AIR QUALITY RESEARCH AND MANAGEMENT IN THE LONG POINT, HALDIMOND, NORFOLK AREA

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"Air Quality Research and Management in the Long Point, Haldimond, Norfolk Area"

1. Introduction:

It is not necessary to go into the historical details of the Nanticoke industrial development here. Suffice it to say that this project is the largest undertaken in Canada to date, with an investment exceeding that projected for the Alberta Oil Sands mining and refining operation up to the year 2000. A development of this magnitude has had profound effects on an area which was previously undeveloped and largely agricultural in nature. In this paper, we are interested in the air quality impact, primarily due to the three major industries at Nanticoke - the Stelco steel making facility, the Texaco refinery, and the Ontario Hydro generating station - although additional problems may be encountered in the future, due to increased population and traffic density, secondary industries, and so on.

The 4000 magawatt Hydro generating station is presently the largest fossil-fuel fired station in the world, and is the major contributor to the atmospheric loading of sulphur dioxide at Nanticoke. The projected emission rate for the fully developed industrial complex could be as high as 300,000-500,000 tons/year, and thus Nanticoke is expected to be the second largest source of sulphur dioxide in Ontario after Sudbury. Nitrogen oxide emissions (again primarily from the generating station) are also expected to be appreciable, at an estimated 100,000 tons/year, making Nanticoke the largest single source of this pollutant in Ontario. Particulate matter emissions are difficult to estimate, but they are expected to be considerable and Stelco will probably be the major local contributor. Also, coal handling operations at Hydro and Stelco are expected to contribute to the dustfall loadings relatively close to these plants. Other pollutants directly emitted by the Nanticoke operations - mainly Stelco and Texaco - are hydrocarbons, various other gases (hydrogen sulfide, carbon monoxide), and fluorides and polynuclear aromatic hydrocarbons (in gaseous and particulate form). In addition to the primary emissions, there exists the possibility of secondary pollutants such as ozone being generated from primary pollutants by atmospheric chemical reactions under certain meteorological conditions.

One should also note here that not only the magnitude, but also the height, of the emissions is important, since relatively small, low-level emissions could have a greater local impact than a large, high chimney source. The generating station has two 198 m chimneys. With the exception of hydrocarbons (which have various potential sources at different heights), most of Texaco's emissions emanate from two stacks approximately 100 m high (these receive gas streams from the power plant, fluid catalytic cracking unit, and sulfur recovery unit). Stelco's emissions originate from various heights, at various locations in the process, but are generally lower than 100 m.

It should be emphasized that the Nanticoke industries have been required to undergo the usual approval procedures necessary under Ontario's Environmental Protection Act of 1971, whereby each particular industry has had to install a sufficient level of emissions control to ensure that point of impingement concentrations, as calculated according to Regulation 15 of this act, do not exceed the Environment Ministry's standards and guidelines. Moreover, a "buffer zone" (approximately 3 km in width) - an area relatively free of residential or other sensitive receptors - has been proposed around the major industries. This zone can be used for secondary industry, agriculture, and parks, and is intended to minimize the nuisance due to pollutants emanating from occasional process upsets, industrial noise, etc., before they affect large residential populations (Cross, (1977)). Nevertheless, it is necessary to establish a monitoring network, to ensure that the Ministry's air quality criteria are not exceeded in the area once full industrial operations commence.

The major part of what follows will be concerned with the Nanticoke Environmental Management Program (NEMP), a joint government-industry venture to monitor current and future levels of air pollution in the Nanticoke area so that the impact of industrial development on air quality can be defined, and an efficient air management program developed. However, a considerable amount of relevant work had been done prior to the implementation of NEMP in 1977, and the next section will briefly review this work.

2. Air Quality Research in Nanticoke Prior to NEMP:

Since the early 1970's, a considerable amount of air quality-related research work has been carried out in the Nanticoke area. A recent compilation (NEMP Technical Committee,

(1980)) shows that, excluding the monthly air quality reports emanating out of Ontario Hydro and NEMP, more than sixty reports, presentations at scientific conferences, and publications in journals have appeared, many of them prior to the inception of NEMP. These deal primarily with the meteorology and climatology of the Nanticoke area, phytotoxicological studies, and results of emission measurement and plume behaviour studies, and have contributed considerably to our present understanding.

Munn (1977) has given a good overview of meteorological studies in this area prior to 1977. Of special interest was the identification of onshore gradient or lake breeze flows as one of the most important potential problem conditions. For the growing season, these occur roughly 25% of the time (Weisman and (Hirt,(1975)), and can lead to thermal internal boundary layers which result in high ground-level concentrations through fumigation of chimney plumes (- for a more complete discussion of this phenomenon, see Weisman and Hirt (1975) and Portelli (1978, 1979)). Long-range transport of air pollutants has also been recognized for some time as a source of concern in the Lake Erie region. For example, even in the early 1960's, damage to tobacco plants in the area was attributed to oxidants imported mainly with southwesterly winds (Mukammal (1965), and subsequent studies have confirmed this early work not only for ozone, but also for airborne particulate matter (see, for example, Chung (1978)). Furthermore, Munn (1976), in a report to the IJC Air Pollution Advisory Board, estimated that occasionally sulfur dioxide emissions from Cleveland could cause air quality criteria for this pollutant to be exceeded on the North Shore of Lake Erie, and his preliminary calculations have been supported by recent air quality measurements (Fleming(1978)).

Starting with the early 1970's, air quality monitoring and air pollution plant damage studies intensified in the Nanticoke area, largely due to the efforts of Ontario Hydro and the Ministry of the Environment (MOE). By 1977, there were 16 Hydro-operated sulfur dioxide monitors within a radius of about 25 km of the generating station, and MOE was running several gaseous pollutant and hi-vol sampler monitoring stations, as well as dustfall jars and sulfation and fluoridation plates, in the area. A hi-vol sampler network, operated by Dr. D. Pengelly of McMaster University and financially supported by MOE, Hydro and Stelco, measured suspended particulate matter levels at several points in a southwest-northeast corridor from Long Point to Hamilton. Vegetation plots were set up in a 40 km radius from Nanticoke, using sensitive plants to provide an indication of air pollution effects on vegetation.

The above work showed that, following startup of the generating station (which then was operating at less than one-third of rated capacity), sulfur dioxide concentrations exceeded the air quality criterion of 0.25 ppm hourly average relatively rarely (less than 20 hours of measured exceedence per year for the network), primarily during lake breeze and high wind conditions (Fleming (1979)) - see, for example, Figure 1. Ozone exceedences were also observed, largely due to long-range transport. These were thought to be responsible for the plant injury noted during this period (no sulfur dioxide or fluoride injury could be detected). Total suspended particulate matter concentrations were mainly in the 40-50 ug m^{-3} range, and suggested that the Nanticoke area can at times be influenced by emissions originating both at Hamilton and south of the border.

Several intensive studies were carried out during this period, mainly by Ontario Hydro. These were designed to examine plume rise and dispersion of the generating station emissions under various meteorological conditions, as well as chemical reactions in the plume (leading, for example, to the brown colour which can be at times observed over large distances downwind of the chimney). Also worth noting is the work of Weisman and Hirt (1975) referred to above, and sponsored by Stelco, which clarified the importance of possible fumigation problems in the area with onshore flows during the summer.

The scope of this paper does not permit a detailed discussion of the air quality research work carried out in the Nanticoke area and only some of the highlights have been mentioned. The reader is referred to the NEMP program review report noted above for more details.

3. The Nanticoke Environmental Management Program:

NEMP is a six to eight year program with a projected funding of about six million 1974 dollars, co-operatively undertaken by Environment Canada, Ministry of the Environment, Ontario Hydro, Stelco and Texaco Canada. Each partner in NEMP retains his independence regarding funding, interpreation of data, and philosophy of maintaining air quality. Nevertheless, all benefit by mutual discussion and co-ordination.

3.1 Objectives, organization, activities of NEMP:

The objectives of NEMP are:

1. To assess the impact on air quality in the Nanticoke area due to local industrial development as well as distant sources.
2. To determine the effects of Nanticoke operations on air quality at more distant receptor areas, including the U.S. side of the border.
3. To provide the basis for an effective and economical abatement strategy and air management program.

Figure 2 illustrates the organization and activities of NEMP. Both the Management and Technical committees consist of representatives from all the participating agencies. The former gives overall direction to the program and approves the budget, while the latter plans the detailed scientific program and formulates recommendations. The NEMP co-ordinator, who is employed by the Ministry of the Environment to coordinate studies among the participating agencies, is presently the chairman of the Technical committee, and a representative on the Management committee.

Current NEMP activities can be broken down into three broad areas - routine pollutant monitoring, special studies related to air quality, and mathematical air quality modelling.

3.1.1 Routine Monitoring:

There are three major routine monitoring networks providing air quality data for the NEMP data base - Hydro's sulfur dioxide network (already mentioned in the previous section), the MOE West-Central Region's gaseous pollutant and airborne particulate matter monitoring network, and the NEMP gaseous and particulate pollutant, and precipitation monitoring network cosponsored by MOE, Stelco and Texaco. In addition, two meteorological towers supply data on atmospheric temperature and wind speed and direction, while an acoustic sounder provides continuous mixing depth data. Gases monitored in real time include sulfur dioxide, hydrogen sulfide, nitrogen oxides, ozone, carbon monoxide, methane, and non-methane hydrocarbons. Airborne particulate monitoring includes soiling index and particulate mass determinations in real time (using the beta-attenuation gauge), as well as 24-hour average total suspended particulate (TSP) measurements at eighteen sites using high volume samplers. Some TSP samples are also analysed for particulate carbon and various polynuclear aromatic hydrocarbons. At eight of these hivol sites, parallel sampling is done with Whatman 41 rather than the usual glass fibre filter media. These particular samples are submitted for detailed chemical analysis including the following parameters: sulfates, nitrates, chloride, fluoride, ammonium, phosphate, and various elements (cadmium, lead, chromium, manganese, copper, zinc, iron, vanadium, boron, calcium, magnesium, aluminum). Precipitation is monitored at seven locations, the samples being analysed for acidity, major ions (including sulfates and nitrates), nutrients, and various trace metals. Continuous measurements of precipitation rate are also made at some locations.

Figure 3 shows the location of the air quality monitoring stations operating in the Nancioke area, while Table 1 describes in detail the parameters measured at each site.

The Hydro and MOE West Central Region's instruments are manned by their own technical staff. The instrumentation purchased and installed specifically for NEMP is operated by Moniteq Ltd. under contract to Stelco, Texaco and MOE. Moniteq is also responsible for maintaining the NEMP database, and producing monthly reports containing the results of the NEMP air quality measurements. The data from all the above networks provide the input for a scientific analysis of air quality at Nanticoke.

Before leaving this section on routine monitoring, mention should be made of the data acquisition and processing system currently being installed by MOE at Nanticoke. At the moment, data loggers and associated telemetry equipment have been installed at four stations (Long Point Park, Jarvis Meteorological Tower, Cheapside and Binbrook). Data is transmitted in real time to a Data-General Eclipse minicomputer located in the MOE offices at Toronto where it is displayed and stored for further processing. It is planned to expand this telemetry network to most of the instrumentation at Nanticoke. Thus, MOE scientists at Toronto will eventually have a real-time picture of air quality at Nanticoke.

3.1.2 Special Studies:

Turning now to recent special studies of air quality in the Nanticoke Region, of special note is a large investigation, jointly undertaken by Environment Canada, MOE and Ontario Hydro, which took place under the leadership of the Atmospheric Environment Service from May 29th to June 16th, 1978. The purpose of this investigation was to study the diffusion conditions, during onshore flows, affecting the plume from the Nanticoke Generating Station stacks. Meteorological measurements were made of the vertical structure of onshore flows and boundary layer development utilizing several different observational systems, and several surface mobile units as well as two aircraft were used to obtain concurrent ground-level and airborne plume and regional air quality measurements (see Portelli (1978, 1979)). This study was followed up by a smaller one with the same objectives, by MOE, during May 29-June 14, 1979. Reports describing the detailed results of these investigations are currently in preparation. When the analysis of these results has been completed, we should have a good understanding of how the industrial emissions behave under one of the most important potential problem meteorological conditions. Some other special studies in the Nanticoke area during the past two years, which might be mentioned here, are - an investigation of generating station plume behaviour under wintertime conditions, measurements of airborne parti-

culate matter chemical composition as a function of particulate size, and a feasibility study to determine if hydrocarbon
7 emissions from Texaco can be quantified by making downwind hydrocarbon flux measurements with surface mobile units and aircraft.

Several special studies are planned for the coming two years, including further work on quantification of emissions from the Nanticoke industries, determination of airborne particulate matter physical and chemical characteristics in the vicinity of Stelco, and studies of chemical reactions and precipitation washout in the generating station plume.

3.1.3 Mathematical Modelling, Development of Abatement Strategy and Air Management Programs:

Mathematical modelling of air quality plays an important role in NEMP, and models are being developed at the Atmospheric Environment Service, Ontario Hydro and MOE. These models can be broken down into two broad categories - short-range and long-range. The long-range models will allow us to quantify the impact of Nanticoke operations on southern Ontario and surrounding communities in the United States, as well as the extent to which other, distant sources contribute to air quality deterioration in the Nanticoke area. The short-range models predict air quality as a function of industrial emissions and meteorological conditions at distances out to about 20 km from the major industries, and may eventually be used in air management programs for the Nanticoke area. For example, several possibilities exist for emission control from the generating station, including the implementation of flue gas desulfurization (a very expensive alternative), switching to low-sulfur coal during adverse meteorological conditions, or cutting back on power production during such adverse conditions on the basis of mathematic model predictions (see, for example, Fleming (1979)). MOE is considering in detail the last option, and is developing an intermittent control system for possible use at Nanticoke which will contain as elements both the real-time air quality and meteorological data provided by the telemetry system described above, and a short-range mathematical model (using these data as inputs) to predict air quality in the area several hours into the future. If unacceptable levels are predicted, the model can be used to determine the extent of emission cutbacks required to restore the air quality, and the industries may be asked to decrease production accordingly.

3.2 NEMP Results to Date, and Future Plans:

The NEMP air quality monitoring network started making initial measurements during the summer of 1978, and most of the instruments have been in operation for more than a year now. A data base has been set up to accept air quality data for the Nanticoke area, and has been used to produce monthly data reports since October of 1978. This data base contains, in addition to the NEMP gaseous pollutant and airborne particulate matter concentration measurements: meteorological data for the area, results of the detailed chemical analysis of precipitation and airborne particulate matter samples, and results of the data generated by Ontario Hydro and West-Central Region networks in the Nanticoke area. A preliminary survey of the

NEMP data has confirmed the earlier air quality measurements mentioned in Section 2, namely, that gaseous pollutant and suspended particulate matter concentrations in the area are generally low, and air quality excedences have been rare to date (see, for example, Figure 4). A more detailed analysis is now underway, and in the near future we shall start producing quarterly reports interpreting air quality in the Nanticoke area as a function of local industrial operations and meteorological conditions, as well as long-range transport.

Special studies and ongoing measurements in the area have already elucidated several questions related to local meteorological conditions and pollutant dispersion. As mentioned in Section 3.1.2., more special studies are being planned. The development of short- and long-range mathematical models is also proceeding, and various air quality management options are being considered (- with the recent growing concern over acidic precipitation and long-range transport of air pollutants, removal at the source, as opposed to intermittent control, is receiving more serious attention).

A literature review of all relevant air quality work in the Nanticoke area has been completed (NEMP Technical Committee (1980)), outstanding problem areas have been identified, and recommendations for future action made. These will be implemented in the remaining years of the program.

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Portelli, R.V., "The Nanticoke Study: Experimental Investigation of Diffusion from Tall Stacks in a Shoreline Environment", 10th NATO/CCMS Internat. Technical Meeting on Air Pollution Modelling and Its Application, Rome, October, 1979.

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TABLE 1: Summary of Operating NEMP Instruments (Listed by Site). Abbreviations: COH = Coefficient of Haze; HC = hydrocarbons; MOE/WCR = Ministry of Environment, West-Central Region. Note also that the geographical identification indicates direction and distance (km) from the Hydro generating station.

GEOGRAPHICAL ID	SITE NAME	INSTRUMENT COMPLIMENT AND NOTES	MAINTAINED BY
SW37	Long Point Park	SO_2, O_3, NO_x, CO TSP Hi-Vol Comp. Hi-Vol TSP Beta Gauge CoH	NEMP Contractor
SW40	Big Creek	Precip gauge Precip collector	NEMP Contractor
WO7	Dogs Nest East	TSP Hi-Vol Comp. Hi-Vol Precip collector Precip gauge	NEMP Contractor
W13	Port Dover	SO_2	Hydro
		TSP Hi-Vol	MOE/WCR
WNWO3	Nanticoke Village	SO_2	Hydro
WNW19	Simcoe Horticul-tural Station	SO_2, O_3, NO_x, HC	MOE/WCR
WNW20	Bloomsburg	SO_2	Hydro
WN03	Nanticoke North	TSP Hi-Vol Comp. Hi-Vol	NEMP Contractor
NNW08	Nanticoke Road	SO_2, H_2S, HC	NEMP Contractor
NNW11	Jarvis	SO_2	Hydro
		TSP Hi-Vol	MOE/WCR

GEOGRAPHICAL ID	SITE NAME	INSTRUMENT COMPLIMENT AND NOTES	MAINTAINED BY
NNW12	Jarvis Met. Tower	10 m wind speed/dir 10 m temperature 10 m dewpoint 30 m wind speed/dir 85 m wind speed/dir 85 m temperature	Hydro
NNW15	Livingston	SO_2	Hydro
NNW18	Villa Nova	TSP Hi-Vol Precip. Collector	NEMP Contractor
NO7	Sandusk	SO_2	Hydro
		NO_x	NEMP Contractor
		TSP Hi-Vol	MOE/WCR
N15	Garnet	SO_2	Hydro
N17	Hagersville South	TSP Hi-Vol Comp. Hi-Vol	NEMP Contractor
NNE05	Walpole South School	SO_2	Hydro
		H_2S, HC TSP Hi-Vol Comp. Hi-Vol	NEMP Contractor
NNE09	Dry Creek	SO_2	Hydro
NNE10	Cheapside	SO_2, NO_x, COH TSP Hi-Vol	MOE/WCR
		H_2S, HC TSP Beta Gauge	NEMP Contractor
NNE16	Balmoral	SO_2	Hydro
NNE20	Decewsville	SO_2	Hydro
NNE 22	Dufferin North	TSP Hi-Vol Precip. Collector	NEMP Contractor

GEOGRAPHICAL ID	SITE NAME	INSTRUMENT COMPLIMENT AND NOTES	MAINTAINED BY
NNE39	Binbrook West	SO_2, O_3, NO_x, CO TSP Hi-Vol CoH Precip collector Precip gauge	NEMP Contractor
NE07	Dry Creek West	Acoustic Sounder	NEMP Contractor
NE16	Fisherville North	TSP Hi-Vol Comp. Hi-Vol	NEMP Contractor
NE19	Kohler Road	SO_2	Hydro
NE27	Canfield South	TSP Hi-Vol Precip collector Precip gauge	NEMP Contractor
NE41	Canboro East	TSP Hi-Vol Precip collector	NEMP Contractor
ENE11	Selkirk	SO_2	Hydro
		TSP Hi-Vol	MOE/WCR
ENE17	Rainham Centre South	TSP Hi-Vol Comp. Hi-Vol	NEMP Contractor
ENE18	Rainham Centre	SO_2	Hydro
E04	Peacock Pt. Park	TSP Hi-Vol Comp. Hi-Vol	NEMP Contractor
E05	Peacock Pt.	SO_2	Hydro

FIGURE 1: Exceedences of Ontario's Hourly Air Quality Criterion for Sulfur Dioxide (0.25 ppm), Measured by the Ontario Hydro Network, 1974-1978.

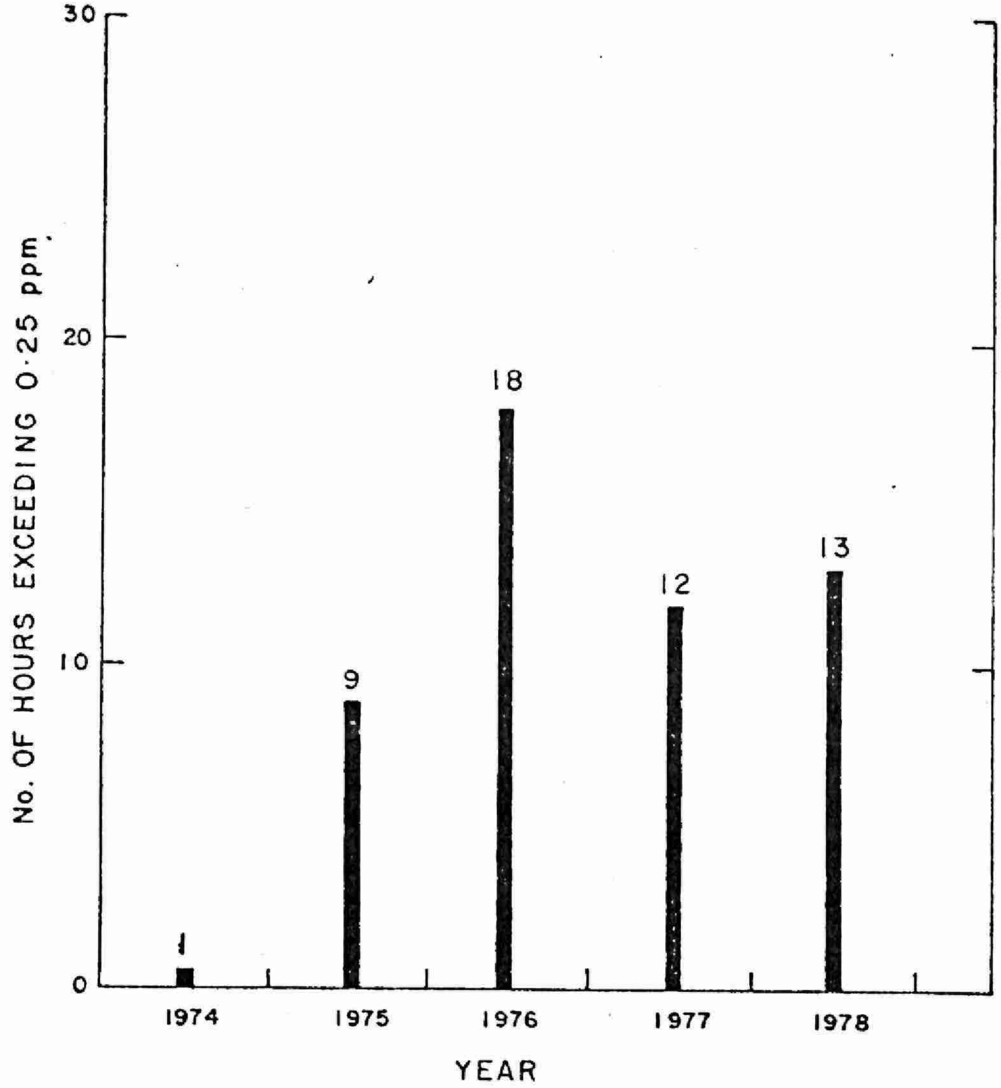

30
20
10
0
No. OF HOURS EXCEEDING 0·25 ppm
1
9
18
12
13
1974
1975
1976
1977
1978
YEAR

FIGURE 2: Organization and Activities of NEMP.

Management Committee

Technical Committee

NEMP Co-ordinator

Notes: - The two committees are staffed from the five partners in N.E.M.P. i.e., Environment Canada, Ministry of the Environment, Ontario Hydro, Stel and Texaco Canada Inc.
- The N.E.M.P. Co-ordinator is employed by the Minist of the Environment.

<u>Routine Monitoring</u> -

- Gaseous Pollutants (SO_2, H_2S, NO_x, O_3, CO, Hydrocarbons)
- Particulate Pollutants (HiVol Sampling for TSP, Sulfates, Nitrates, Trace Metals; B-Gauge for High Time Resolution Measurements)
- Precipitation
- Meteorological Parameters

<u>Special Studies</u> -

- Intensive, short-term studies of meteorological conditions which lead to air quality problems.
- Airborne studies of plume chemistry and dispersion, long-range transport.
- Sizing and chemical analysis of airborne particulate matter.
- Source Strength Determination.

<u>Mathematical Modelling</u> -

- Short-Range Model
- Long-Range Model

FIGURE 3: Location of Air Quality Monitoring Stations in the Nanticoke Area.

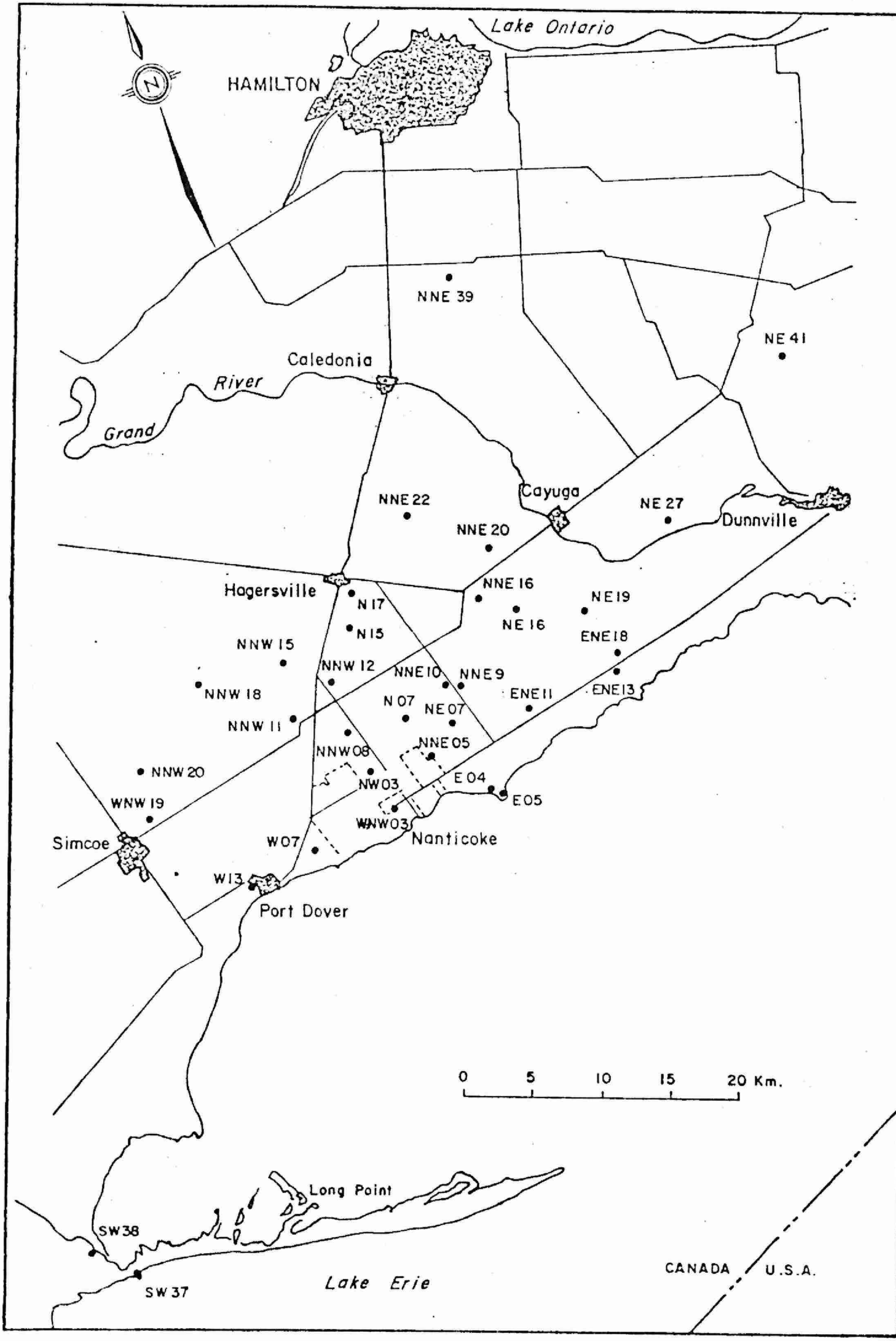
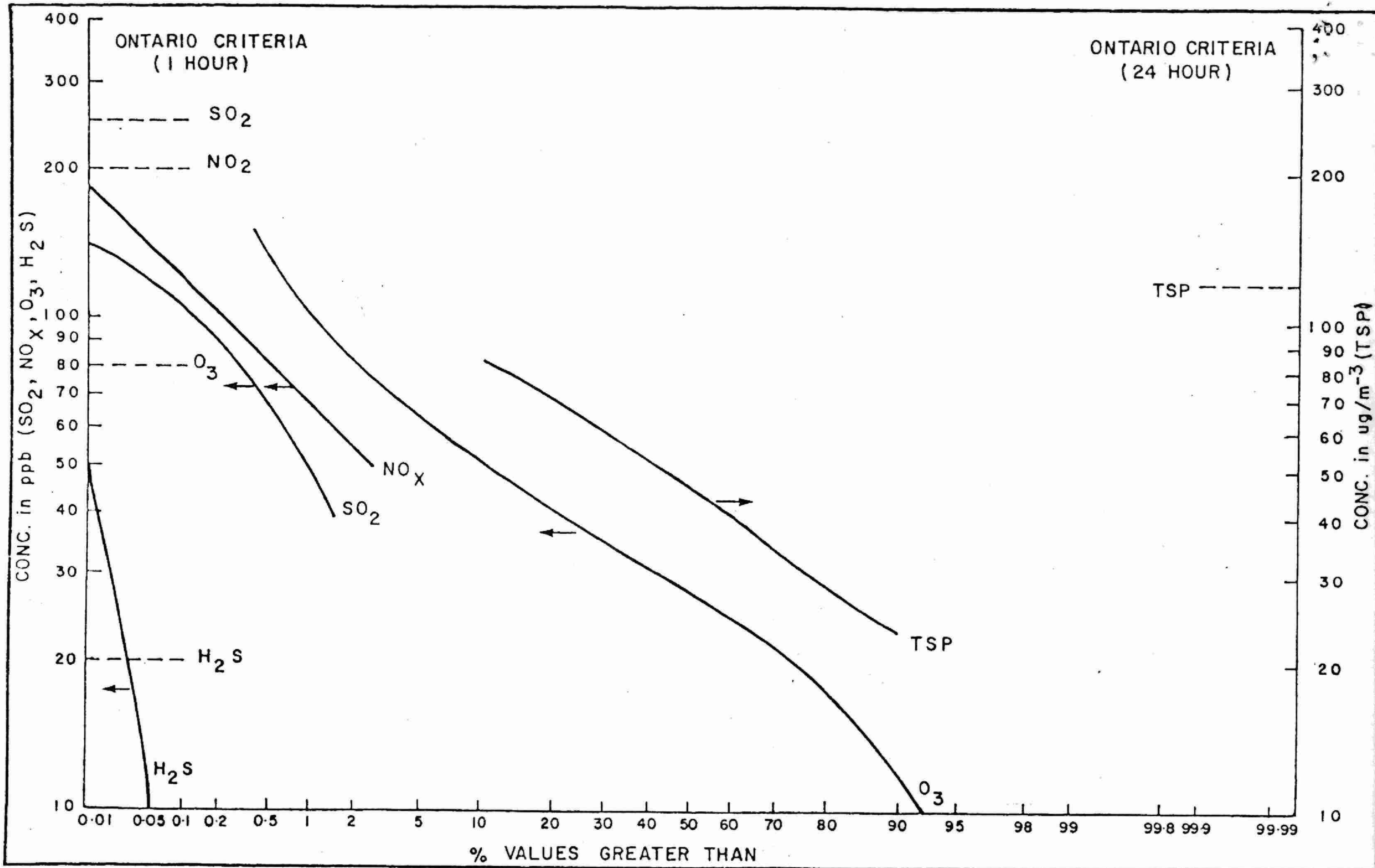

Lake Ontario
HAMILTON
N
NNE 39
NE 41
Caledonia
River
Grand
Cayuga
NNE 22
NNE 20
NE 27
Dunnville
Hagersville
NNE 16
NE19
N 17
NE 16
N 15
NNW 15
ENE18
NNW 12
NNE10
NNE9
NNW 18
ENE11
ENE13
N 07
NE 07
NNW 11
NNW08
NNE 05
NNW 20
NW03
E 04
E05
WNW 19
WNW03
Nanticoke
Simcoe
W07
W13
Port Dover
0
5
10
15
20 Km.
Long Point
SW38
SW 37
Lake Erie
CANADA
U.S.A.

FIGURE 4: Summary of NEMP Network Results for SO_2, H_2S, O_3, NO_2 and TSP, Jan.-Sept. 1979 (MOE Criteria for these pollutants are also shown).



ONTARIO CRITERIA
(1 HOUR)
ONTARIO CRITERIA
(24 HOUR)
SO_2
NO_2
O_3
H_2S
TSP
NO_X
SO_2
TSP
O_3
H_2S
CONC. in ppb (SO_2, NO_X, O_3, H_2S)
CONC. in ug/m^{-3} (TSP)
400
300
200
100
90
80
70
60
50
40
30
20
10
0·01
0·05
0·1
0·2
0·5
1
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5
10
20
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70
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90
95
98
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99·8
99·9
99·99
% VALUES GREATER THAN

Date Due
