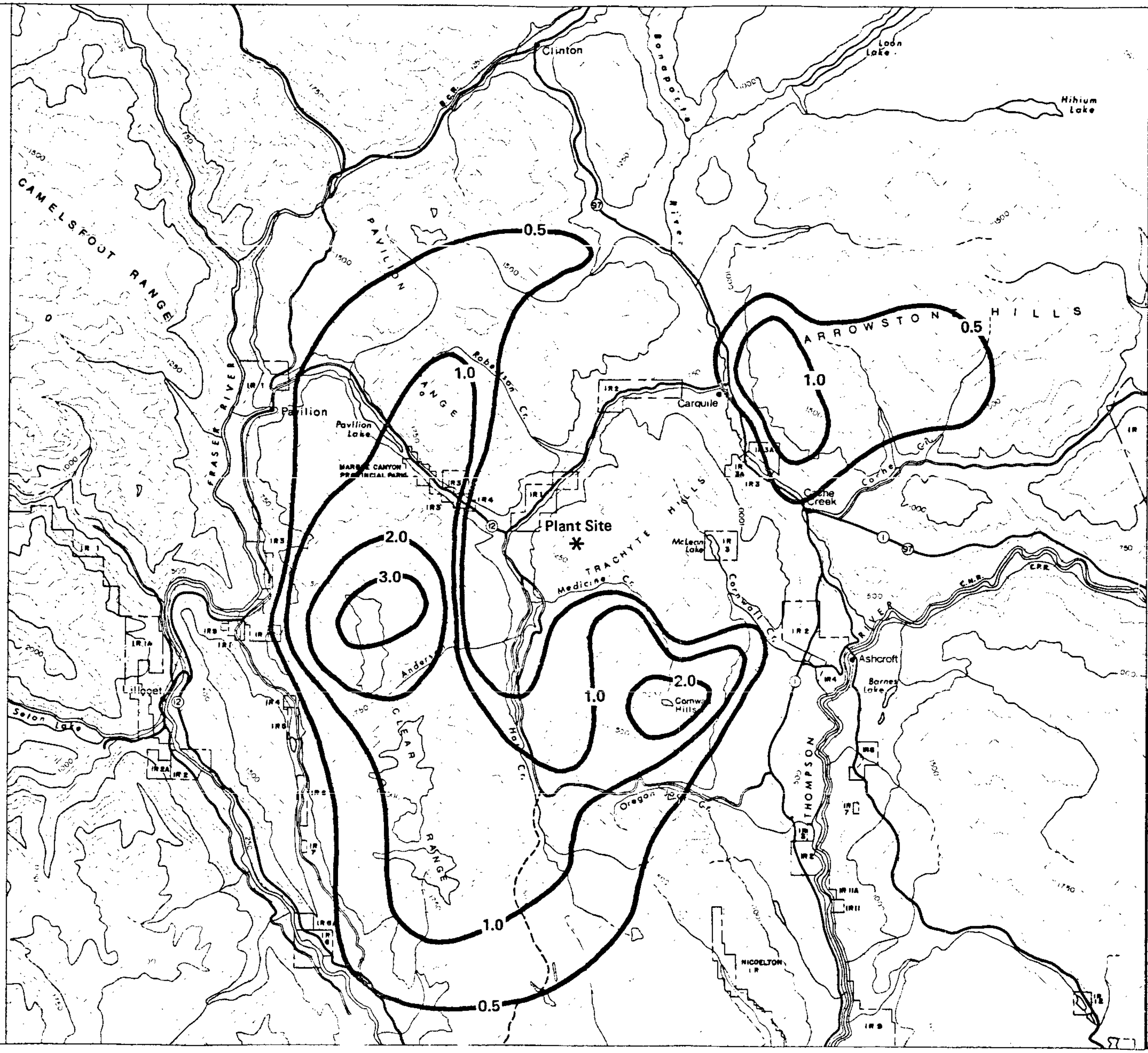
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-41

Predicted Frequencies (%) of 1-Hour SO_2 Concentrations Greater than 1300 $\mu g/m^3$: 244 m Stack with MCS (Local Scale)

804215

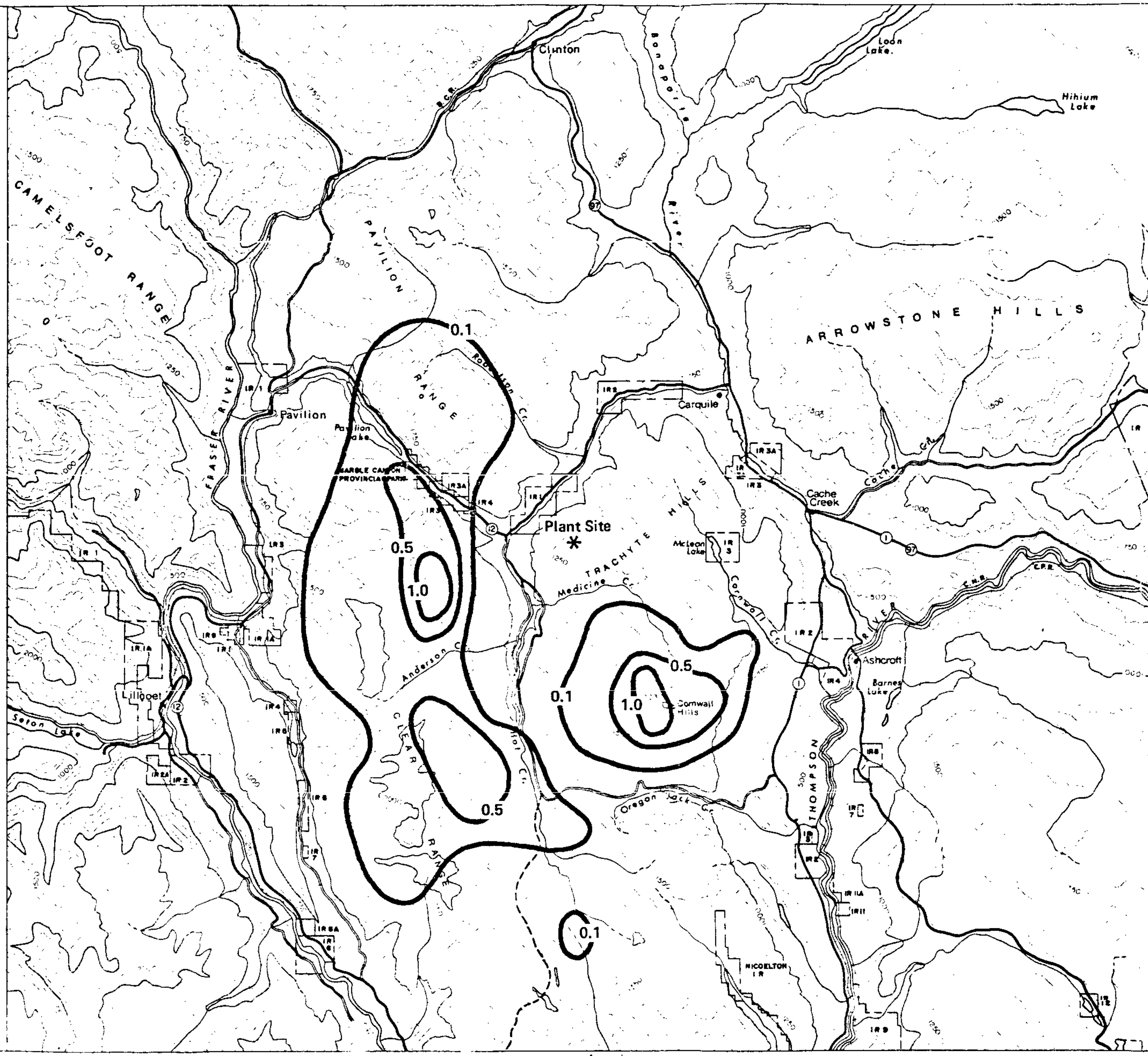


804219

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-42
Predicted Frequencies (%) of 3-Hour SO_2 Concentrations Greater than 150 $\mu g/m^3$: 244 m Stack with MCS (Local Scale)



SCALE - 1:250,000

5 0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

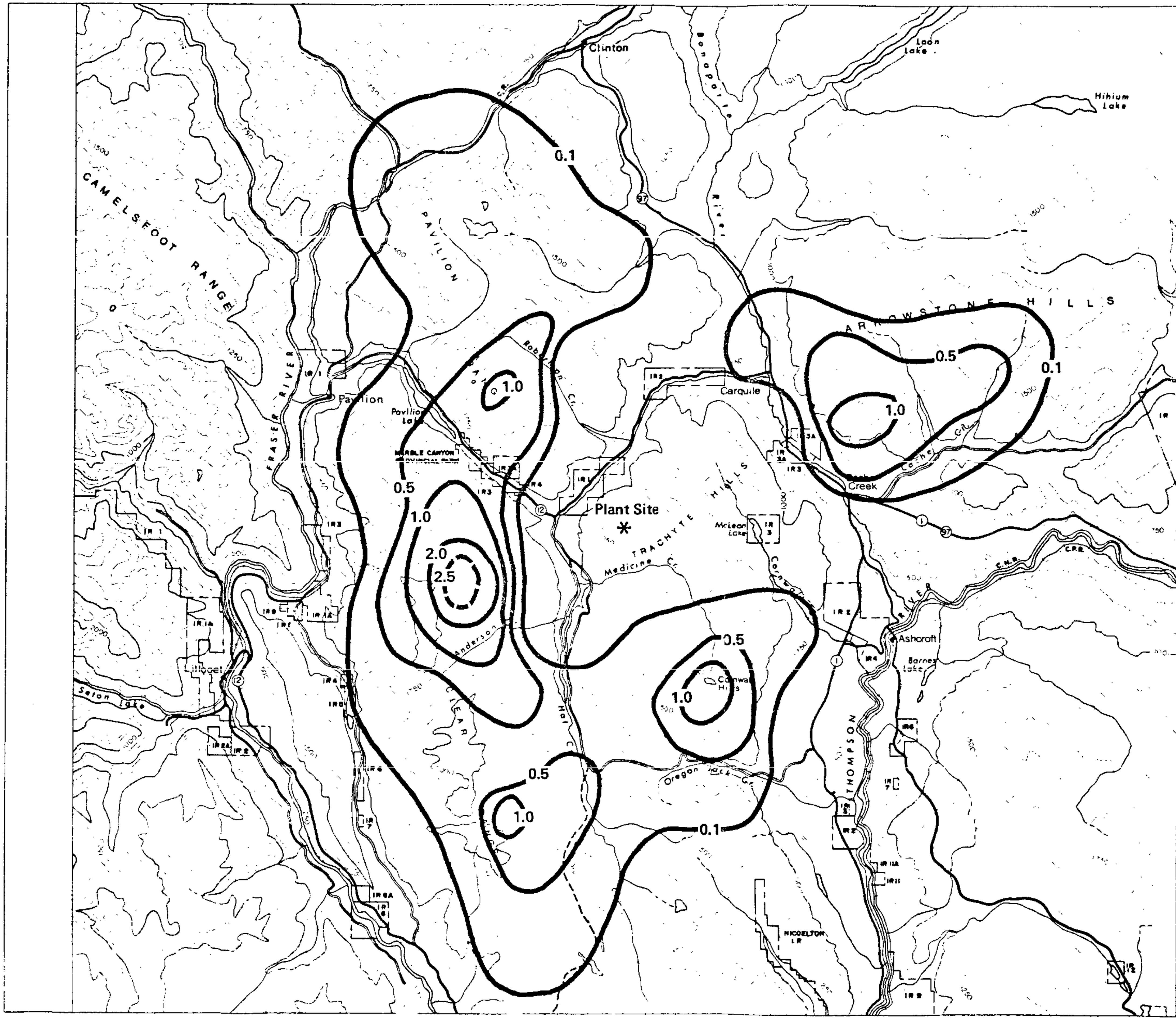
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HATCREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-43

Predicted Frequencies (%) of 3-Hour SO_2 Concentrations Greater than 300 µg/m^3: 244 m Stack with MCS (Local Scale)

804220



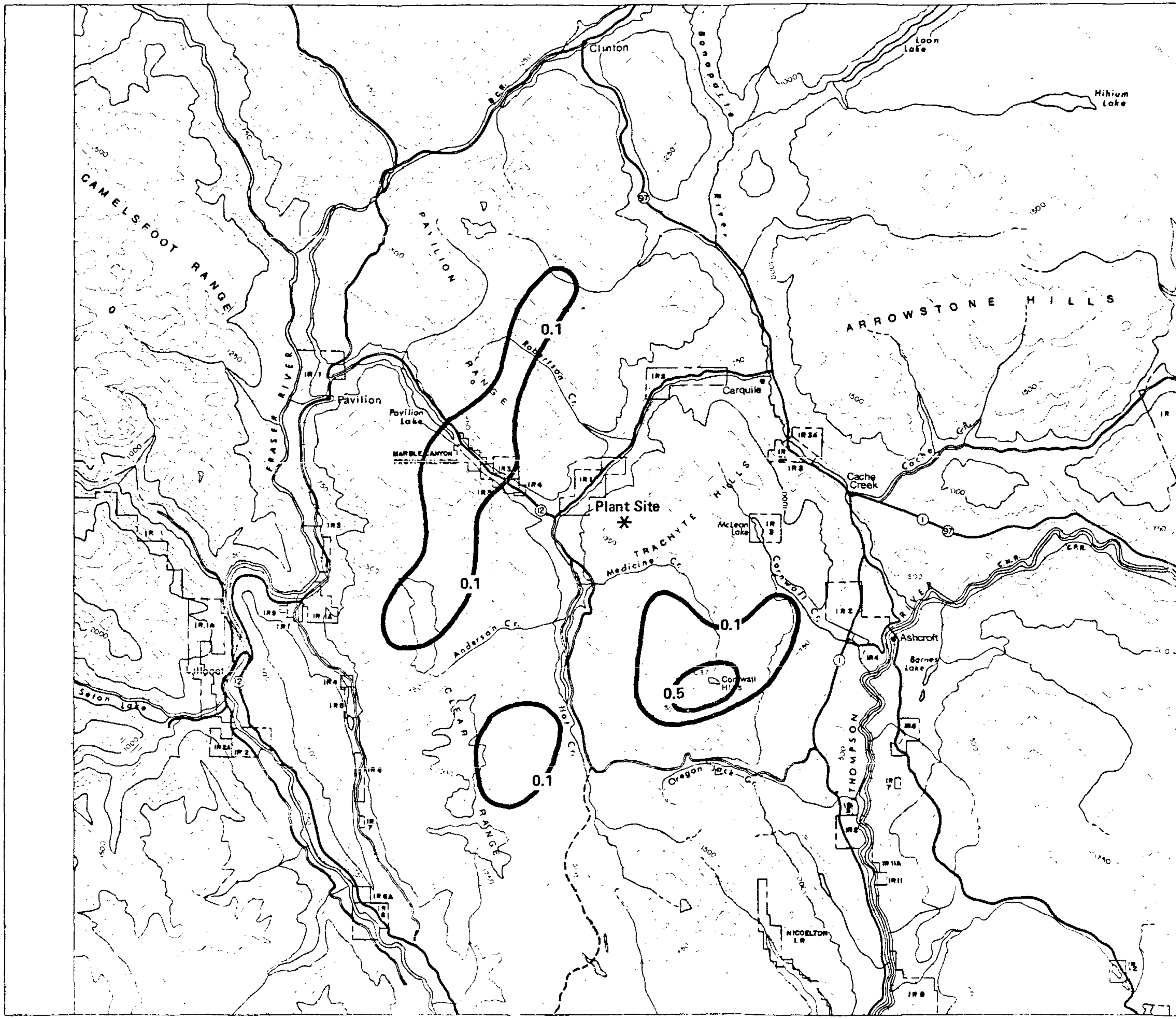
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-44

Predicted Frequencies (%) of 8-Hour SO_2 Concentrations Greater than 150 $\mu g/m^3$: 244 m Stack with MCS (Local Scale)

804221



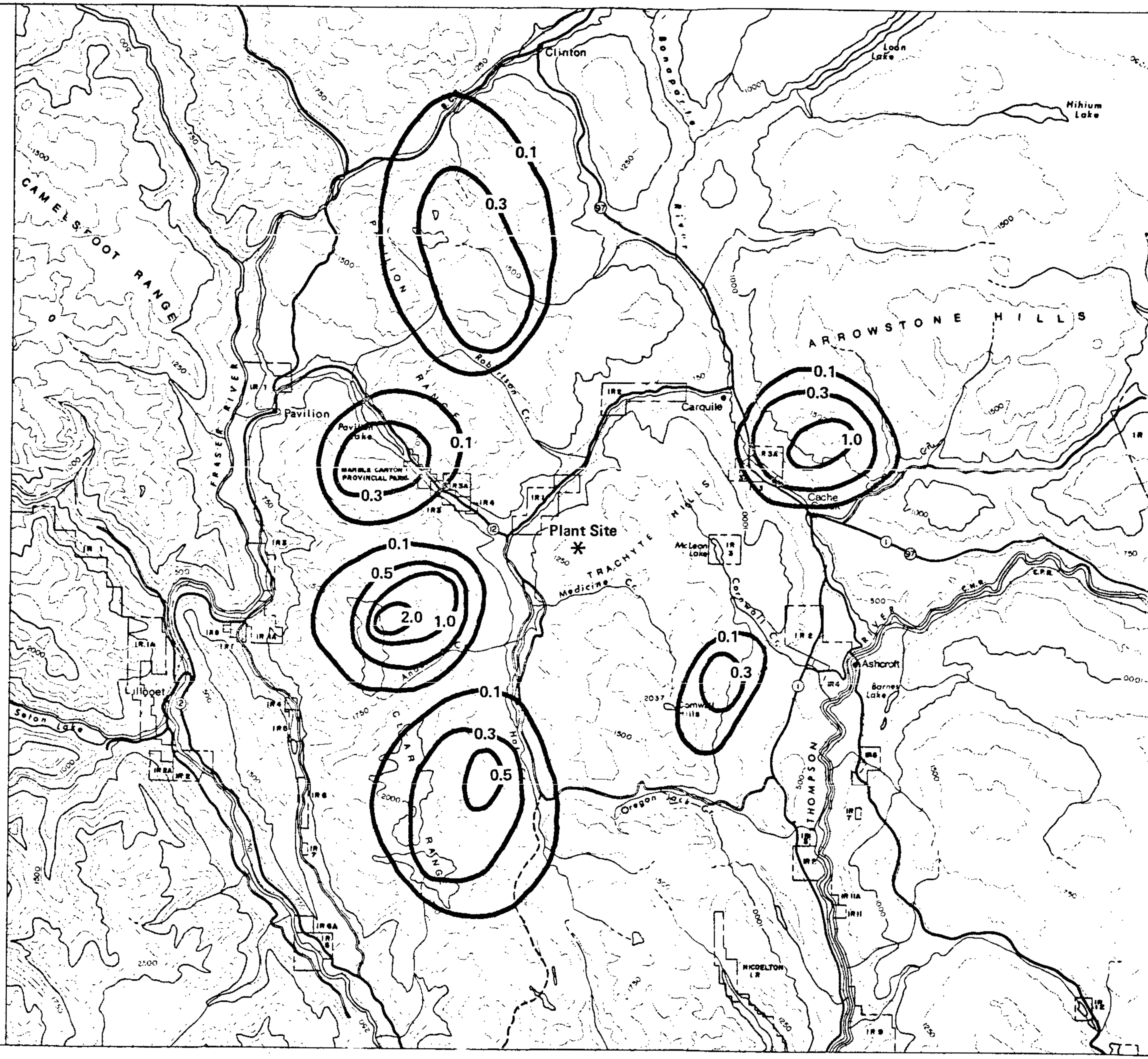
BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-45

Predicted Frequencies (%) of 8-Hour SO_2 Concentrations Greater than 300 $\mu g/m^3$: 244 m Stack with MCS (Local Scale)

804222



SCALE - 1:250,000

0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

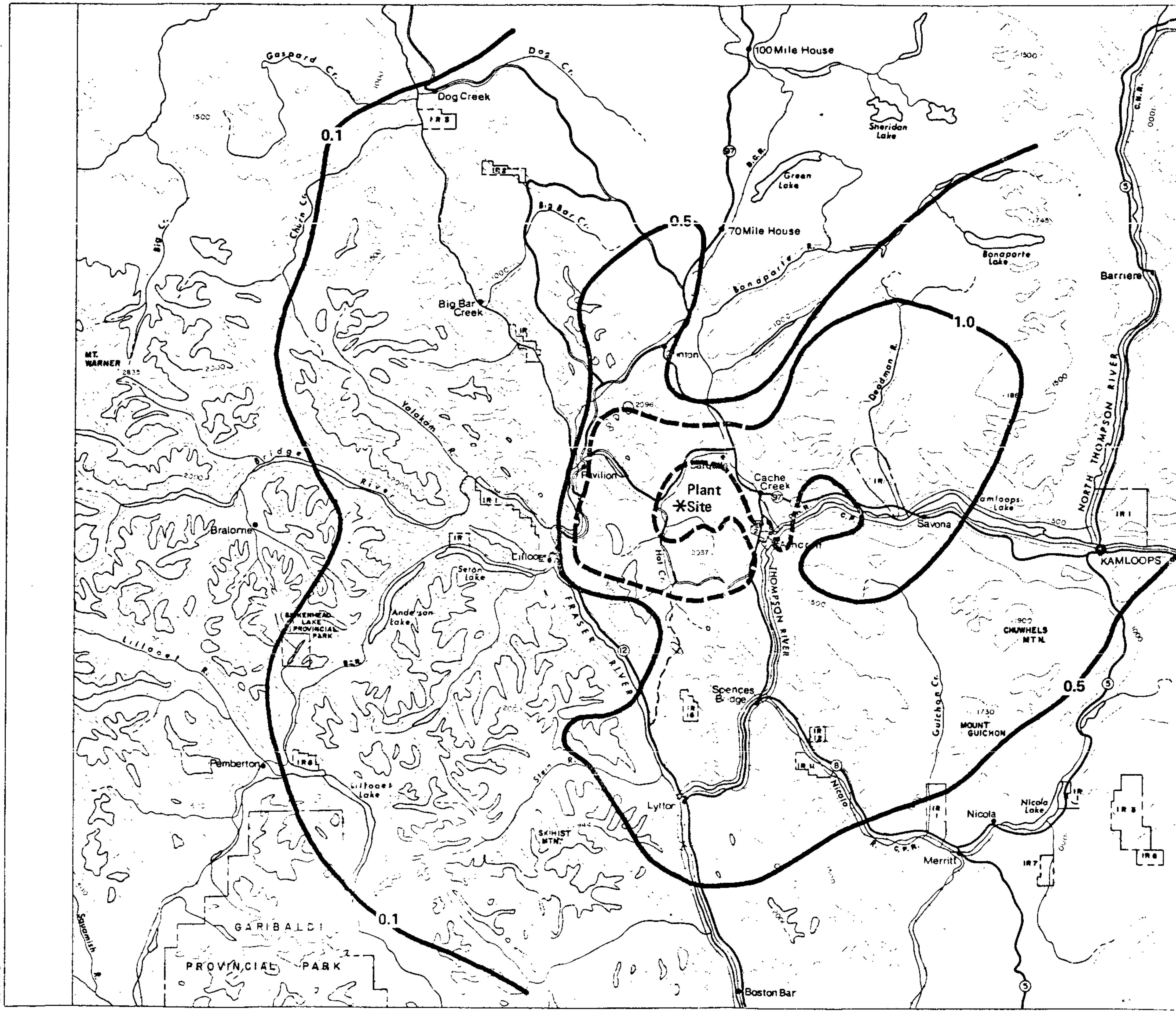
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-46

Predicted Frequencies (%) of 24-Hour SO_2 Concentrations Greater than 160 $\mu g/m^3$: 244 m Stack with MCS (Local Scale)

804223



SCALE - 1:750,000

10 0 Kilometres 10 20 30 40 50

CONTOUR INTERVAL - 500 METRES

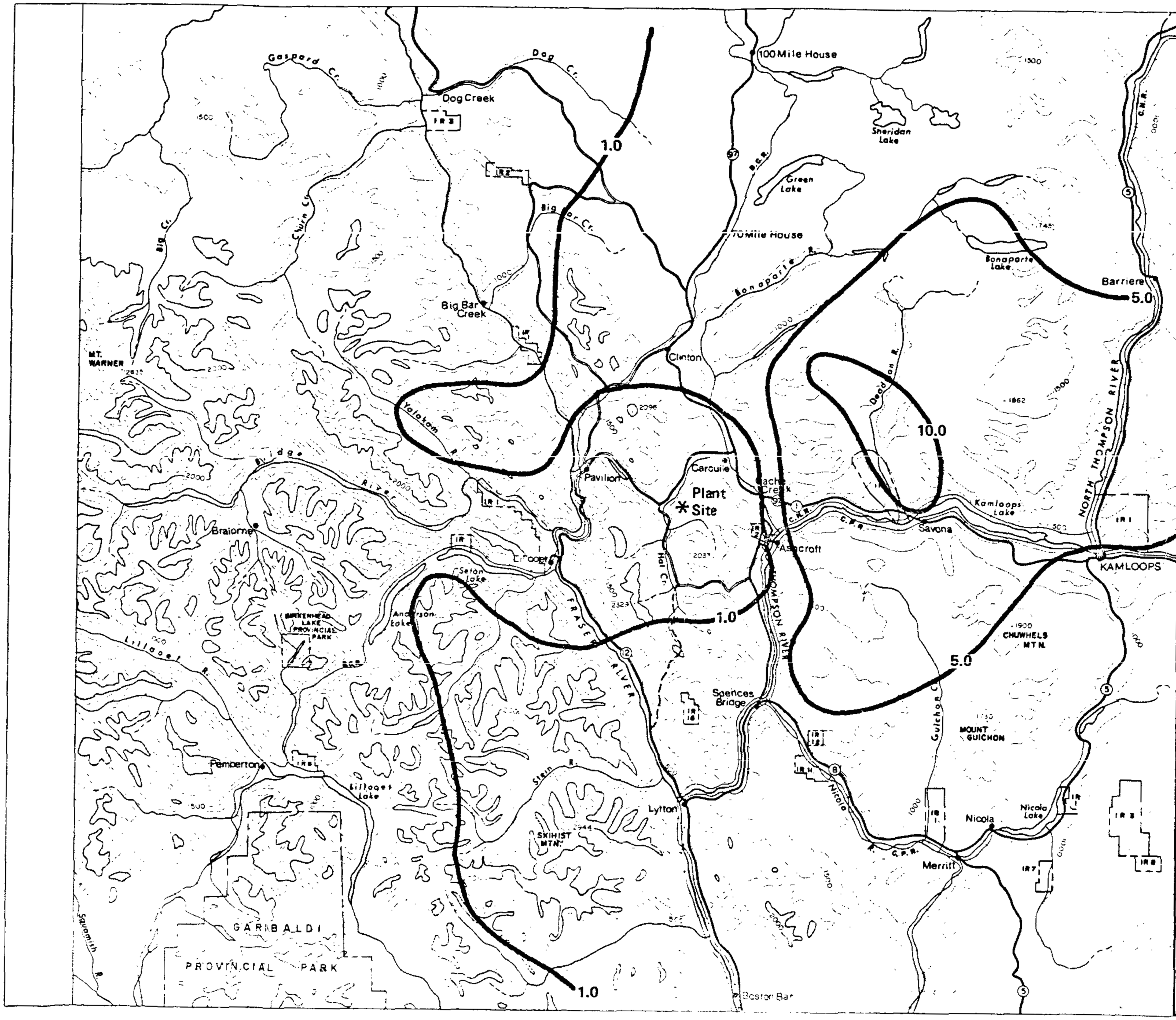
BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-47

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

804170



SCALE - 1:750,000

10 0 Kilometres 10 20 30 40 50

CONTOUR INTERVAL - 500 METRES

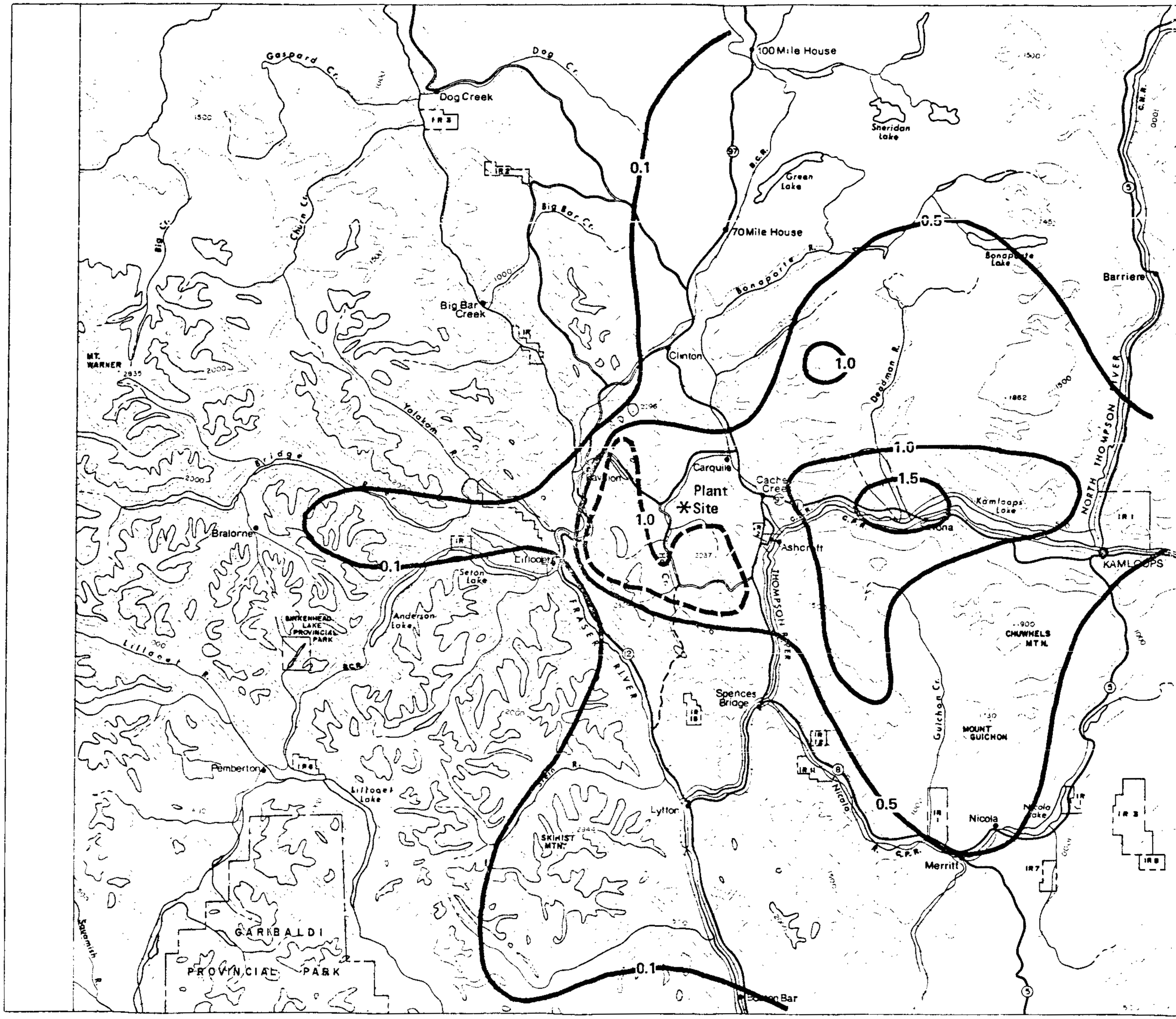
BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-48

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

804171



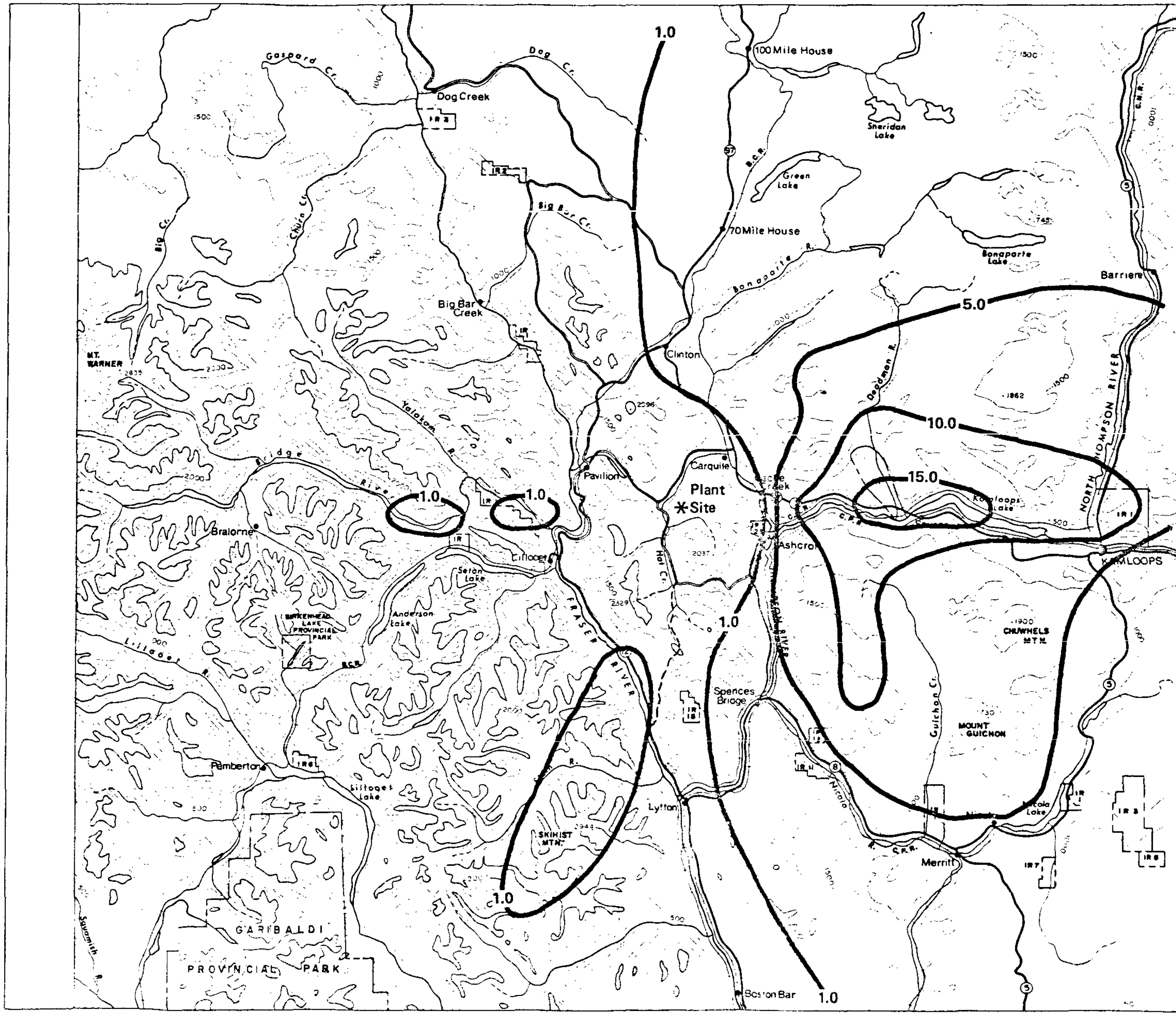
BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-49

Predicted Seasonal (Winter) Averaged SO_2 Concentrations ($\mu g/m^3$): 366 m Stack with Uncontrolled Emissions (Regional Scale)

804172



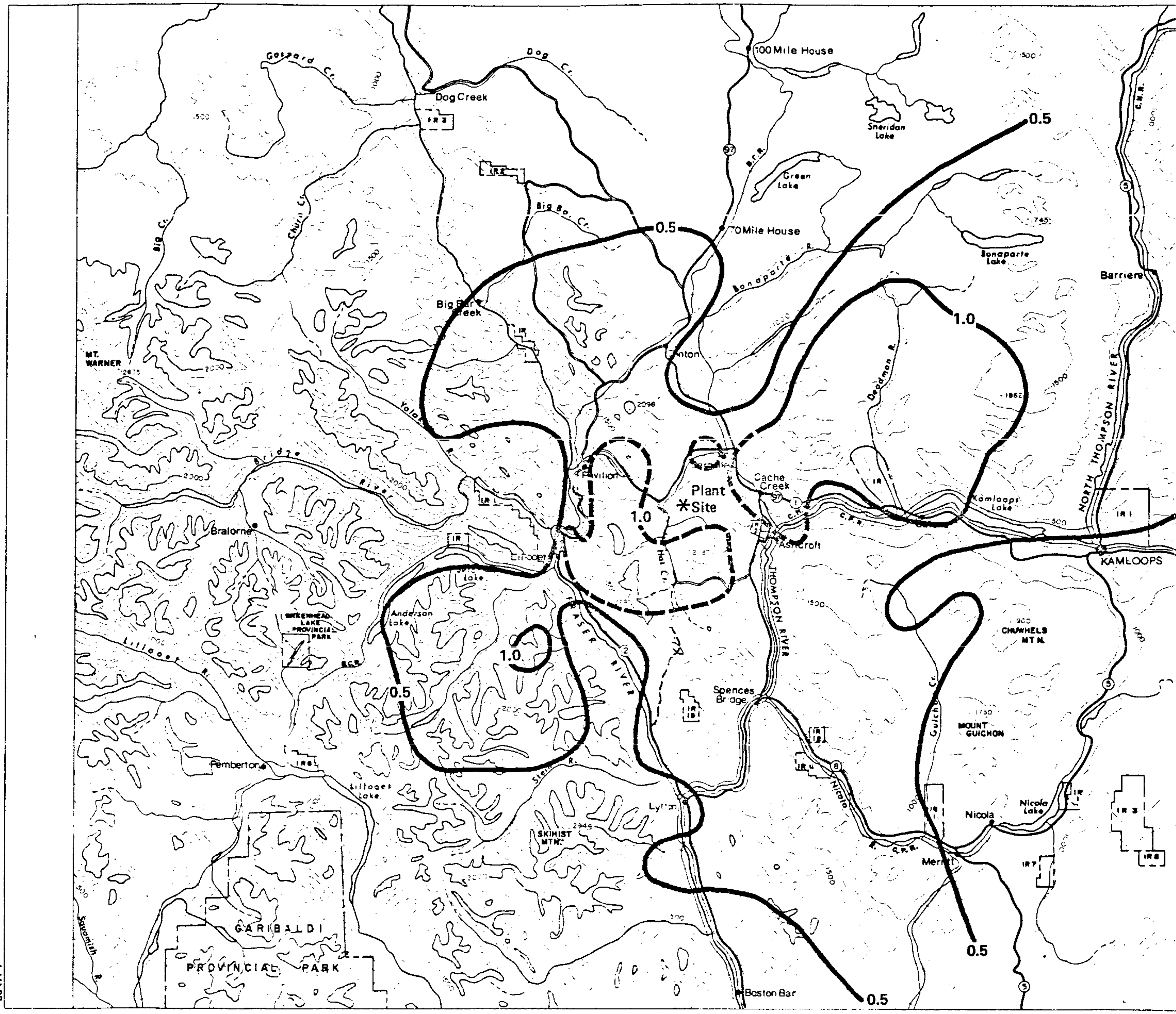
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-50

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

804173

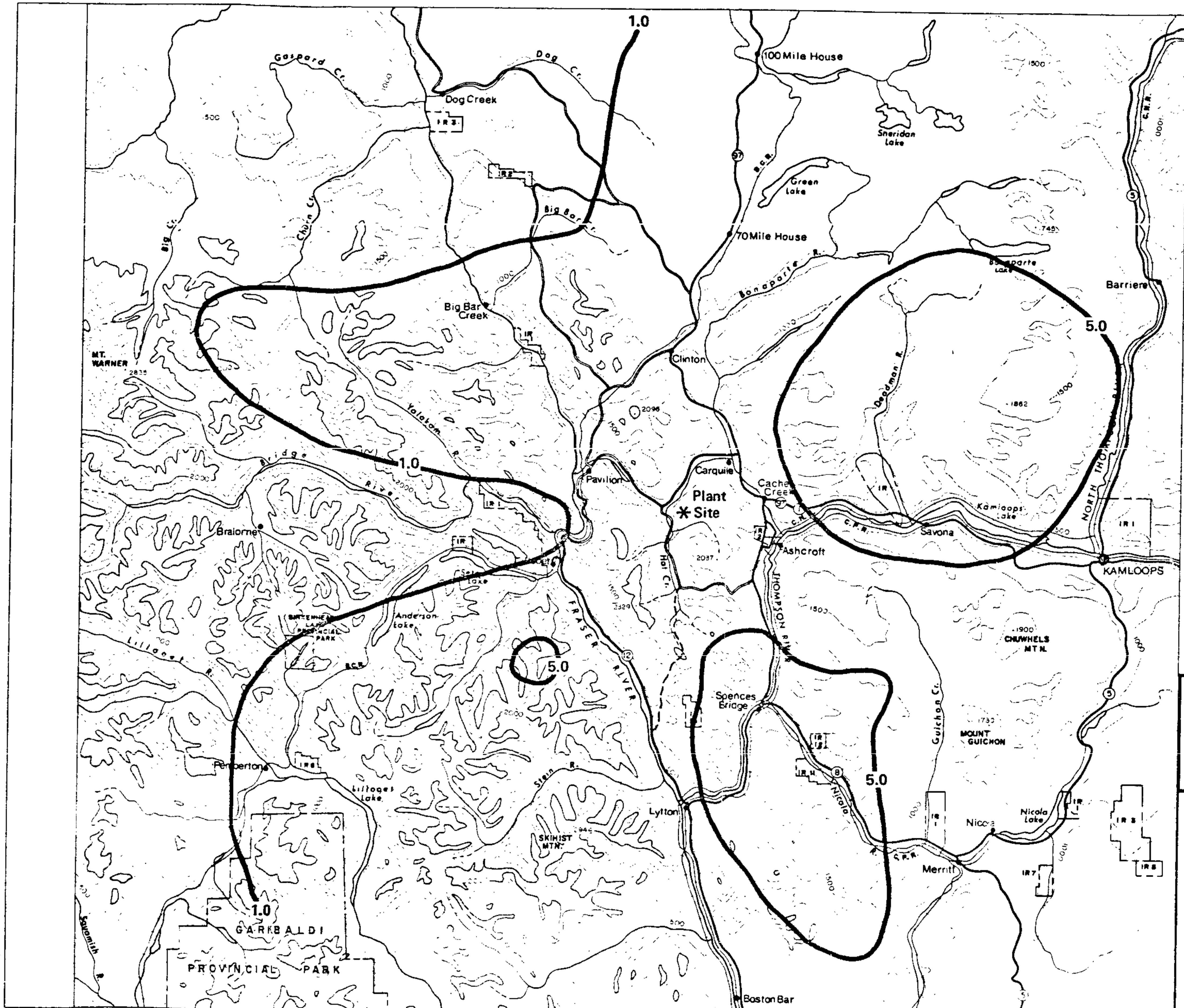


BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-51

Predicted Seasonal (Spring) Averaged SO_2 Concentrations ($\mu g/m^3$): 366 m Stack with Uncontrolled Emissions (Regional Scale)



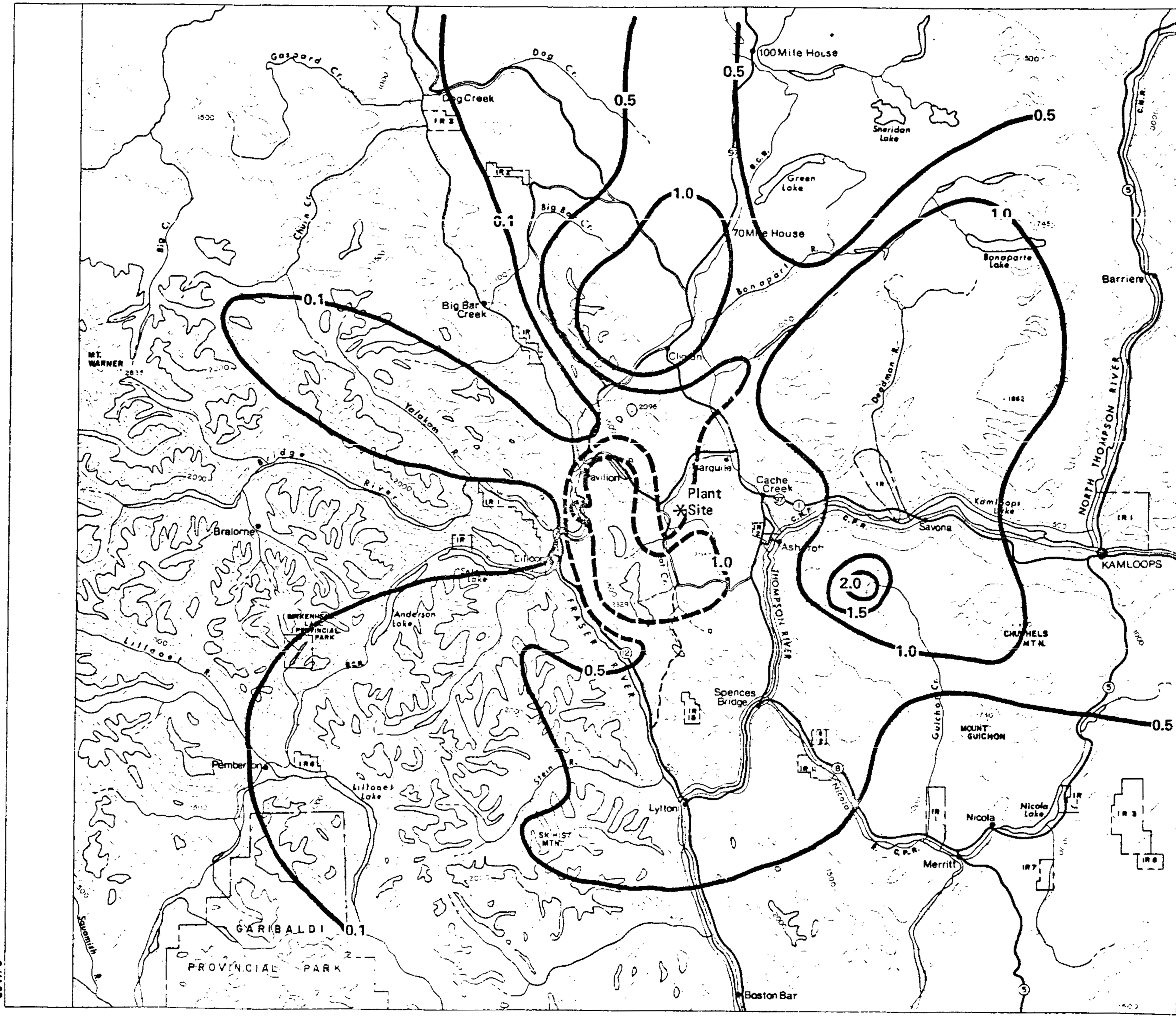
BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-52

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

804175

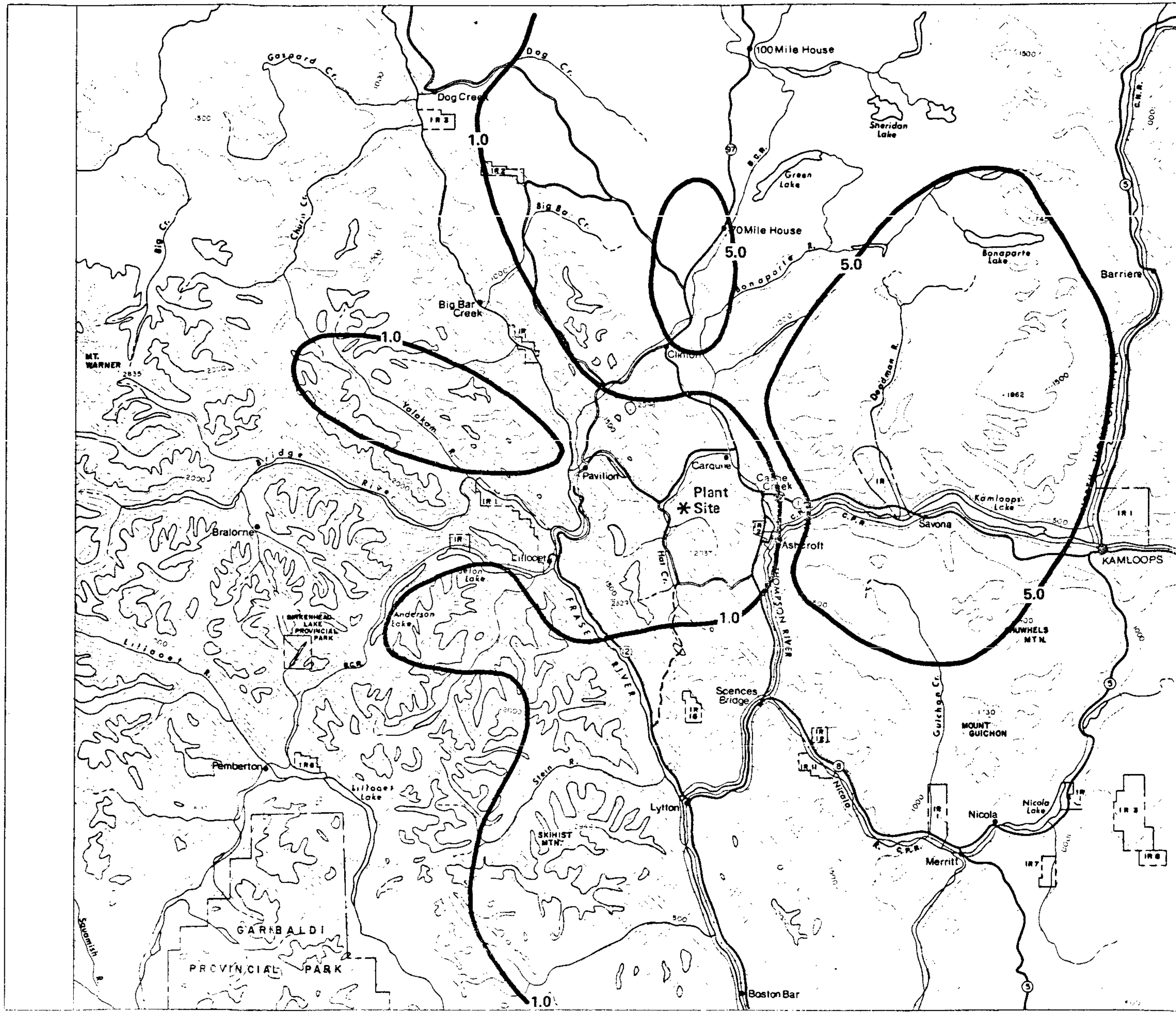


BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-55

Predicted Seasonal (Summer) Averaged SO_2 Concentrations ($\mu g/m^3$): 366 m Stack with Uncontrolled Emissions (Regional Scale)



SCALE - 1:750,000

0 Kilometres 10 20 30 40 50

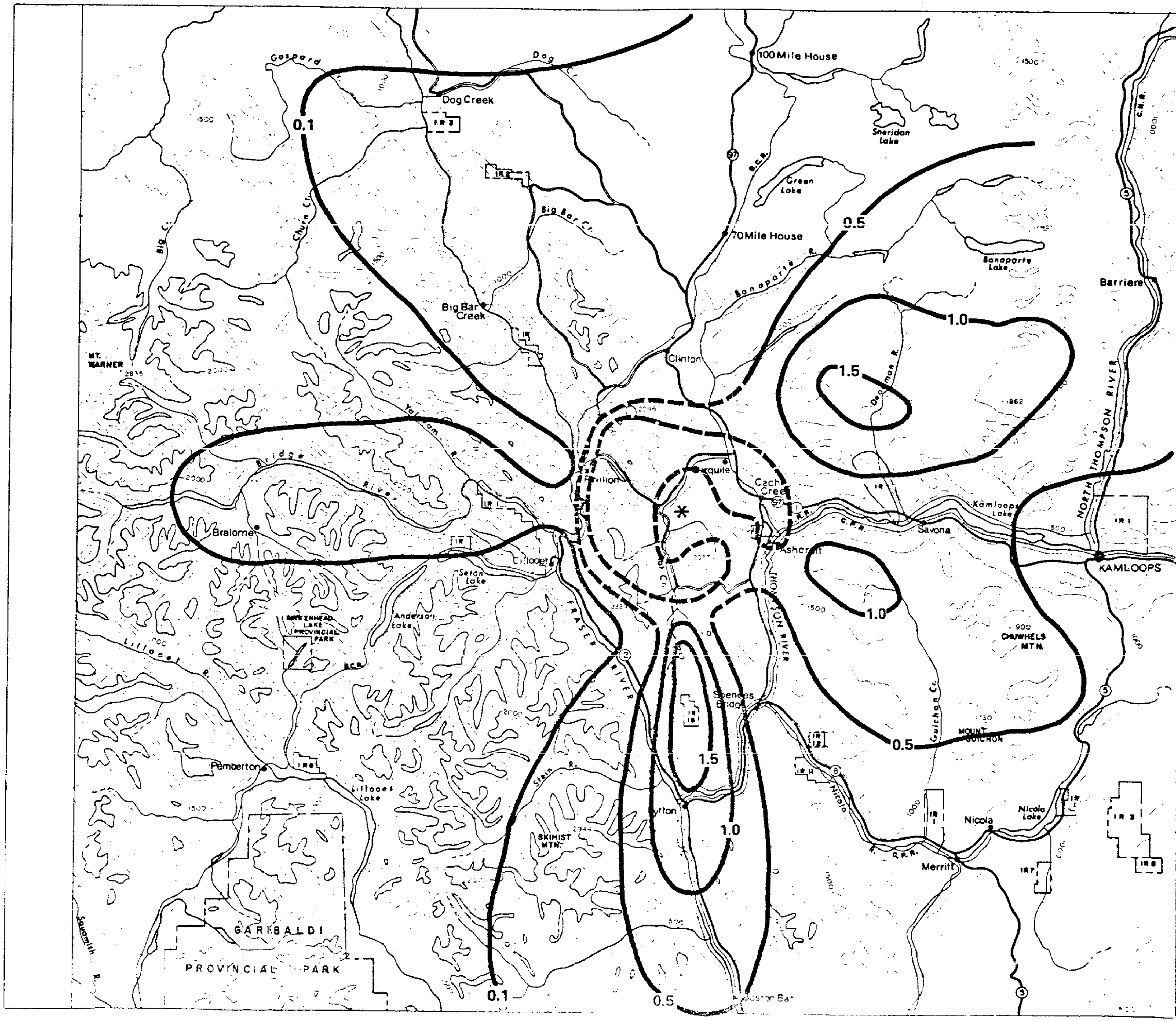
CONTOUR INTERVAL - 500 METRES

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-54

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



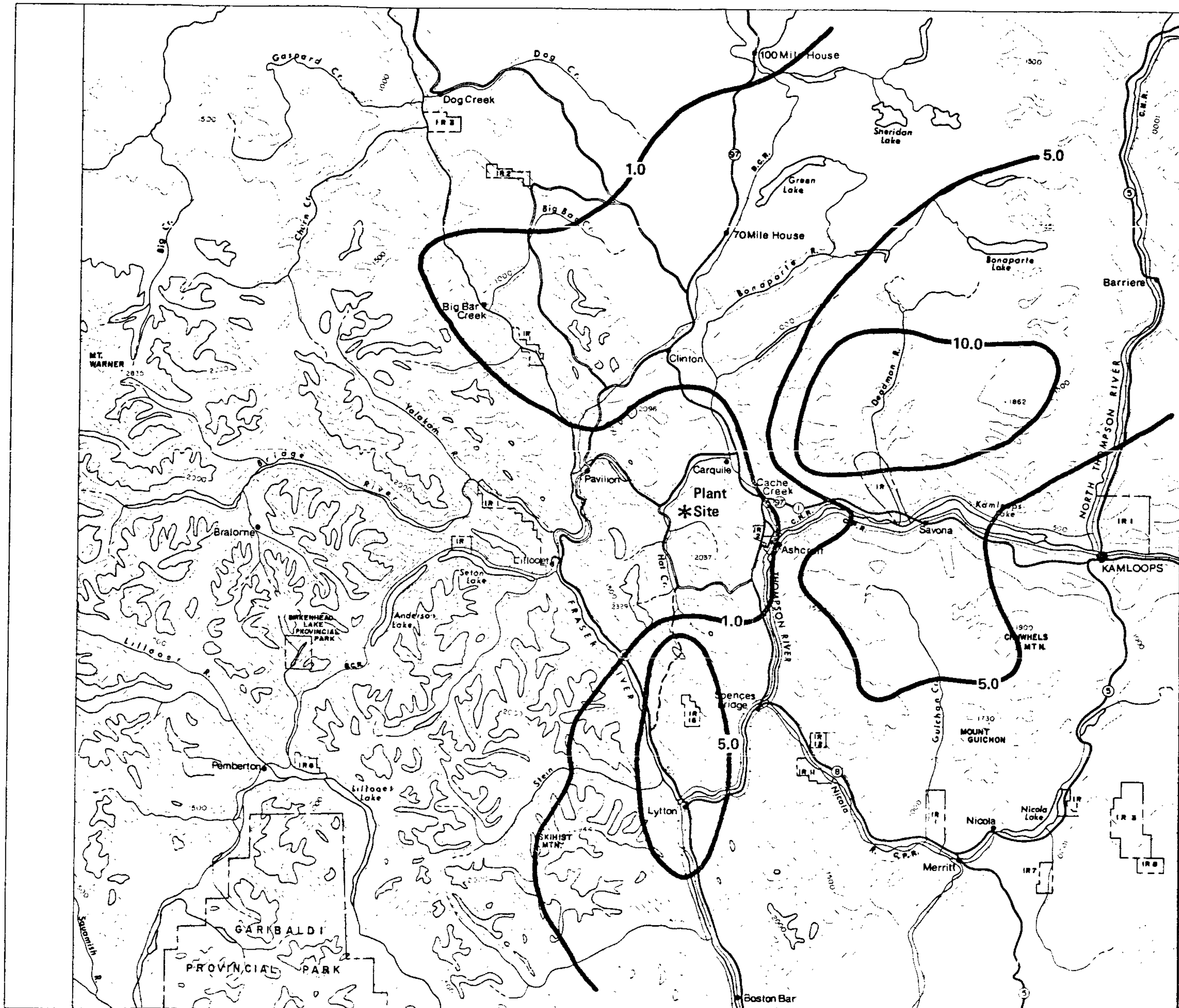
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-55

Predicted Seasonal (Fall) SO_2 Concentrations ($\mu g/m^3$): 366 m Stack with Uncontrolled Emissions (Regional Scale)

804178



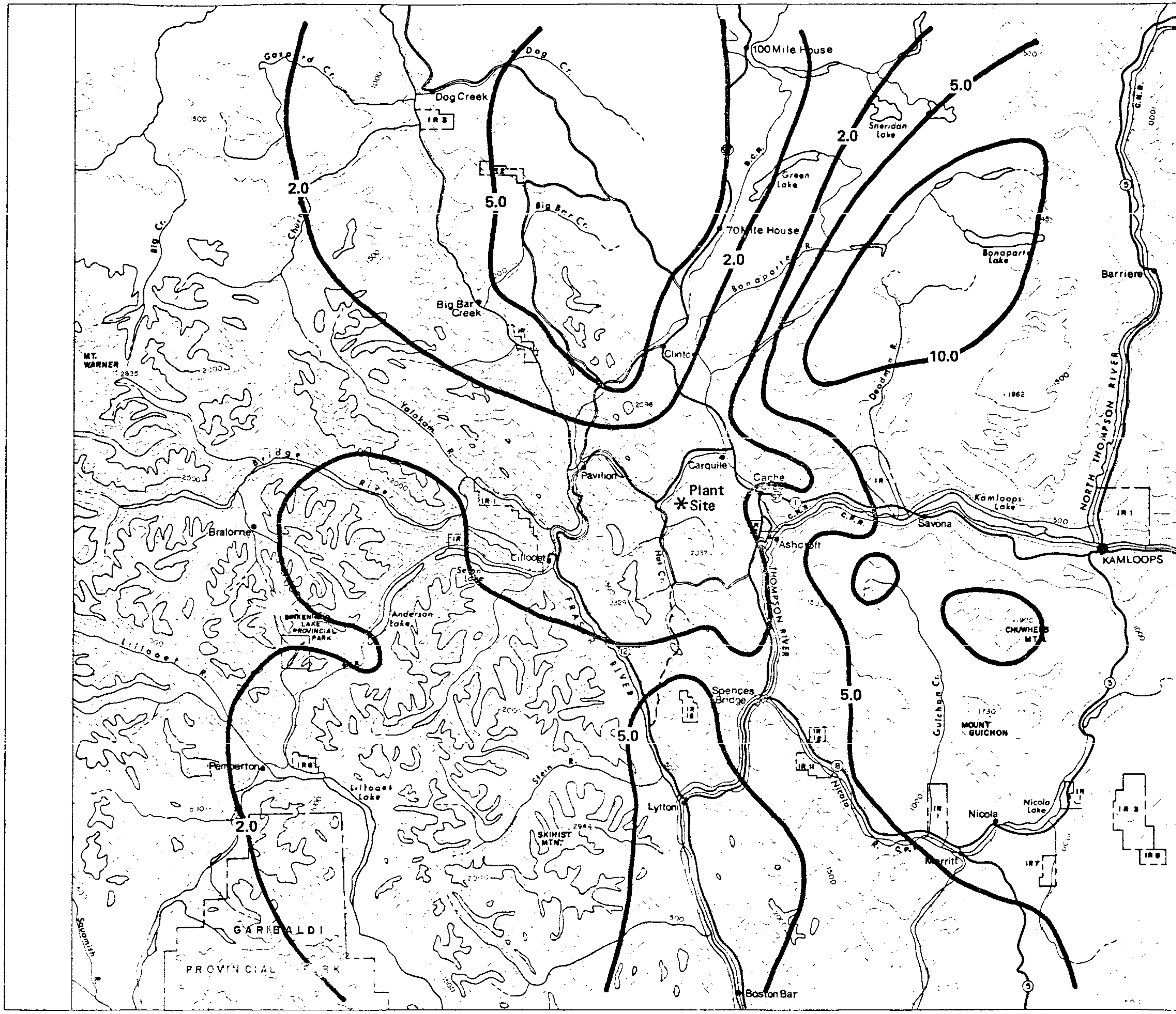
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-56

Predicted Seasonal (Fall) Averaged SO_2 Deposition Rates ($\mu g/m^2/sec$): 366 m Stack with Uncontrolled Emissions (Regional Scale)

804179



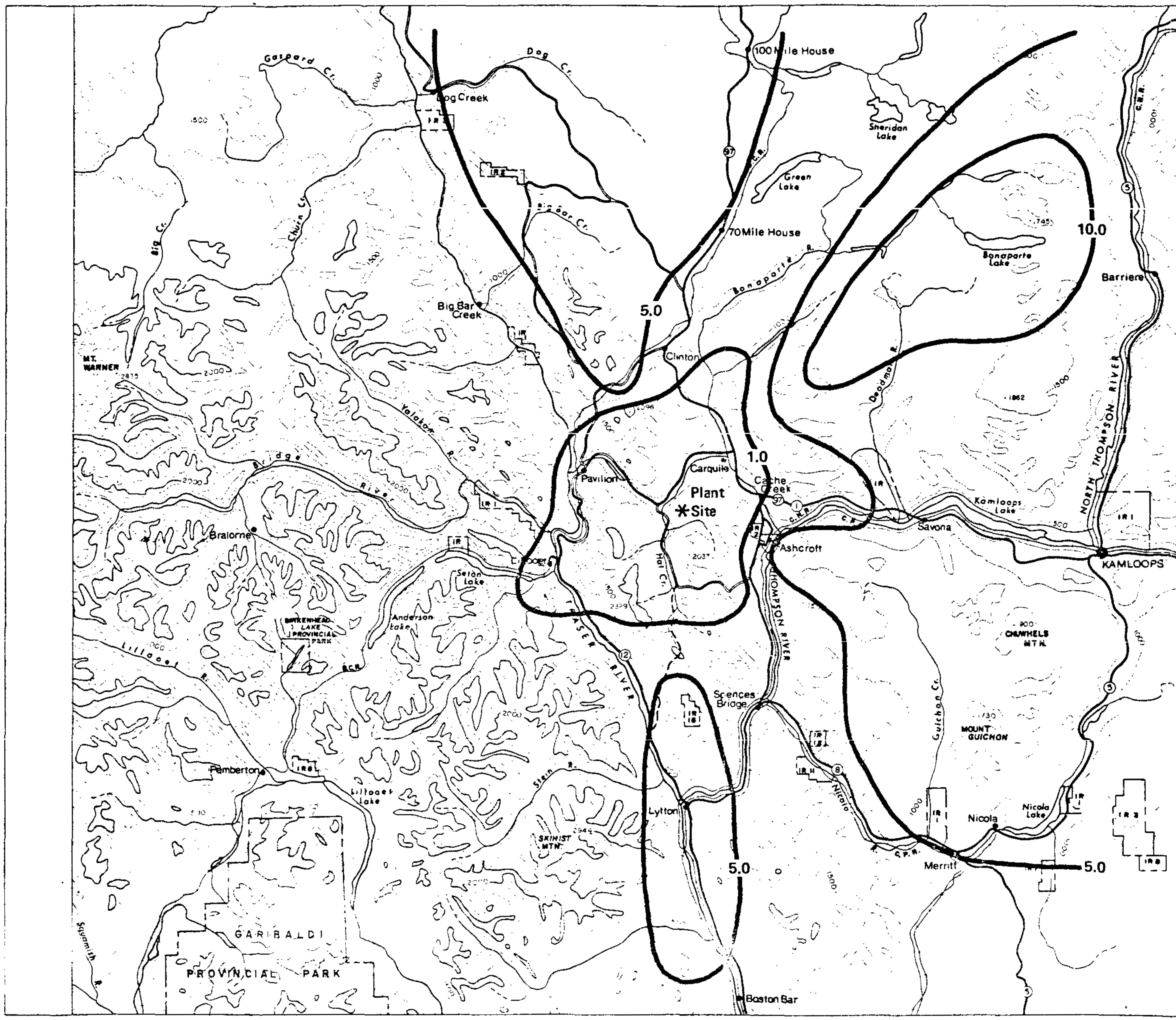
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-57

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

804180



SCALE - 1:750,000

10 0 Kilometres 10 20 30 40 50

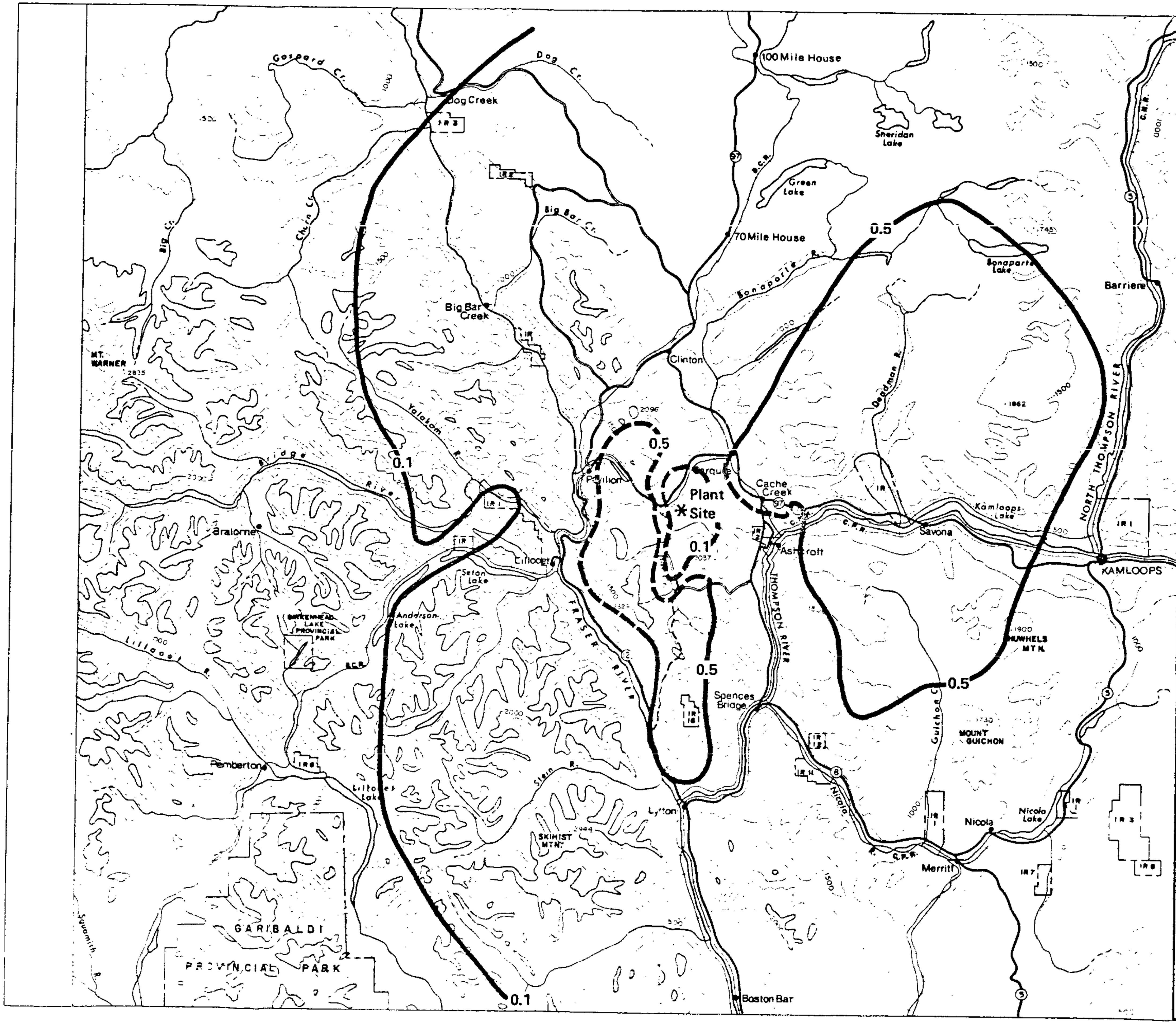
CONTOUR INTERVAL - 500 METRES

BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-58

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



SCALE - 1:750,000

10 0 Kilometres 10 20 30 40 50

CONTOUR INTERVAL - 500 METRES

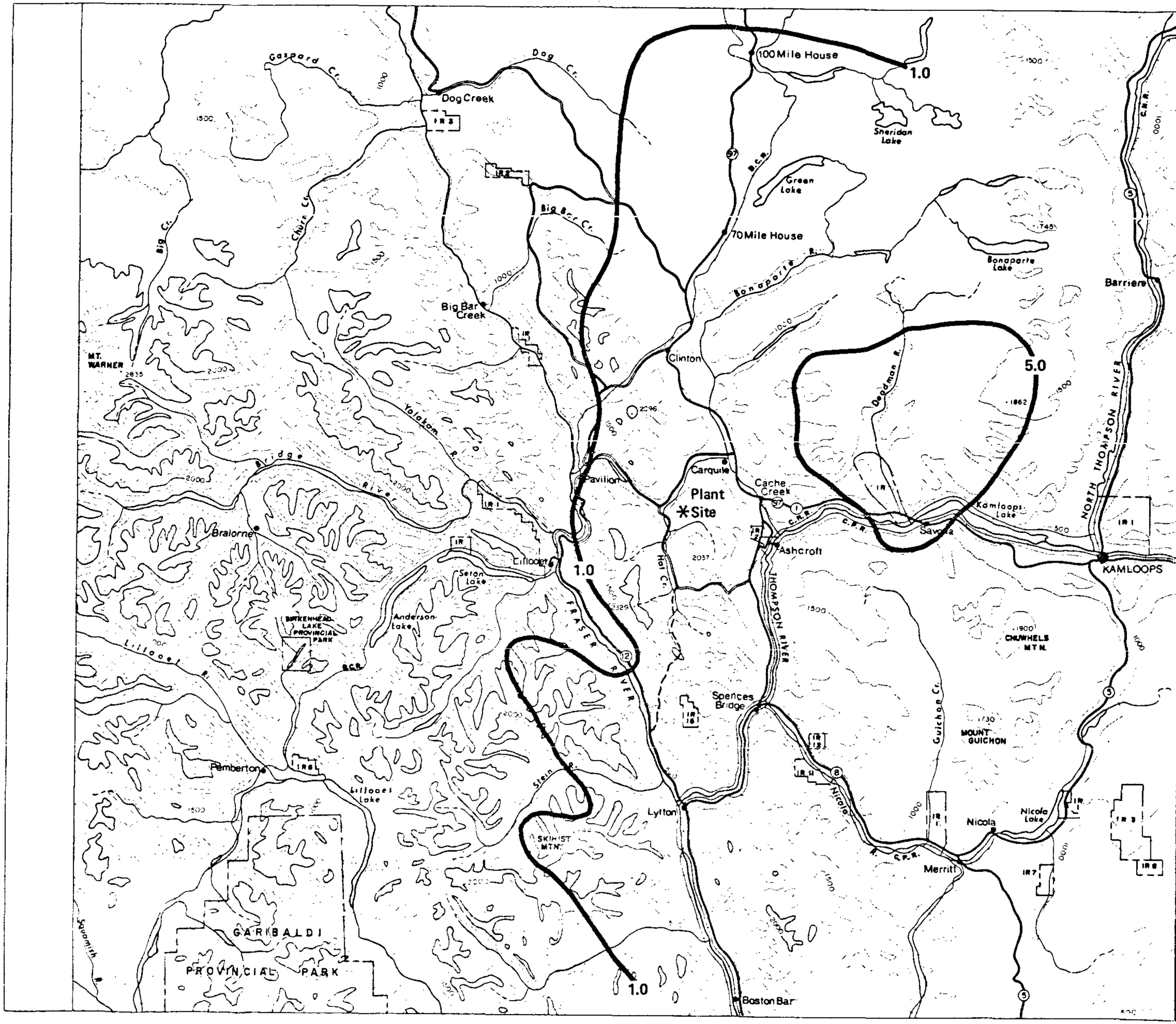
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-59

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

804182



SCALE - 1:750,000

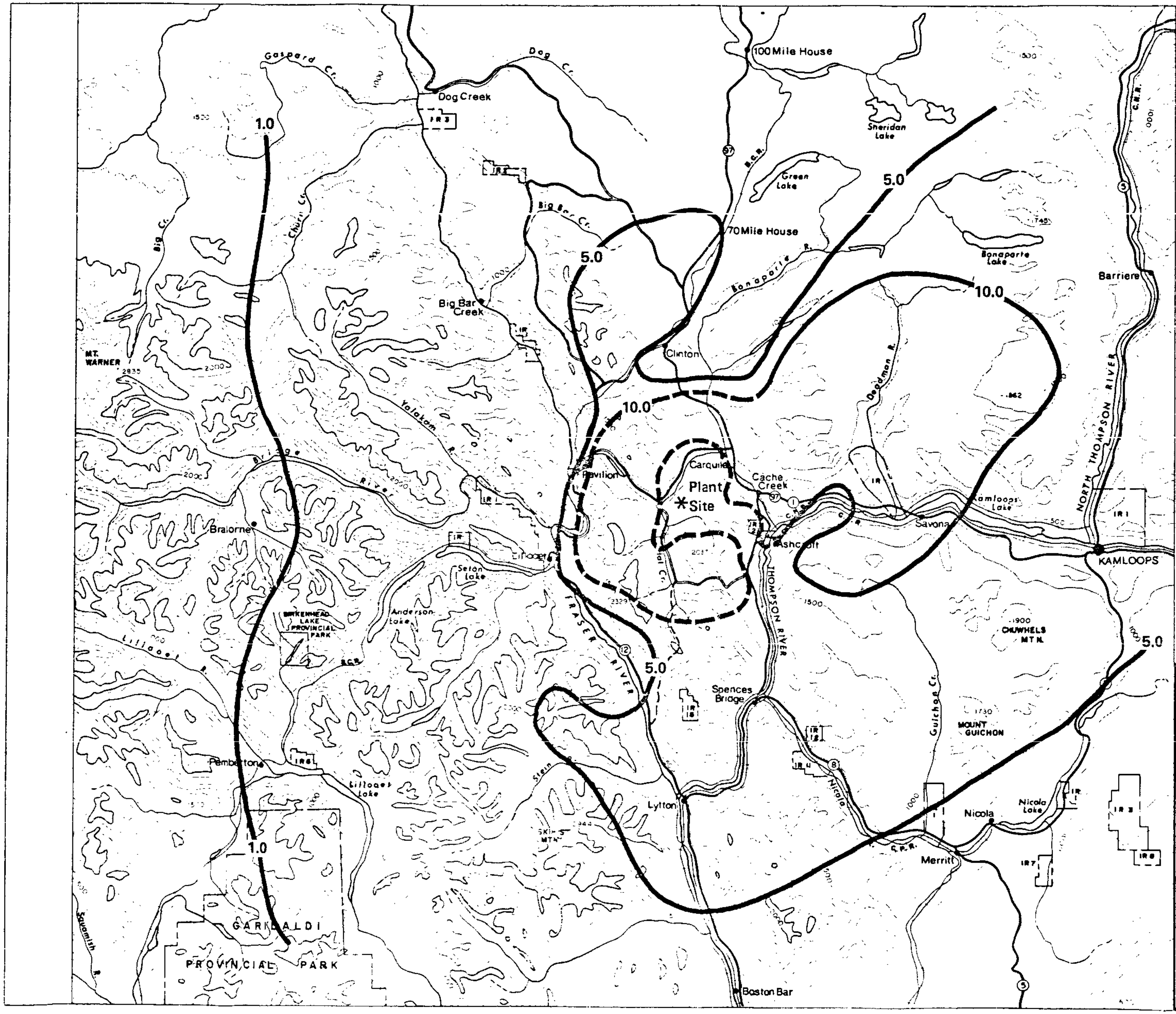
CONTOUR INTERVAL - 500 METRES

BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-60

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



SCALE - 1:750,000

10 0 Kilometres 10 20 30 40 50

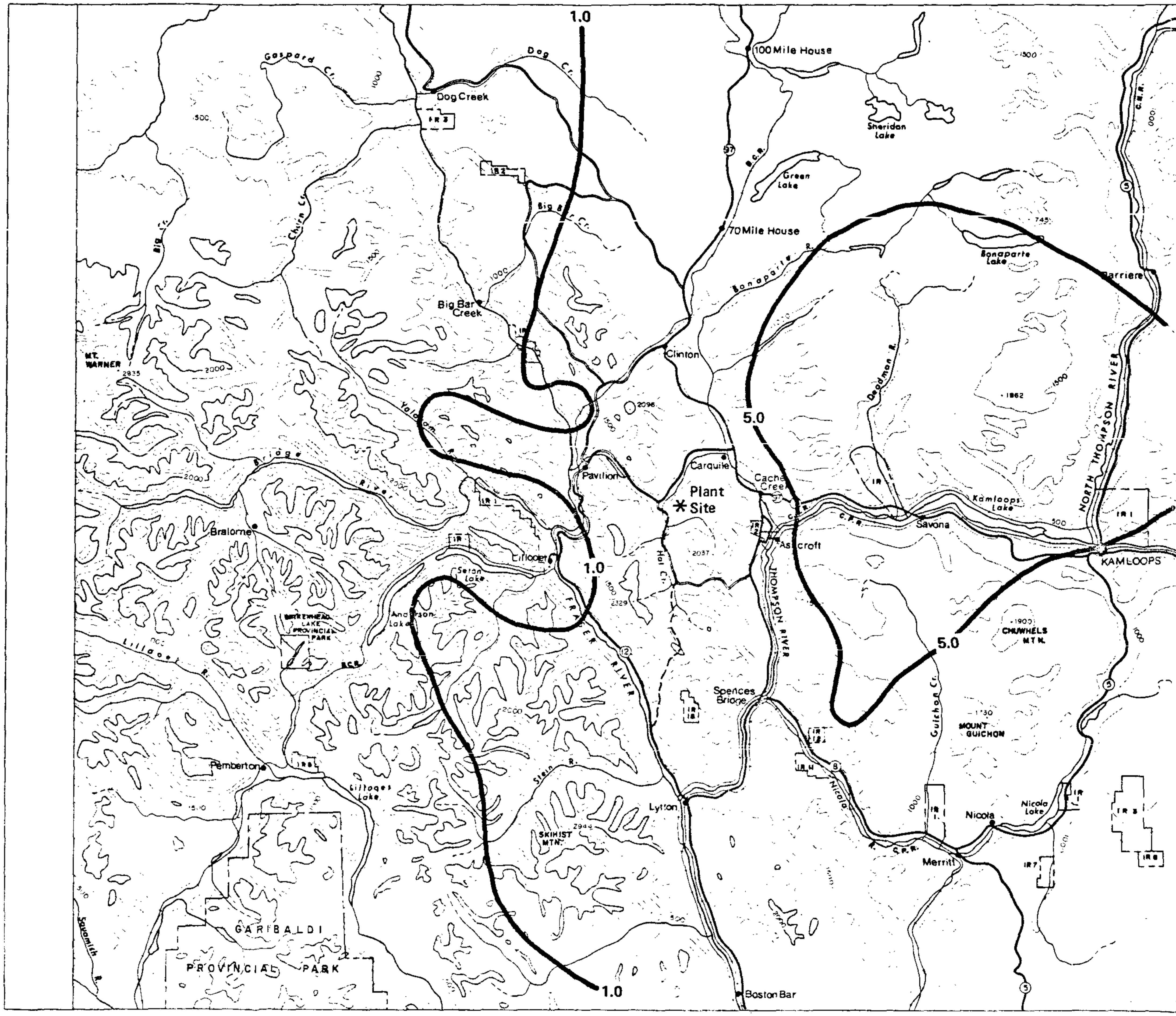
CONTOUR INTERVAL - 500 METRES

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-61

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



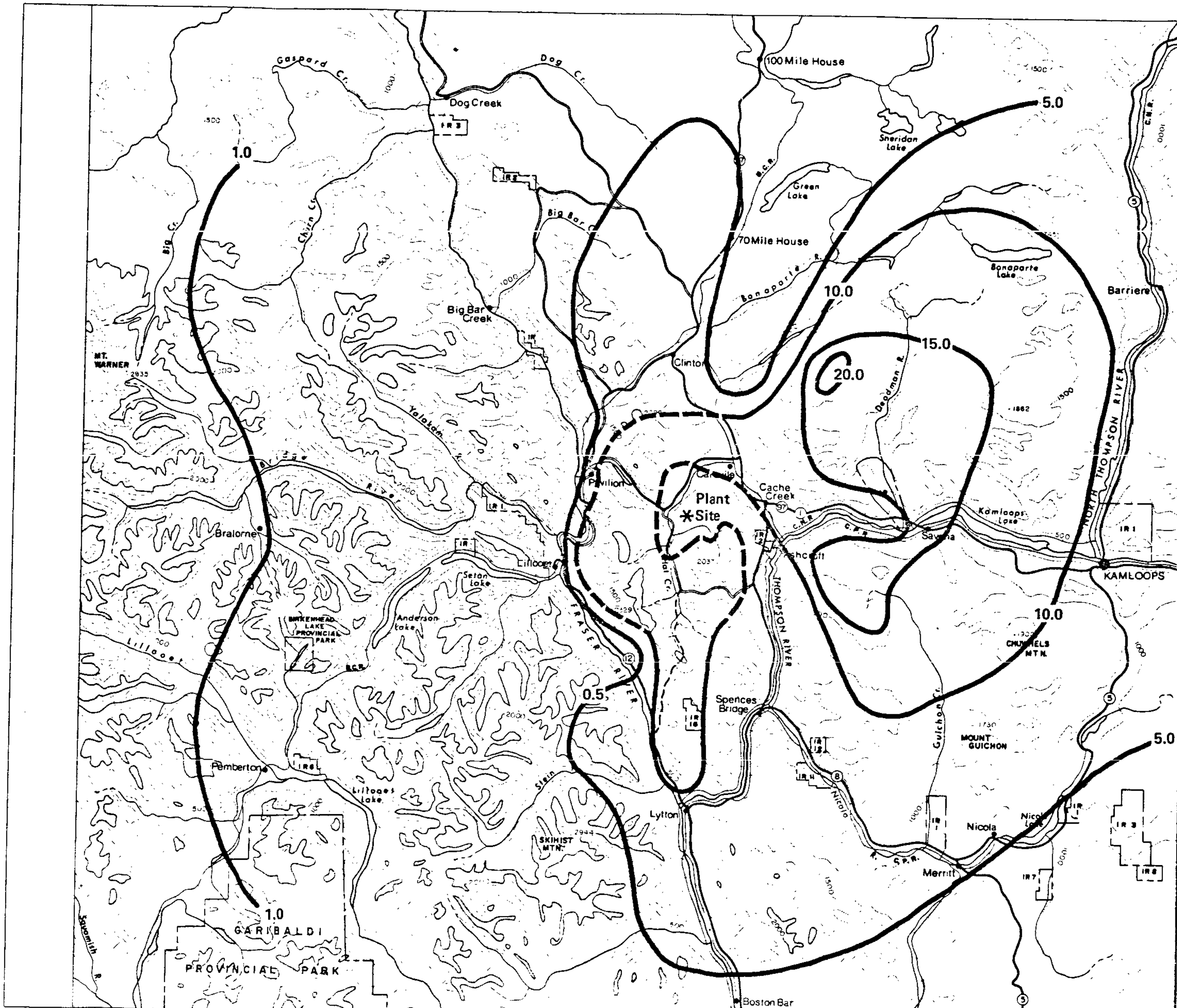
804185

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-62

Predicted Annual Averaged NO Deposition Rates (10^{-5} μg/m^2/sec): 366 m Stack with Uncontrolled Emissions (Regional Scale)



SCALE - 1:750,000

10 0 Kilometres 10 20 30 40 50

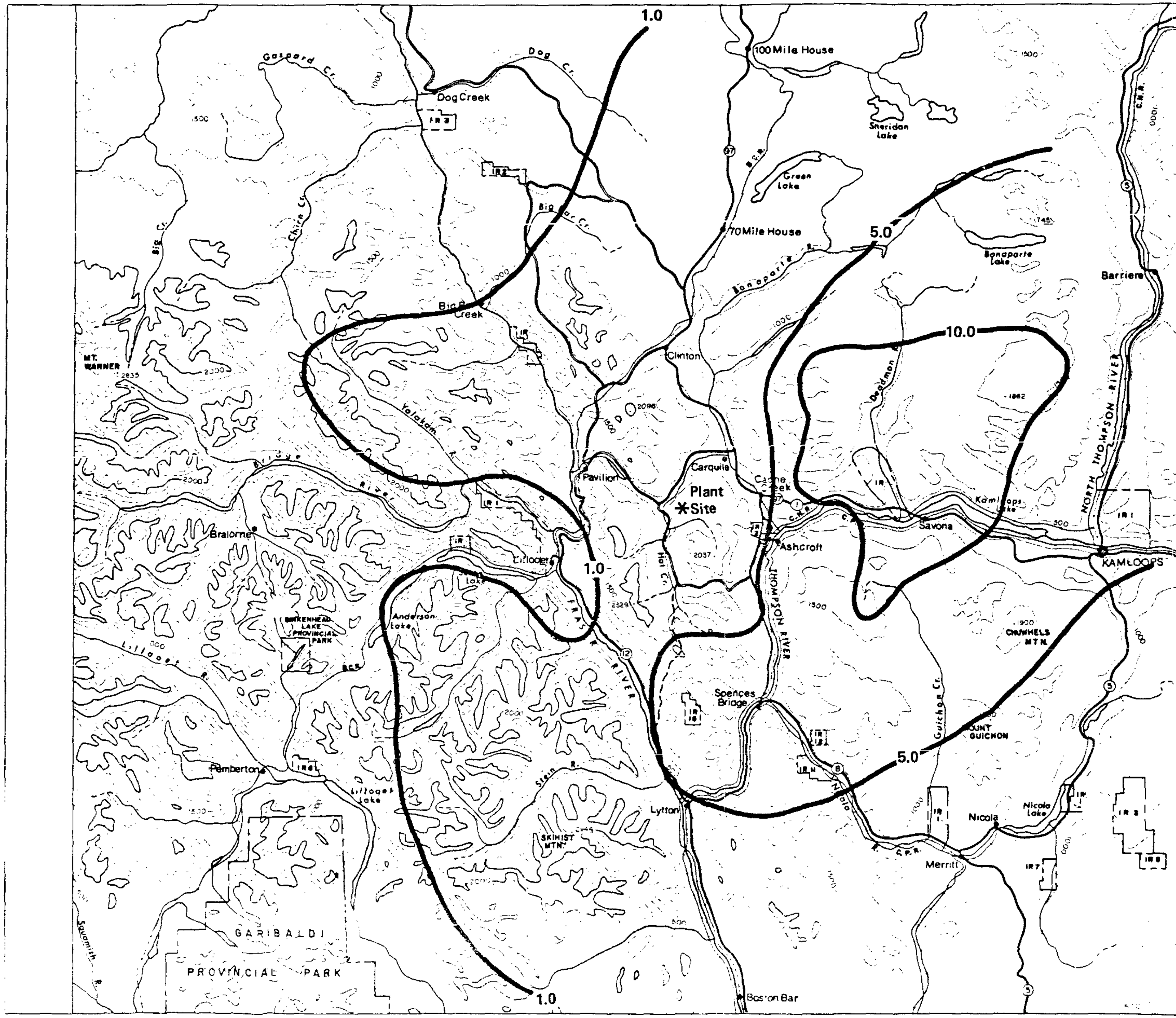
CONTOUR INTERVAL - 500 METRES

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

Figure (B)-63

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 (B)-64

Predicted Annual Averaged TSP Deposition Rates (10^{-3} µg/m^2/sec): 366 m Stack with Uncontrolled Emissions (Regional Scale)

804187

ADDENDUM C

(C)1.0 IMPACT ASSESSMENT MATRICES

(C)1.1 EXPLANATION OF IMPACT MATRICES

This Addendum consists of matrices indicating the predicted impact of the Hat Creek Project on the air resource in its vicinity. The purpose of these matrices is to identify for each type of impact: (1) the cause of the impact; (2) the affected resources; and (3) the area over which the impact will occur. Quantitative definitions of the 'air resource' and 'impacts' on this resource are difficult; for purposes of this discussion, the amount of the resource 'used' by the project is stated in terms of a fraction of the applicable ambient guideline. For this reason, only contaminants for which such guidelines exist are considered in the analysis. After examining predicted effects for all these contaminants, it was decided to prepare matrices only for sulfur dioxide (SO_2) and total suspended particulates (TSP) from the power plant and TSP from the coal mine. Air quality effects due to other contaminants are considered negligible.

In the matrices, impacts are presented separately for each of four zones: Zone A includes the site and immediate environs; Zone B is an ellipse centered at the site with a north-south semi-major axis of 30 km and an east-west semi-minor axis of 20 km; Zone C is a concentric ellipse with semi-major and semi-minor axes of 60 and 32 km respectively; Zone D is a circle centered at the site with 100 km radius. A fifth zone, Zone E, includes the remainder of the Province of British Columbia, but no significant impacts on this scale have been predicted.

The percent commitment of the air resource associated with Project operation is determined from the fraction of the appropriate guideline corresponding to the maximum predicted concentration. Averaging times of 3 hours, 24 hours, and 1 year are considered for SO_2; 24-hour and annual average TSP concentrations were examined. The assumed guidelines for 3-hour, 24-hour, and annual SO_2 concentrations are 655, 260, and 25 $\mu g/m^3$, respectively. The values for 24-hour and annual TSP concentrations are 150 and 60 $\mu g/m^3$. Separate matrices were prepared for effects due to the power plant and coal mine.

Existing air quality over most of the study region is classified as indeterminate (I), but, in view of the lack of major nearby sources, presumed high (H). Measurement data are available only for TSP levels in the Hat Creek Valley (Zone A). For this area, present air quality is designated as high (H) in the matrices.

Significance of impacts is determined by the fraction of the appropriate guideline represented by the maximum predicted concentration for the averaging time in question. This is somewhat unsatisfying in terms of contaminants for which more than one guideline exists, since the impact is generally different for each averaging time. The annual average is probably the most appropriate value for judging the amount of the air quality resource that will be 'used' by operation of the Hat Creek Project, because 3-hour and 24-hour peaks generally occur only once and at only one location. The Impact Assessment Matrices for SO_2 and TSP follow in Tables (C)-1 through (C)-12.

TABLE (C)-1

IMPACT MATRIX FOR INCREMENTAL 3-HR SULFUR DIOXIDE CONCENTRATIONS DUE TO HAT CREEK POWER PLANT: FLUE GAS DESULFURIZATION WITH 366 m STACK

Resource	Amount: Absolute ($\mu g/m^3$)	Amount: % Resource	Existing Quality	Impact Significance: Extreme	High	Moderate	Low	Insignificant
3-hr SO_2 Concentration								
ZONE A	0	0	H/I					X
ZONE B								
B-1	267	41	H/I			X		
B-2	102	16	H/I				X	
B-3	227	35	H/I			X		
B-4	366	56	H/I			X		
ZONE C								
C-1	84	13	H/I				X	
C-2	94	14	H/I				X	
C-3	51	8	H/I				X	
C-4	127	19	H/I				X	
ZONE D			H/I				X	
Concentration Estimates not Available								

TABLE (C)-2

IMPACT MATRIX FOR INCREMENTAL 3-HR SULFUR DIOXIDE CONCENTRATIONS DUE TO HAT CREEK POWER PLANT: METEOROLOGICAL CONTROL SYSTEM WITH 366 m STACK

	Amount			Impact Significance				
Resource	Absolute ($\mu g/m^3$)	% Resource	Existing Quality	Extreme	High	Moderate	Low	Insignificant
3-hr SO_2 Concentration								
ZONE A	0	0	H/I					X
ZONE B								
B-1	498	76	H/I			X		
B-2	187	29	H/I			X		
B-3	645	98	H/I		X			
B-4	647	99	H/I		X			
ZONE C								
C-1	356	54	H/I			X		
C-2	185	28	H/I				X	
C-3	97	15	H/I				X	
C-4	193	29	H/I					
ZONE D			H/I					
Concentration Estimates not Available								

TABLE (C)-3

IMPACT MATRIX FOR INCREMENTAL 3-HR SULFUR DIOXIDE CONCENTRATIONS DUE TO HAT CREEK POWER PLANT: METEOROLOGICAL CONTROL SYSTEM WITH 244 m STACK

Resource	Amount: Absolute ($\mu g/m^3$)	Amount: % Resource	Existing Quality	Impact Significance: Extreme	High	Moderate	Low	Insignificant
3-hr SO_2 Concentration								
ZONE A	0	0	H/I					X
ZONE B								
B-1	568	87	H/I		X			
B-2	276	42	H/I			X		
B-3	648	99	H/I		X			
B-4	647	99	H/I		X			
ZONE C								
C-1	269	41	H/I			X		
C-2	232	35	H/I			X		
C-3	132	20	H/I				X	
C-4	197	30	H/I			X		
ZONE D			H/I				X	
Concentration Estimates not Available								

TABLE (C)-4

IMPACT MATRIX FOR INCREMENTAL 24-HR SULFUR DIOXIDE CONCENTRATIONS DUE TO HAT CREEK POWER PLANT: FLUE GAS DESULFURIZATION WITH 366 m STACK

Resource	Amount: Absolute ($\mu g/m^3$)	Amount: % Resource	Existing Quality	Impact Significance: Extreme	High	Moderate	Low	Insignificant
24-hr SO_2 Concentration								
ZONE A	0	0	H/I					X
ZONE B								
B-1	138	53	H/I			X		
B-2	102	39	H/I			X		
B-3	76	29	H/I				X	
B-4	200	77	H/I			X		
ZONE C								
C-1	47	18	H/I				X	
C-2	67	25	H/I				X	
C-3	11	4	H/I				X	
C-4	63	24	H/I					
ZONE D			H/I				X	
Concentration Estimates not Available								

TABLE (C)-5

IMPACT MATRIX FOR INCREMENTAL 24-HR SULFUR DIOXIDE CONCENTRATIONS DUE TO HAT CREEK POWER PLANT: METEOROLOGICAL CONTROL SYSTEM WITH 366 m STACK

Resource	Amount: Absolute ($\mu g/m^3$)	Amount: % Resource	Existing Quality	Impact Significance: Extreme	High	Moderate	Low	Insignificant
24-hr SO_2 Concentration								
ZONE A	0	0						X
ZONE B								
B-1	252	97	H/I		X			
B-2	183	70	H/I			X		
B-3	158	61	H/I			X		
B-4	140	100	H/I		X			
ZONE C								
C-1	99	38	H/I			X		
C-2	134	52	H/I			X		
C-3	45	17	H/I				X	
C-4	79	30	H/I			X		
ZONE D			H/I				X	
Concentration Estimates not Available								

TABLE (C)-6

IMPACT MATRIX FOR INCREMENTAL 24-HR SULFUR DIOXIDE CONCENTRATIONS DUE TO HAT CREEK POWER PLANT: METEOROLOGICAL CONTROL SYSTEM WITH 244 m STACK

	Amount			Impact Significance				
Resource	Absolute ($\mu g/m^3$)	% Resource	Existing Quality	Extreme	High	Moderate	Low	Insignificant
24-hr SO_2 Concentration								
ZONE A	0	0						X
ZONE B								
B-1	260	100	H/I		X			
B-2	250	96	H/I		X			
B-3	159	61	H/I			X		
B-4	237	91	H/I		X			
ZONE C								
C-1	84	32	H/I			X		
C-2	149	57	H/I			X		
C-3	21	8	H/I				X	
C-4	66	25	H/I				X	
ZONE D			H/I				X	
Concentration Estimates not Available								

TABLE (C)-7

IMPACT MATRIX FOR INCREMENTAL ANNUAL SULFUR DIOXIDE CONCENTRATIONS DUE TO HAT CREEK POWER PLANT: FLUE GAS DESULFURIZATION WITH 366 m STACK

Resource	Amount: Absolute ($\mu g/m^3$)	Amount: % Resource	Existing Quality	Impact Significance: Extreme	High	Moderate	Low	Insignificant
Annual Concentration								
ZONE A	0	0	H/I					X
ZONE B								
B-1	4.5	8	H/I				X	
B-2	4.0	7	H/I				X	
B-3	2.1	4	H/I				X	
B-4	2.9	5	H/I				X	
ZONE C								
C-1	0.6	1	H/I				X	
C-2	1.2	2	H/I				X	
C-3	1.2	2	H/I				X	
C-4	0.5	1	H/I				X	
ZONE D								
D-1	0.4	1	H/I				X	
D-2	1.3	2	H/I				X	
D-3	1.3	2	H/I				X	
D-4	0.3	1	H/I				X	

TABLE (C)-8

IMPACT MATRIX FOR INCREMENTAL ANNUAL SULFUR DIOXIDE CONCENTRATIONS DUE TO HAT CREEK POWER PLANT: METEOROLOGICAL CONTROL SYSTEM WITH 366 m STACK

Resource	Amount: Absolute ($\mu g/m^3$)	Amount: % Resource	Existing Quality	Impact Significance: Extreme	High	Moderate	Low	Insignificant
Annual SO_2 Concentration								
ZONE A	0	0	H/I					X
ZONE B								
B-1	3.6	6	H/I				X	
B-2	5.1	9	H/I				X	
B-3	8.3	14	H/I				X	
B-4	7.0	12	H/I				X	
ZONE C								
C-1	0.6	1	H/I				X	
C-2	1.2	2	H/I				X	
C-3	1.2	2	H/I				X	
C-4	0.5	1	H/I				X	
ZONE D								
D-1	0.4	1	H/I				X	
D-2	1.3	2	H/I				X	
D-3	1.3	2	H/I				X	
D-4	0.3	1	H/I				X	

TABLE (C)-9

IMPACT MATRIX FOR INCREMENTAL ANNUAL SULFUR DIOXIDE CONCENTRATIONS DUE TO HAT CREEK POWER PLANT: METEOROLOGICAL CONTROL SYSTEM WITH 244 m STACK

Resource	Amount: Absolute ($\mu g/m^3$)	Amount: % Resource	Existing Quality	Impact Significance: Extreme	High	Moderate	Low	Insignificant
Annual SO_2 Concentration								
ZONE A	0	0	H/I					X
ZONE B								
B-1	4.9	8	H/I				X	
B-2	6.8	11	H/I				X	
B-3	9.3	16	H/I				X	
B-4	7.7	13	H/I				X	
ZONE C								
C-1	0.6	1	H/I				X	
C-2	1.2	2	H/I				X	
C-3	1.2	2	H/I				X	
C-4	0.5	1	H/I				X	
ZONE D								
D-1	0.4	1	H/I				X	
D-2	1.3	2	H/I				X	
D-3	1.3	2	H/I				X	
D-4	0.3	1	H/I				X	

TABLE (C)-10

IMPACT MATRIX FOR 24-HR TOTAL SUSPENDED PARTICULATE CONCENTRATIONS DUE TO HAT CREEK POWER PLANT: UNCONTROLLED EMISSIONS

Resource	Amount		Existing Quality	Impact Significance				
	Absolute (µg/m³)	% Resource		Extreme	High	Moderate	Low	Insignificant
24-hr SO_2 Concentration								
ZONE A	0	0	H/I					X
ZONE B								
B-1	31	21	H/I				X	
B-2	23	15	H/I				X	
B-3	19	13	H/I				X	
B-4	32	21	H/I				X	
ZONE C								
C-1	12	8	H/I				X	
C-2	17	11	H/I				X	
C-3	6	4	H/I				X	
C-4	10	7	H/I				X	
ZONE D			H/I				X	
Concentration Estimates not Available								

TABLE (C)-11

IMPACT MATRIX FOR ANNUAL TOTAL SUSPENDED PARTICULATE CONCENTRATIONS DUE TO HAT CREEK POWER PLANT: UNCONTROLLED EMISSIONS

Resource	Amount: Absolute ($\mu g/m^3$)	Amount: % Resource	Existing Quality	Impact Significance: Extreme	High	Moderate	Low	Insignificant
Annual TSP Concentration								
ZONE A	0	0	H					X
ZONE B								
B-1	0.6	1	H/I				X	
B-2	0.8	1	H/I				X	
B-3	1.2	2	H/I				X	
B-4	1.0	2	H/I				X	
ZONE C								
C-1	.07	<1	H/I					X
C-2	.15	<1	H/I					X
C-3	.15	<1	H/I					X
C-4	.06	<1	H/I					X
ZONE D								
D-1	.05	<1	H/I					X
D-2	.16	<1	H/I					X
D-3	.16	<1	H/I					X
D-4	.04	<1	H/I					X

TABLE (C)-12

IMPACT MATRIX OF 24-HR AND ANNUAL TOTAL SUSPENDED PARTICULATE CONCENTRATIONS DUE TO HAT CREEK MINE

	Amount			Impact Significance				
Resource	Absolute ($\mu g/m^3$)	% Resource	Existing Quality	Extreme	High	Moderate	Low	Insignificant
24-Hr TSP Concentration								
ZONE A	400	>100	H		X			
ZONES B, C, D			H					X
No Concentration Estimates Available								
Annual TSP Concentration								
ZONE A	260	>100	H		X			
ZONES B, C, D			H					X
Concentration Estimates not Available								