AMBIENT AIR QUALITY
IN THE AOSERP STUDY AREA, 1977

by

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONCLUDED)

LIST OF TABLES

LIST OF TABLES (CONCLUDED)

LIST OF FIGURES

ABSTRACT

The monitoring network for ambient air quality in the AOSERP study area is described with particular reference to site location, instrumentation, measurement techniques and data sources. The results of one to three years of data from 68 exposure cylinders and 8 continuous monitoring stations are shown in tables and maps. Emission characteristics of the existing and proposed oil sands plants are described and related to processes for bitumen extraction and upgrading.

Initial evaluation of data indicates that sulphur dioxide concentrations at ground level in background air are in the .001 ppm range. Annual average SO_2 concentrations at monitoring sites closer to the source range from .003 to .006 ppm. Monthly average levels of O_3 and NO_2 at a background station are approximately .045 ppm and .01 ppm, respectively.

Results of total sulphation measurements show no change in levels of total sulphur over the past three years. Initial results of total suspended particulates indicate very low levels except at Fort McMurray where levels greater than 100 $\mu g.m^{-3}$ were recorded. The report recommends that a similar document be prepared with all available data up to the time of start up of the second oil sands plant.

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1. INTRODUCTION

The Air System of the Alberta Oil Sands Environmental Research Program (AOSERP), has established a need for ambient air quality data in order to assess effects of oil sands development on air quality. The Air Quality Data Acquisition Project was identified early in the program but, due to the large capital investment and diverse sources for equipment, it has taken nearly a year and a half to implement.

The general objective of this project was to provide baseline air quality data for: (1) other research sectors, (2) land use planning, (3) inputs to simulation modelling and (4) verification of outputs from air quality simulation modelling.

Alberta Environment, under agreement with and funding from AOSERP, undertook the design, installation and operation of three continuous ambient air quality stations. In addition, in co-operation with the AOSERP Land System and the Air Quality Control Branch of the Alberta Environment, twenty total sulphation (TS) and hydrogen sulphide exposure stations have been established. To complement this network, the project has access to data from five continuous ambient air quality stations and forty exposure stations for total sulphation (TS) and hydrogen sulphide (H_2S) operated by Great Canadian Oil Sands Ltd., and will have access to data from an equivalent sized network recently installed by Syncrude Canada Ltd.

The presentation used in this report includes a synopsis of means, frequency distributions, comparisons and trends of the data collected to July, 1977. It also provides an overview of the prime emission sources, an insight into the prime emission parameters as well as monitoring techniques used and relates, where possible, the results found here to other areas of Alberta or to other projects of significant interest. This method of reporting was chosen after discussing the data needs of other research sectors. Since many air quality data requirements for other research sectors would be specific to the type of research project undertaken, the kinds of analysis required could not be predetermined and, therefore, could not be reported. However, individual requests for data can be accommodated, as all raw data will remain on file and can be made available through the Environmental Protection Services of Alberta Environment.

2. MONITORING NETWORK

Prior to the formation of the Alberta Oil Sands Environmental Research Program, continuous air monitoring stations in the oil sand area were limited to those established by Great Canadian Oil Sands in partial compliance with their Licence-to-Operate. The company was also obliged by licence to establish an exposure cylinder network. The ambient monitoring just begun by Syncrude is identical to that of Great Canadian Oil Sands in magnitude and purpose. In both cases, industrial monitoring is compulsory by licence and is designed to measure pollutants within a 15 to 20 km radius of the source, where there is potential for highest ground level concentration to occur. Another term for this type of measurement is compliance monitoring. Through the co-operation of industry, these data are made available to AOSERP.

Through the agreement made with AOSERP, Alberta Environment complemented this network with one designed for gathering background data. With this objective in mind, the network operated for AOSERP has continuous monitoring stations as far as 75 km from the development area and exposure sites over 100 km from the two plants.

Figure 1 illustrates the AOSERP network, with three continuous ambient stations and fourteen exposure sites. Figures 2 and 3 show the industrial networks, with five continuous ambient stations and forty exposure sites per oil sands plant. The obvious difference is the number of sites per unit area. The limited road access in the area has definitely influenced the density pattern of the industrial network as can be seen from Figures 2 and 3. Nevertheless, three of ten continuous stations have been located in remote areas with supporting power supplies and approximately 10% of the exposure stations can be reached only by all terrain vehicle or helicopter. In contrast, base line monitoring needs to be remote from development; consequently, two of three continuous stations operated by AOSERP are only accessible by air travel and have supporting power supplies, and approximately 60% of the exposure sites are accessible only by air.

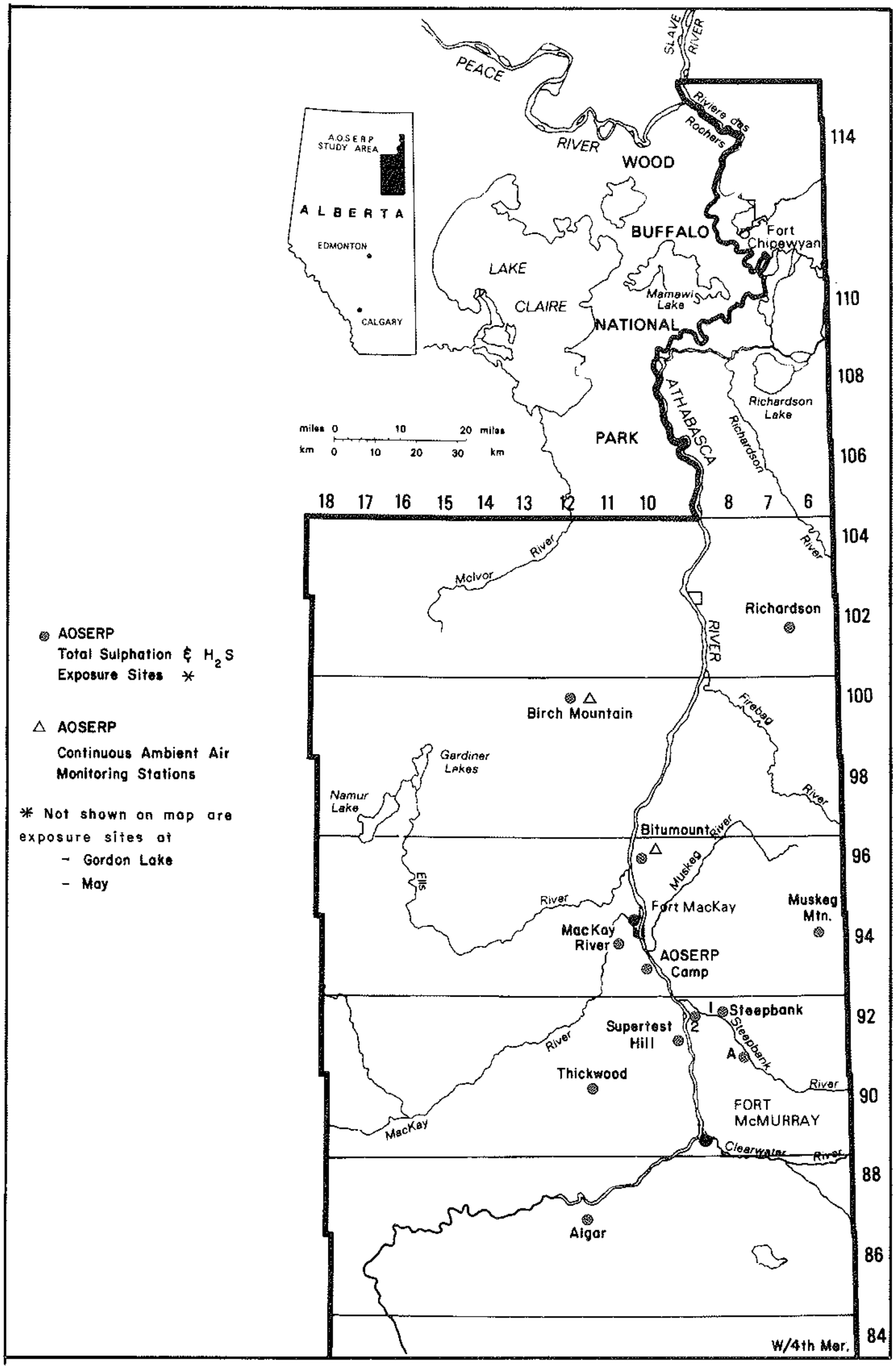

Figure I. Map of AOSERP air monitoring stations.

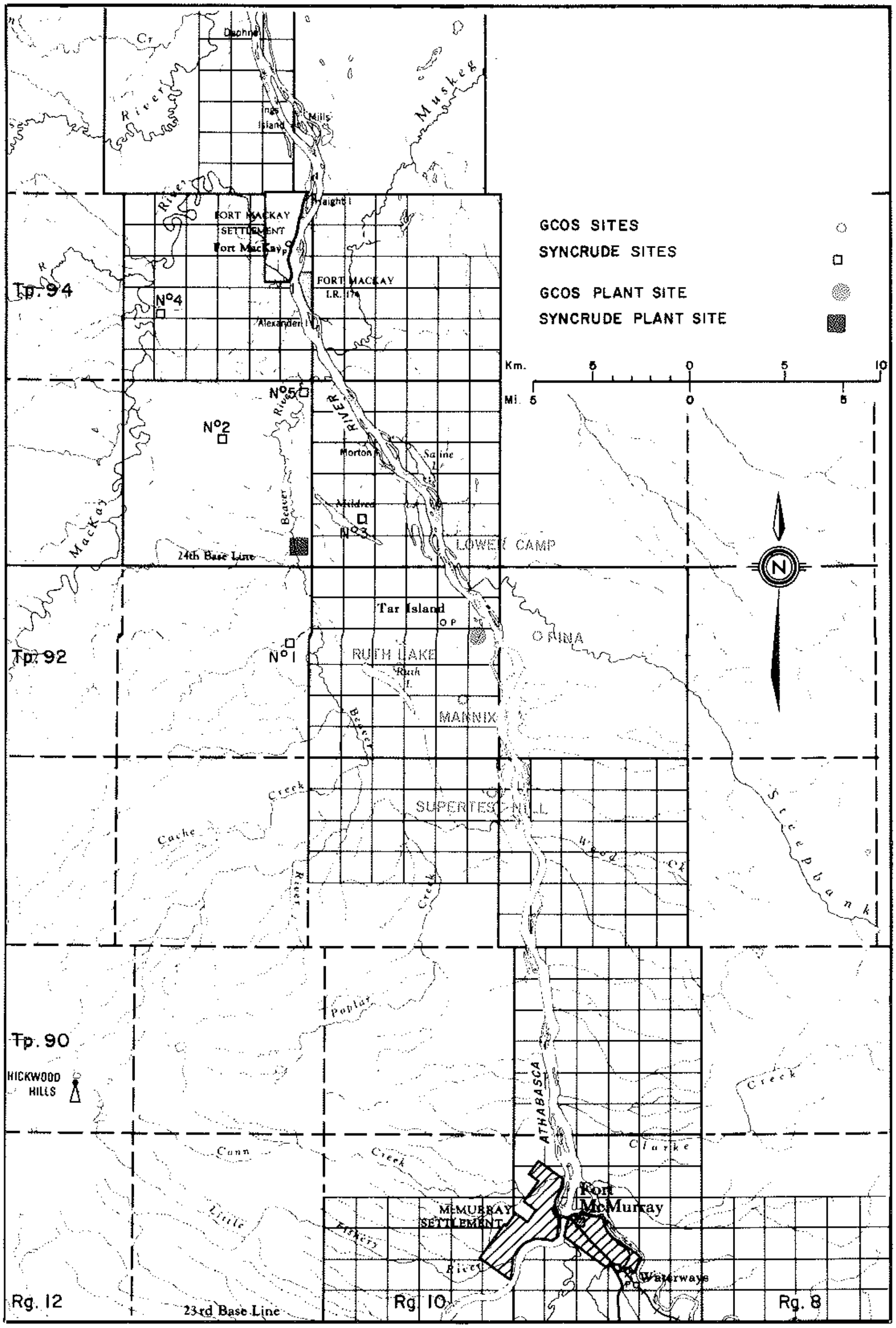

Figure 2. Map of continuous ambient air monitoring stations, 1977.

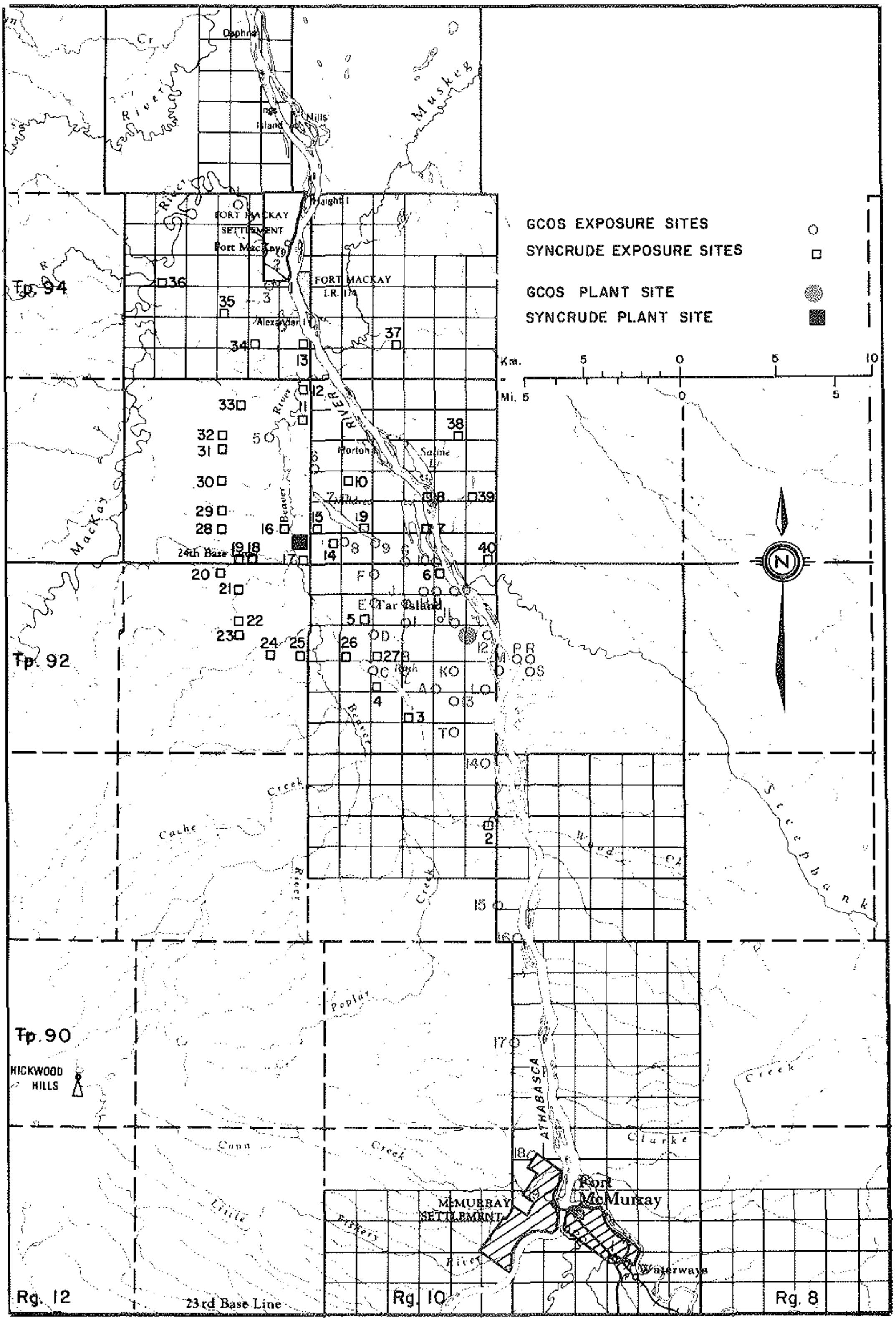

Figure 3. Map of exposure cylinder sites, 1977.

Not mapped on any of the Figures but included in the Data Catalogue in Appendix 8.2 are six exposure sites operated by the Department of Environment and eight exposure sites operated by AMOCO.

2.1 SITE SELECTION

Full details of site criteria and instrumentation can be reviewed in Appendix 8.1. A complete catalogue of all ambient air data collected as well as whose sites they are, their elevations and locations in multiple co-ordinate systems may be found in Appendix 8.2.

Based on compliance monitoring, made compulsory by the Provincial Government, all continuous monitoring stations operated by the oil sands industry must include SO_2, H_2S and wind speed and direction data on a continuous basis. Since part of the AOSERP objective was to determine base line states of air quality in the study area, continuous measurement for other prime pollutants became necessary. Three continuous stations were established.

2.1.1 Fort McMurray Town

This station monitors SO_2, H_2S, CO, NO_x/NO_2, HC, O_3, smoke and wind speed and direction on a continuous basis. High volume sampling for particulates is also collected on a periodic basis. The town site was chosen because of its rapid urban growth and, therefore, its potential for increase in air pollutant concentrations. Also, the site is located such that any SO_2 transported to the town from the development area would be recorded. The photograph in Figure 4 illustrates the site (see arrow) and surrounding features as they appear from the air.

2.1.2 Bitumount

Parameters monitored at this station are identical to the Fort McMurray Town station. The only difference is its source of power. The station receives its power supply from a prime and standby pair of 11 kw diesel generating units. Appendix 8.1 describes the layout at the site for minimal interference of the diesel plume with the monitoring results.

The Bitumount site was chosen because of its location near an area of potential town and industrial plant development. The photograph in Figure 4 shows the site (see arrow) with respect to the other buildings and bush around the Forestry Lookout Tower.

2.1.3 Birch Mountain

This station monitors SO_2, O_3 and wind speed and direction on a continuous basis. Again, high volume sampling is also collected on a periodic basis. This station also has a portable power source with prime and standby 6 kw diesel generating units. Located some 75 km north of the developnent area, this site was chosen to provide continuous background data with minimal interference from present and future development. The photograph in Figure 4 illustrates this site with respect to the surrounding features.

2.1.4 Exposure Cylinder Network

The prime objective in establishing the exposure cylinder network was to ensure that some data would be available from the remote sections of the study area for base line or background purposes. To overcome the accessibility problem, the first choice for sites became the Alberta Forest Service Forestry Lookout Towers, since these sites are cleared and, in most cases, have runways. Another asset was the fact that the AOSERP Land System was interested in sulphation plate data at their vegetation plots, which were also located at Forestry Tower sites. Thus, with two research groups using the data, the expensive air travel trips to these sites are now multi-purpose and provide a more reasonable cost/benefit ratio.

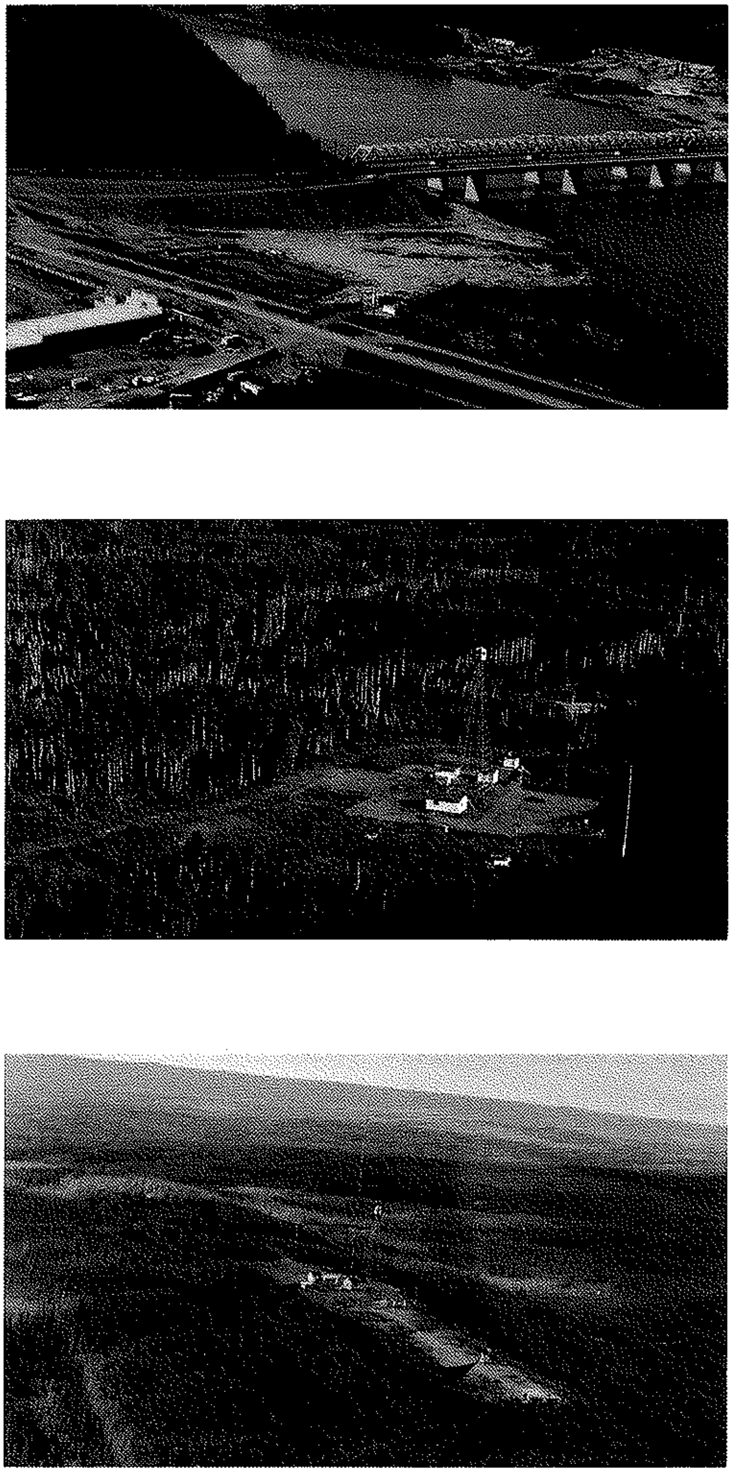

Figure 4. Ambient monitoring stations. Top: Fort McMurray looking S.W. Centre: Bitumont looking N.W. Bottom: Birch Mountain looking S.W.

3. SOURCES AND EMISSIONS

Among the influences on ambient air quality are location, topography and plant process. Consequently, a description of location and topography of the area as well as a review of the stack parameters and plant processes is given in the following sections.

3.1 LOCATION AND TOPOGRAPHY

The predominant feature of the AOSERP study area in northeastern Alberta is the Athabasca River Valley cutting a north-south line through the area with a base elevation of approximately 240 m above mean sea level (MSL). The oil sands development sites are centrally located in the study area, with Great Canadian Oil Sands located approximately 245 m MSL on the valley floor while Syncrude, 10 km to the northwest, is based at 305 m MSL (see Figure 2 for location). With these Plant locations as a focal point, main geographic features are the Birch Mountains (810 m MSL), 75 km to the north; Muskeg Mountain (580 m MSL), 60 km to the east; and Stony Mountain (790 m MSL), 75 km to the south.

3.2 EMISSION CHARACTERISTICS AND PLANT PROCESSES

Tables 1 and 2 identify those characteristics most often used for dispersion calculations. Positioning of the emission points is given by reference points from Plant maps. Transposing these locations to a desired co-ordinate system can be accomplished with minimal effort. One can notice from Tables 1 and 2 that flare temperature are not given. For dispersion calculations from flares, BTU contents of the left gas are normally used; consequently, composition of the gas to the flare is necessary in each episode for accurate dispersion calculations.

3.2.1 Great Canadian Oil Sands Process

By mixing the oil sand with steam and hot water, coarse sand and particulates will settle out by washing and froth floatation. The viscosity and gravity of the froth is then reduced by diluting with naptha to allow centrifuge separation of water and solids from the diluted bitumen.

Table 1. Great Canadian Oil Sands major emission point parameters.

Ground Level Elevation: 800 feet (244 m) above sea level.

Definition of Plant North: 32.5° W of true North.

Definition of Plant Reference Point: N 3580' E 4050'

Location of Plant Reference Point: NE corner of LSD 8, Section 23, Township 92, Range 10, W of the 4th Meridian.

	Main Flare	Acid Gas Flare	Powerhouse Stack	Incinerator Stack
Location within plant	N 6175' and E 7185'	N 5963' and E 7185'	N 5297' and E 6155'	N 6061' and E 6509'
Ground level elevation (MSL)	800' (244 m)	800' (244 m)	848' (255 m)	848' (255 m)
Height	325' (99 m)	250' (76.2 m)	350' (106.7 m)	350' (106.7 m)
Tip diameter	3.5' (1.1 m)	1.7' (.52 m)	19' (5.8 m)	5.9' (1.8 m)
Exit temperature	*	*	450°F (232°C)	1000°F (538°C)

Sources of above information:

1. Department of Environment, Standards & Approvals file;
2. SNC Tottrup (1978).

* Sulphur emission, flow rate and net BTU values must be obtained for each flaring episode.

Table 2. Syncrude major emission point parameters.

Ground Level Elevation: 1000 feet (305 m) above sea level.

Definition of Plant North: 17° 21' 15" W of true North.

Definition of Plant Reference Point: 0000' N 5000' E for Drawing #50 R-A-1, Rev. 8.

Location of Plant Reference Point: Approximately at the NE corner of LSD 7-1-93-11-W4 for Drawing #50 R-A-1, Rev. 8.

	Main Stack	H_2S Flare (19F-2)	HC FLare (19F-1)	HC Flare (19F-4)
Location within plant	N 0855' and E 5425'	N 1290' and E 2835'	N 2285' and E 2750'	N 2585' and E 2750'
Ground level elevation (MSL)	1000' (305 m)	980' (299 m)	980' (299 m)	980' (299 m)
Height	600' (183 m)	235' (71.6 m)	250' (76.2 m)	250' (76.2 m)
Tip diameter	26' (7.9 m)	42" (1.06 m)	30" (.76 m)	48" (1.2 m)
Exit temperature	450°F (232°C)	*	*	*

Source of above information:

Syncrude Canada Ltd.

* Sulphur emission, flow rate and net BTU value must be obtained for each flaring episode.

The diluted bitumen is heated in furnaces and cracked in large vessels to separate the lighter oils from the coke residue. The process at Great Canadian Oil Sands is delayed coking. The coke is then removed or steam stripped from the cokers on a batch basis and stored for fuel for the utility plant. The lighter ends are treated in a coker distillation column, from which the gas oil, naptha and kerosene components are hydrotreated in unifiners, and eventually blended to a synthetic crude. The feed stock for the hydrogen plant is natural gas. The off-gases from the distillation column and the unifiners are treated for ammonia and H_2S removal. The refined gas is then used in the plant process in various heaters and furnaces.

The utility plant, often confused with being strictly a power plant, provides electric power, steam and boiler feed water for the overall complex using coke from the initial upgrading process as the primary fuel. The sulphur content of the coke leaves the exhaust gas rich in SO_2.

At Great Canadian Oil Sands there are two main stacks with respect to venting SO_2 emissions. The utility plant's stack exhausts only those gases from the combustion of coke in the boilers (300 long tons per day as Licenced limit of SO_2). The incinerator stack vents sulphur recovery plant off-gases only (48 long tons per day as Licenced limit of SO_2) (Alberta Environment 1973a).

3.2.2 Syncrude Process

Basically the same extraction procedure as Great Canadian Oil Sands' is followed to yield diluted bitumen. Processing of the diluted bitumen is carried out in two stages:

1. Thermal cracking will take place in fluid cokers. (Steam and fine coke particles flow like a liquid). The heat generated allows cracking of the bitumen to form lighter cuts with the available hydrogen content of the bitumen and conversion of excess carbon to coke.

2. Hydrotreating (using natural gas for raw stock) the distillate streams from the fluid coker then takes place to stabilize unsaturated carbon chains, and to reduce sulphur and nitrogen levels for blending into a synthetic crude.

Light gases from fluid cokers and hydrotreating are processed to remove H_2S (Claus process). Light hydrocarbon streams separated from the H_2S make up part of the plant fuel system; the remainder is supplemented by natural gas.

The fluid cokers also produce a low BTU gas in a separate stream which will be fired in CO boilers to supply part of the steam requirement for the processing areas. Part of this gas consists of SO_2, the result of using coke as a fuel for the coker unit. Design emissions from the fluid coker are 154 long tons SO_2 per day. After routing through the CO boilers, and the electrostatic precipitators for particulate removal, this gas is reunited with the off-gas from the utility plant and exhausted in the main stack.

The utility plant will provide electric power, steam and boiler feed water for the overall complex using as fuels, gas from the main plant fuel gas system, supplemented with natural gas. Unlike Great Canadian Oil Sands, coke is not used as a fuel in the utility plant.

Streams to the main stack include: flue gases from the utility plant boilers and gas turbines; the sulphur recovery plant off-gases which are incinerated in the burner section of the CO boilers; off-gases from the sour water stripper; and the effluent from the CO boilers which includes the sulphur rich gases from the fluid cokers subsequent to passing through the electrostatic precipitators. The limit of SO_2 emissions in the streams from the main stack permitted by the Department of Environment is 287 long tons per day of SO_2 (Alberta Environment 1973b).

4. AMBIENT AIR QUALITY DATA RESULTS

The data referred to in this section in no way includes the complete data set collected in the Fort McMurray area. Selected analytical techniques have been used to represent the results in a more concise form. A complete set of all raw data will remain on file and can be made available through the Environmental Protection Services of Alberta Environment, for those needing more detailed results for their specific needs.

The data collected and presented here are mostly expressed in ppm by volume, which has an equivalent in $\mu g.m^{-3}$. All continuous ambient data referred to in this report is based on clock 1/2-hour, clock 1-hour or clock 24-hour periods as opposed to running time period averages. For example, when 1-hour concentrations are referred to, they are for periods beginning and ending on the hour, such as 1300 hours to 1400 hours. One hour concentrations for period not on the hour such as 1316 hours to 1416 hours, are not documented.

4.1 SO_2 - CONTINUOUS MONITORING RESULTS

The results of sulphur dioxide ambient monitoring shown in this report are based on the operation of five stations by Great Canadian Oil Sands since July 1976 and two stations prior to July 1976, as well as three stations by AOSERP since February 1977. The five stations operated by Syncrude were being commissioned at the time of writing of this report. Appendix 8.2 provides more details on this matter.

4.1.1 Occurrences of Readings in Excess of Standard

Under The Clean Air Act, the Department of Environment has established the following ambient objectives for SO_2:

The concentration in ambient air should not exceed the given concentration for the given time period:

Time Period	Concentration $\mu g.m^{-3}$	ppm (approx.)
1/2-h	525	0.20
1-h	450	0.17
24-h	150	0.06
annual	30	0.01

Based on the Great Canadian Oil Sands network of ambient monitoring stations in 1974, 1975 and 1976, the company reported the following results (Great Canadian Oil Sands Ltd. 1975, 1976, 1977):

Time Period	No. of Readings in Excess of SO_2 Objective 1974	1975	1976
1/2-h	85	154	64
1-h	57	90	46
24-h	4	8	6

In order to have a comparison to other areas of Alberta, 1/2-hour readings in excess of the standard from Great Canadian Oil Sands (the only operating plant) were compared to four gas plants in various areas of Alberta, chosen for their similar mass emission rate and number of monitoring stations. Three years of results from 1974 to 1976 are illustrated by the histogram in Figure 5. Evident from this figure is the fact that Great Canadian Oil Sands has the greatest number of occurrences in excess of the 1/2-hour objective when compared to plants of similar size.

With reference to Figure 5 and the direct comparison of ambient air pollution from gas plants to oil sands plants, major differences in the plants are listed below to help qualify the results of the comparison:

1. Table 3 illustrates that Great Canadian Oil Sands has by far the highest design and licenced emission rate. This fact coupled with the design to a ground

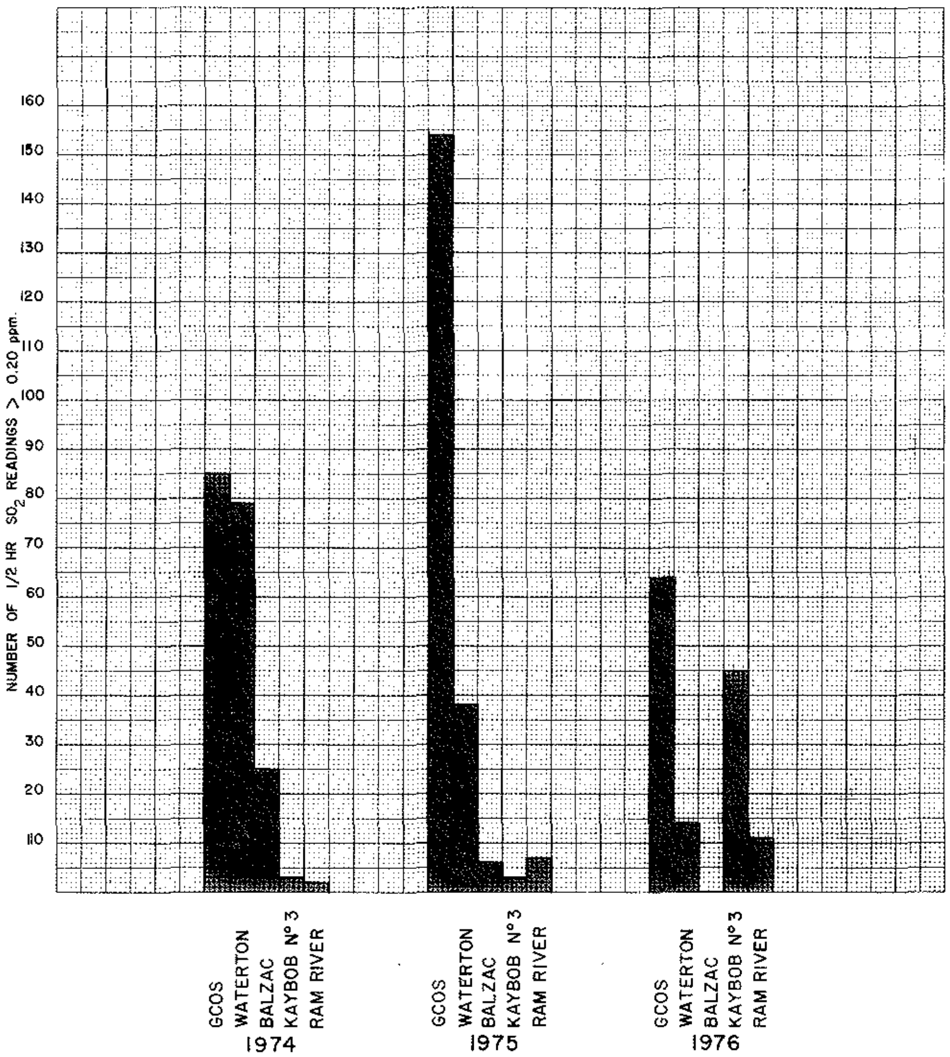

Figure 5. Comparisons of plants with readings in excess of the 1/2 hr. ambient SO_2 standard.

Table 3. Licence emission rates and number of ambient monitors used.[a]

Plant	SO_2 LT/D			Number of Stations		
	1974	1975	1976	1974	1975	1976
Great Canadian Oil Sands	348	348	348	2	2-3	2-5
Waterton	248	124	80.6	3	3	3
Balzac	102	102	87.4	7	7	6
Kaybob #3	215	215	215	4	4	4
Ram River	168	168-184	184	4	4	4

[a] Source: Department of Environment files.

level concentration of 0.3 ppm (the accepted design level at that time) would contribute to higher recorded ground level concentrations.

2. In making a comparison of this kind, one should be mindful of the fact that the four comparison plants are all gas plants which have the ability to turn down production within hours to avoid further violation, while the Great Canadian Oil Sands process which includes a utility plant, where the bulk of the emissions originate (see section 3.2.1), as well as a Claus process, does not have this luxury. Turn down in production at Great Canadian Oil Sands would consume 12 to 24 hours, by which time meteorological conditions would probably have changed.

4.1.2 Frequency Distributions and Monthly Averages of One-Half Hour SO_2 Data

One-half hour SO_2 data are currently collected on a continuous basis from five Great Canadian Oil Sands monitors and three AOSERP monitors. Five more monitors belonging to Syncrude are to be commissioned in the summer of 1977. Rather than present that volume of data in this report, monthly averages and frequency of occurrence for selected ranges of SO_2 concentration have been extracted from the data and are illustrated in Tables 4 through 11.[1]

Data from the AOSERP monitors are provided on a continuous basis from May 1977. SO_2 data in the two to three months previous to the middle of May are suspect and have, therefore, been discarded.

Data thus far from the two AOSERP remote sites indicate a high percentage of zero readings and an average monthly concentration in the 1 ppb range. This is slightly higher than an atmospheric background concentration of 0.2 ppb as quoted in Stern (Robinson and Robbins 1972). It should be kept in mind, however, that only a few months of data are available at the present time. It would be useful to conduct this type of review on an annual basis, as a twelve month data base is much more statistically reliable. The detection limit of the AOSERP SO_2 instruments is 0.005 ppm, based on the measurement scale that is used. This means that monthly averaging to numbers less than 0.001 ppm is the result of including months where 0.000 ppm is recorded. In any event, this threshold should be completely adequate for the AOSERP objectives, as detection below 0.005 ppm as a 1/2-hour average has not been established as an expressed need for any scientific use of the data.

The industry operated monitors (Tables 7 to 11) show a higher frequency of readings than the AOSERP sites in all of the concentration ranges, obviously due to their closer proximity to the source (see Figure 2). One can see from Tables 7 to 11 that

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[1] Great Canadian Oil Sands data are extracted from monthly reports submitted to Alberta Environment.

Table 4. Monthly averages and SO_2 frequency distributions of 1/2-hour readings, Birch Mountain station, 1977.

Conc. Range (ppm SO_2)	0		0.001 - 0.060		0.061 - 0.170		0.171 - 0.200		0.201 - 0.340		0.341 +		SO_2 ppm Monthly Average
Readings	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Month													
May	563	49.7	571	50.3	0	0.0	0	0.0	0	0.0	0	0.0	.003
June	1338	99.6	5	0.4	0	0.0	0	0.0	0	0.0	0	0.0	.000
July	1018	73.4	368	26.6	0	0.0	0	0.0	0	0.0	0	0.0	.002

Table 5. Monthly averages and SO_2 frequency distributions of 1/2-hour readings, Bitumount station, 1977.

Conc. Range (ppm SO_2)	0		0.001 - 0.060		0.061 - 0.170		0.171 - 0.200		0.201 - 0.340		0.341 +		
Readings	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	SO_2 ppm Monthly Average
Month													
May	1032	72.8	386	27.2	0	0.0	0	0.0	0	0.0	0	0.0	.008
June	1068	96.2	39	3.5	0	0.0	0	0.0	0	0.0	0	0.0	.001
July	1261	90.3	135	9.7	0	0.0	0	0.0	0	0.0	0	0.0	.001

Table 6. Monthly averages and SO_2 frequency distributions of 1/2-hour readings, Fort McMurray station, 1977.

Conc. Range (ppm SO_2)	0		0.001 - 0.060		0.061 - 0.170		0.171 - 0.200		0.201 - 0.340		0.341 +		
Readings	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	SO_2 ppm Monthly Average
Month													
May	904	61.7	560	38.3	0	0.0	0	0.0	0	0.0	0	0.0	.003
June	1398	97.5	36	2.5	0	0.0	0	0.0	0	0.0	0	0.0	.000
July	1371	92.8	107	7.2	0	0.0	0	0.0	0	0.0	0	0.0	.001

Table 7. Monthly averages and SO_2 frequency distributions of 1/2-hour readings, Great Canadian Oil Sands - Supertest Hill station.

Conc. Range (ppm SO_2)	0		0.001 - 0.060		0.061 - 0.170		0.171 - 0.200		0.201 - 0.340		0.341 +		
Readings	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	SO_2 ppm Monthly Average
Month													
Apr./76	1319	91.8	104	7.2	13	1.0	0	0.0	0	0.0	0	0.0	.003
May	1222	84.7	215	14.9	5	0.4	0	0.0	0	0.0	0	0.0	.003
June	1037	76.6	287	21.2	30	2.2	0	0.0	0	0.0	0	0.0	.006
July	1367	91.9	119	8.0	2	0.1	0	0.0	0	0.0	0	0.0	.002
Aug.	1339	90.1	146	9.8	1	0.1	0	0.0	0	0.0	0	0.0	.002
Sept.	1180	95.2	56	4.5	3	0.2	1	0.1	0	0.0	0	0.0	.001
Oct.	1459	98.1	29	1.9	0	0.0	0	0.0	0	0.0	0	0.0	.000
Nov.	1328	98.1	26	1.9	0	0.0	0	0.0	0	0.0	0	0.0	.001
Dec.	1406	94.6	75	5.0	5	0.3	0	0.0	0	0.0	0	0.0	.001
Jan./77	1358	97.3	37	2.6	1	0.1	0	0.0	0	0.0	0	0.0	.001
Feb.	1321	98.3	21	1.6	2	0.1	0	0.0	0	0.0	0	0.0	.000
Mar.	1335	89.9	142	9.6	7	0.5	0	0.0	0	0.0	0	0.0	.002
Apr.	1361	94.5	72	5.0	7	0.5	0	0.0	0	0.0	0	0.0	.002
May	1431	98.9	15	1.1	0	0.0	0	0.0	0	0.0	0	0.0	.000
June	1388	96.9	44	3.1	0	0.0	0	0.0	0	0.0	0	0.0	.001

Table 8. Monthly averages and SO_2 frequency distributions of 1/2-hour readings, Great Canadian Oil Sands - Mannix station.

Conc. Range (ppm SO_2)	0		0.001 - 0.060		0.061 - 0.170		0.171 - 0.200		0.201 - 0.340		0.341 +		
Readings	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	SO_2 ppm Monthly Average
Month													
July/76	1193	81.2	269	18.3	6	0.3	1	0.1	1	0.1	0	0.0	.004
Aug.	1173	81.0	245	16.9	29	2.0	0	0.0	1	0.1	0	0.0	.005
Sep.	1232	85.7	194	13.5	9	0.6	1	0.1	2	0.1	0	0.0	.003
Oct.	1423	95.6	57	3.8	8	0.5	0	0.0	0	0.0	0	0.0	.006
Nov.	1383	96.0	49	3.4	8	0.5	0	0.0	0	0.0	0	0.0	.001
Dec.	1400	94.2	72	4.8	11	0.7	1	0.1	2	0.1	0	0.0	.002
Jan./77	1335	89.8	104	7.0	42	2.8	2	0.1	3	0.2	0	0.0	.005
Feb.	1276	94.9	66	4.9	2	0.1	0	0.0	0	0.0	0	0.0	.001
Mar.	1378	92.8	92	6.2	14	1.0	0	0.0	0	0.0	0	0.0	.002
Apr.	1364	95.0	51	3.5	21	1.5	0	0.0	0	0.0	0	0.0	.002
May	1399	96.4	51	3.5	1	0.1	0	0.0	0	0.0	0	0.0	.001
June	1431	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	.000

Table 9. Monthly averages and SO_2 frequency distributions of 1/2-hour readings, Great Canadian Oil Sands - Ruth Lake station.

Conc. Range (ppm SO_2)	0		0.001 - 0.060		0.061 - 0.170		0.171 - 0.200		0.201 - 0.340		0.341 +		
Readings	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	SO_2 ppm Monthly Average
Month													
July/76	1162	78.2	322	21.7	2	0.1	0	0.0	0	0.0	0	0.0	.005
Aug.	1199	83.1	239	16.6	5	0.3	0	0.0	0	0.0	0	0.0	.003
Sept.	1120	77.9	309	21.5	7	0.5	0	0.0	1	0.1	1	0.1	.004
Oct.	1196	80.4	292	19.6	0	0.0	0	0.0	0	0.0	0	0.0	.005
Nov.	1384	98.9	16	1.1	0	0.0	0	0.0	0	0.0	0	0.0	.000
Dec.	1425	95.9	61	4.1	0	0.0	0	0.0	0	0.0	0	0.0	.000
Jan./77	1269	85.4	197	13.2	19	1.3	1	0.1	0	0.0	0	0.0	.004
Feb.	1058	81.0	248	19.0	0	0.0	0	0.0	0	0.0	0	0.0	.003
Mar.	1479	99.7	5	0.3	0	0.0	0	0.0	0	0.0	0	0.0	.000
Apr.	1380	95.8	60	4.2	0	0.0	0	0.0	0	0.0	0	0.0	.001
May	1135	98.6	16	1.4	0	0.0	0	0.0	0	0.0	0	0.0	.000
June	1425	99.4	8	0.6	0	0.0	0	0.0	0	0.0	0	0.0	.000

Table 10. Monthly averages and SO_2 frequency distributions of 1/2-hour readings, Great Canadian Oil Sands - Mildred Lake station.

Conc. Range (ppm SO_2)	0		0.001 - 0.060		0.061 - 0.170		0.171 - 0.200		0.201 - 0.340		0.341 +		
Readings	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	SO_2 ppm Monthly Average
Month													
Apr./76	992	77.3	185	14.4	90	7.0	1	0.1	12	0.9	4	0.3	.013
May	1110	74.8	330	22.3	32	2.2	2	0.1	7	0.5	2	0.1	.011
June	1229	86.3	191	13.4	4	0.3	0	0.0	0	0.0	0	0.0	.002
July	1136	88.6	137	10.7	6	0.5	1	0.1	2	0.2	0	0.0	.003
Aug.	1197	82.9	213	14.8	32	2.2	1	0.1	1	0.1	0	0.0	.005
Sept.	1310	91.1	114	7.9	11	0.8	0	0.0	3	0.2	0	0.0	.003
Oct.	1272	87.8	171	11.8	5	0.3	0	0.0	0	0.0	0	0.0	.004
Nov.	1396	97.5	35	2.4	1	0.1	0	0.0	0	0.0	0	0.0	.001
Dec.	1486	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	.000
Jan./77	1409	94.8	71	4.8	6	0.4	0	0.0	0	0.0	0	0.0	.001
Feb.	1137	84.6	206	15.3	1	0.1	0	0.0	0	0.0	0	0.0	.002
Mar.	1364	91.9	109	7.3	11	0.7	0	0.0	0	0.0	0	0.0	.002
Apr.	1400	97.2	38	2.6	2	0.1	0	0.0	0	0.0	0	0.0	.001
May	1440	96.8	46	3.1	2	0.1	0	0.0	0	0.0	0	0.0	.001
June	986	92.0	77	7.2	8	0.7	1	0.1	0	0.0	0	0.0	.002

Table 11. Monthly averages and SO_2 frequency distributions of 1/2-hour readings, Great Canadian Oil Sands - Fina Airstrip station.

Conc. Range (ppm SO_2)	0		0.001 - 0.060		0.061 - 0.170		0.171 - 0.200		0.201 - 0.340		0.341 +		
Readings	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	SO_2 ppm Monthly Average
Month													
July/76	820	70.8	317	27.3	22	1.9	0	0.0	0	0.0	0	0.0	.007
Aug.	973	68.9	429	30.4	11	0.8	0	0.0	0	0.0	0	0.0	.007
Sept.	636	44.2	646	44.9	144	10.0	6	0.4	8	0.5	0	0.0	.024
Oct.	1132	81.0	258	18.5	8	0.6	0	0.0	0	0.0	0	0.0	.006
Nov.	807	57.0	543	38.4	47	3.3	6	0.4	11	0.8	1	0.1	.013
Dec.	1214	81.8	255	17.2	12	0.8	0	0.0	3	0.2	0	0.0	.004
Jan./77	1287	86.7	186	12.5	8	0.5	1	0.1	2	0.1	0	0.0	.003
Feb.	914	73.6	291	23.4	34	2.7	0	0.0	3	0.2	0	0.0	.008
Mar.	1202	84.6	199	14.0	17	1.2	1	0.1	1	0.1	0	0.0	.004
Apr.	1364	94.7	51	3.5	20	1.4	2	0.1	1	0.1	2	0.1	.003
May	1428	96.4	49	3.3	5	0.3	0	0.0	0	0.0	0	0.0	.001
June	1148	80.2	243	17.0	35	2.4	3	0.2	3	0.2	0	0.0	.007

September 1976 had the highest occurrence of readings from all stations, compared to the other selected months. Monthly averages are slightly higher in the 0.005 ppm range.

Annual averages can be calculated on a weighted basis from the monthly averages shown in Tables 7 to 11 by ratio of the number of readings in the month to the total number of readings in that 12 month period, so that:

$$C_{12} = \sum_{m\to 1}^{m\to 12} Cm \frac{Rm}{R_{12}}$$

where C_{12} and Cm are the average concentrations for the year and month respectively and R_{12} and Rm are the number of 1/2-hour readings in the year and month respectively. Annual averages for previous calendar years from Great Canadian Oil Sands (1975, 1976, 1977) stations are listed below:

	Annual Average SO_2 Concentration (ppm)		
Station	1976	1975[a]	1974[a]
Supertest Hill	.0019	.0011	.0033
Mannix	.0031		
Ruth Lake	.0027		
Mildred Lake	.0037	.0014	.0020
Fina	.0065		

[a] Annual averages are lower than actual in these years due to the method of chart reading used that elimiated all readings below 0.05 ppm. The actual value may be from 20% to 50% higher depending on the number of readings eliminated that were in that range.

4.2 AIR POLLUTANT DATA ANALYSIS, EXCLUDING SO_2

As noted in Section 2, continuous monitoring for specified pollutants is provided for in the three AOSERP air quality stations operated by Alberta Environment.

Since the stations were not commissioned until March of 1977, the data base is small. Nevertheless, preliminary results are given in Tables 12 through 17. They include analysis of oxides of nitrogen, nitrogen dioxide, ozone, reactive hydrocarbon, total hydrocarbon, and carbon monoxide, respectively. Continuous data for H_2S from the AOSERP stations is nonexistent as the instrumentation has just been received from the supplier.

Of some significance are the higher ozone levels at Birch Mountain when compared with Fort McMurray or Bitumount sites. Average NO_2 concentrations from the remote site at Bitumount are at the 0.01 ppm level. This is less than the air quality objective of 0.03 ppm as an annual average and slightly higher than the estimated background concentration in Stern (Robinson and Robbins 1972) of 0.4 to 5 ppb NO_2. Individual pollutant readings of an unusually high or low nature are explained where possible with footnotes in the tables.

Detailed data on a continuous one hour basis for these pollutants can be made available through the Environmental Protection Services of Alberta Environment.

4.3 PARTICULATE RESULTS

Particulate analysis given by high volume air samplers are available from four locations, namely Birch Mountain, Bitumount, Mannix, and Fort McMurray townsite (see Figures 1 and 2). Particulate analysis given by soiling index or coefficient of haze (COH) are available from Fort McMurray and Bitumount.

4.3.1 High Volume Sampler Analysis

Results of total suspended particulates from four sites are presented in Table 18. The higher results from the Mannix and Fort McMurray sites can be directly attributed to man-induced

Table 12. NO_x data, 1977.

Station	Monitoring Period	Instrument Operational (%)	Range of 1 h Concentration (ppm)		Monthly Avg. (ppm)	Maximum 24 h Concentration (ppm)
			Low	High		
Fort McMurray	February	74.1	0.01	0.34	0.07	0.16
	March	70.7	0.00	0.02	0.00	0.01
	April	99.7	0.00	0.16	0.02	0.04
	May	90.5	0.00	0.08	0.02	0.03
	June	93.3	0.00	0.10	0.01	0.03
Bitumount	March	60.6	0.01	0.09	0.02	0.04
	April	70.6	0.00	0.65[a]	0.03	0.18
	May	98.8	0.01	0.12	0.03	0.06
	June	99.3	0.01	0.05	0.02	0.04

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[a] No known cause. Probable cause is portable power supply.

Table 13. NO_2 Data, 1977.

Station	Monitoring Period	Instrument Operational (%)	Range of 1 h Concentration (ppm) Low	Range of 1 h Concentration (ppm) High	Monthly Avg. (ppm)	Maximum 24 h Concentration (ppm)	No. of Readings[a] >.21 ppm per 1 h	No. of Readings[a] >.11 ppm per 24 h
Fort McMurray	February	85.9	0.01	0.09	0.03	0.06	0	0
	March	71.5	0.00	0.01	0.00	0.00	0	0
	April	91.7	0.00	0.06	0.01	0.02	0	0
	May	61.3	0.00	0.05	0.01	0.02	0	0
	June	72.5	0.00	0.04	0.01	0.02	0	0
Bitumount	March	60.6	0.00	0.05	0.01	0.04	0	0
	April	65.7	0.00	0.11[b]	0.02	0.04	0	0
	May	98.8	0.00	0.09	0.01	0.05	0	0
	June	99.3	0.00	0.03	0.01	0.01	0	0

[a] Alberta Environment (1975).

[b] No known cause. Probable cause is portable power supply.

Table 14. Ozone data, 1977.

Station	Monitoring Period	Instrument Operational (%)	Range of 1 h Concentration (pphm)		Monthly Average (pphm)	Maximum 24 h Concentration (pphm)	No. of Readings[a]	
			Low	High			>5.1 pphm per 1 h	>1.5 pphm per 24 h
Fort McMurray	February	79.9	0.5	4.0	1.37	2.35	0	6
	March	87.1	0.5	6.5	2.31	3.63	2	20
	April	98.7	0.5	5.5	2.84	4.04	6	30
	May	97.7	0.5	6.0	3.02	4.07	23	29
	June	89.7	0.5	5.5	2.54	4.36	10	26
Bitumount	March	87.6	0.5	13.0[b]	3.34	8.31	126	19
	April	64.2	0.0	4.0	1.08	2.50	0	5
	May	68.2	1.0	6.5	3.28	4.65	19	15
	June	73.1	1.0	6.0	3.21	4.40	8	20
Birch Mountain	March	94.5	0.5	6.0	4.15	5.35	40	26
	April	69.3	3.5	6.5	4.54	5.70	36	16
	May	75.8	1.5	7.5	4.76	6.15	202	20
	June	93.1	2.0	6.0	3.84	5.06	35	26

[a] Alberta Environment (1975).

[b] No known cause.

Table 15. Reactive hydrocarbon data, 1977.

Station	Monitoring Period	Instrument Operational (%)	Range of 1 h Concentration (ppm) Low	High	Monthly Avg. (ppm)	Maximum 24 h Concentration (ppm)
Fort McMurray	February	82.3	0.10	1.90	0.52	1.04
	March	24.9	0.20	1.70	0.41	0.58
	April	-	-	-	-	-
	May	49.3	0.20	0.70	0.40	0.55
	June	95.7	0.20	2.00	0.72	1.57
Bitumount	March	-	-	-	-	-
	April	40.6	0.50	4.50	1.14	1.92
	May	82.5	0.50	2.00	0.69	1.15
	June	99.0	0.20	3.00	0.24	0.44

Table 16. Total hydrocarbon data, 1977.

Station	Monitoring Period	Instrument Operational (%)	Range 1 h Concentration (ppm) Low	High	Monthly Avg. (ppm)	Maximum 24 h Concentration (ppm)
Fort McMurray	February	83.5	1.60	4.30	2.19	2.99
	March	15.9	1.60	2.90	1.97	2.10
	April	-	-	-	-	-
	May	49.3	1.70	2.30	1.97	2.07
	June	95.7	1.80	3.70	2.52	3.12
Bitumount	March	-	-	-	-	-
	April	37.2	2.00	5.50	2.68	3.02
	May	75.5	1.50	3.50	1.85	2.59
	June	99.0	1.60	4.00	1.70	1.87

Table 17. Carbon monoxide data, 1977.

Station	Monitoring Period	Instrument Operational (%)	Range of 1 h Concentration (ppm)		Monthly Avg. (ppm)	Maximum 24h Concentration (ppm)	No. of Readings[a]	
			Low	High			>13 ppm per 1 h	>5 ppm per 8 h
Fort McMurray	February	95.4	0.50	8.00	1.02	6.63	0	0
	March	84.3	0.50	7.50	1.45	5.79	0	7
	April	90.0	0.00	12.50[b]	1.33	6.17	0	3
	May	82.9	0.00	3.50	0.60	1.46	0	0
	June	70.8	0.50	1.50	0.60	1.06	0	0
Bitumount	March	66.4	0.50	6.50[c]	1.03	2.79	0	0
	April	-	-	-	-	-	-	-
	May	46.6	0.00	3.00	0.73	2.27	0	0
	June	99.3	0.50	10.00[c]	1.28	2.29	0	0

[a] Alberta Environment (1975)

[b] Vehicle parked and running near station.

[c] No known cause. Probable cause is power supply for forestry house or power supply for AOSERP.

Table 18. Total suspended particulate results, AOSERP study area, 1977.

Station	Sample Date	Total Suspended Particulates $ug.m^{-3}$
Birch Mountain	19-5-77	18
	25-5-77	29
	31-5-77	11
	9&10-7-77	16
Bitumount	13-5-77	55
	19-5-77	14
	31-5-77	8
Mannix	25-5-77	121 - Close to road
	31-5-77 & 16-6-77	93
	12-6-77 & 18-6-77	14
	24&25-6-77	11
Fort McMurray	13-5-77	128
	19-5-77	120
	25-5-77	257
	31-5-77	121
	6-6-77	383 - dusty road - const.
	12-6-77 & 18-6-77	561 - dusty road - const.
	24&25-6-77	107

activities, including road dust. The Birch Mountain and Bitumount results are relatively clean in comparison. Compared to an Alberta Regulation for total suspended particulates of 100 $\mu g.m^{-3}$ of air (Alberta Environment 1975), all Fort McMurray samples exceed that level; one Mannix sample is in excess while all Birch Mountain and Bitumount samples are below that level.

Other parameters analysed from the high volume samples included two well-known carcinogens, sulphates and nitrates (Table 19). The mass per unit of air volume of the two carcinogens is consistently between one and two orders of magnitude lower than results of an Edmonton station from a similar time a year ago. Mass of carcinogen per unit of mass particulate, however, range from equal, to one order of magnitude lower when compared with that same Edmonton station.[1] More detailed results on carcinogens will soon be available through the Research Secretariat of Alberta Environment from work done by Peake (1976). The sulphate analysis was conducted using the following technique. Sulphate is extracted from the filter paper with water, mixed with $BaCl_2$ solution and the resulting $BaSO_4$ precipitate is analyzed turbidimetrically. Since the filter paper is not specific for SO_4, some SO_2 can react with the filter paper used, thus increasing the actual amount of sulphate present. This is evident when comparing the sulphate results for background air in Table 19, (2.1 - 3.0 $\mu g.m^{-3}$ (SO_4)), to those obtained by Barrie and Whelpdale (1978), (0.3 - 1.5 $\mu g.m^{-3}$ (SO_4)). Average concentrations of nitrates in $\mu g.m^{-3}$ of air were determined by the NO_3 ion electrode method.

An attempt was made to analyse for selected metals in the high volume samples. All metals shown in Table 20 were obtained using the solvent extraction, atomic absorption technique. Detection limits are also given in Table 20.

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[1] Results are from the Department of Environment files for station Edmonton Residential Monitoring Unit (ERMU).

Table 19. High volume sample results, AOSERP study area, 1977.

Station	Sample Date	Parameter					
		Benzo (a) pyrene		Benzo (k) fluoranthene		Sulphate (SO_4)	Nitrate
		$ng \cdot m^{-3}$ air	$ug \cdot g^{-1}$ particulates	$ng \cdot m^{-3}$ air	$ug \cdot g^{-1}$ particulates	$ug \cdot m^{-3}$ air	(NO_3) $ug \cdot m^{-3}$ air
Birch Mountain	19-5-77	0.008	0.440	0.000	0.000	2.1	0.00
	25-5-77	0.002	0.069	0.002	0.069	3.0	0.09
	31-5-77	0.002	0.175	0.002	0.175	2.8	0.09
Bitumount	13-5-77	0.001	0.018	0.002	0.036	2.3	0.09
	19-5-77	0.001	0.073	0.001	0.073	9.2	0.22
	31-5-77	0.007	0.850	0.000	0.000	3.1	0.09
Mannix	25-5-77	0.007	0.058	0.007	0.058	11.1	0.75
Fort McMurray	13-5-77	0.001	0.008	0.003	0.023	6.0	0.27
	19-5-77	0.008	0.066	0.015	0.123	3.0	0.13
	25-5-77	0.008	0.031	0.010	0.040	8.1	0.75
	31-5-77	0.006	0.049	0.017	0.140	5.0	0.62

Table 20. Metals in high volume samples, AOSERP study area, 1977.

Station	Sample Date	Parameter ($ug.m^{-3}$ air)													
		Cu	Pb	Zn	Ni	Co	Cd	Be	Mo	Mn	Cr	Hg	Fe	Al	V
Birch Mountain	19-5-77	0.179	0.018	0.034	0.005	0.003	0.002	BDL[a]	BDL	0.017	BDL	0.0002	0.266	BDL	BDL
	25-5-77	0.198	0.016	0.030	0.007	0.002	0.001	BDL	BDL	0.011	BDL	0.0003	0.152	BDL	BDL
	31-5-77	0.168	0.009	0.042	0.003	BDL	BDL	BDL	BDL	0.011	BDL	0.0002	0.145	BDL	BDL
Bitumount	13-5-77	0.194	0.045	0.039	0.003	0.003	BDL	BDL	BDL	0.031	BDL	BDL	0.428	BDL	BDL
	19-5-77	0.132	0.037	0.012	0.002	0.004	BDL	BDL	BDL	0.004	BDL	0.0005	0.113	BDL	BDL
	31-5-77	0.210	0.018	0.004	0.002	0.002	BDL	BDL	BDL	0.004	BDL	0.0001	0.162	BDL	BDL
Mannix	25-5-77	0.220	0.042	0.021	0.068	0.006	0.003	BDL	0.010	0.037	0.014	0.0002	1.893	BDL	0.011
Fort McMurray	13-5-77	0.188	0.014	0.048	0.008	0.001	0.001	BDL	BDL	0.071	BDL	0.0002	1.401	BDL	BDL
	19-5-77	0.230	0.090	0.024	0.005	0.003	0.002	BDL	BDL	0.040	BDL	BDL	1.920	BDL	BDL
	25-5-77	0.172	0.053	0.046	0.016	0.007	0.003	BDL	BDL	0.117	0.021	BDL	5.863	BDL	0.002
	31-5-77	0.107	0.039	0.052	0.023	0.005	0.001	BDL	0.003	0.090	BDL	0.0003	4.215	BDL	0.005
Detection Limit		0.001	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.008	0.010	0.0001	0.005	0.020	0.002

[a] Symbol: BDL = below detection limit.

A few of the metals analysed by Barrie and Whelpdale (1978) are common to those in Table 20 for Birch Mountain. However, due to the greater resolution of neutron activation, some of the results differ. Techniques used by Barrie and Whelpdale more accurately represent a true background sample because of the greater resolution of their technique and the contamination-free nature of their sample. Results quoted in Table 20 could have been contributed to by local helicopter landings, or the local diesel plumes. As long as these facts regarding analytical techniques are considered while interpreting the data, one can selectively choose the data set to fit the interpretation needed. For example, Table 20 illustrates well the difference in iron (Fe) content at the remote sites (0.3 $\mu g.m^{-3}$ range) compared to the sites near developed areas (3.0 $\mu g.m^{-3}$ range). On the other hand, only the data set from Barrie and Whelpdale could be used to determine the significance of man made sources versus natural sources as components of metals samples.

These results as well as those gathered in the field studies by Barrie and Whelpdale (1978) will allow for a more comprehensive continuing sampling program for the next reporting period.

4.3.2 COH Results

Coefficient of haze (COH) is the measurement of light transmission through a filter whose exposure to metered air flow is constant in time and volume. This provides the capability for an optical density reading proportional to the haze or particulate matter in the atmosphere. Similar to results of other prime pollutants as described in section 4.2, the data base for this measurement is very small. Nevertheless, Table 21 illustrates these initial results, with a comparison to an Edmonton station. For the time period illustrated, Fort McMurray shows a higher soiling index than the Edmonton station (EDMU). This fact is confirmed when comparing the total suspended particulate (TSP) high volume results to the Edmonton station (EDMU). Results for TSP for

Table 21. Coefficient of haze.

Station	Month (1977)	Peak Hourly Reading COH
Bitumount	March	0.50
	April	0.50
	May	0.70
Fort McMurray	Feb	1.52
	March	1.00
	April	1.30
	May	1.30
Edmonton (EDMU)	Feb	1.30
	March	0.80
	April	1.00
	May	0.60

Fort McMurray are on the average higher than the EDMU station in Edmonton. Most probable cause for the higher readings in the Fort McMurray region is fugitive dust, either traffic or wind-induced.

4.4 TOTAL SULPHATION AND H_2S EXPOSURE CYLINDER RESULTS

Data used in this section originates mainly from Great Canadian Oil Sands (1975, 1976, 1977) reports submitted to the Department of Environment. The network of exposure sites is shown in Figure 3. The expanded exposure network, including the AOSERP sites (Figure 1), has data common for the four month period of June to September 1976. Future analysis will also include Syncrude's exposure network (Figure 3), put into operation in the summer of 1977.

4.4.1 Discussion of Isopleth Shape

Figure 6 shows the isopleth concentrations of total sulphation for four months in 1976, using some AOSERP station data as well as the data from the Great Canadian Oil Sands network. The isopleths show contour lines ranging from 0.04 to 0.10 mg SO_3 equivalent/day/100 cm^2. From experience, the Air Quality Control Branch uses a guideline level of 0.5 mg SO_3 equivalent/day/100 cm^2. The contour lines shown are well below the guideline level.

A strong north-south elongation of the contour lines along the Athabasca River is apparent. This could be largely the result of the station distribution up and down the valley (Figure 3). However, by including results of some AOSERP sites, located in a more east-west direction (Figure 6), the narrow east-west, long north-south dependence of the contour gradient is somewhat supported. Inclusion of all exposure results (Great Canadian Oil Sands, Syncrude, and AOSERP) in the future, and prior to Syncrude start-up, would provide a much improved data base, free from bias of location.

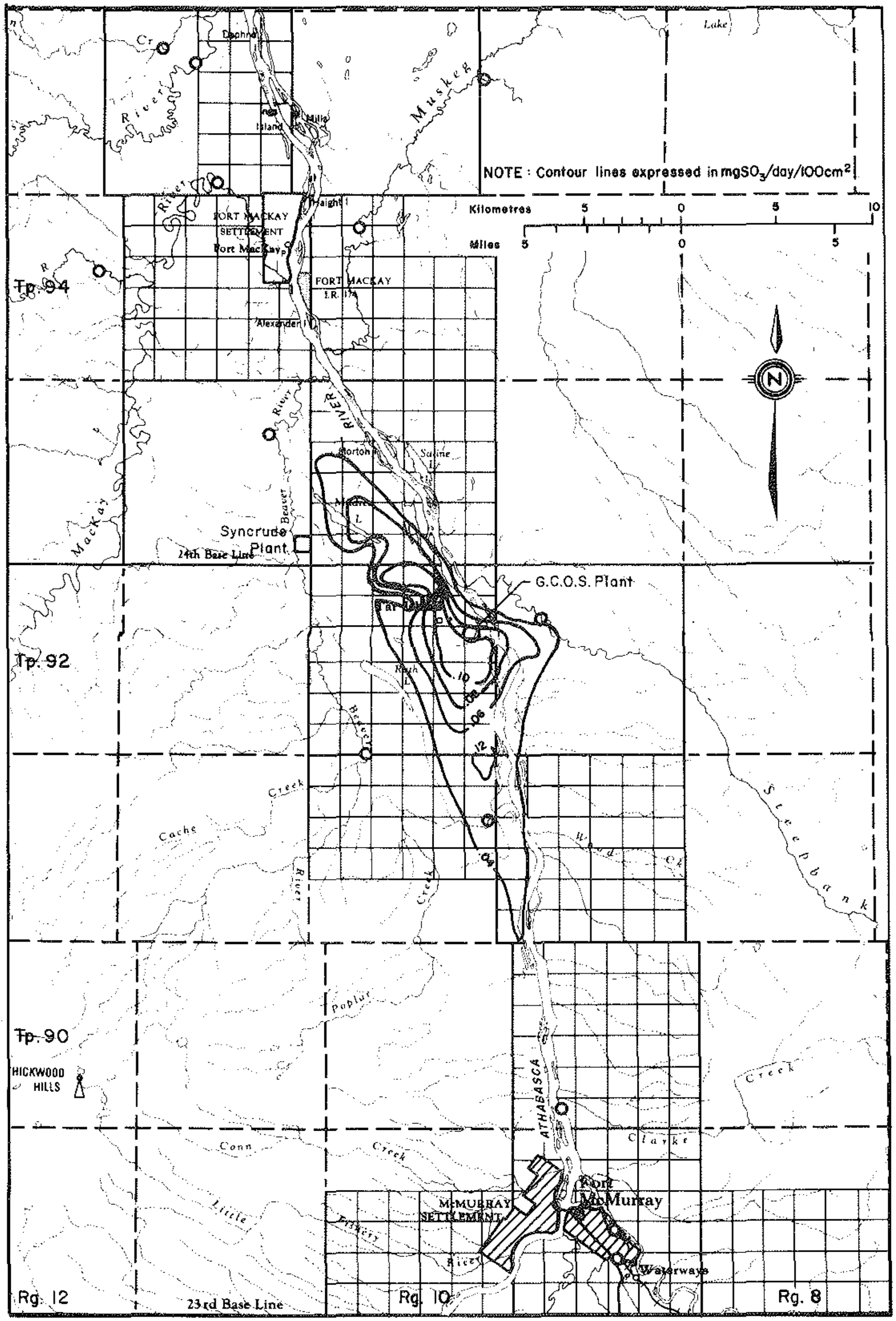

Figure 6. Total sulphation isopleths, Fort McMurray area 1976 seasonal average (June - September).

4.4.2 Discussion of Figures

Figures 7, 8 and 9 illustrate that the magnitude of the total sulphation contours has not deviated much through the three year period shown. The range of contour lines is from 0.04 to 0.15 mg SO_3 equivalent/day/100 cm^2 for the year average. Six stations operated by the Department of Environment in the oil sand region report results that fit very well to the 1974 and 1976 annual average contours. Data from 1975 has a 50% fit.

Figures 10, 11 and 12 illustrate that H_2S isopleths also have little variation from year to year from 1974 to 1976. The range of the isopleths is from 0.02 to 0.06 mg SO_3 equivalent/day/100 cm^2.

The fact that these contour levels have not varied significantly over the period 1974 to 1976, provides a potential for these exposure cylinders to be used as an indicator of increased ambient sulphation levels in future years. Similar interpretation of sulphation data after start-up of additional processing plants could aid in establishing environmental impact, as well as aid in the location of continuous monitoring stations.

When compared to other parts of Alberta the 1976 annual averages of TS and H_2S exposure results from the Kaybob No. 3 plant range from 0.04 to 0.20 and 0.01 to 0.10 mg SO_3 equivalent/day/100 cm^2 respectively.[1] Similarly, results for Balzac show ranges from 0.1 to 0.2 and 0.02 to 0.03 respectively.[1]

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[1] Results extracted from annual reports submitted to the Department of Environment.

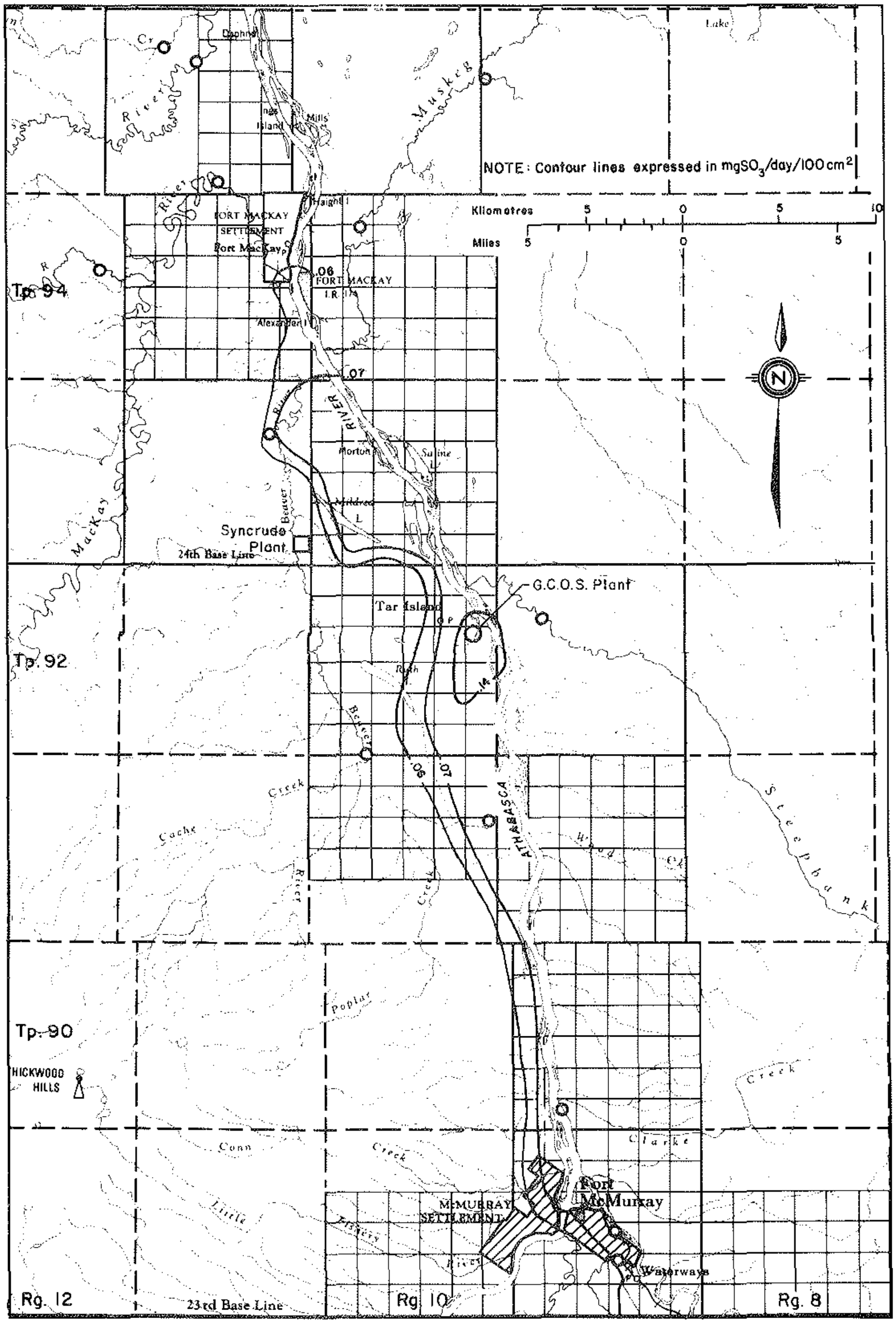
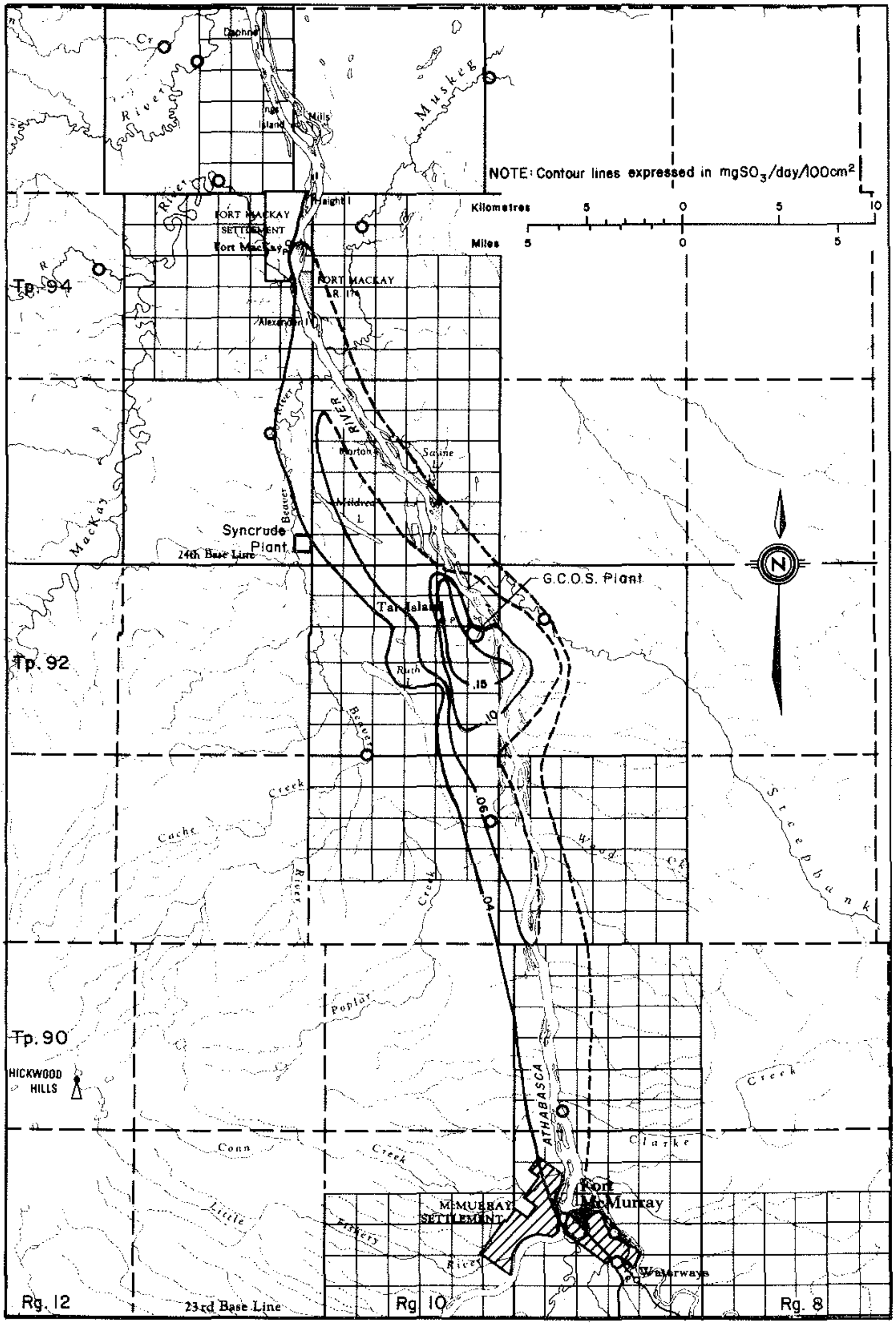


Figure 7. Total sulphation isopleths, Fort McMurray area 1974 annual averages.



NOTE: Contour lines expressed in mgSO_3/day/100cm^2

Figure 8. Total sulphation isopleths, Fort McMurray area 1975 annual averages.

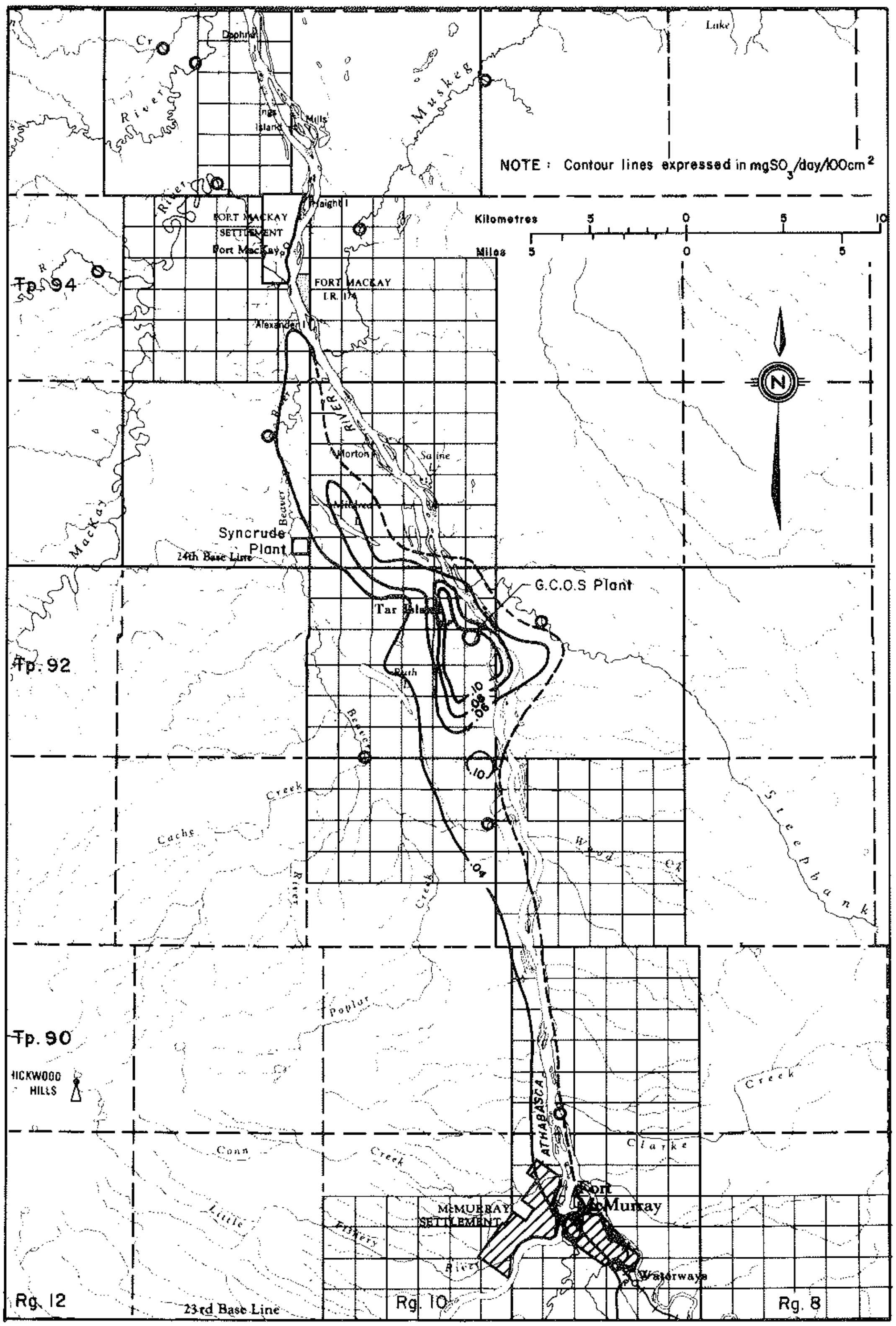


Figure 9. Total sulphation isopleths, Fort McMurray area 1976 annual averages.

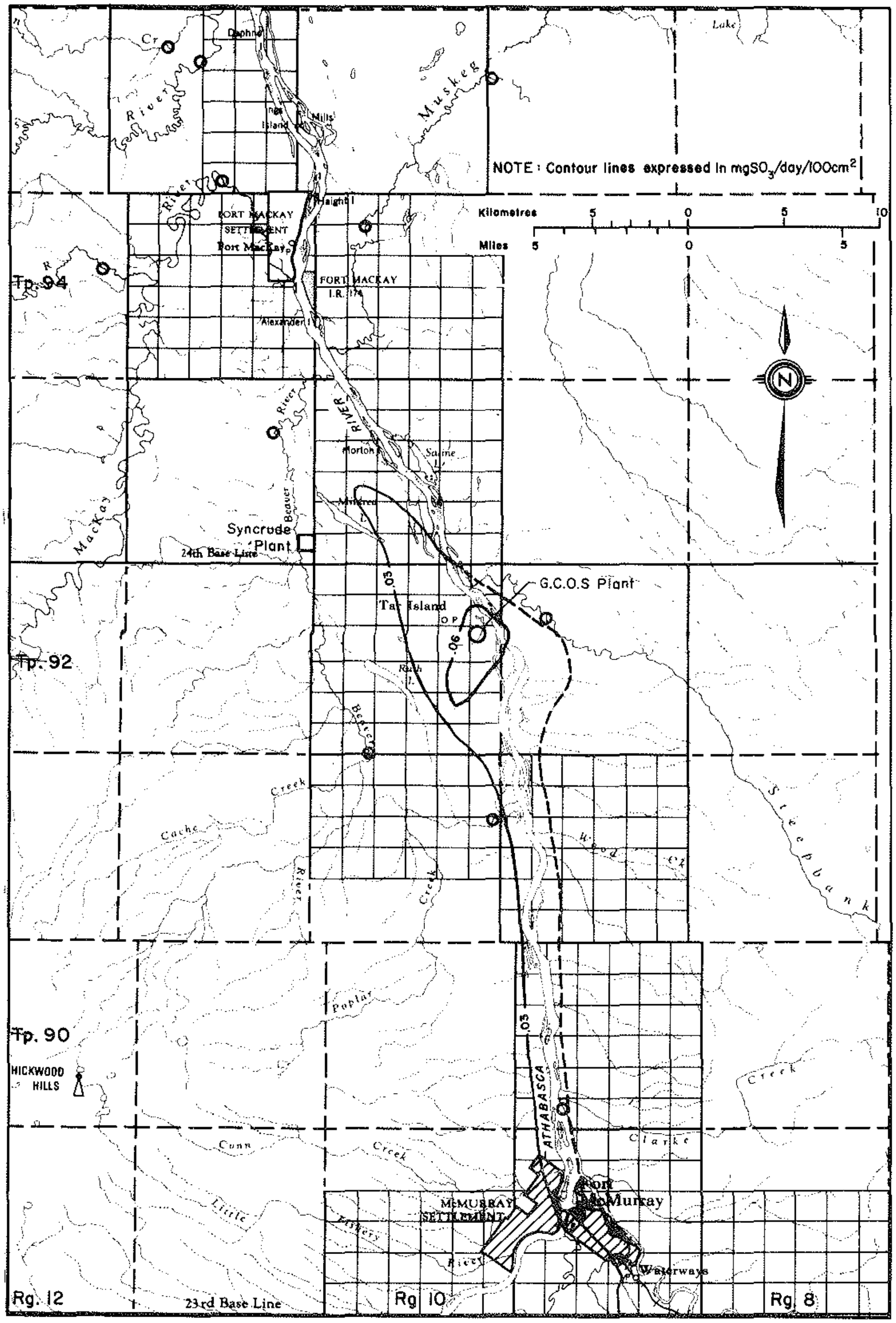


Figure 10. Hydrogen sulphide isopleths , Fort McMurray area 1974 annual averages.

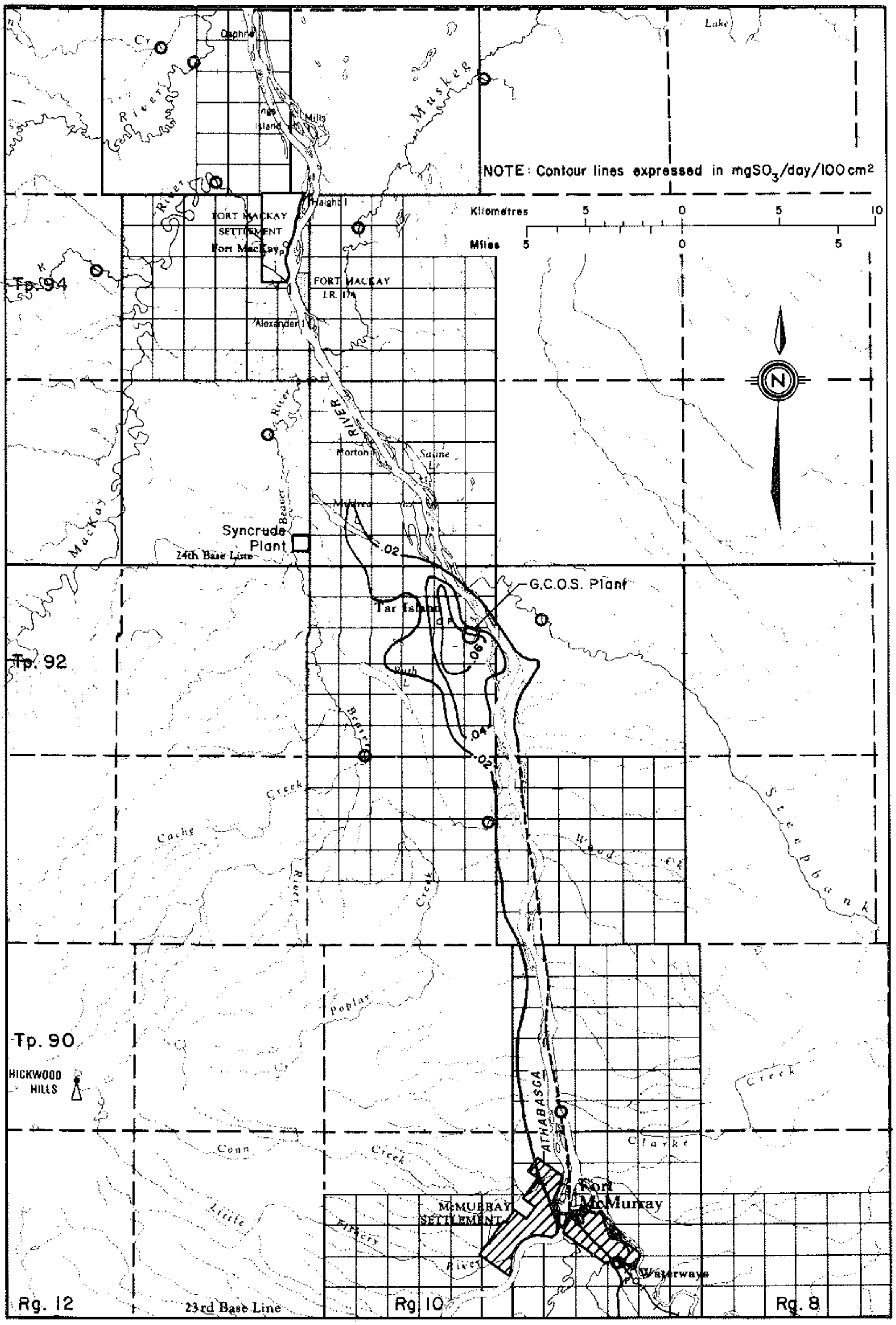


Figure 11. Hydrogen sulphide isopleths, Fort McMurray area 1975 annual averages.

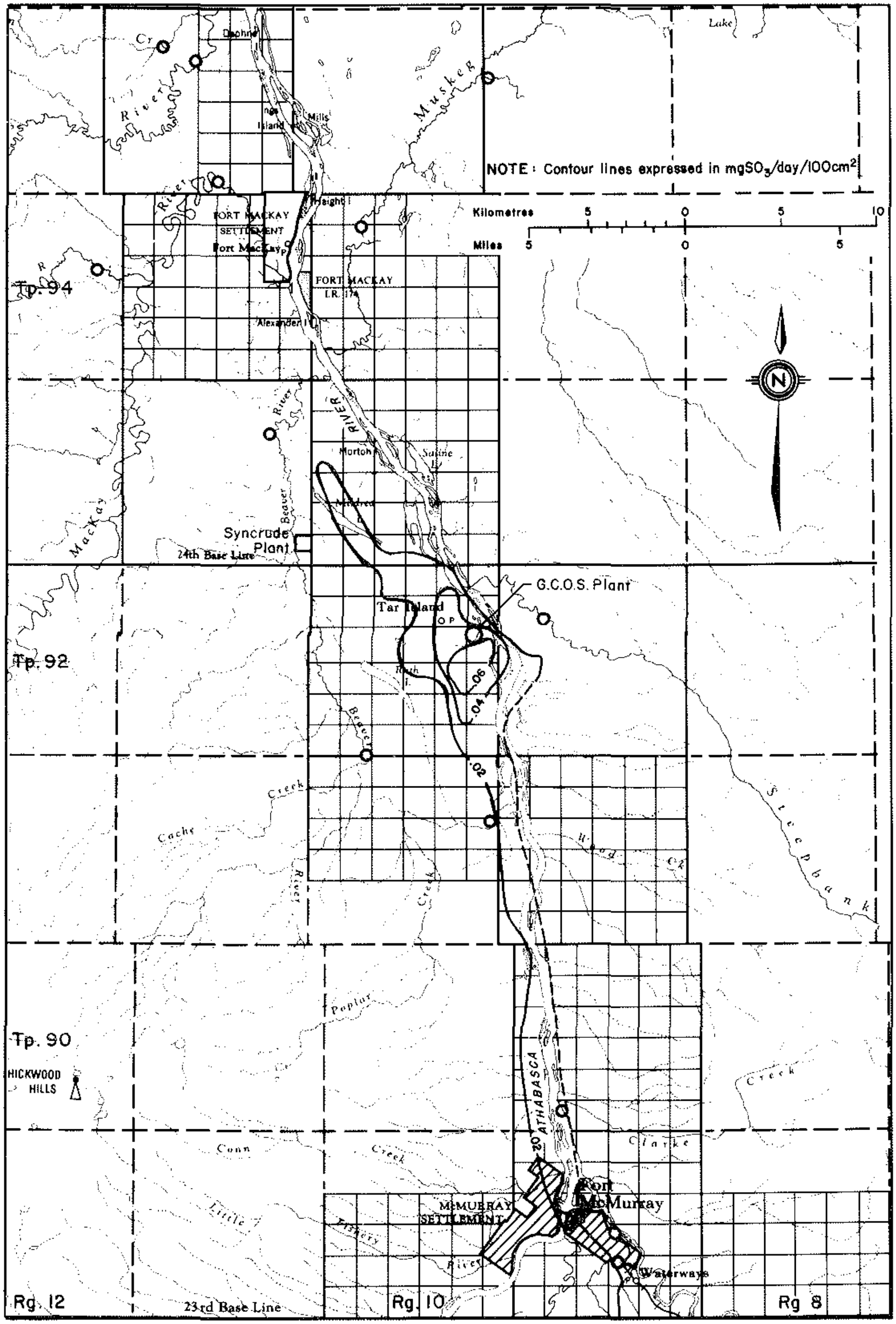


Figure 12. Hydrogen sulphide isopleths, Fort McMurray area 1976 annual averages.

5. SUMMARY

1. Section 2: Monitoring Network
   a) Prior to 1977, five continuous monitors for SO_2 and H_2S were in operation by Great Canadian Oil Sands. After 1977, five more continuous monitors for SO_2 and H_2S will be commissioned by Syncrude and three continuous monitors covering all prime pollutants will be operated by the Department of Environment for AOSERP.
   b) The total number of Total Sulphation and H_2S exposure cylinder sites in the area is 108.
2. Section 3: Sources and Emissions
   a) Main air pollution sources from Great Canadian Oil Sands are the Powerhouse Stack which burns coke to generate steam and electricity, and the Incinerator Stack which vents the unrecoverable H_2S from the Claus process as the combusted product, SO_2.
   b) One main stack at Syncrude vents all of the prime pollution sources at the plant. They include the off gases rich in SO_2 from the fluid cokers, electrostatic precipitator treated gas from the CO boiler and unrecoverable H_2S in its combusted product, SO_2, from the Claus process. Coke is not burned for power and steam generation at Syncrude.
3. Section 4: Ambient Air Quality Data Results
   a) When compared to four other major gas plants in Alberta, Great Canadian Oil Sands has maintained the highest frequency of occurrence of SO_2 readings in excess of the half hour standard for the past three years. However, Great Canadian Oil Sands, being the only utility plant in the comparison, has the greatest difficulty in reducing

SO_2 mass emission rates allowed by licence under the Clean Air Act, on a real time basis.

b) Thus far, with the limited amount of background data available, the remote monitoring stations operated for AOSERP yield SO_2 average concentrations of 1 ppb, a reasonable comparison to the estimated global background SO_2 concentration of 0.2 ppb.

c) Frequency distributions of SO_2 readings from Great Canadian Oil Sands stations showed a higher collection of readings in September 1976, than any other of the 12 to 14 months reported. Occurrence of readings was, naturally, greater at monitoring sites closer to the source (Great Canadian Oil Sands).

d) Annual average SO_2 concentrations from monitoring sites closer to the source (Great Canadian Oil Sands stations) range from 3 to 6 ppb. This is lower than the air quality objective of 10 ppb as an annual average.

e) Maximum and average hourly concentrations of ozone are highest at Birch Mountain. Maximum 24 hour concentrations are 0.05 to 0.06 ppm, while the monthly average is 0.04 to 0.045 ppm.

f) Average NO_2 concentrations at Bitumount station are similar to those at Fort McMurray at 10 ppb, lower than the air quality objective of 30 ppb as an annual average and higher than an estimated global background concentration of 0.4 to 5 ppb of NO_2.

g) Total Suspended Particulate (TSP) results in Fort McMurray are greater than 100 $\mu g.m^{-3}$ and can most likely be attributed to road dust.

h) Metal results using atomic absorption analysis with high volume collection should be interpreted with due consideration given to the method of collection as outlined in the report. Results from the high volume samplers as well as results from Barrie and Whelpdale (1976) will be used to establish future metal analysis programs.

i) Contour lines for Total Sulphation and H_2S in mg SO_3 equivalent/day/100 cm^2 have not changed significantly in magnitude or shape over the past three years.

4. Section 8: Appendices

Detailed information on AOSERP site documentation and instrumentation as well as a complete catalogue of the geographic location of all monitoring sites and type of data collected is given in the appendices.

6. RECOMMENDATIONS

The result of co-ordinating the data from three separate monitoring networks in the study area for the first time has no doubt exposed obstructions to efficiently providing consistent high quality data from all sources. Since the use of all these data is vital in providing an adequate air quality assessment, the following recommendations are offered in view of the ongoing nature of this work.

1. Since the air quality assessment in the Athabasca oil sands area is dependent on three separate organizations for a data base, a co-ordinated effort to provide continuity in the data is mandatory. The Air System recognized early a need for a quality control program; this program is underway, beginning with standardizing of calibrations. It is recommended that this program receive more emphasis, covering subjects such as site documentation, standardization in chart reading or signal pick-up, and standardizing analytical techniques for such items as exposure cylinders.
2. Because the evaluation of air quality data collected thus far is relevant only to the Great Canadian Oil Sands plant operation, the start-up of the Syncrude plant in the early summer of 1978 will be a significant historic time with respect to environmental impact. In order to synchronize the time of start-up of Syncrude with an up to date assessment of air quality, it is recommended that an evaluation of air quality similar to this report, be carried out on all data to the start-up date of the Syncrude plant.
3. One objective of the data analysis was to exploit simple techniques of reviewing the data that could be used again in the future for the purpose of drawing a direct historic comparison. Many of these

techniques are referred to in the Report Summary. Among these procedures is the use of isopleths for exposure cylinder results, frequency distributions of half-hour SO_2 concentrations, and weighted monthly and annual SO_2 average concentrations. In order to ensure the continual flow of these data in a compatable format from the different organizations involved, it is recommended that AOSERP co-ordinate the industrial sector to encourage reporting of data in formats to facilitate the plotting of exposure cylinder isopleths, frequency distributions and time averages.

7. REFERENCES CITED

Alberta Environment. 1973a. Licence to Operate, No. 73-AL-114 A, issued to Great Canadian Oil Sands, Ltd. Edmonton, Alberta.

Alberta Environment. 1973b. Permit to Construct, No. 73-AP-054, issued to Syncrude Canada Ltd. Edmonton, Alberta.

Alberta Environment. 1975. Clean air regulations 218/75. Edmonton, Alberta.

Alberta Environment. 1976. Air monitoring directive AMD-76-1. Edmonton, Alberta

Barrie, L.A., and D.M. Whelpdale. 1978. Background air and precipitation chemistry. Pages 124-159 in F. Fanaki, compiler. Meteorology and air quality winter field study in the AOSERP study area, March 1976. Prep. for the Alberta Oil Sands Environmental Research Program by Atmospheric Environment Service. AOSERP Report 27. 249 pp.

Great Canadian Oil Sands Ltd. 1975. Annual air quality report (1974). Submitted to Alberta Environment, Edmonton, Alberta.

Great Canadian Oil Sands Ltd. 1976. Annual air quality report (1975). Submitted to Alberta Environment, Edmonton, Alberta.

Great Canadian Oil Sands Ltd. 1977. Annual air quality report (1976). Submitted to Alberta Environment, Edmonton, Alberta.

Peake, E. 1976. Carcinogenic hydrocarbons as potential environmental pollutants in Alberta resource development. Environmental Sciences Centre, University of Calgary, Calgary, Alberta. Current work for Alberta Environmental Research Trust, Alberta Department of Environment, Edmonton, Alberta.

Robinson, E.R., and R.C. Robbins. 1972. Page 1 to 93 in W. Strauss, ed. Air pollution control Part II. Wiley (interscience), New York, New York. Reprinted in A.C. Stern, ed. 1976. Air Pollution, 3rd ed. Volume 1, Air pollutants; their transformation and transport, Academic Press.

SNC Tottrup Ltd. 1978. An inventory system for atmospheric emissions in the AOSERP study area. Prep. for the Alberta Oil Sands Environmental Research Program. AOSERP Report 29. 58 pp.

8. APPENDICES

8.1 SITE AND INSTRUMENT DOCUMENTATION, AOSERP CONTINUOUS AIR QUALITY MONITORING STATIONS

8.1.1 Siting

Included in this document is a description of each of the three AOSERP continuous monitoring sites and maps showing cross-sectional terrain features for the AOSERP Research Facility at Mildred Lake. As the AOSERP Research Facility is located in the heart of the oil sand development area, it is used as a reference point. (See Appendix 8.2, Data Catalogue, for location).

8.1.1.1 Fort McMurray Town site. The Fort McMurray Town site is located approximately 40 km south-southeast of the AOSERP Mildred Lake Research Facility. The station is located in the Athabasca Valley near the confluence of the Clearwater and Athabasca rivers. The majority of town development lies to the southeast; however, across the Athabasca to the west is Thickwood Hills residential development. There are no immediate obstructions that would compromise the standard station siting criteria. Closest obstructions are two thirteen story apartment towers approximately 200 m to the east, and the Athabasca river bank, which is not high enough to interfere with the siting criteria specified by Alberta Environment (1976) 400 m to the south. Figure 13 shows the elevation change by cross-section from the Mildred Lake Research Facility to the site. Instrumentation details are provided in the next section, and more station information can be found in the Data Catalogue in Appendix 8.2.

8.1.1.2 Bitumount site. Bitumount is located approximately 34 km north-northeast of the AOSERP Mildred Lake Research Facility. The site is located in a clearing established some time ago for the Alberta Forest Service for their lookout tower. A dense deciduous

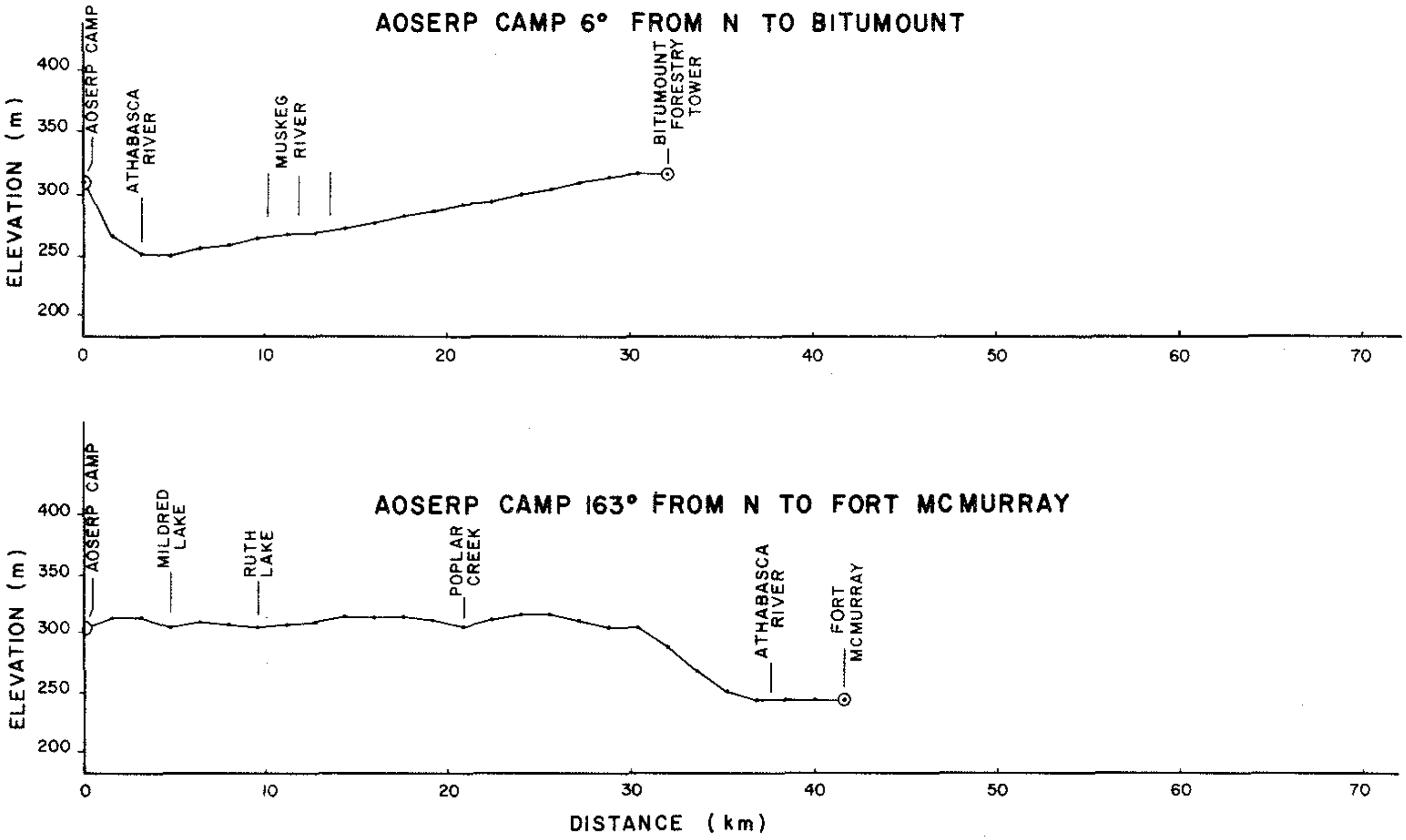


Figure 13. TOPOGRAPHICAL cross section.

forest canopy, approximately 10 to 15 m in height, surrounds the clearing with the closest portion of the canopy approximately 30 m from the station. Because the station requires continuous power a dual 11 kw diesel generating plant is located approximately 130 m north of the station. The only alteration to this site to meet the siting criteria was the installation of a 17 m wind tower instead of the standard 10 m variety. Figure 13 shows the elevation change by cross-section from the Mildred Lake Research Facility to the site. Instrument details are provided in the next section, and more station statistics on location and elevation may be found in the Data Catalogue in Appendix 8.2.

8.1.1.3 Birch Mountain site. The Birch Mountain site is located in a panoramic setting in the Birch Mountains, approximately 70 km to the north-northwest of the AOSERP Mildred Lake Research Facility. The site is located on a gravel plateau approximately 300 m by 50 m, oriented north-south. Land slopes away from the plateau in all directions. Figure 14 shows the elevation change by cross-section from the Mildred Lake Research Facility to the site. As at the Bitumount site, continuous power is provided by dual 6 kw diesel generators located approximately 70 m to the north of the station. Since A.G.T. operates a communication tower at this site, they also run dual 10 kw diesel generators approximately 200 m to the south of the station. Instrument details are provided in the next section, and more detailed station information can be found in the Data Catalogue in Appendix 8.2.

8.1.2 Instrumentation

Table 22 provides basic specificiations on instrumentation used at the AOSERP Air Quality monitoring sites. Following is a brief description of the operating principles and specifications for the major instruments.

8.1.2.1 Oxides of nitrogen. The Thermo Electron Model 14 Chemiluminescent Analyser measures NO and NO_x (by converting NO_2 to NO) and can provide NO_2 by difference (NO_x - NO).

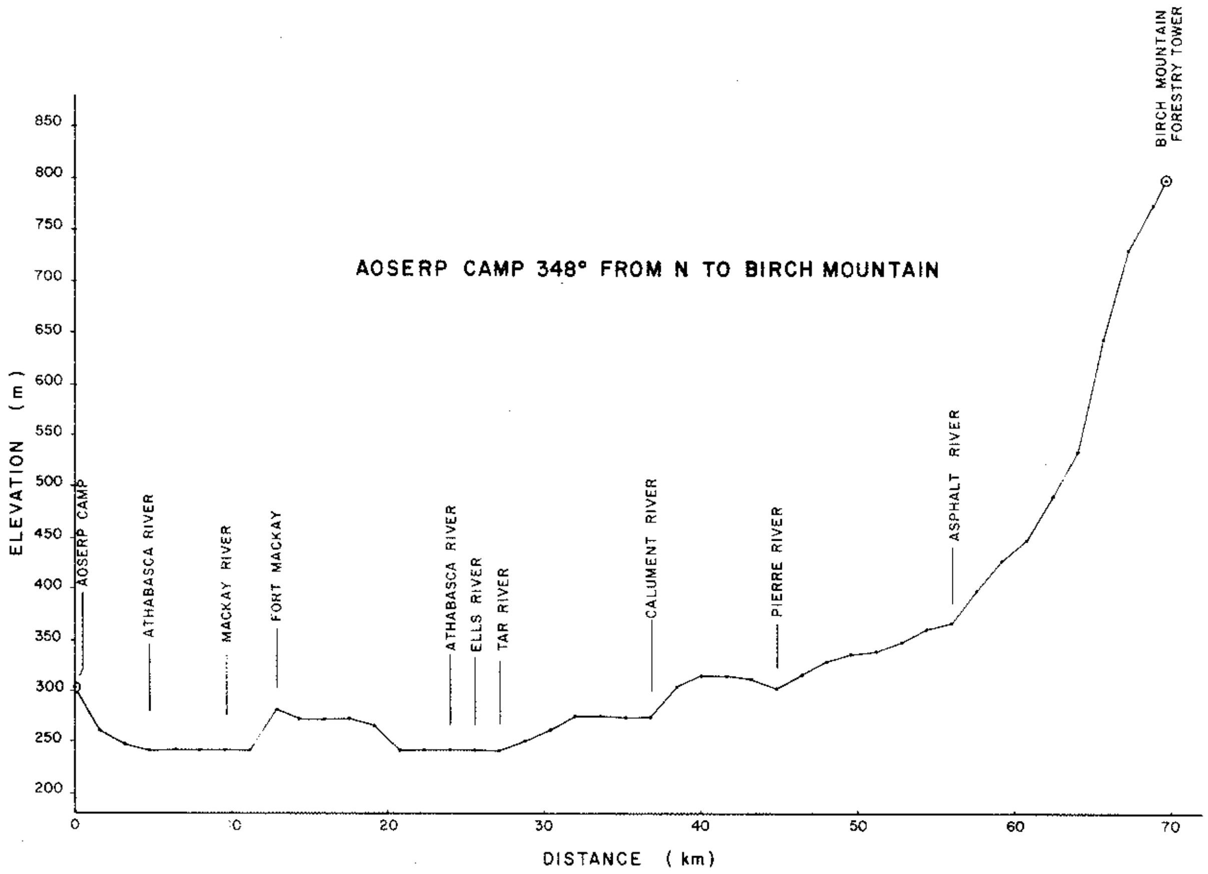


Figure 14. TOPOGRAPHICAL cross section.

Table 22. AOSERP instrument specifications.

Quantity	Make	Model	Type	Weight	Power Requirements
2	Bendix	8201	Hydrocarbon (RHC-THC-CH_4)	60 lbs	700 W
3	Bendix	8002	O_3	45 lbs	350 W
2	Thermo Electron	14B	NO_x-NO_2-NO	75 lbs	550 W
12	Philips	PM 8221	Recorder (2 channel)	20 lbs	150 W
2	RAC	5000	A.I.S.I. Tape Sampler (smoke & dust or H_2S)	80 lbs	500 W
2	Bendix	8501-5LA	I.R. Gas Analyzer (CO)	60 lbs	300 W
6	General Metal Works	2000 H	H.V. Sampler (dust)	50 lbs	1500 W
2	General Electic	15EHG1A1	H_2 Generator	27 lbs	180 W
2	Air Generators & Purifiers			40 lbs	500 W
3	Teco	#43	Sulphur	70 lbs	300 W
3	Climet	75810MS	Wind		200 W

The chemiluminescent reaction of NO and O_3 is monitored through an optical filter by a high sensitivity photomultiplier. Resolution of NO, NO_x, and NO_2 is accomplished by alternately monitoring an air sampler for NO and a conditioned sample, having passed through a converter ($NO_2 \rightarrow NO$). The resulting concentration is NO_x, and NO_2 is found by difference (NO_x - NO).

Zero drift is less than ± 1% in 24 hours, and precision is 1% of full scale. Range used is 0-1.0 ppm.

8.1.2.2 Carbon monoxide. Carbon monoxide is measured with a Bendix Model 8501-5CA Infrared Gas Analyzer. CO has a known characteristic absorption spectra in the infrared range. The infrared detector uses the nondispersive single beam technique with alternate modulation of the sample and reference cells. The capacitance change in the detector (reference to sample) is converted to a voltage and outputted as a concentration of CO.

The lower detectable limit is 0.5 ppm; zero drift is 0.5% per hour or ± 1% per 24 hours, whichever is lower; precision is 1% of full scale; and noise is ± 0.5% of full scale. Range used is 0-50 ppm.

8.1.2.3 Ozone. A Bendix Model 8002 Ozone Analyzer is used to monitor ozone. The chemiluminescence from the flameless-gas-phase reaction of ethylene and ozone is monitored by a photomultiplier.

The lower detectable limit is 0.001 ppm; zero drift is ± 1% per day or ± 2% per three days; precision ± 2% from the mean value on the 0-0.1 ppm range; and noise is 1% on the 0-0.1 ppm range. Range used is 0-0.50 ppm.

8.1.2.4 Hydrocarbon. The Bendix Model 8201 Analyzer operates on the principle of flame ionization whereby the electronic current generated by the burning sample is measured. By means of a series of flow valves, the first sample passes through an analytical column where only methane is eluted to the detector. The second sample (within a 200 second time span) by-passes the column giving an analysis of total hydrocarbon. The reactive hydrocarbon (total - methane) is calculated as the difference.

The lower detectable limit is 0.005 ppm; zero drift is ± 1% per 24 hours; precision is ± 1% of full scale; and noise is ± 1%. Range used is 0-10 ppm.

8.1.2.5 Sulphur dioxide. The Teco Model 43 Pulse Fluorescent Analyzer exploits the fact that SO_2 absorbs light in the 190-230 nm range. The excited SO_2 then decays to the ground state and the corresponding fluorescence can be related to ppm using a photomultipler and preamplifier/band-pass filter which converts the fluorescence energy to a voltage waveform. The instrument uses a pulsating ultraviolet light source and is insensitive to sample flow.

The lower detectable limit is 0.005 ppm; zero drift is ± 0.005 ppm; precision is 0.005 ppm; and noise is 0.001 ppm. Range used is 0-1 ppm.

8.1.2.6. Hydrogen sulphide and particulates (COH). Both pollutants listed above can be monitored using the RAC 500 AISI Tape Sampler, with only slight modifications. The filter tape method for particulates draws ambient air at constant flow rate through the filter tape, depositing the particulates on a one inch spot. During a preset time period (usually one hour), the change in light transmittance is measured by a densitometer and the result can be calculated after each one-hour period in a unit of coefficient of haze (COH).

Using this method for H_2S requires a lead acetate impregnated tape, a soda lime scrubber to provide H_2S free air for pressurizing the sampling area and a humidifer to condition the sample prior to passing through the tape. The change in light transmittance can be calculated in ppm H_2S by comparing to a standard.

8.2 DATA CATALOGUE FOR AMBIENT AIR QUALITY DATA, AOSERP STUDY AREA

This catalogue is a complete listing of the monitoring being conducted in the AOSERP study area.

TABLE 23

DATA CATALOGUE FOR AMBIENT AIR QUALITY DATA

AOSERP STUDY AREA

TYPE OF DATA														AVAILABLE FROM				FREQUENCY					FORM AVAILABLE IN					COLLECTED BY				
SO_2 CONCENTRATION AVG. (ppm)	H_2S CONCENTRATION AVG. (ppm)	CO CONCENTRATION AVG. (ppm)	NO_x CONCENTRATION AVG. (ppm)	NO_2 CONCENTRATION AVG. (ppm)	O_3 CONCENTRATION AVG. (ppm)	HC CONCENTRATION AVG. (ppm)	COEFFICIENT OF HAZE (COH)	TOTAL SUSPENDED PARTICULATES	PARTICLE SIZE RANGE IN SUSPENDED PARTICULATES	METALS IN SUSPENDED PARTICULATES	SPECIAL ANALYSIS IN SUSPENDED PARTICULATES	WIND SPEED	WIND DIRECTION	T S EXPOSURE CYLINDERS	– GCOS	– SYNCRUDE	– OTHER (CONTACT DOE)	1/2 HOUR	1 HOUR	24 HOUR	MONTHLY	OTHER		CHART RECORDING	REPORT	COMPUTOR PRINT – OUT		ADOE	AOSERP	GCOS	SYNCRUDE	OTHER
X					X			X	X	X	X	X	X					X	X	X		X		X	X	X		X				
X	X	X	X	X	X	X	X	X	X	X	X	X	X					X	X	X		X		X	X	X		X				
X	X	X	X	X	X	X	X	X	X	X	X	X	X					X	X	X		X		X	X	X		X				
X	X							X	X	X	X	X	X		X			X	X	X					X			X		X		
X	X											X	X		X			X	X						X					X		
X	X											X	X		X			X	X						X					X		
X	X											X	X		X			X	X						X					X		
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														X	X						X				X					X		
														X		X					X				X						X	
														X			X				X				X							X
														X							X				X			X				

Table 24. Great Canadian Oil Sands exposure cylinder locations.

			Co-ordinates				UTM	
			Latitude		Longitude		6° GRID	
Station	Elevation (Metres)	Legal Description	Deg.	Min.	Deg.	Min.	Northing	Easting
1	280	NE-34-94-11-W4	57	13.5	111	40.0	6340312	459627
2	245	SW-25-94-11-W4	57	12.0	111	37.5	6337870	462046
3	275	SE-23-94-11-W4	57	11.0	111	38.5	6336249	461209
4	265	NW-12-94-11-W4	57	10.0	111	37.5	6333809	462008
5	290	SE-26-93-11-W4	57	07.0	111	38.5	6328166	461133
6	310	SW-19-93-10-W4	57	06.0	111	36.0	6326514	463572
7	320	SW-17-93-10-W4	57	05.0	111	34.5	6324893	465185
8	315	NW-5-93-10-W4	57	04.0	111	34.5	6322179	465477
9	310	NW-4-93-10-W4	57	04.0	111	33.0	6322074	466514
10	240	NW-35-92-10-W4	57	01.5	111	30.0	6320708	469582
11	310	SW-26-92-10-W4	57	00.5	111	30.0	6318088	470021
12	245	NE-24-92-10-W4	57	00.0	111	28.0	6317327	471966
13	335	SE-11-92-10-W4	57	58.0	111	29.0	6313710	470465
14	310	NE-36-91-10-W4	56	51.5	111	27.0	6311063	472405
15	260	SW-7-91-9-W4	56	54.0	111	26.5	6303780	473187
16	244	SE-6-91-9-W4	56	53.0	111	25.5	6302166	473988
17	265	NW-18-90-9-W4	56	50.0	111	25.5	6296472	473965
18	275	SE-31-89-9-W4	56	47.0	111	25.0	6290793	474731
19	260	NW-20-89-9-W4	56	45.5	111	24.0	6288360	475538
20	260	NE-17-89-9-W4	56	44.5	111	23.0	6286747	476331
A	330	4-14-92-10-W4	56	58.5	111	30.0	6314805	469059
B	330	11-15-92-10-W4	57	00.5	111	31.5	6315259	467947
C	325	14-16-92-10-W4	57	00.5	111	33.0	6315951	466614
D	325	14-21-92-10-W4	57	01.0	111	33.0	6317575	466279
E	320	16-29-92-10-W4	57	01.0	111	34.0	6319110	465945

. . . continued

Table 24. Concluded.

			Co-ordinates				UTM	
			Latitude		Longitude		6° GRID	
Station	Elevation (Metres)	Legal Description	Deg.	Min.	Deg.	Min.	Northing	Easting
F	315	12-33-92-10-W4	57	03.0	111	33.0	6320940	466398
G	310	12-34-92-10-W4	57	03.0	111	32.0	6320510	467636
H	320	15-27-92-10-W4	57	01.0	111	31.0	6319115	468963
I	325	3-27-92-10-W4	57	01.5	111	31.5	6318101	467948
J	320	12-28-92-10-W4	57	00.5	111	32.0	6318113	467738
K	330	1-14-92-10-W4	56	58.5	111	29.0	6315008	470775
L	250	8-13-92-10-W4	56	58.5	111	27.5	6314713	472420
M	250	14-18-92-9-W4	56	58.5	111	26.0	6315863	472959
N	255	10-26-92-10-W4	57	00.5	111	29.5	6318596	470458
O	240	8-35-92-10-W4	57	01.5	111	29.5	6319452	470820
P	260	1-19-92-9-W4	56	59.5	111	26.5	6316325	473374
Q	250	8-13-92-10-W4	56	58.5	111	27.5	6315174	472753
R	295	4-20-92-9-W4	56	59.0	111	26.0	6316457	473669
S	295	13-17-92-9-W4	56	59.0	111	25.5	6316471	473750
T	340	12-1-92-10-W4	56	57.0	111	28.5	6312104	471167

Table 25. Syncrude exposure cylinder location.

			Co-ordinates				UTM 6° GRID	
			Latitude		Longitude			
Station	Elevation (Metres)	Legal Description	Deg.	Min.	Deg.	Min.	Northing	Easting
1	260	13-10-89-9-W4	56	43.5	111	21.0	6285108	478773
2	275	16-24-91-10-W4	56	56.0	111	27.0	6307826	473383
3	320	12-10-92-10-W4	56	59.5	111	31.5	6314332	468361
4	320	3-16-92-10-W4	57	00.0	111	33.0	6315168	466737
5	320	8-29-92-10-W4	57	01.5	111	33.5	6318411	465937
6	310	13-35-92-10-W4	57	03.0	111	29.5	6320792	470037
7	245	2-10-93-10-W4	57	04.0	111	30.5	6323233	469231
8	235	2-15-93-10-W4	57	05.0	111	30.5	6324863	469243
9	320	1-18-93-10-W4	57	04.0	111	33.5	6323257	465975
10	320	13-17-93-10-W4	57	05.5	111	34.5	6325697	465192
11	295	10-25-93-11-W4	57	07.5	111	37.0	6328953	462770
12	260	10-36-93-11-W4	57	07.0	111	37.0	6330562	462784
13	265	2-12-94-11-W4	57	09.5	111	35.5	6333004	462001
14	315	10-6-93-10-W4	57	04.0	111	35.5	6322466	464341
15	310	6-7-93-10-W4	57	04.0	111	36.0	6323277	463544
16	300	4-12-93-11-W4	57	04.0	111	37.5	6323291	461915
17	305	7-1-93-11-W4	57	03.5	111	37.0	6321674	462706
18	310	2-2-93-11-W4	57	03.5	111	38.5	6321691	461077
19	320	1-3-93-11-W4	57	03.5	111	40.0	6321708	459448
20	330	13-34-93-11-W4	57	03.0	111	41.0	6320891	458636
21	330	2-34-92-11-W4	57	02.5	111	40.0	6320079	459433
22	330	4-26-92-11-W4	57	01.5	111	39.5	6318462	460242
23	330	12-23-92-11-W4	57	01.0	111	39.5	6317638	460234
24	330	8-23-92-11-W4	57	00.5	111	38.5	6316825	461032
25	330	8-24-92-11-W4	57	00.5	111	37.0	6316809	462662

. . . continued

Table 25. Concluded.

			Co-ordinates				UTM	
			Latitude		Longitude		6° GRID	
Station	Elevation (Metres)	Legal Description	Deg.	Min.	Deg.	Min.	Northing	Easting
26	320	5-20-92-10-W4	57	00.5	111	34.5	6316789	465119
27	320	5-21-92-10-W4	57	00.5	111	33.0	6316777	466750
28	330	4-10-93-11-W4	57	04.0	111	41.0	6323325	458659
29	330	13-10-93-11-W4	57	04.5	111	41.0	6324129	458667
30	330	12-15-93-11-W4	57	05.5	111	41.0	6325758	458683
31	330	12-22-93-11-W4	57	06.5	111	41.0	6327367	458698
32	330	3-27-93-11-W4	57	07.0	111	41.0	6328191	458706
33	320	2-34-93-11-W4	57	07.5	111	40.0	6329791	459523
34	305	4-11-94-11-W4	57	09.5	111	39.5	6333022	460376
35	310	4-15-94-11-W4	57	10.5	111	41.0	6334668	458771
36	310	6-20-94-11-W4	57	11.0	111	44.0	6336311	455545
37	290	7-9-94-10-W4	57	09.5	111	32.0	6332958	467678
38	320	8-26-93-10-W4	57	07.0	111	27.0	6328084	470890
39	330	6-13-93-10-W4	57	05.0	111	29.0	6324846	470870
40	320	1-1-93-10-W4	57	03.5	111	27.0	6321597	472474

Table 26. Department of Environment exposure cylinder locations.

			Co-ordinates				UTM	
			Latitude		Longitude		6° GRID	
Station	Elevation (Metres)	Legal Description	Deg.	Min.	Deg.	Min.	Northing	Easting
1	305	NE-16-89-9-W4	56	44.5	111	21.5	6286741	477957
2	265	NW-7-90-9-W4	56	49.0	111	25.5	6294843	473955
3	305	NW-1-92-10-W4	56	58.5	111	28.0	6312698	471610
4	245	SW-35-92-10-W4	57	02.5	111	29.5	6319988	470031
5	320	SW-17-93-10-W4	57	05.0	111	34.5	6324893	465185
6	295	SE-25-93-11-W4	57	07.0	111	37.0	6328149	462583

Table 27. Amoco exposure cylinder locations.

			Co-ordinates				UTM 6° GRID	
			Latitude		Longitude			
Station	Elevation (Metres)	Legal Description	Deg.	Min.	Deg.	Min.	Northing	Easting
1	560	3-27-85-8-W4	56	24.0	111	10.5	6248124	489203
2	610	2-28-85-8-W4	56	24.0	111	12.0	6247624	488003
3	535	3-5-86-8-W4	56	25.0	111	14.0	6251123	486004
4	480	8-3-86-8-W4	56	25.5	111	10.0	6251623	489803
5	500	14-26-85-8-W4	56	24.5	111	09.0	6249124	490802
6	475	13-6-86-7-W4	56	26.5	111	06.0	6252123	493502
7	510	15-24-85-8-W4	56	23.5	111	06.5	6257122	493002
8	505	16-18-85-7-W4	56	23.0	111	05.0	6255622	494501

9 AOSERP RESEARCH REPORTS

1.		AOSERP First Annual Report, 1975
2.	AF 4.1.1	Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta
3.	HE 1.1.1	Structure of a Traditional Baseline Data System
4.	VE 2.2	A Preliminary Vegetation Survey of the Alberta Oil Sands Environmental Research Program Area
5.	HY 3.1	The Evaluation of Wastewaters from an Oil Sand Extraction Plant
6.		Housing for the North--The Stackwall System
7.	AF 3.1.1	A Synopsis of the Physical and Biological Limnology and Fisheries Programs within the Alberta Oil Sands Area
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12.	ME 1.7	Very High Resolution Meteorological Satellite Study of Oil Sands Weather, a Feasibility Study
13.	ME 2.3.1	Plume Dispersion Measurements from an Oil Sands Extraction Plant
14.	HE 2.4	Athabasca Oil Sands Historical Research Design (3 volumes) (in review)
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16.	ME 1.6	The Feasibility of a Weather Radar near Fort McMurray, Alberta
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18.	HY 1.1	Alberta Oil Sands Region Stream Gauging Data
19.	ME 4.1	Calculations of Annual Averaged Sulphur Dioxide Concentrations at Ground Level in the AOSERP Study Area
20.	HY 3.1.1	Evaluation of Organic Constituents (in review)
21.		AOSERP Second Annual Report, 1976-77
22.	HE 2.3	Maximization of Technical Training and Involvement of Area Manpower (in review)
23.	AF 1.1.2	Acute Lethality of Mine Depressurization Water on Trout Perch and Rainbow Trout (in review)
24.	ME 4.2.1	Review of Dispersion Models and Possible Applications in the Alberta Oil Sands Area (in review)
25.	ME 3.5.1	Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area

26.	AF 4.5.1	Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
27.	ME 1.5.1	Meteorology and Air Quality Winter Field Study in the AOSERP Study Area, March 1976 (in review)
28.	VE 2.1	Interim Report on a Soils Inventory in the Athabasca Oil Sands Area
29.	ME 2.2	An Inventory System for Atmospheric Emissions in the AOSERP Study Area
30.	ME 2.1	Ambient Air Quality in the AOSERP Study Area, 1977
31.	VE 2.3	Ecological Habitat Mapping of the AOSERP Study Area: Phase I

These reports are not available upon request. For further information about availability and location of depositories, please contact:

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