# INDUSTRIAL LOCATION PLANNING:
# A MEANS TO CONTROL ATMOSPHERIC POLLUTION

by

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# ABSTRACT

There appears to be a need for communication between community and regional planners and air pollution control specialists since atmospheric pollution has become one of the chief problems of the present day. A number of professions have approached the study of air pollution and its control in unique ways. The hypothesis is advanced that the control of industrial location by all levels of government in a cooperative manner, taking into account the applicable meteorological factors, would significantly reduce potential atmospheric pollution.

Air pollution existed from the earliest times, but it was not until 1273 that legal control was recognized as necessary. After the industrial revolution and a series of acute health episodes in the twentieth century the various effects of atmospheric contamination were discovered. The physical planner has not sufficiently recognized the problem, and should strive to make clean air a goal towards which the planning process is directed.

In Canada the British North America Act allocates the responsibility for atmospheric pollution control between the federal and provincial jurisdictions. Engineering control aspects may be given legal force by either government depending on the pollutant source, though the provincial authority appears much broader in

scope. Technical abatement methods are complex and costly, and are particularly difficult for both the odourless and detectable gases. Costs of recovery may limit abatement solutions beyond 95%, indicating that other methods are required. Performance standards are an attempt to enforce the use of such methods through municipal zoning by-laws, though there is some question as to whether they are necessary with good general regulation of emissions.

The national and provincial (or state) governments have been chiefly concerned with industrial location from the socio-economic point of view. Local government has continued to be concerned with physical planning through zoning which both protects residents of the area and guides industrial growth. This power derives from the provincial legislatures in Canada, and not from court interpretations of the extent of community power as in the United States. Air zoning is an attempt to employ meteorological data in larger areas, recognizing that urban complexes themselves have a tremendous effect on climate, and that many factors have to be quantified and assessed. Detailed knowledge of area microclimates is considered to be most important in air zoning decisions.

The metropolitan areas of Los Angeles and Edmonton illustrate the approach advocated to control atmospheric pollution. Los Angeles has not yet effectively integrated

its air pollution control and planning control administrations, the county being responsible for the former and 70 different authorities for the latter. In Edmonton the administrations have been partially integrated, but in the field of major rezoning decisions no liaison exists. An investigation of the hypothesis by means of a quantifiable method, depending on wind direction and distance variables, reveals that locating air pollutant industries in accordance with meteorological factors could significantly lower potential pollution levels. The hypothesis is deficient in that it does not recognize the complementary need for engineering abatement controls.

Many other factors are considered in industrial location planning besides air pollution control, the problem really being that it is not usually considered as a factor. The various aspects of the hypothesis are assessed in order to formulate policy recommendations for research, legislation, and control measures. Federal government leadership manifested through a Canada Air Pollution Control Act is advocated, with accompanying provincial Acts making for a total cooperative approach. The goal of clean air would, therefore, be given substance on a national basis.

# ACKNOWLEDGMENTS

I wish to thank Mr. Frank Marlyn, Executive Director of the Edmonton Regional Planning Commission, for introducing me to the topic and providing me with an opportunity to develop it into this thesis. My thanks are also due to Dr. Kevin J. Cross who advised me during the actual writing. Furthermore I would like to thank everyone who supplied me with information, advice and aid at the various stages of preparation, without whom a coherent and comprehensive study would not have been possible.

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# CHAPTER I

## PLANNING AND AIR POLLUTION CONTROL

### I. INTRODUCTION

The organization of communities and regions in spatial terms requires the widest degree of knowledge possible on the part of planners. Today there should be agreement that "air pollution control is a vital factor in community planning"[1] so that it is important that the physical planner particularly be concerned and knowledgeable about the subject. "There has been too little communication between air pollution experts and town planners."[2]

John Evelyn produced Fumifugium in 1661 documenting the fact that London had first suffered from atmospheric pollution "as early as 1273".[3] With the growth of populations concentrated in metropolitan areas and the great technological changes, particularly after 1850, air pollution has become a matter of real concern.

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[1] Lee Schreibeis et. al., "Air Pollution Control in Urban Planning", American Journal of Public Health, LI (February, 1961), p. 174.

[2] M. Scrivener, "The Nuisance that Kills", Community Planning Review, XIII (Spring, 1963), p. 19.

[3] J. Evelyn, Fumifugium (London: National Society for Clean Air, 1961), p. 3.

In 1963 Civic Administration listed 113 steps to pollution control and outlined planning research needs. Dr. A.P. Bernhart stated that

> Proper planning must now be employed so that concentrated air pollution cannot occur. Industries, ideally, should be placed where their smokes are blown or drift over thinly populated areas. Communities should develop an awareness of air pollution (sic) as part of the planning function. [4]

The community planner has always been aware to a certain extent that industry should be located in certain areas so as to minimize nuisance, though few authorities have successfully integrated air pollution control with the planning function. It should be recognized that "industrial sources are extremely important but are only part of the overall problem."[5]

## II. THE PROBLEM

Air pollution may be examined from many points of view. The adverse effects of atmospheric pollution upon human health, agriculture and property, for example, have been extensively documented. Chemical analysis of pollutants and their abatement through source controls have been investigated within the realm of the physical sciences also.

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[4] Civic Administration, XV (September, 1963), p. 51.

[5] Lee Schreibeis et. al., op. cit., p. 175.

Control of source location may be considered another abatement technique, and it is in this area that the community and regional planner may contribute.

The sources of atmospheric pollution are numerous though three are of prime importance--the internal combustion engine, garbage and other incineration, and industrial processes. The decline in the use of coal for residential heating and railway purposes has significantly changed the nature of the problem. The technical control of incineration and automobile emissions is now possible while control of industrial emissions is uneconomic beyond a certain level. It is the intention to explore the control of the location of industry as a method of air pollution abatement. This type of control would be intergovernmental in nature so that all levels of government would be involved.

The Hypothesis. In order to focus the point of view more closely it is hypothesized here that the control of industrial location by all levels of government in a cooperative manner, taking into account the applicable meteorological factors, would significantly reduce potential atmospheric pollution. It is realized that in the location of industry many other factors may be taken into consideration both from the community and industry viewpoints. However, in this approach they will be considered

secondary to the air pollution effects. The validity of this hypothesis is reviewed in the final chapter.

The Approach. The statement of the hypothesis has given the point of view to be pursued in the whole study. In the remainder of this chapter the various professions contributing to the solution of the air pollution problem are described. The unique role of the planner in industrial source location is also emphasized.

In Chapter II the effects of atmospheric contamination are documented as the rationale for control. The history of the problem illustrates the changing nature of its effects and abatement. Human health, animals, plants, property and other aspects are affected, the implications for community and regional planning being significant.

The methods employed in the control of atmospheric pollution are outlined in Chapter III. Implementation of any solutions requires knowledge of legislative jurisdictions. Abatement techniques are examined and their limitations made known in order to illustrate the necessity of the locational approach. Performance standards incorporated into zoning regulations are directly related to the abatement methods, their limitations also being presented.

The control of the location of industry is described in Chapter IV. The ends and means of government in such

control are outlined with the purpose of illustrating the use of locational techniques in the abatement of atmospheric pollution. The meteorological background to industrial location planning as a means of such control is then documented.

In Chapter V two metropolitan areas are examined to show the difficulties in administrative integration of source abatement and location planning. Los Angeles, California and Edmonton, Alberta are the two urban complexes of quite different size which are documented. An inquiry is then made into the effects of air zoning on potential pollution levels, a model involving wind frequency and distance to industrial areas being employed. The contribution of industrial location planning is therefore measured.

In Chapter VI, before analyzing the hypothesis, other industrial location factors are described in order to put atmospheric pollution control in perspective. After the hypothesis is examined certain policy recommendations are presented and then suggested methods of implementation are outlined. The purpose is to use the previously documented material in formulating proposals for future action.

## III. THE PROFESSIONAL INTERESTS

Many professions are concerned with the problems of atmospheric pollution. The editors of the Air Pollution Handbook state that "It is sometimes hard to remember that remedial action on any given problem may require chemists, engineers, meteorologists, plant physiologists, biologists and others."[6] There is no doubt that the community and regional planner must rely on the work of others to a great extent in this field, since it is of such a complex interdisciplinary nature. However, he should be aware of the problem, the variables, and the potential techniques for solution. The viewpoints of the various contributory professions will now be described.

Chemistry. The chemist is concerned with the analysis of the air and the definition of what is contained in the ambient or surrounding atmosphere. Jacobs says, for example, that

> methods of air analysis are fundamental in the control of air pollution. With the aid of...objective analytical methods, tests and studies for the detection, elimination, and control of smoke, gases, fumes, odors and other pollutants can be made. [7]

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[6] P.L. Magill et. al., (ed.), Air Pollution Handbook (New York: McGraw-Hill, 1956), p. ix.

[7] M.B. Jacobs, The Chemical Analysis of Air Pollutants (New York: Interscience Publishers, 1960), p. 1.

The chemist studies the constituents of the atmosphere be they part of natural or contaminated air. He compares the so-called natural atmospheric composition with that of the polluted atmosphere in order to "understand what man has added".[8]

He is also concerned with the reactions which take place in the atmosphere between the various constituents. The theory developed to explain smog formation over Los Angeles is an example of the contribution of chemistry to the study of atmospheric pollution. The role of the automobile in the air pollution problem was discovered in this way.

Meteorology. The science of weather and climate is closely allied to that of physics. Since the atmosphere is the medium in which the various pollutants are transferred, the air pollution meteorologist is a fundamental researcher.

Micrometeorology deals with small areas and with the physical processes creating their unique character, microclimatology being concerned with the "average" weather conditions of these areas in a particular epoch.

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[8]R.D. Cadle and P.L. Magill, "Chemistry of Contaminated Atmospheres", Air Pollution Handbook (New York: McGraw-Hill, 1956), p. 3, 2.

Essentially air pollution climatology is part of the overall study of microclimatology. The preparation of various diffusion models has been the great contribution of the meteorologist. Munn has described it this way:

> The essential problem facing the air pollution meteorologist can be put very simply. Given the emission strength Q from a stack height h, calculate the resulting ground level concentration in space and time. 9

An intimate knowledge of the microclimatology of an area is an underlying prerequisite for such a meteorological study.

Faith has described the applicability of meteorology in simpler terms:

> We cannot do much about the weather, but we can understand how it affects the air pollution problem if we have a knowledge of meteorology, which is that branch of physics that treats of the atmosphere and its phenomena. 10

He listed the chief areas in which meteorology contributes;

1. Determination of allowable emission rates.
2. Planning and interpreting air pollution surveys.
3. Stack design.
4. Plant-site selection.
5. Prediction of areal pollution potentials.

The importance of meteorology in air pollution study cannot be overstressed.

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[9] R.E. Munn, Some Basic Concepts of Air Pollution Meteorology (Toronto: Dept. of Transport, 1960), p. 1.

[10] W.L. Faith, Air Pollution Control (New York: John Wiley and Sons, 1959), p. 30.

Biology. Those disciplines within which the study of plants and animals is pursued may also be involved with air pollution problems. Botanists, zoologists, agriculturalists, naturalists and others are included since they are all concerned with the effects of atmospheric contaminants.

Here is an example of such study:

> In the case of cattle, the hazard obviously is not the result of inhaling the polluted air, but rather the ingestion of forage which has become contaminated with fluorine from the air. [11]

The biologist is concerned with the causes, the effects, and tolerance levels. He desires to discover the substances which are causing the ill effects and to determine the level at which the substance has deleterious ramifications.

An example of the type of study on which biologists would be involved was found at Trail, British Columbia. The lead-zinc smelter was enlarged in 1925 and subsequently its effluent damaged "farm and forest lands in northern Stevens County, Washington".[12] Sulphur dioxide was the substance causing the problem.

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[11] P.H. Phillips, "The Effects of Air Pollutants on Farm Animals", Air Pollution Handbook (New York: McGraw-Hill, 1956), p. 8, 1.

[12] M. Katz, "City Planning, Industrial Plant Location", Air Pollution Handbook (New York: McGraw-Hill, 1956), p. 2, 33.

Medicine. The medical researcher is usually a specialist in public health if he is investigating the effects of atmospheric contamination. One of the chief reasons for control is evidenced by the effects of air pollution on human health, both over the short and long term period. The materials in the atmosphere which man breathes may effect physiological changes with high concentration or long exposure. There are also the psychological effects of smoke and odour to consider.

The definition of safe and tolerable ambient air, from the public health viewpoint, is one of the prime goals of the medical researcher. Certain extraneous compounds should not be disowned but may even aid in the provision of more desirable living conditions;[13] others cause a high morbidity rate.

The importance of air to health has been put rather succinctly by J.R. Goldsmith:

> The average adult male requires about 30 lb. of air each day compared with about 2 3/4 lb. of food and about 4 1/2 lb. of water. Compared with the other necessities of life, obligatory continuous consumption is a unique property of air. The insensible, intimate interpenetration of air which courses in and out from the lungs gives to air pollution its essential importance. It has been estimated that man can live for 5 weeks without

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[13] J.J. Phair, "The Epidemiology of Air Pollution", Air Pollution Handbook (New York: McGraw-Hill, 1956), p. 7, 3.

> food, for 5 days without water, but for only 5 minutes without air. Air is essential to the senses of sight, smell and hearing, and its pollution assaults the first two of these. 14

The physician has always concerned himself with his patient's environment. The town of the early industrial revolution was an unhealthy physical environment not only because of its lack of sewage facilities, hospitals, cleanliness, good housing and so on but also because of the smoky atmosphere which produced major respiratory infections. Good health has been defined as a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity.[15] The medical doctor must go beyond mere diagnosis and treatment today and wrestle with the causes themselves in a preventive approach.

Engineering. The instrumentation for data collection and abatement is the prerogative of the engineer. Various engineering specialties may be required--chemical, sanitary, mechanical, metallurgical and others.

In the increasingly technically oriented world of today the engineer is particularly important. The know-

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[14] J.R. Goldsmith, "Effects of Air Pollution on Humans", Air Pollution (I), A.C. Stern, ed. (New York: Academic Press, 1962), p. 336.

[15] Ibid.

ledge of process and design is particularly significant since, for example, the abatement of a pollution source to a tolerable level can nearly always be accomplished though it may be costly. The economic limitations to engineering innovation have been discussed by Silverman:

> We may consider our needs in engineering control as distributed into several basic areas. The area which is perhaps the most important is economics. Most of the other aspects impinge upon this area and must therefore consider cost factors as paramount.[16]

The control of air pollution relies heavily on engineering knowledge drawn from theory and data already collected. The staff of any air pollution control authority is largely composed of engineering specialists who in turn rely on researchers in many fields.

## IV. THE PLANNER'S POINT OF VIEW

The community and regional or physical planner is essentially directed in his approach to the proper allocation of space keeping in mind the social and economic objectives of the community together with its resources. The planner's client is usually "the municipal legislative body"[17] though other levels of government and

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[16] L. Silverman, "Engineering Research and Development in Air Pollution Control", Problems and Control of Air Pollution, F.S. Mallette, ed. (New York: Reinhold, 1955), p. 42.

[17] T.J. Kent, The Urban General Plan (San Francisco: Chandler Publishing, 1964), p. 2.

even the private sector often utilize his services. Lewis Keeble has drawn attention to the fact that planning "has both social and economic aims" and that "it results in a physical environment which conduces to health [sic]".[18]

Frances Herring says that the planning agency should not be the air pollution control authority, but goes on to state that

> The planner's problem is one of locating residences, industries and agriculture, parks, recreation areas, and freeways so as to minimize conflicts of interest while permitting normal areal growth. 19

Katherine N. Gabbell puts the point of view quite simply:

> A regional planning agency would determine at least the broad outlines for land use in the region, with air pollution effects as one of its criteria of judgement. 20

In the Edmonton area the regional planning agency has done this for the metropolitan area and is now establishing the plans for sectors beyond.[21] The regional plan for the

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[18] L. Keeble, Town and Country Planning (London: Estates Gazette Ltd., 1959), p. 9.

[19] F.W. Herring, "Effects of Air Pollution on Urban Planning and Development", Proceedings, National Conference on Air Pollution (Washington: U.S. Public Health Service, 1962), p. 195.

[20] K.N. Gabbell, Clearing the Air, a Regional Challenge (Philadelphia: Penjerdel, 1963), p. 14.

[21] Edmonton Regional Planning Commission, Background Information--Fort Saskatchewan Part Preliminary Regional Plan (Edmonton: The Commission, 1964), p. 1.

Lower Mainland of British Columbia is a similar instrument, though still at the proposal stage.[22]

A plan is an attempt to arrive at certain goals--one of which would presumably be pure air. One romantic view was proposed in 1896:

> My ideal city of Leeds--a smokeless atmosphere through which the sun when he did shine, would shine with his full brilliancy, wide streets interrupted by open spaces with green turf, trees, and flower beds, and a little ornamental relief to the dead monotony of our brick walls. 23

In short, the planner must conceptualize the future in spatial terms. In order to do this he must gain knowledge from other disciplines including those focusing on air pollution. His plans should reflect both politically accepted goals and the objectives of the persons for whom he is planning, the spatial proposals being formulated upon the basis of maximum information.

## V. SUMMARY

There appears to be a lack of communication between the planner and air pollution specialists, though atmospheric pollution has become one of the chief problems of

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[22] Lower Mainland Regional Planning Board, Chance and Challenge (New Westminster: The Board, 1963).

[23] J.B. Cohen, "The Air of Towns", Smithsonian Miscellaneous Collections (Washington: Smithsonian Institute, 1896), p. 3.

the present day. It is hypothesized here that the planner can contribute significantly to the reduction of air pollution levels by locating industry according to air pollution control criteria and by enlisting the cooperation of all levels of government. The chemist, meteorologist, biologist, medical researcher, and engineer have all approached air pollution study in a unique manner. The planner should establish pure air as a goal to be conceptualized in spatial terms, utilizing all the information and documentation contributed by these specialists.

# CHAPTER II

## THE REASONS FOR AIR POLLUTION CONTROL

### I. INTRODUCTION

The necessity for the regulation of atmospheric pollution can be explained by its history and the nature of its effects. The concept of pure unpolluted air has long been of dubious validity. Contamination by fire, dust storms and so on has been present "even before our human ancestors became organized in fixed communities".[1] However, it has been only since communities of Man have become industrialized and urbanized that acute levels of air contamination have been approached. The purpose here is to outline the reasons for controls which have evolved, and to outline the implications in terms of the physical planning of the community and region.

### II. HISTORY OF AIR POLLUTION AND ITS CONTROL

Origins. Most researchers have pointed to early London as the first example of the air pollution threat. The first legal control was passed in 1273 "regulating the use of coal because it gave off a black, sooty smoke

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[1] L.A. Chambers, "Classification and Extent of Air Pollution Problems", Air Pollution (I), A.C. Stern, ed. (New York: Academic Press, 1962), p. 3.

considered injurious to health."[2] Again in 1306 Edward I prohibited the use of sea coal for the same reason, violators to be condemned and executed.[3] Despite this fact the "decree seems to have had little effect"[4] and the necessity for coal as a manufacturing fuel persisted (wood and peat being used domestically).

By the 1600's the use of coal as a domestic fuel was made necessary by the increasing price of wood. The indictment of London's smoke, Fumifugium, has already been referred to above as the first published work on the subject. John Evelyn was the only serious thinker about the "evil" until the nineteenth century. He was not merely a negativist, but also for clean air, green trees and a healthy environment. He made concrete proposals for source relocation:

> I propose therefore by an Act of this present parliament, this infernal nuisance be reformed; enjoyning that all those Works be removed five or six miles from London below the River Thames. [5]

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[2] K.B. Duke, "Air Pollution: An Increasing Menace to Cities", Tennessee Planner (October, 1957), p. 56.

[3] S.M. Rogers, "Air Pollution Control Legislation", Air Pollution (II), A.C. Stern, ed., op. cit., p. 429.

[4] A. Marsh, Smoke (London: Faber and Faber, 1947), p. 21.

[5] J. Evelyn, Fumifugium (London: National Society for Clean Air, 1961), p. 30.

He also suggested that it was a problem international in scope, referring to the injury of French "Vines in flower" by "Smoakes driven from our Maritime Coasts".[6]

Growth of Problem. There was a rapid increase in smoke density through the 150 years after Evelyn's expose:

> Up to now the smoke problem had been local and relatively insignificant, but the dark age was beginning, and a deeper gloom than had ever been dreamed of by Evelyn was to cover the face of Britain. With the coming of the steam engine a revolutionary development occurred in the means of translating the energy of coal into power. [7]

In Lewis Mumford's terminology the first mark of paleotechnic industry was the pollution of the air. However, it became more than just a contamination of the atmosphere by smoke:

> Chlorine, ammonia, carbon monoxide, phosphoric acid, fluorine, methane, not to add a long list of some two hundred cancer-producing chemicals, pervaded the atmosphere and sapped vitality; often in stagnant lethal concentration, increasing the incidence of bronchitis and pneumonia, causing widespread death.[8]

The term smog, derived from smoke and fog, was being used commonly in Great Britain before World War I. "Coketown" became the symbol of industry in grey, dirty brown and black tones. In the last century the nature of industrial

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[6]Evelyn, op. cit., p. 30.

[7]Marsh, op. cit., p. 30.

[8]L. Mumford, The City in History (New York: Harcourt, Brace and World, 1961), p. 467.

atmospheric emissions has changed, the pollution problem becoming more severe in the process.

The Automobile. An example of the change that has taken place in the twentieth century has been the introduction of internal combustion engine.[9] Ingredients of the automobile exhaust react with each other in strong sunlight to create an eye-irritating "smog". (The term is a misnomer since no fog is present.) The chief ingredients in this mix are nitrogen dioxide and the olofenic hydrocarbons. The former is created as a result of all combustion operations after several reactions. The nitrogen combines with oxygen to form nitric oxide which in turn combines with oxygen to form nitrogen dioxide. Hydrocarbons, on the other hand, are emitted as unburned or partially burned gasoline from the exhaust process being formed within the combustion engine.[10] The effects of these pollutants and others may be diverse in nature, but give further insight into the needs for effective controls.

## III. THE EFFECTS OF AIR POLLUTION

W.L. Faith has aptly stated that an "air pollution

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[9]Society of Automotive Engineers, Vehicle Emissions (New York: The Society, 1964), pp. 1-6.

[10]Air Pollution Foundation, Air Pollution and Smog (San Marino, Calif.: The Foundation, 1960).

problem arises when the concentration of these substances interferes with the well-being of people."[11] However, one might call a situation problematic when property or vegetation are affected also. The effects of atmospheric contamination on human health, vegetation, animal life, property, and transportation are outlined below.

Health Effects. The effects upon health of atmospheric pollutants have reached the extremes of chronic illness and even death.

> For some of the bacterial and viral diseases and for some of the allergic conditions the evidence that the air is a carrier of the eteological agent is incontrovertible. 12

However, actual pollutants, their effects when present in the air and their relationships to disease are still being debated. It is evident that any imbalance in the natural constituents of the air may lead to injury of health. "There is little doubt that deleterious physical and mental effects result from air pollutants, their concentrations, inter-reactions and duration."[13] Small concentrations of

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[11]W.L. Faith, Air Pollution Control (New York: John Wiley and Sons, 1959), p. 1.

[12]World Health Organization, Air Pollution (Geneva: The Organization, 1961), p. 159.

[13]M.C. Wohlers, "Air Pollutants and their Effects", (San Francisco: Stanford Research Institute), p. 5. (mimeographed).

some substances may due to their chemical nature cause considerable injury. Since the sources are widespread and miscellaneous in their nature there remains much research to be accomplished in this field.

Various acute episodes have been known to occur in this century. The Meuse Valley in Belgium in 1930, the City of Donora, Pennsylvania in 1948, and London in 1952 were the scenes of the worst tragedies.

> With respect to the acute air pollution episodes which have assumed disastrous proportions in terms of number of persons who became ill or died, (these) three episodes are well documented and leave little question as to the lethal role of air pollution. [14]

In the first example weather conditions were such as to keep pollutants within the valley and not allow for ventilation, so that the number of deaths recorded were ten times the normal level.[15] The meteorological conditions allowed for the accumulation to toxic concentrations of those pollutants normally discharged into the air by factories in the valley. Medical researchers examined and analyzed in detail the nature of these contaminants.

In October of 1948 in Pennsylvania, in a valley with similar characteristics and also with an abnormal

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[14] L. Goldner, "Air Pollution Effects and Planning", (paper read at the Department of Landscape Architecture, University of Pennsylvania, January 30, 1963), p. 3.

[15] World Health Organization, op. cit., p. 164.

meteorological situation, another extreme period of air pollution developed. There were seventeen deaths in a five-day period, well above the "normal" figure of two. Extensive study revealed that many non-fatal illnesses also occurred. Evidently no one single substance was responsible. A combination of the action of two or more compounds such as sulphur dioxide, its oxidation products, and other particulate matter were thought to be the cause. The 5,910 people affected amounted to 42.7% of the Donora area population.

In 1952 the Greater London Metropolitan Area suffered under a temperature inversion and a stable air mass for four days. Various respiratory diseases became apparent and were related to the large quantities of smoke and sulphur dioxide, some five times the normal. Eventually the situation led to new legislation aimed at clean air in the urban area. London has had an air pollution problem for a very long time, so that strong control was long overdue.

Another problem area of note has been Los Angeles, California. There were considerable difficulties in identifying the actual pollutants there as many thought to be "transient or non-existent"[16] are now known to

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[16] J.R. Goldsmith, "Effects of Air Pollution on Humans", Air Pollution (I), A.C. Stern, ed. (New York: Academic Press, 1962), p. 357.

have deleterious effects. Chronic disease may also have been caused by air pollution exposure.

Other health problems are also found such as the effects of loss of sunlight, dust inhalation, odours and so on. As early as 1905 Nicholson noted that decreased sunshine was unhealthy.[17] The works of other researchers have noted that "man is resistant and resilient, readily accepting stresses and insults."[18] It may be that he may be able to stand much higher tolerance levels than heretofore imagined.

Effects on Animals. The effect of air pollution on animal life is allied to the discussion on human health. Medical research laboratories have utilized animals in various experiments, while the previously outlined disasters have also markedly affected animal life.

Goldner draws attention to the fact that damage to livestock is caused not only by direct inhalation of air pollutants, but by feeding on exposed plants.[19] Phillips

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[17] W. Nicholson, Smoke Abatement (London: Charles Griffin, 1905), p. 14.

[18] J.J. Phair et. al., "Measuring Human Reactions to Air Pollution", Particulate Emissions (Philadelphia: Franklin Institute, 1958), p. 37.

[19] Goldner, op. cit., p. 15.

also refers to this "two step process",[20] before discussing all the pathological effects of various extraneous airborne substances. Animal fluorosis has been studied most extensively, but research has also progressed on arsenic and lead effects and tolerances.

The so-called "etiologic agent" is usually found in the field as the cause of disease, the laboratory being used to determine whether the agent affects man. There can also be severe economic effects on the agricultural industry.

Effects on Plants. Sulphur dioxide and hydrogen sulphide are two major pollutants affecting plant life, the first resulting from the combustion of all fuels. Toxic concentration are gradually absorbed by the plant until normal photosynthetic processes no longer function and acute injury results. Commercial farming may be affected such as was the case at Trail, B.C. (see page 9).

Plants have been used as "indicators of air pollution...identifying the specific pollutant."[21] Dust can cover plants, for example, and dyes can cause spotting

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[20] P.H. Phillips, "The Effects on Air Pollutants on Farm Animals", Air Pollution Handbook (New York: McGraw-Hill, 1956), p. 8, 1.

[21] Interstate Sanitation Commission, op. cit., p. 71.

on blossoms and foliage. In urban areas, gardens may be affected significantly.

The economic ramifications of this disturbance can be substantial. In 1956 "a loss of more than 6 million dollars in crop damage in California because of smog"[22] was estimated to have occurred. Along urban streets trees have been affected by the carbon dioxide content of automobile exhaust.

Other Effects. Atmospheric pollution affects the environment in many ways. Decreased visibility for example may cause congestion at airports and in the air, besides delays of flights and increased operating costs.[23] The darkening of the sky may affect man psychologically and also his physical environment by altering weather patterns.

The "degeneration of objects useful to man"[24] with such results as increased laundry costs, frequency of painting, cleaning and decorating should be mentioned. The facades of buildings may be damaged by the emission

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[22]W.L. Faith, op. cit., p. 9.

[23]Interstate Sanitation Commission, op. cit., p. 74.

[24]World Health Organization, op. cit., p. 279.

from fuel oil which contains 2 to 3% sulphur. In the Edmonton area the effects of the physical environment on the value and desirability of residential property were examined recently.[25] The most critical factor among six was "bad odor" with lack of safety, lack of amenities, depressed appearance, noise and vibration, and smoke and dirt being considered by survey respondents to be decreasingly critical.

Damage to property by pollutants takes several forms. The corrosion of metals by acidic compounds is one example of this aspect. Rubber cracking from ozone concentration is another such case. There are also a variety of secondary effects occasioned by the primary.[26] The interference with production and services is important in this regard. Every event from student lethargy to retail trade losses during periods of smog may be cited. The cost of control itself is significant.

## IV. IMPLICATIONS FOR PLANNING

Because air pollution sources may be located in spatial terms their siting is of particular relevance to

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[25] City of Edmonton, Urban Renewal Study (Part II) (Edmonton: Planning Department, 1964), pp. 26-27.

[26] W.L. Faith, op. cit., p. 22.

land use planning. Even the mobile source may be affected by the street layout and design. It appears to be crucial that the planner address himself to the problem of atmospheric pollution since clean air is a basic goal of a society which desires optimum physical and mental health. Howard has posed the question as to how far man's biological requirements

> conflict with the laws of land economics, which create the pressures that result in population densities and structural densities that resist our best efforts....27

The planner, as an innovator in the formation of public policy, should incorporate the community-wide interest when in his advisory capacity.

The planner has long possessed the tool of zoning bylaws "which frequently prohibit from certain districts or the entire community, industries which...are obnoxious."[28] While zoning has been a form of location control applied at the local level, other forms have been utilized by the senior governments as described in

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[27] J.T. Howard, "Basic Research Problems of the Urban-Metropolitan Region: Problems Related to Planning", Regional Science Association, Paper and Proceedings, II (1956), p. 104.

[28] Planning Advisory Service, Air Pollution Control (Chicago: American Society of Planning Officials, 1950), p. 11.

Chapter IV. It has been said that

> General zoning and planning could be utilized to reduce the mobile smog source by decentralization of industry, encouragement of rapid transit, elimination of automobile traffic congested city centres, use of the free-flow type of roadway or freeway, and reduction of home to work travel.[29]

One overall goal of transportation planning is to provide for minimum travel time for all trips; the control of air pollution reinforces that objective.

Lester Goldner has explained the implications of the air pollution problem in planning terms:

> one of the responsibilities of the planner, in assisting society in achieving its goals, is the assessment of diverse proposals for action, often put forth in light of some special point of view, in terms of their total impact upon society, including those troublesome side effects which are apt to be overlooked by others. 30

He felt that air pollution abatement should be part of the planning function since the problem affects the quality of life. This did not mean that all control was in the province of the planner, but that he should consider abatement as one of the objectives of the planning process.

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[29]J.R. Taylor et. al., "Control of Air Pollution by Site Selection and Zoning", World Health Organization, Air Pollution (Geneva: The Organization, 1961), p. 294.

[30]Goldner, op. cit., pp. 1-2.

# V. SUMMARY

Though air pollution has existed since early times it was not until 1273 that legal control was recognized as necessary. The problem grew to critical dimensions with the growth of industry, while the internal combustion engine added a further complication in this century. Atmospheric pollution has affected the health of man to the extreme of numerous fatalities in acute episodes since 1930, besides having various less acute ramifications. Animals and plants may also be affected physiologically. Diverse results of atmospheric contamination range from the disturbance of air transportation to the decrease of property values. The planner has not sufficiently focused his attention on this increasing problem and should make clean air a societal goal to be accepted and expressed by his profession in terms of his interest in spatial organization.

# CHAPTER III

# THE METHODS OF AIR POLLUTION CONTROL

## I. INTRODUCTION

For the reasons documented in the preceeding chapter it would appear that abatement and control of atmospheric pollution is necessary in the public interest. The legislative background for such control in Canada is reviewed below in order to ascertain the jurisdictional aspects and conflicts. The traditional methods of source control utilizing engineering abatement techniques are outlined subsequently. The concept of performance standards, which is an outcome of source control technology, is then critically examined.

## II. LEGISLATIVE FRAMEWORK

The legal process in Canada has inherited its foundations from Great Britain's compilation of law. The Courts of Canada proceed by rules of law which derived over centuries, gradually evolving to the present time. The responsibility for statute law creation was allocated to the Federal Parliament and the Provincial Legislatures by the British North America Act of 1867, which was based on inter-provincial conference resolutions agreed to before passage of the Act by the British

Parliament. The Act essentially divided the responsibilities of government between the two levels, while at the same time providing a unique judiciary in which the "federal idea...is completely absent."[1]

In air pollution control the constitutional question is of great importance, since sources may be either in the federal or provincial jurisdiction. It can be stated that "the Dominion Parliament and provincial legislatures each enjoy, within their own area of competence, substantially the same supremacy as the British Parliament."[2] Both the Federal Government and the Provincial may control source emissions, the latter being able to delegate authority to the municipal level.

Federal Powers. The area of responsibility for governing has been defined not only by the B.N.A. Act, but also by judicial decisions. Until 1949 the Judicial Committee of the Privy Council of the United Kingdom was the final arbitrator. The federal authority over trade and commerce was, for example, limited by that body so that it was legally interpreted as the regulation of

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[1] R.M. Dawson, The Government of Canada (Toronto: University of Toronto Press, 1963), p. 93.

[2] J.A. Corry, Democratic Government and Politics (Toronto: University of Toronto Press, 1951), p. 104.

international and interprovincial trade, while on the other hand aeronautics and radio communication became federal responsibilities.

Criminal Law. This area was deemed a prerogative of Ottawa, and is largely represented by the Criminal Code. Nuisance is defined in the Code so that air pollution of a grave nature may be considered a crime. Nuisance is defined as an act which endangers the lives, safety, health, property or comfort of the public; obstructs the public in the exercise or enjoyment of any common right; or which incurs physical injury (short of violence).

In the British tradition the definition of a public nuisance such as air pollution "may be the creation of statute or subordinate legislation or of the common law".[3] At common law each particular case was judged on its own merits so that air pollution was not a nuisance per se. An individual, for example, may use his civil rights if a public nuisance has caused special and peculiar damage to him beyond the normal nuisance to the public at large. Non criminal nuisance usually has been left for the courts to define in a common law manner.

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[3] P.S. James, General Principles of the Laws of Torts (London: Butterworth and Co., 1959), p. 93.

The British Columbia Municipal Act, for example, was judged not to

> enable a council to define what constitutes a nuisance and acts prohibited thereunder must be nuisances at law, which is a matter for the courts to determine. [4]

Rogers has stated that the distinction between criminal and non-criminal nuisance "is not clear".[5] The City of Vancouver anti-smoke bylaw's nuisance provisions were found *intra vires* as a regulation of a nuisance harmful to public health for example.[6]

Railways. Interprovincial railways are subject to federal regulation under the Act. Local smoke nuisance by-laws do not apply to railway locomotives even if the discharge is by way of ventilating ducts out of a round-house.[7] Provincial railways, on the other hand, are under the legislature's control. The Board of Transport Commissioners is the authority over such matters at the federal level.

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[4] *Re New Westminster "Nuisance Prohibition By-law 1962"*, 39 D.L.R. 676 (1963).

[5] I.M. Rogers, *The Law of Canadian Municipal Corporations* (Toronto: Carswell, 1959), p. 861.

[6] *R. v. Capilano Lumber Co.*, 96 C.C.C. 141 (1950).

[7] *R. v. G.T.R.*, 37 O.L.R. 457 (1916), 27 C.C.C. 138 (1916).

Shipping. All shipping is under federal control as derived from the B.N.A. Act. Moreover international and interprovincial ferries are within Ottawa's jurisdiction. The National Harbours Board administers their own air pollution regulations over shipping under this constitutional provision.

Public land (federal). Any federal creature on crown land in the right of Canada is free from local regulation of atmospheric pollution. Lessees, however, are subject to such provisions since the jurisdiction is then considered to be provincial.

Provincial powers. The control of air pollution is largely of provincial jurisdiction save the exceptions described above so that it is relevant to outline the various areas of provincial prerogative.

Municipal institutions. Prior to 1896 it was held that s. 92(8) of the B.N.A. Act enabled the provinces to delegate all powers which municipalities held previous to 1867.[8] At that time it was restricted to mean that only those powers possessed by the provinces could be conferred and that this clause merely allowed for the creation of

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[8]Smith v. London, 20 O.L.R. 133 (1909).

"a legal body for the management of municipal affairs".[9]

Property and civil rights. This power has been called "the true residual clause" of the B.N.A. Act since it is so all encompassing. Each province may legislate separately in this area to the extent that federal powers do not have priority. Bankruptcy, for example, is dealt with by the Federal Parliament. The use of property would appear to include the utilization of real property for the emission of pollutants into the atmosphere so that control is clearly within the provincial government's competence.

Police power. All governments have this power to enforce their laws:

> Public health, nuisance and trade regulation also fall within the general scope of the municipal police power which would have its origin in s. 92 (15). [10]

In the United States this power to regulate where there is interference with the rights of others[11] is much wider in scope.

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[9] Canadian Encyclopedic Digest (Western), (2nd. ed.), IV, pp. 556-7.

[10] Rogers, op. cit., p. 285.

[11] H.W. Kennedy and A.O. Porter, "Air Pollution: Its Control and Abatement", 8 Vanderbilt Law Review 861 (1954).

> The criteria used to judge the validity of a statute regulating conduct which does not constitute a common law nuisance are those applied to determine the proper exercise of the police power.[12]

The public welfare is the basis for deciding the legality of state legislation, whereas in Canada it would be the duty of the court to look to Part VI of the B.N.A. Act.

Conclusion. The Federal Government has contributed to the solution of the air pollution problem by aiming at standardization of data gathering and centralizing this information for research purposes. The Meteorological Branch of the Department of Transport has correlated this pollution data with meteorological measurements for different cities contributing to the programme. Along with enforcement of anti-pollution regulations for their creatures, the federal government has also provided strong leadership and research capability. National standards could be attained for instance, which then could be enforced at the provincial level.

## III. ENGINEERING ABATEMENT METHODS

The legislative framework provides the basis by which various methods of control may be made compulsory,

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[12] S.M. Rogers and S. Edelman, "Air Pollution Control Legislation", Air Pollution (II), A.C. Stern, ed. (New York: Academic Press, 1962), p. 433.

or at least it provides the encouragement of abatement by establishing certain emission standards from various sources. New techniques are being developed continuously so that only a general introduction to this specialized discipline is outlined here. The following breakdown is by pollutant category, rather than by method of control so as to describe modes of control in direct terms.

Smoke. This pollutant is mostly nongaseous material made up largely of carbon particles though other particulate matter is usually present. Incomplete combustion of carbonaceous fuels has made smoke the historic pollutant and caused it still to be problematic in many contemporary communities.

Insufficient air is an important factor in "smoke" emission and heat losses",[13] but loss may occur with an excess of air and for other diverse reasons. Too much air causing cooling below the ignition point or bad stoking practices are cases in point. Also the fuel itself is important since the percentage of carbon and volatile material varies considerably in coal, for example. Combustible trash is burned in order to dispose of it, but often combustion is so poor that a problem of magnitude results.

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[13] A. Marsh, Smoke (London: Faber & Faber, 1947), p. 179.

Smoke may originate from domestic heating plants, industrial power plants, refuse incinerators, open fires, railway locomotives, ships, diesel engines and automobiles, each source being quite varied as to the amount of smoke emitted. The process of combustion, involving carbon or hydrogen plus oxygen, has to be understood in order to improve the situation. The requirements for the smokeless combustion of any fuel are:

1. Proper air-fuel ratio.
2. Sufficient mixing of air and fuel.
3. Sufficient emission temperature.
4. Sufficient space to permit time for proper burning.
5. Proper distance from the grate. 14

In practice these conditions are not met all the time so that a certain amount of pollution results. In different terms it has been stated that

> The "three T's" of combustion--time, temperature, turbulence--govern the speed and completeness of the combustion reaction. For complete combustion, the oxygen must come into intimate contact with the combustible molecule at sufficient temperature, and for a sufficient length of time, in order that the reaction be completed. 15

In the United Kingdom, the solution is found in smokeless fuels since open fireplaces are found in most

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[14] W.L. Faith, Air Pollution Control (New York: John Wiley and Son, 1959), p. 68.

[15] R.J. Ruff, "Nuisance Abatement by Combustion", Air Pollution (II), A.C. Stern, ed. (New York: Academic Press, 1962), p. 357.

homes. Coke, anthracite, low-volatile coal and various briquetted fuels are termed smokeless. Furnaces, on the other hand, may be designed to eliminate smoke if care is taken from the firing to the flue. The type of combustion chamber is especially significant. Wood burning requires a primary drying zone since the moisture content is much greater than that of coal.

The burning of refuse is of special significance since it is so widespread and proper incinerators are not present. The wide variation in the moisture content, density, physical form, and calorific value of waste materials must be accommodated in the design. However, it can still be said that reduction by burning in well-designed incinerators, private and municipal, is the satisfactory solution. Design standards for incinerators may be enforced readily to minimize smoke and particle emissions.

The measurement of smoke is accomplished by two chief methods--the use of the Ringelmann chart and the automatic smoke sampler. The chart relies on visual observation and comparison with four shades of grey plus a white and black. Number one is 20% black, two 40%, three 60%, four 80% and five 100%.

> These measurements are direct and require no equipment in the field. The results are, of course, in arbitrary units and become somewhat doubtful if the

> smoke is not black. Nevertheless it is an important method and remains likely to remain one because its use is specified in most legal codes. 16

The smoke is sighted as it emerges from the stack and timed, most regulations limiting emission beyond a certain number on the Ringelmann chart, longer than a certain time. The amount of sunlight will affect the reading markedly and it should be noted that coloured smoke cannot be measured.

Another most suitable method for determining smoke concentration in the open atmosphere is based on filtration of a known volume of air through a white filter paper, estimating the blackness by optical means. The Coh unit

> defined as the quantity of light-scattering solids capable of producing an optical density of 0.01 when the smount of light transmitted through the spot of dust...is measured. 17

One Coh indicates a bright clear day while 10 corresponds to one darkened appreciably by the presence of smoke.

Dust, fumes and mist. Particulate matter is the collective term for liquid droplets and solid particles.

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[16] C. Steffens, "Visibility and Air Pollution", Air Pollution Handbook, P.L. Magill, ed. (New York: McGraw-Hill, 1956), p. 6, 34.

[17] W.L. Faith, op. cit., p. 88.

During the time particulate matter is suspended in the air it is known as an aerosol.

The air contains suspended matter even over the oceans where salt nuclei and marine micro-organisms are present. Over cities the values may be 4000 times that of the ocean air suspension. The size of particle can, of course, range from the minute to the relatively large. Chemically the composition of these particles is extremely complex. Aerosol content of the atmosphere varies considerably as a function of weather conditions and industrialization.

The actual dustfall is a common measure of air pollution severity measured in tons per square mile per month. The figure varies tremendously within an urban area, as was seen in an areal study of Sheffield,[18] and also it varies by season.

Sampling and analysis of particulates is a very exacting technique; a sample from a duct, for example, must be representative and reproducible. Filters may be used in removing particulate matter from streams of gas, while other devices may force the gas through a system where it changes direction at a solid surface where the

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[18] J. Pemberton et. al., "The Spatial Distribution of Pollution in Sheffield", International Journal of Air Pollution, II (1959), pp. 175-187.

particles cling. Centrifugal and electrostatic precipitation methods may also be utilized in collecting particulate matter.

Reduction at source is the best way of controlling particulate emission whatever the method. The settling chamber is perhaps the simplest type of dust collection equipment. The food and metallurgical industries use the chamber as a first step in dust and fume recovery. Only the larger particles may be collected so that other methods prove necessary. The cyclone separator with multi cones or filters through which air is forced may perform the task. Wet collectors, using a spray chamber or other techniques increase the size of a particle to facilitate its removal from the gas stream. Another reduction at source method would be the employment of electrostatic precipitators: "This is done by passing the gas between two electrodes",[19] gas ions forming near the discharge electrode, moving towards the collecting, and transferring their charge to particles by collision with them, these aerosols then being deposited on the collecting electrode. Some collection systems have also been developed recently.

Gases. There are two main sources of gaseous

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[19]C.F. Gottschlich, "Source Control by Electrical, Thermal, and Sonic Forces", Air Pollution (II), op. cit., p. 314.

contaminants: combustion of fuels and handling of chemicals. Petroleum refining, chemical manufacture, ore smelting and other industrial activities emit gases of every conceivable description. The chief gases and abatement methods for each are outlined below.

Sulphur dioxide is a gas with no colour yet it has a very suffocating odour such that it is considered an emergency situation with a concentration over five parts per million. The taste and smell occurrence can be detected at much lower levels. Irritation of the nose and throat is the main health effect, while it can lead to the more serious episodes which were outlined in the previous chapter.

All fuels with the exception of wood contain sulphur dioxide. One abatement method would involve the reduction of this content in the particle fuel being burned. Coke is an example of such a conversion (from coal). Sampling methods are similar to those for all gases, whereas monitoring the open atmosphere requires special instrumentation.

Hydrogen sulphide is another air pollutant being toxic to the extreme and nasally detectable in concentrations as low as 0.1 p.p.m. It may readily be burned to sulphur dioxide and used for the manufacture of sulphuric acid if it is in sufficient quantity. Industrial

operations are the chief sources of the gas, "although vegetable matter, volcanos and natural springs are also among its contributors."[20] The processing and refining of crude oil usually involves the recovery of hydrogen sulphide by economic necessity whereas in other chemical operations control may be necessary because of air pollution. Wet collectors may be used for treating the gas by means of a liquid spray which dissolves it.

Hydrogen fluoride is another toxic gas, though it is practically never found in the air except in small concentrations. Fluorosis of cattle is the main effect caused through ingestion of vegetable matter exposed to dust. Since the affinity of water and alkaline water solution for both gaseous HF and soluble fluorides is very high, any gas-liquid contact apparatus may be used for abatement.

Chlorine and its compounds should also be described though its concentrations are usually quite low. Corrosion, respiratory irritation, and vegetation damage can result from them. Chemical manufacturing plants are the common sources of chlorine, which is manufactured itself for water purification purposes. Scrubbers or spray towers

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[20]Faith, op. cit., p. 150.

may be used to remove the compounds from gas streams in the production process.

Nitrous oxide, nitric oxide, and nitrogen dioxide are found in the atmosphere, the first normally as a result of a reaction between atomic oxygen (ozone) and nitrogen in the upper atmosphere. The latter two are a result of human activities and are classed as pollutants. The health effects and nuisance effects of photochemical smog result from these oxides. Combustion of fuels and chemical manufacturing operations produce the gases. Fuels produce engine exhaust, for example, which contributes to these pollutants. Abatement of nitrogen dioxide is accomplished using absorption by water in bubble towers, spray towers or the like. For nitric oxide, oxygen or air must also be added for the oxidation to nitrogen dioxide. At low concentrations these methods are not usable and catalytic decomposition is necessary.

Carbon monoxide is another gas which is highly poisonous, the chief source being combustion. Except for internal combustion engines, very little $CO_2$ is found in the effluent of properly adjusted, properly operated installations. Along city streets the concentration can rise to 90 p.p.m. The most common abatement method is oxidation to carbon dioxide, waste heat boilers utilizing $CO_2$ being part of catalytic cracking units in petroleum

refineries, for example. Small concentrations require catalytic techniques. For gasoline engines antiknock fluids foul catalysts rapidly, so that abatement is a critical problem.

Hydrocarbons are important as pollutants "in their reactivity with nitrogen dioxide in the presence of sunlight to form photochemical smog",[21] in themselves being harmless and non-toxic. The compounds of hydrogen and carbon cover a wide variety of forms. Natural gas and crude petroleum are the ultimate sources of the atmospheric hydrocarbons. Any devices utilizing these materials or their products may prove to be a source of the compounds. Spectrometers or oxidation meters may be used in detecting hydrocarbons in the ambient air. Methods for abatement fall into two categories, the first being where the emission is prevented or the hydrocarbon recovered and second where it is destroyed. Prevention involves process design while vapor-recovery methods are also used. Oxidation is the second abatement method either by direct burning or catalytic means.

Many other gases also exist which enter the atmosphere, practically every chemical compound having a gas phase. Ammonia is one example. Liquid scrubbing

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[21] Faith, op. cit., p. 165.

incineration or catalytic combustion are the preferred abatement methods. Radioactive gases also merit comment since their incidence will presumably be much greater in future.

Odours. The odour threshold is the "point at which the odour is barely perceived".[22] Air deodorization is a subject of great interest today, the problem being "the establishing of standards which are scientifically justifiable",[23] and which "do not require judicial interpretation, and can easily be applied in the field."[24]

The only measuring device for odours is the human nose, so that there may be wide differences of opinion not only as to how offensive an odour is but at what level it is perceived. An unfamiliar odour may cause more complaint than a familiar one. An odour may not become offensive until the source is discovered. The effects are primarily at the nuisance level but often odours can lead to extreme nausea.

Nitrogen or sulphur compounds are generally the

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[22] M.B. Jacobs, The Chemical Analyses of Air Pollutants, (New York: Interscience Publishers, 1960), p. 375.

[23] W. Summer, Methods of Air Deodorization (Amsterdam: Elsevier Publishing Co., 1963), p. 272.

[24] Ibid., p. 273.

culprits as far as smell is concerned. Chemicals, paints, rendering plants, oil refineries, coke works and so on are sources. Motor vehicles, including diesel powered trucks and buses, also rank high. Abatement is accomplished most effectively by source control, most odours being gases in a similar way to the methods described above. They also may be masked by neutralizers--this technique is known as odour counteraction.

Conclusion. The wide range of sources and pollutants shows why a variety of abatement methods has been necessary. Morris Katz has said that:

> Costs of recovery and disposal of waste products rise rapidly at higher efficiencies and may become prohibitive beyond 95% removal. 25

The emission of pollutants will still occur even with abatement methods good to 95% efficiency (i.e. ultimate engineering control at source). The great complexity of source control methodology illustrates that other than engineering abatement techniques are required.

## IV. PERFORMANCE STANDARDS

Dennis O'Harrow has explained the concept of performance standards in this way:

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[25] M. Katz, "Air Pollution as a Canadian Regional Problem", Resources for Tomorrow--Supplementary Volume (Ottawa: Queen's Printer, 1962), p. 115.

> The expression "performance standard" is taken from building code terminology. Modern building codes are written more in terms of what materials and methods will do--their performance under stated conditions--rather than in specific descriptions of materials and building methods. 26

The specification standard on the other hand has made use of an arbitrary figure for such measures as side yards and so on. The focus will be on performance standards whose purpose is the control or regulation of air contamination.

History. The use of performance standards as an attempt to insure satisfactory land use compatibility through the employment of specific criteria for the regulation of emission levels was first put into practice in 1952.[27] The 1957 Chicago zoning ordinance was the first in the United States "applying a full scale of performance standards to industrial zoning for a large urban area."[28] Since that time they have been utilized extensively in that country.

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[26] D. O'Harrow, Performance Standards (Columbus National Industrial Zoning Committee, 1958), p. 2.

[27] R.A. Morrow, "Performance Standards as a Control Device for Industrial Nuisances..." (unpublished Master's Thesis, The University of Washington, Seattle, 1960), p. ii.

[28] E.E. Schulze, Performance Standards in Zoning Ordinances (Pittsburgh: Air Pollution Control Association, 1959), p. 4.

Basis. Certain aspects of zoning are examined more fully in the next chapter. However, performance standards are so related to engineering abatement methods that the concept should be introduced at this stage. The standards attempt to classify and assign industrial activities to different zones "solely on the basis of their external effects."[29] In theory then the clean industries would be able to locate with more freedom, whereas the dirty would be relegated to particular areas. Noble has called them "the most permissive type of regulations"[30] since they are positive not negative in their philosophical basis.

Substance. The following contaminants are important in air pollution control: smoke, odour, dust and dirt, and noxious gases. The other considerations are noise, vibration, glare and heat, electromagnetic interference, density controls, and aesthetics. Psychological effects of industry might also be mentioned.

Density of black smoke can be measured by the Ringelmann chart fairly easily. Either absolute prohibition, Number one density (20% black) or Number two

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[29] R.B. Garrabrant, "Performance Standards for Industrial Zoning An Appraisal", Urban Land, XV (June, 1956), p.3.

[30] O.W. Noble, "Industrial Performance Standards: A Proposal", Urban Problems and Techniques (No. 1), P.L.Norton, ed. (West Trenton, N.J.: Chandler Davis, 1959), p. 181.

density (40% black) may be the effective limit. If the general air pollution regulations prohibit smoke more dense than No. 2 then performance standards presumably must be more strict if they are to have any real meaning.

Odour is difficult to measure in quantitative terms since its detection is quite subjective in character. Some descriptive attempts at odour definition have been attempted, but the threshold varies considerably among individuals. The only real "control" is absolute prohibition in restricted zones.

Dust and dirt production can be measured at the flue and restricted beyond a certain emission. The best standard is absolute containment within the industrial premises, however, unless decentralized locations are utilized.

Noxious gases may be odourless, but are dangerous to all forms of life. Maximum safe concentration figures are available for most gases, but it would probably be best to restrict the location of poison gas producing industries to isolated areas.

The other areas of performance standard measurement are beyond the scope of air pollution control. However, it does appear that more research is needed in determining many of the measurements, and that there is some need for national standards.[31] These would have to

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[31]Noble, loc. cit.

be modified for particular regional conditions. A retroactive clause giving reasonable time for compliance has also been suggested for existing industry.

Criticism. Under this type of system almost every application is accepted as a matter of routine. It is only when the plant in question violates standards subsequently that action can be taken. The use list on the other hand was found lacking because not enough control could be exerted over changes in use. Schulze has written that "the more conventional use list and ... a properly designed regulatory ordinance"[32] might be more sensible. An area breakdown could also be applied for the latter if necessary. Performance standards tend to be arbitrary so that they may be difficult to maintain if contained with the zoning regulations. For air pollution measurements a general overall restriction beyond a certain level of emission is urged, and a return to the use list approach. Performance standards do not possess precision because of their inherent flexibility, but they are important due to their effectiveness and are probably no more arbitrary than the use list.

Conclusion. The regulation of new pollution sources on an area basis, integrated into the zoning process relies on research into the abatement methods described

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[32]Schulze, loc. cit.

above. Administration of such regulations requires detailed engineering knowledge of a specialized nature. If such standards are adopted they are merely supplementary to the overall regulations. In non-air pollution matters, however, they do have a primary purpose to attain.

## V. SUMMARY

The British North America Act has divided the responsibilities for air pollution control between the federal and provincial jurisdictions. Though the responsibility for most sources appears to be within the latter's jurisdiction the Federal Government does exert control through the Criminal Code over certain degrees of nuisance, and over railways, shipping and other aspects. It is in the provincial realm of property and civil rights that most legislation has its constitutional origin. The Federal Government does have a role in air pollution research in data collection and in its nation-wide leadership capability.

The various engineering abatement methods are complex and costly for the emission control of various pollutants. Measuring methods also have been developed so as to quantify emission levels and formulate standards. With many contaminants the solution may be relegation of

the source to decentralized areas whereas for others technological solutions can be found. The gases, both odourless and otherwise, are perhaps most difficult to isolate and control. Costs of recovery may limit abatement solutions beyond 95%, indicating that other methods are required.

Performance standards set limits on pollutant emission which vary for different areas, ranging from absolute prohibition to the community-wide standard cited in the anti-pollution bylaw. Whereas smoke and dust production can be measured and limited in a scientific manner, odour and toxic gases are difficult to measure so that industries producing them have to be restricted to certain areas. There is some question as to whether these controls are necessary with good general regulation of emissions, and whether the use list approach is less arbitrary. In non-air pollution matters performance standards may be required, however, even if deemed not to be suitable here.

# CHAPTER IV

# THE LOCATIONAL CONTROL OF INDUSTRY

## I. INTRODUCTION

The spatial distribution of industry can be studied at different scales, and similarly so can its locational control. Most governments in the world have been concerned with influencing industrial development at different rates of areal growth for economic and social reasons. Local governments in North America by themselves and on an intermunicipal basis, have become concerned with socio-economic and physical aspects of industrial expansion. Climatology, the basis of any industrial location planning allied to air pollution control will also be described.

## II. ROLE OF THE SENIOR GOVERNMENTS

The senior level of government may be unitary or federal in nature, the latter being the case in Canada. However, there has been a "spatial incidence of national development"[1] in all countries regardless of their administrative structures. In this limited study the roles of

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[1] J. Friedmann, "Regional Development in a Post-Industrial Society", Journal of the American Institute of Planners, XXX (May, 1964), 84.

the senior governments in the United States, the United Kingdom and Canada are described.

The United States. In 1943 the National Resources Planning Board wrote that the "location of industry presents issues of such continuing importance to the Nation as a whole"[2] that a comprehensive analysis was necessary. They stated that the Federal Government had always had an influence on industrial patterns ranging from its promotion of minimum wage legislation to the construction of low-cost public power installations "thereby increasing or decreasing the attractiveness of various possible locations for particular industries."[3] During World War II strategic factors became of prime importance. However, in peacetime labour, material, power, transportation, and capital costs could be made areally diverse to encourage industrial development in certain regions. Income relationships were affected by other means such as customs duties. States could both inform industrial corporations of opportunities and subsidize development. They have been known to tax outside goods at higher rates and thus encourage local products.

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[2] National Resources Planning Board, Industrial Location and National Resources (Washington: The Board, 1943), p. 1.

[3] Ibid., p. 8.

The different regions of the United States vary markedly in standard of living and employment opportunity. The goal of equalizing opportunity is far reaching, but for socio-economic reasons the senior government level can utilize its influences to encourage industrial growth in lower income areas. These same incentives could be employed to encourage control of atmospheric pollution.

Great Britain. In the United Kingdom the idea of national control has been related to the "human and economic problem in the depressed areas".[4] The drift of population to the south-east began after World War I and resulted in governmental action. The motive power was persuasion and cash in the interwar period, at the end of which the Barlow Royal Commission recommended stronger more positive controls.

In 1945 the Distribution of Industry Act was passed to implement the recommendation of the Commission that a "central board...be established to organize research, and advise upon and regulate the location of industry".[5] The Board of Trade as it was called would develop factories in the depressed areas, and regulate erection of large

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[4]G. Logie, Industry in Towns (London: George Allen and Unwin Ltd., 1952), p. 20.

[5]His Majesty's Stationery Office, Distribution of Industry (London: The Office, 1948), p. 10.

industrial plants (over 3,000 square feet) elsewhere. It could not be sure that the factory prevented from building in a congested area would build somewhere else. Local planning law required their certification before development permission could be approved. Logie has said that

> The free play of economic forces has in the past generally produced, in time, more or less efficient location, although often with considerable waste of material and man-power. The economic planners' belief is that by taking thought, the same adaptation to circumstance can be brought about more quickly, with less waste, and with less damage to other non-economic interests such as amenity, health and happiness. 6

The industrial plant may be located because of public policy, therefore, in order to provide a better environment for the people of a depressed area.

Canada. The Federal Government's control of economic policy has had regional effects in Canada with the ribbon-like market focused on the central populous St. Lawrence lowlands. The primary goal has been full employment.

> The general policy through which all would benefit must however be supplemented by a creative approach to specific local policies to meet regional needs. 7

Grants to the Maritime region were considered basic to

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[6]Logie, op. cit., p. 25.

[7]W.F. Lougheed, Secondary Manufacturing Industry in the Canadian Economy (Toronto: Baxter Publishing Co., 1961), p. 153.

Confederation, and are still found in today's equalization payments and tax incentives. A general level of prosperity across the country has been a goal of the senior governments to the present day.

The division of powers and responsibilities of government has made cooperation essential. Otherwise social capital outlays might have no developmental effects. The role of the provinces in development has become more important with the importance of highway transportation and natural resources. Public power and industrial promotion have also been furthered by the provincial level. Within the provinces various techniques have been utilized to encourage expansion in certain areas.

Conclusion. In North America the techniques of indirect encouragement have been employed at the senior governmental level to further areal growth. Industrial growth at this scale has been oriented to the social and economic maladies of depressed regions. A national board for the location of industry may be difficult to achieve in a federal country but financial inducements are possible with intergovernmental cooperation. With the cooperation of the third level, (municipal government) presumably these inducements could be further used for physical planning purposes such as air pollution control.

## III. ROLE OF LOCAL GOVERNMENTS

Physical planning has generally been left to local government in Canada, with the provinces taking administrative control of the process in varying degrees. Although the general plan should be the primary product of local planning, the actual legal controls are usually separate.

> The general plan is the official statement of a municipal legislative body which sets forth its major policies concerning desirable physical development. [8]

The relationship between physical-development policies and social and economic goals should be clarified by the document. This plan should "provide a firm basis for the control of land use prescribed in zoning".[9] The legal control of location at the local scale rests on the zoning by-law of a community and not on the general plan in most jurisdictions. Many communities, in fact, have no plan setting forth their development policies.

The Industry. Industrial site selection should be differentiated from industrial location planning. The former is concerned with the various factors which private

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[8] T.J. Kent, The Urban General Plan (San Francisco: Chandler Publishing Co., 1964), p. 18.

[9] A.B. Gallion and S. Eisner, The Urban Pattern (New York: D. Van Nostrand Co. Inc., 1963), p. 184.

industry must analyze before establishing a plant in a given area, while the latter involves public policy and industrial land allocation.

The private firm has considered cost primarily in its locational decisions, though physical factors related to the site and public relations have been taken into account. In selecting the general area and the community accessibility to raw materials, proximity to markets, proximity to like industries and the costs of various inputs have to be thoroughly analyzed. Site selection requires study of size and shape, topography, utilities, water supply, flooding, drainage, soil conditions, cost of development, specific location, transportation facilities, fire and police protection, taxes and insurance, zoning (and other legal aspects) existing buildings and price. Zoning is regarded as investment protection "against undesirable neighbors or other incompatible land use".[10]

The municipality can do much to attract industry by providing for these desires. An example that has been successful is the industrial estate specifically designed for industrial use. Redevelopment programmes could also involve preparing sites for industry. These are positive

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[10]Small Business Administration, Methods of Plant Site Selection Available to Small Business Firms (Washington: The Adminstration, 1961), p. 55.

planning attempts to attract industry to given sectors of the municipality besides being techniques to promote industrial development for economic reasons.

History of Zoning. The common law provided for a limited form of land use control based on the protective covenant and the nuisance concept. Restrictions of legislative origin by the community at large on building may be traced back to early times. In the United States the zoning ordinance came out of the community's power to regulate land use for the health and welfare of the public at large, whereas in Canada the Province always could legislate in the field of property rights. The restrictions of the U.S. Constitution made court interpretation of zoning ordinances necessary.[11]

In 1926 the United States Supreme Court found that the Village of Euclid had a right and responsibility to determine its own character. Industrial growth had extended to the village and until this time it was assumed that the market should dictate the course of action. Since that time the Courts of that country have upheld this local community power to be in the public interest except where its application was arbitrary.

The Canadian system of law is quite different from

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[11]Gallion, op. cit., p. 168.

that described above. The right to zone is a delegated power of the provincial legislature expressed in an Act of that body. It should be pointed out that zoning regulates more than use of land and buildings, as it also controls building heights, bulk, parking provisions, and may, of course, include other standards. It is interesting to note that one author states that American planners have had little influence in Canada,[12] and that British and home based innovations have prevailed.

Principles of Industrial Zoning. In many municipalities the so-called open-ended by-law relegated most land uses to the industrial zone, the one family district being the most protected. However, in recent years this approach has been unacceptable. No longer is the single family residence to be protected at all cost and the other land uses gradually permitted in "lower" zoning districts.

The National Industrial Zoning Committee[13] suggested certain objectives of industrial zoning in 1951. These are paraphrased as follows:

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[12] J.B. Milner, "An Introduction to Zoning Enabling Legislation, Pt. 2 Zoning Procedures", Plan Canada IV (June, 1963), 37.

[13] National Industrial Zoning Committee (Columbus: The Committee, 1951), pp. unnumbered.

1. Most communities need a certain amount of industrial development to produce a sound economy.
2. Zoning controls are basic tools in reservation of space for industry, guidance of industrial location into a desirable pattern, provision of related facilities and areas for convenience and a balanced economy.
3. Industry is a legitimate land use entitled to protection against encroachment by non-industrial land uses.
4. Through proper zoning, industrial and residential areas can be good neighbours.
5. Zoning provides for a continuity of industrial growth and the larger area requirements of modern plants.
6. There is need for reclassification of industry based on an analysis of modern manufacturing processes and the prevailing policy of plant construction so as to determine the desirability or lack of desirability for inclusion in a given district.
7. The industrial potential of lands bearing a favorable relationship to transportation should be recognized.
8. Industrial zoning and highway planning should go hand in hand.

9. Special consideration should be given to street layout in industrial areas.
10. Zoning ordinances should be permissive rather than prohibitive.
11. A good ordinance should be sufficiently definite to convey to a land owner a clear concept of what he can do with his land.
12. Industrial zoning can be most effective on a metropolitan basis.

The report thus ignored air pollution control as a potential goal of industrial zoning. Prohibition "from certain districts or the entire community"[14] of industries which emit obnoxious smoke, noise, dust and odours could be an objective of the community's land use policies. However, in numbers six and ten above there is a suggestion that performance standards could be utilized by the zoning authority.

Another point of view is that offered by Morris Katz:

> The primary objective of planning is to ensure that the normal growth of industry and population does not result in raising the level of pollution to the point where it becomes a persistent nuisance and a potential hazard to health. 15

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[14] American Society of Planning Officials, Air Pollution Control (Chicago: The Society, 1950), p. 11.

[15] M. Katz, "City Planning, Industrial Plant Location", Air Pollution Handbook, P.L. Magill, ed. (New York: McGraw-Hill, 1956), p.2, 9.

Gordon Whitnall speaks of the "atmospheric sewer system"[16] and its contamination. The great problem is that everyone lives along this open sewer and pure air or at least air at a certain acceptable standard may be difficult to obtain. Control of the location of the source of emissions into the atmosphere may be part of the overall approach to the problem.

Conclusion. The typical zoning by-law classifies and segregates the various uses of land and buildings into particular districts, these being drawn upon an attached map. Zoning can also "programme" development over a time period and direct certain types of uses into given areas. The problems of existing uses and divided authority should be mentioned. Zoning to be more effective must transcend the municipal boundary and be employed as a regional technique. Its role in air pollution control is discussed below.

## IV. LOCATION OF INDUSTRY AND SOURCE CONTROL

The basis for the point of view that locational control may be part of the overall approach to abatement of atmospheric pollution has already been presented.

> As population and industrial growth continue in large urban areas, the cumulative effect of multiple sources or an area source will rapidly become an air pollution problem. This problem evolves since no

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[16] G. Whitnall, "Attacking Smog Through Zoning", Urban Problems and Techniques No. 1, P.L. Norton, ed. (West Trenton, N.J.: Chandler Davis, 1959), p. 205.

source control device can be economically engineered with 100% efficiency. 17

Zoning has been employed to direct an area's growth in the interests of the welfare of its inhabitants. Frenkiel has stated that "one should be concerned with zoning the use of the atmosphere above the land...air zoning",[18] in order to regulate emission. The objective would be to reduce the potential concentration of pollutants by locating sources in an optimum manner. For stationary sources this "requires detailed knowledge of meteorological patterns."[19] For the mobile source, reduction in travel time (and thus emission time) would mean the minimization of trip distance and encouragement of non-pollutant emitting modes of transportation. Since abatement controls for the internal combustion engine have been developed and transportation planning already aims at these objectives in any case it is proposed to discuss the bases of stationary source control.

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[17] W.O. Holland et. al., "Industrial Zoning as a Means of Controlling Area Source Air Pollution" (paper read at 52nd annual meeting of Air Pollution Control Assoc., Pittsburgh, June, 1959), p. 19.

[18] F.W. Frenkiel, "Atmospheric Pollution and Zoning in Our Urban Areas", Scientific Monthly LXXXVII (April, 1956), 195.

[19] J.J. Shueneman, "Air Pollution Control Administration: Planning and Zoning", Air Pollution (II), op. cit., p. 424.

Fundamentals. Since the atmosphere is the medium of pollutant transmission from the source to the point of reception, the meteorology of an area is vital to any attempt at abatement. The atmosphere may be thought of as the diffusing agent conditioned by the non-meteorological elements of physical geography. Air flow is fundamental in this diffusion process: "the greater the wind speed, the greater is the turbulence and the more rapid and complete is the dispersion of contaminants".[20] The direction of the air flow is of importance to sectors of an area down wind from pollutant sources.

Diffusion is made effective with turbulence of both mechanical and thermal derivation. The first is caused by local topographic factors while the second is a result of solar radiation affecting vertical temperature gradients. Dispersion of contaminants is the result in either case. Sutton notes that

> the daytime temperature gradient very near the ground frequently amounts to thousands of times the dry adiabatic lapse rate. 21

This concept is important to human life since the mixing which takes place serves to modify temperature extremes,

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[20]World Health Organization, Air Pollution (Geneva: The Organization, 1961), p. 50.

[21]G. Sutton, Micrometeorology, Scientific American CCXI (October, 1964), p. 64.

permit evaporation and remove poisons from the air. The lapse rate referred to concerns the "normal" 0.54 degree drop in temperature with each 100 feet of altitude. When the lapse rate is greater than this figure air motions are enhanced, and dispersion is facilitated, but if it is less than normal or reversed movement is impeded.

Illustration I following this page shows the effects of different lapse conditions on stack effluents. When the air at ground level cools more rapidly at sunset there is an inversion of the gradient, this air being trapped below or within the layer. The five major types of plume behaviour result from the "limited number of configurations of the vertical temperature gradient that are likely to occur in nature".[22]

Ventilation is the normal term employed to describe the dispersion process. Self-cleansing is accomplished by gravity, strong winds and rain. Ventilation cannot be aided artifically even with tall stacks, as air flow horizontally and vertically is thermally produced. A basin or valley topography can confine atmospheric contaminants and really create a most serious situation, in which horizontal air flows are impeded.

Urban Climate. The city has markedly affected the

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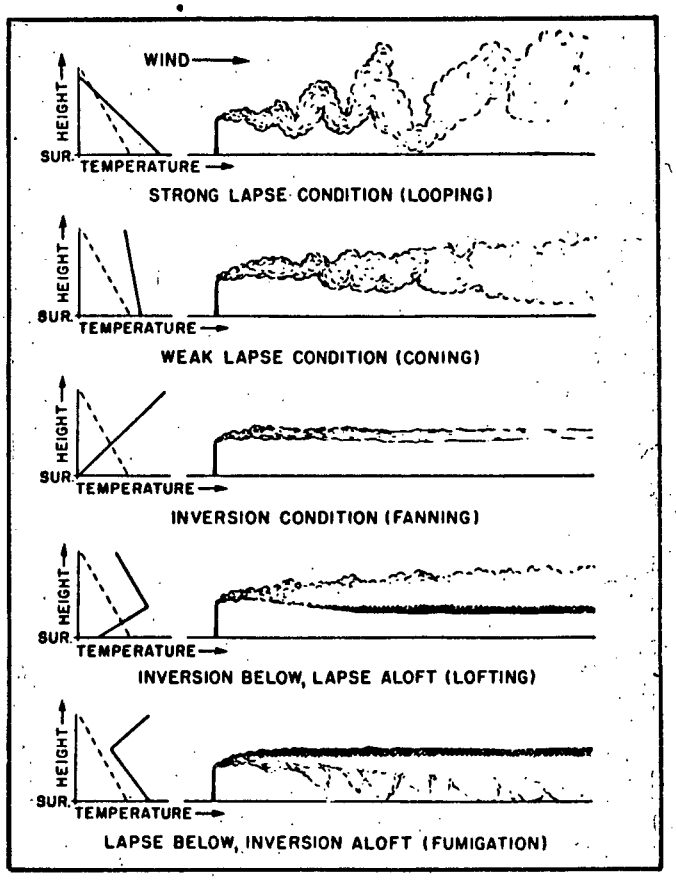
[22]U.S. Dept. of Commerce, Meteorology and Atomic Energy (Washington: The Department, 1955), p. 59.




# DIFFERENT LAPSE CONDITIONS

SOURCE: U.S. DEPT. OF COMMERCE

climate of the area in which it is located:

> The meteorological properties of air mass are characteristically altered by a town, to a degree dependent on the physical traits of the settlement.[23]

The change in atmospheric composition with the addition of the various emitted products of industry, domestic fires, and motor vehicles has been significant.

> Investigations have shown that cities or large industrial areas do indeed produce significant temperature effects and consequently have a different temperature profile than exists over the surrounding countryside. 24

The suspensions affect the radiation conditions in the area, absorbing sunlight and preventing cooling. Visual range is decreased and fogs increased which greatly reduces the number of sunshine hours.

Air temperatures are normally raised even with the absorption of solar energy by the polluted atmosphere. "On the average, cities have an annual temperature of 1°C (1.8°F) higher than their immediate vicinity."[25] At street level the difference could be much higher, these urban temperatures usually being measured on high structures. This effect has been called the heat island.

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[23]E.N. Lawrence, "Microclimatology and the Town Planner", Weather IX (No. 8, 1954), 228.

[24]U.S. Dept. of Commerce, op. cit., p. 32.

[25]H. Landsberg, Physical Climatology (DuBois, Penna.: Gray Printing Co., 1962), p. 320.

Wind velocities also are affected by the physical development of urban areas. The wind speed is usually reduced from 10% to 15%, the result being decreased ventilation. Cloudiness, precipitation and relative humidity are also affected. Landsberg[26] has provided a convenient table:

TABLE I

URBAN CLIMATE

| Element | Compared to Rural Environs |
|---|---|
| Contaminants | |
| dust particles | 10 times more |
| sulphur dioxide | 5 times more |
| carbon dioxide | 10 times more |
| carbon monoxide | 25 times more |
| Radiation | |
| total on horizontal surface | 15 to 20% less |
| ultraviolet, winter | 30% less |
| ultraviolet, summer | 5% less |
| Cloudiness | |
| clouds | 5 to 10% more |
| fogs, winter | 100% more |
| fogs, summer | 30% more |
| Precipitation | |
| amounts | 5 to 10% more |
| days with less than 0.2 in. | 10% more |
| Temperature | |
| annual mean | 1 to 1.5°F more |
| winter minima | 2 to 30°F more |
| Relative Humidity | |
| annual mean | 6% less |
| winter | 2% less |
| summer | 8% less |
| Wind Speed | |
| annual mean | 20 to 30% less |
| extreme gusts | 10 to 20% less |
| calms | 5 to 20% more |

Source: Landsberg

[26]Landsberg, op. cit., pp. 325-26.

It should be recognized that the preceeding table indicates an order of magnitude only, and that differences would be significantly varied for any given urban area.

Air Zoning. The concept of atmospheric zoning has already been introduced.

> The usefulness of the airshed concept for planning to prevent and control air pollution will hinge on ability to determine dilution capacities and air pollution levels with objectivity. 27

Professional meteorological assistance will be needed for any such attempt, and it should be stressed that zoning will require knowledge not only of air movement but of microclimate.

R.E. Munn has described the complex problems associated with industrial location and the factors to consider in an air zoning decision.[28] The allowable threshold concentration of various pollutants and the future population density distribution should be known. If several tracts of potential industrial land were deemed acceptable by other criteria such as water supply, rail services, topography, site cost and so on the

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[27]F.W. Herring, "Effects of Air Pollution on Urban Planning and Development", National Conference on Air Pollution (Washington: Public Health Service, 1963), p. 191.

[28]R.E. Munn, "The Application of An Air Pollution Climatology to Town Planning", International Journal of Air Pollution, I (1959), p. 277.

meteorological factor would then be introduced. Several mechanisms can lead to air pollutant concentrations at ground level, but it is air stability and wind movement which most directly determine the capability of the atmosphere of a particular region to disperse air pollution.[29]

Winds may be examined both at the surface and aloft. Daily and seasonal variations occur in frequency and velocity. For lapse and inversion conditions (in reality day and night) frequencies are quite different. In a study of the Ottawa area it was found that the inversion period was from sunset to one hour after sunrise while the lapse period occupied the balance.[30] The frequencies of wind which should be studied are those during the night inversion period. Munn, in fact, would examine the frequencies in the three hour "morning change-over"[31] or fumigation period. The intensity of the inversion may be quite different for any set of stations.

Munn found that there was some difference between wind frequencies at Detroit under specified meteorological conditions:

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[29] Ibid., p. 279.

[30] Statement of J.H. Emslie, Department of Transport (Air Pollution Climatologist), Vancouver Airport, Jan. 8, 1965.

[31] R.E. Munn et. al., A Preliminary Analysis of the Inversion Climatology of Southern Ontario (Toronto: Meteorological Branch, 1963), p. 11.

TABLE II

WIND FREQUENCIES AT DETROIT

| Wind Direction | N | NE | E | SE | S | SW | W | NW | C |
|---|---|---|---|---|---|---|---|---|---|
| Overall Frequency | 15 | 9 | 10 | 8 | 14 | 13 | 17 | 13 | 1 |
| Fumigation Period Frequency | 14 | 10 | 10 | 6 | 13 | 16 | 17 | 16 | 0 |

Source: Munn.

The significant differences were "at exactly the 95 per cent confidence level."[32] For fixed distances from the populated area industrial development sites would be chosen in the eastern quadrant of the metropolitan area.

Although Munn emphasized that there is no simple relationship between ground-level concentrations and distances downwind from the emission source he did develop a ratio technique for decision making between two alternate areas:

$$\frac{F_1 E_1}{F_2 E_2} = \frac{F_1}{F_2} \left(\frac{X_2}{X_1}\right)^{(2-n)/2}$$

The variables are as follows:

$X_1$--distance from site A to urban area O

$X_2$--Distance from site B to urban area O

$E_1$--ground level concentration at O when downwind from A

$E_2$--ground level concentration at O when downwind from B

[32]Munn, op. cit., p. 283.

$F_1$--frequency of fumigations with wind direction AO

$F_2$--frequency of fumigations with wind direction BO

n --stability parameter (related to wind gustiness i.e., 0.2 to 0.4)

"If the ratio is greater than one choose site B; if less than one, choose A."[33] The range of interest in his air zoning concept lies in distances of more than two miles so that the puff of smoke brought down to ground level, the looping plume, is of no concern.

Conclusion. Air zoning would allow or prohibit industries in certain districts of the area under control. Intense meteorological study is necessary to provide a reasonable basis for this form of zoning, the air movement and flow having to be thoroughly documented. Simple models such as that contributed by Munn may aid, however, in making decisions even with detailed microclimatological information.

## V. SUMMARY

The senior governments have chiefly been concerned with industrial location from the socio-economic point of view. The United Kingdom went beyond the indirect inducement role to that of centralized control of industrial

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[33] Ibid., p. 284.

development. In North America this degree of control may not be desired but it would be possible to utilize indirect inducements for industrial location planning.

Local government has chiefly been concerned with physical planning by zoning which protects the industrial plant and the resident from each other yet guides areal growth. Spatial and economic considerations have generally prevailed in zoning law. The history of zoning, as developed in the United States, was one of court interpretation unlike the situation in Canada where the Provincial legislatures provided municipal planning enabling Acts. Zoning has been described as a method of controlling source locations of air pollution.

Meteorology provides the basis for air zoning of areas, with wind data of various kinds being important in regards to air pollution control. The city has had an immense effect on climate, known as a heat island. One useful method for air zoning was introduced by R.E. Munn in an attempt to simplify the analysis of industrial location related to such control. Detailed knowledge of area microclimates has been considered to be important in air zoning decisions and the method would not make such a background unnecessary.

# CHAPTER V

# AREA SOURCE AIR POLLUTION CONTROL

## I. INTRODUCTION

The "cumulative effect of the residual emission from many sources in an area has been termed 'Area Source'."[1] This chapter will describe the efforts in two metropolitan areas in North America to integrate their air pollution control and land use planning administrations in order more effectively to reduce atmospheric pollution levels. This is followed by a theoretical illustration of the effectiveness of location control techniques in the abatement of air pollution. Thereupon, considerations of the implications of this illustration will be outlined.

## II. AIR POLLUTION CONTROL IN LOS ANGELES

The Metropolitan Area. Los Angeles County doubled in population from 1941 to 1960 being six million at the latter date.[2] This increment is expected to be added to

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[1] W.D. Holland, et. al., Industrial Zoning as a Means of Controlling Area Source Air Pollution (Pittsburgh: Air Pollution Control Association, 1959), p. 1.

[2] M. Breivogel, et. al., Air Pollution--Potential Advisory Service for Industrial Zoning Cases (Los Angeles: Air Pollution Control District, 1960), p. 2.

resulting in a population of 10 to 12 million completely filling the basin in which the urban area is situated. There are 70 municipal jurisdictions in the County with the power to control land use, representing 69 incorporated cities and the unincorporated portion of the County. The City and County of Los Angeles together account for approximately 60 per cent of the land area and population.

No regional or metropolitan-wide authority exists in Los Angeles to coordinate all the local planning efforts through a binding plan. Incorporation law has actually encouraged the rapid increase in number of separate jurisdictions.[3] Annexation by cities has been impeded by the creation of new cities, 29 in the period 1954 to 1963. This urban multiplicity has meant that "the potential for...a comprehensive and extensive planning activity"[4] has been lacking and that an interagency cooperative approach has been essential.

Los Angeles' location in a topographic basin has seriously augmented the air pollution problem. With an inversion at such an altitude as to be below the surrounding mountain summits, and off-sea breezes, contam-

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[3] W.W. Crouch and R.N. Giordano, "The Example of Dairy Valley", The Yearbook of Agriculture 1963 (Washington: Government Printing Office, 1963), p. 491.

[4] M. Breivogel, et. al., op. cit., p. 4.

inants are trapped in the topographic basin. Ventilation cannot take place in this situation thus the air pollution control authority went so far as to recommend prohibition of new industrial sources in parts of the County.[5]

Air Pollution Control. In California air pollution control is a county responsibility. Intercounty air pollution control districts have also been created by legislation, the best example being the San Francisco Air Pollution Control District. Standards are being set at the state level by the State Board of Health for both the County Control Districts and the State Motor Vehicle Pollution Control Board.

In Los Angeles the Air Pollution Control District has applied an "intensive source control program"[6] since the early 1950's. The following table indicates the average daily emission level from different land uses in tons per day:

TABLE III

AIR POLLUTION EMISSIONS IN LOS ANGELES

| Category | Inorganic bases | Organic bases | Aerosols | Total |
|---|---|---|---|---|
| Streets | 4684 | 950 | 34 | 5668 |
| Industrial | 1952 | 890 | 67 | 2909 |
| Commercial | 58 | 111 | 5 | 174 |
| Residential | nil | nil | nil | nil |

Source: A.P.C.D., 1959.

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[5]W. Holland, et. al., op. cit., p. 19.

[6]M. Breivogel, et. al., op.cit., p. 10.

The programme, aimed at control of the motor vehicle, had not been implemented by 1959 so that "streets" should produce less within ten years, devices now in the process of being installed on all new vehicles. With higher central area densities in future, and less trip miles per capita, the increase in this category may be much less than the industrial.[7] Of the total stationary source emissions, 93% are of industrial character.

Administrative Integration. Pollution control and land use control are difficult to integrate in this multi-jurisdictional situation, but the City and the County both send zoning cases to the control district technicians for their review and recommendations. This two to three week operation analyzes industrial zoning applications which could create new air contaminant sources. A list was prepared by Control District personnel to aid in the identification of problem land uses by the planning staffs of the two jurisdictions. For single sources Control District recommendations were adopted as conditions 64% of the time, while a further 22% were generally accepted. In only 14% of cases the planning authority did not adopt the recommendations.

Recommendations for area source situations are difficult to formulate:

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[7] M. Breivogel, et. al., op. cit., p. 10.

> The Los Angeles County experience indicates that zoning cases involving expansion or creation of industrial areas do not readily lend themselves to air pollution control analyses and recommendations.[8]

The Metropolitan Industrial Zoning Plan concept was an attempt to use predictive techniques.[9] The natural dilution capacity of the atmosphere in different areas, community air standards, and analysis of present and future sources were to be employed. The whole County was analyzed for wind trajectories through the use of computer methods, though dispersion horizontally and vertically resulting from gustiness and mixing was not taken into account. A regulation was proposed to divide the County into four major areas, restricting expansion of undesirable processes in two of them. This was never enacted "since it was felt that it was necessary to gether more substantiating data".[10]

In order to facilitate individual case review it was felt that many air pollution regulations could be incorporated in the zoning class specifications. It is interesting that air pollution control officials advocated the use list approach. It was recognized however, that the advisory service was only an interim situation since

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[8] M. Breivogel, et. al., op. cit., p. 26.

[9] Holland, et. al., op. cit., p. 2.

[10] Ibid., p. 19.

if all municipalities participated, it would mean 2,000 hours of meetings per week if technicians were to present their arguments.[11]

Conclusion. Mandatory regulation is really of necessity for complete area source location control if one is to judge from the Los Angeles experience. The air pollution control officials there have concluded that all municipal planning authorities should be subject to metropolitan air zoning. The actual air zones would be defined by meteorological research into the variables affecting air dilution capacity. It would appear that in Los Angeles where the pioneer research has been completed, a stalemate in air zoning for industry has been reached.

## III. AIR POLLUTION CONTROL IN EDMONTON

The Metropolitan Area. The Dominion Bureau of Statistics boundaries now include five municipalities, three rural and two urban, in their definition of Greater Edmonton. Since the 1961 census two other urban municipalities had been amalgamated to the City of Edmonton by the Province, so that 349,232 of the 373,806 people in the metropolitan area were residents of the City by 1964.[12]

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[11] M. Breivogel, et. al., op. cit., p. 29.

[12] Edmonton Regional Planning Commission, Annual Report (Edmonton: The Commission, 1964), p. 17.

By 1980 a population of 660,000 has been forecast for the Metropolitan Area.[13]

Before the discovery of oil near Leduc, 30 miles south of Edmonton, in 1947 the City had been a service centre and provincial capital with a limited amount of industry.[14] The economy changed dramatically in this period and new petrochemical industries were established south-east of the City in what is now the County of Strathcona. By 1961 the Metropolitan Area was selling $436 million of industrial produce annually,[15] ranking eighth in Canada. Three large oil refineries, a large petrochemical plant, a large ore refining plant, a steel plant and others have been introduced to the area.

The Planning Commission. It was on June 26, 1950 that a planning commission was formed to coordinate developmental patterns in an area around and including the City of Edmonton.[16] The body, now known as the Regional

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[13]Edmonton Regional Planning Commission, Metropolitan Edmonton Transportation Study (I) (Edmonton: The Commission, 1963), p. 14.

[14]F. Marlyn and H.N. Lash, "The Edmonton District: A City Centred Multiple Resource Region", Resources for Tomorrow (I) (Ottawa: Queen's Printer, 1961), p. 459.

[15]Dominion Bureau of Statistics, The Manufacturing Industries of Canada 1961 (Ottawa: Queen's Printer, 1964), p. 104.

[16]Edmonton District Planning Commission, Annual Report (Edmonton: The Commission, 1951), p. 7.

Planning Commission, included representatives from the Councils of the various muncipalities and officials of provincial departments. Land use policies for the metropolitan area were considered to be of highest priority so that by May 1951 a report had been prepared recommending a "Broad Land Use Plan".[17] Though this was accepted as a guide it was not binding on the municipalities and it should be noted that industry was not allocated to simply one zone. A year later, however, requirements were more severe so that any industrial plant which would emit "noise, odor, fumes, etc. which can be detrimental to the Urban Land Use Zone must be sited...in relation to prevailing winds"[18] and be a proper distance from that zone.

Many of the large industries described above were located in the industrial zone to the east of the City. Canadian Industries Ltd., for example, though originally purchasing land in the urban zone was prevailed upon to locate further east in the industrial zone. Inland Cement Co. could only locate to the north-west because of abatement controls that were to be installed.

In 1953, moreover, the Commission became the

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[17]Edmonton District Planning Commission, Annual Report (Edmonton: The Commission, 1952), p. 3.

[18]Edmonton District Planning Commission, Annual Report (Edmonton: The Commission, 1953), p. 9.

subdivision authority in the area beyond the corporate limits of the City so that parcellation restriction could be utilized to prevent undesirable development. Other changes also occurred due to the implementation of several recommendations of the McNally Royal Commission which was empowered by the Province to investigate metropolitan matters.

The Royal Commission. The McNally Commission was empowered, in fact, to study the administration and financing of school and municipal services in the metropolitan areas of Edmonton and Calgary. During 1955 an inquiry was made which arrived at certain recommendations, many of which, because of the focus on problems of rapid growth, pertained to planning. Amalgamation of fringe suburban municipalities was the key issue, but the Royal Commission also recommended that the regional planning commissions in the two areas be given authority to have prepared and to adopt district general plans.[19]

In 1957 under amendments to the Planning Act this authority was given to the two planning commissions of the metropolitan centres. All regional planning commissions by the new 1963 Planning Act possessed similar

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[19]Report of the Royal Commission on the Metropolitan Development of Calgary and Edmonton (Edmonton: Queen's Printer, 1956), p. 17.2.

powers. The metropolitan zoning plan for Edmonton was adopted in early 1958, and is still in force today, as amended and consolidated, as the Preliminary Regional Plan, Metropolitan Part.

Industrial Location Control. In 1957 of the 12,633 acres of land allocated to industry 5,487 were being utilized, and 7,146 remained for future usage.[20] In the 1958 plan two major provisions were incorporated regarding air pollutant industries:

1. They could be further restricted to particular parts of the zone and/or subject to special regulations.
2. Where they were particularly noxious, reclassification of agricultural land would be permitted.

Since every municipality exercises development control to implement the plan, local policies would be required. The main amendment with reference to development applications since 1958 concerned recommendations of the Provincial Sanitary Engineer. All single source applications suspected of being an atmospheric problem are reviewed, but rezoning decisions at the regional or municipal level have not been referred to him.

Each municipality may further define municipal zoning districts within the Major Industrial Zone of the

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[20]Edmonton District Planning Commission, Annual Report (Edmonton: The Commission, 1958), p. 7.

metropolitan plan, based on policies related to development. The City of Edmonton has divided the Regional Planning Commission's metropolitan zone into M-1, M-2, and M-3 districts. Within each of these classes, regulations have been drafted which control the following objectionable features as to how far they may become "apparent beyond any building":[21]

1. noise
2. vibration
3. smoke, dust and other kinds of particulate matter
4. odour
5. toxic and noxious matters
6. radiation hazards
7. fire and explosive hazards
8. heat, humidity and glare

For the M-1 zone this type of condition is not permitted beyond the building housing the process. The boundary line of the site is the limit in the M-2, and the boundary of the zoning district for the M-3. In fact, radiation hazards, for example, would presumably be controlled within the building in all cases, whereas smoke does not respect boundaries. It is important to note however, that the by-law does not have the ordinary list of permissible uses, that any non-industrial use of

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[21]City of Edmonton, Zoning By-law (Edmonton: The City of Edmonton, 1961), ss. 26-28.

a commercial nature is conditional only, and that other uses are generally prohibited.

Where there is no such zoning by-law, the municipality exercises development control. Every application has to be approved by the municipal council before development can proceed. The regional plan and municipal policies passed by council resolution pursuant to the development control by-law are the chief considerations.

Air Pollution Control. Sections 24 and 25 of the Public Health Act of the Province of Alberta permit the Provincial Board of Health to inquire into and hear complaints in regards to air pollution. Before the source may be eliminated or a degree of treatment specified, a Court order is necessary. The Board may make and issue regulations subject to the approval of the Lieutenant Governor in Council. The purpose of the regulations was as follows:

> the prevention of the pollution, defilement or fouling of the atmosphere and the regulation of plants, industries and pipelines discharging chemical or other waste matter into the atmosphere.[22]

They were passed by the cabinet on September 15, 1961, applied to new sources at once, and all sources five years later.[23]

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[22]The Public Health Act (Office Consolidation), (Edmonton: Queen's Printer, 1962), s. 7 (u).

[23]Provincial Board of Health, Regulations for the Control of Air Pollution (Edmonton: Queen's Printer, 1961), s. 7.

The municipalities cooperate in measurement and in referral of problems to the Sanitary Engineering Division of the Department of Health, who administer the regulations. Alberta is the only Province in Canada which "has assumed direct responsibility",[24] ignoring municipal boundaries and applying province wide abatement rules.

Pollution Levels. In May of 1964 a survey of atmospheric pollution sources was commenced in the Edmonton Metropolitan Area by the Sanitary Engineering Division of the Department of Public Health. A questionaire technique was employed in order to provide data and to evaluate contributions of 210 specific sources. The quality of the air in the area was considered quite safe except for the presence of hydrocarbons. However, the smog formation potential of the area was considered high, and existing emission quantities high for a city of Edmonton's population size.[25]

Five key recommendations resulted from the report which was produced:

1. Hydrocarbon emissions be controlled through

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[24] M. Katz, "Air Pollution as a Canadian Regional Problem", Resources for Tomorrow--Supplementary Volume (Ottawa: Queen's Printer, 1961), p. 135.

[25] J.J. Rolston, A Study of Air Pollution Sources and their Significance in Edmonton, Alberta (Edmonton: Dept. of Public Health, 1964), p. iv.

a) regulation of garbage and refuse incineration

b) regulation of petrochemical industry emission

c) cooperative efforts with the automobile industry

2. The present air monitoring network be expanded.
3. Localized pollution sources should be eliminated or minimized by the use of control equipment or careful plant location.
4. Continued surveillance of new industry.
5. An increased use of source sampling surveys.[26]

What appears to be lacking, however, was a conscious thought of the role of area source locational control. The third recommendation recognizes the role of location for the nuisance industries: "asphaltic concrete plants, plastic plants, meat packing plants and rendering plants".[27] There exists also a need for conscious air pollution goals in metropolitan industrial land allocation.

The following table indicates the general results of the survey:

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[26]Rolston, op. cit., p. v.

[27]Ibid.

TABLE IV

AIR POLLUTION EMISSION LEVELS AT EDMONTON

| Category | Industry | Incineration | Dom. Fuel | Auto. |
|---|---|---|---|---|
| Tons per year | 131,748 | 80,891 | 8,778 | 132,950 |
| Tons per day | 361 | 222 | 24 | 364 |
| % of total | 37.2 | 22.8 | 2.5 | 37.5 |

Source: Alberta Dept. of Public Health

The results show that industrial atmospheric pollution will be the major problem once automobile emissions are brought under control. This may, in fact, occur without legislation, since American manufacturers are now installing exhaust controls on all cars though only required in California. Crankcase control devices were installed in Canadian plants, after such a move in the United States, so that it is probable that the exhaust control devices will similarly be put in place.[28] The result would be a 90 per cent reduction in motor vehicle emissions.

Public Opinion. Though newspaper references to air pollution seem usually to be exaggerated in order to impress readers they do help create a public opinion that control should be implemented:

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[28]Rolston, op. cit., pp. 36-7.

> Governments at all levels should be leading the way in eliminating the causes of air pollution with its incalculable danger to human life and health.[29]

It would be quite right to say that almost every citizen would support this view, unless he happened to be an offender. Professor T.Blanch has asked "Doesn't the public realize the danger to their health and to Metropolitan Edmonton?"[30] He, like the journalist, was attempting to inform them that they should not only do so, but through their particular interest groups utilize the law in abating the pollution nuisance.

Administrative Integration. In order to achieve the goal of an acceptable standard of clean air administrative integration of atmospheric pollution and planning, control is necessary. Such is the contention presented in earlier chapters. In the Edmonton area a limited integration now exists, since planning permission and Department of Health approval are necessary before the construction of a new pollution source. The municipality concerned sends information concerning the development application to the Sanitary Engineer, and he sends back his recommendations. In fact, any industrial

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[29] The Edmonton Journal, November 21, 1964, editorial.

[30] Ibid., "The Journal for Dissent", January 12, 1965.

development approval is generally conditional to his approval which is governed by the regulations described above. These regulations make his permission mandatory.

The problem that has not been successfully integrated involves the potential area source which results from major rezoning decisions. The forecast of emissions from these areas is difficult and really beyond the competence and jurisdiction of the Sanitary Engineer. A meteorological type of analysis, similar to that of Munn described in Chapter IV is necessary. There has been no real research in this field in the Edmonton area except for a limited study of wind movements into the North Saskatchewan River Valley which cuts a 200 foot deep trough across the urban complex.[31] Illustration II, following page 95 shows the location of this river.

Conclusion. The Edmonton area appears to possess the administrative organization necessary for successful air pollution control through abatement and land use regulation. The intergovernmental cooperation has proven to have been successful insofar as it has gone. What is really lacking is the ability to comprehend the atmos-

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[31] W.Klassen, Micrometeorological Observations in the North Saskatchewan River Valley at Edmonton (Toronto: Meteorological Branch, Department of Transport, 1962), 24 pp.

pheric pollution ramifications of increments to the allocation of industrial land. There has been a recognition of prevailing wind and distance as being two variables of extreme importance however.

## IV. AN INQUIRY INTO THE EFFECTS OF AIR ZONING

It was hypothesized in Chapter I that by taking into account the applicable meteorological factors, control of industrial location would significantly reduce potential atmospheric pollution. In an attempt to illustrate this statement in quantified terms, the following inquiry was undertaken. This was a theoretical approach, however, and has not actually been attempted in the Edmonton Metropolitan Area.

The Concept. It will be remembered that Munn used two chief variables in his method of decision-making[32] namely one related to wind direction and another related to distance. He also introduced a stability parameter in order to reconcile gustiness. This factor was ignored in this study since the potential pollution level of given areas was to be calculated.

The major assumption was that the potential pollution level of an area varies directly as to the frequency

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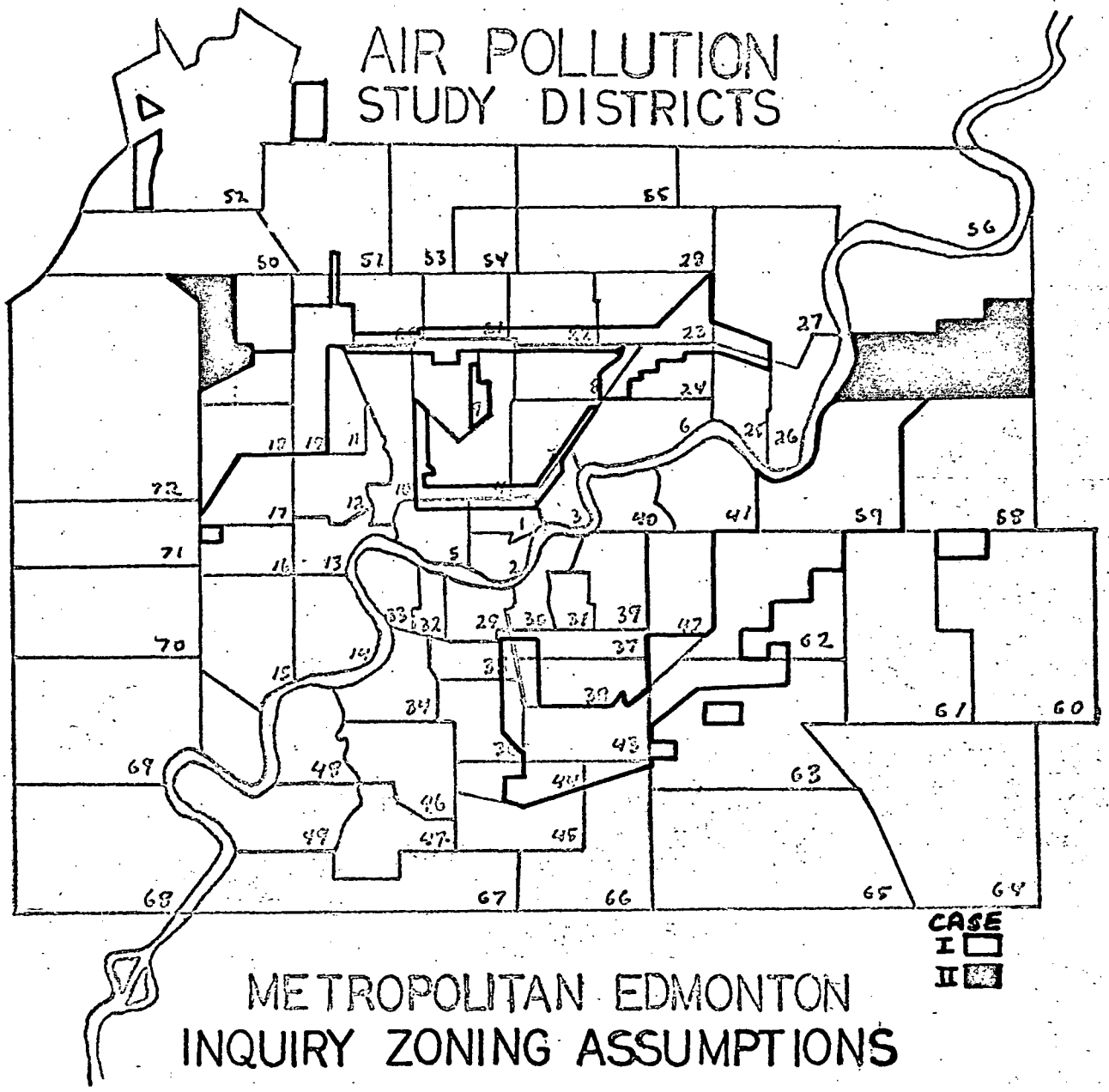
[32] See page 74.


AIR POLLUTION
STUDY DISTRICTS
52
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56
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22
17
12
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41
59
58
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CASE
I
II
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MILES
METROPOLITAN EDMONTON
INQUIRY ZONING ASSUMPTIONS

of winds from that direction, and indirectly as to the distance to the nearest industrial zone. Non-industrial sources were ignored for the purpose of the study, it being now possible to use abatement techniques for their control. Exotic sources such as forest-fires and natural occurrences were also ignored.

By dividing the wind direction frequency by the distance measure a coefficient of pollution was derived for any direction. The frequency could have been the percentage of total hours of wind, or of a selected portion of the 24 hour day. The three hour fumigation period in the morning when night-time inversions change over to the normal lapse conditions or the total inversion period from sunset to one hour after sunrise could have been used. Since these data were not available, the annual gross averages from 1938 to 1963 inclusive were employed in this case. This may be a fault in the analysis, but not in the method itself.

The Edmonton Metropolitan Area was divided into 73 districts for the purposes of the Metropolitan Edmonton Transportation Study and these subdivisions were used here. Distances in miles and fractions thereof were calculated from each district in eight compass directions to the industrial zones.

Illustration II following this page shows the

industrial zoning assumed for study purposes. The zoning was assumed to be totally infilled in the first case and no restrictions put on atmospheric pollution emissions except those already in existence. In the second case two air pollutant industrial zones were created where the only limit was the Provincial regulation of emissions. One of these M-4 zones was in the north-east and the other in the north-west portion of the area. The rest of the industrial zoning was assumed to be in the M-3 category at least and no emissions permitted beyond zone boundaries. Another way of regarding this zone was that no new pollution sources were permitted which would violate M-3 regulations. In other words all zones except the two for pollutant industry were areas of restricted atmospheric emission.

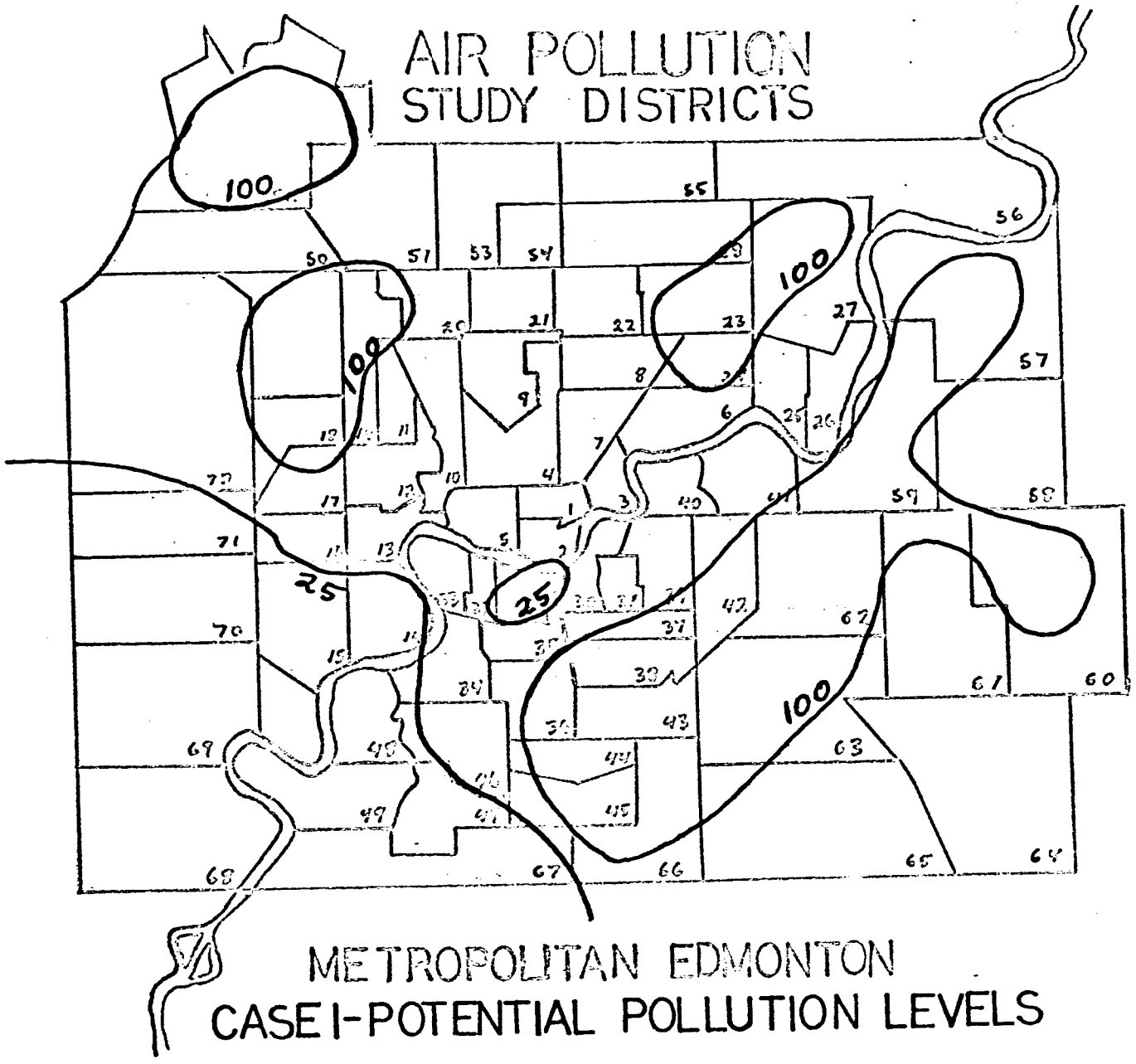
The Procedure. In order to measure the relative potential pollution levels of the 73 districts, the eight coefficients of pollution were added together. This operation was performed twice in order to compare the two situations. The appendix lists the wind direction data used for the study, plus the results for each study district.

The approximate mileage was calculated from each district in the eight compass directions to the nearest industrial zone, and to the air pollutant industry M-4

zone. If no industrially zoned area existed in that direction within the metropolitan area then the distance was considered to be infinite. If there was industrially zoned land within the district or at its edge the distance was assumed to be zero miles. In calculating the coefficient of pollution however, any distance from zero to one mile was considered to be one mile. The total wind frequency was assumed potentially to produce pollution if an industrial zone were one mile or less away from the district.

What the method meant in reality was that for a given district surrounded in all directions by industry, and this could be as far as a mile away, the potential pollution level was 100. With increasing distances in any direction this would decrease; if there were no industrial zones in any given direction the coefficient of pollution would be zero. The result was that each district of the metropolitan area could be compared relatively, and the two air zoning situations could also be contrasted.

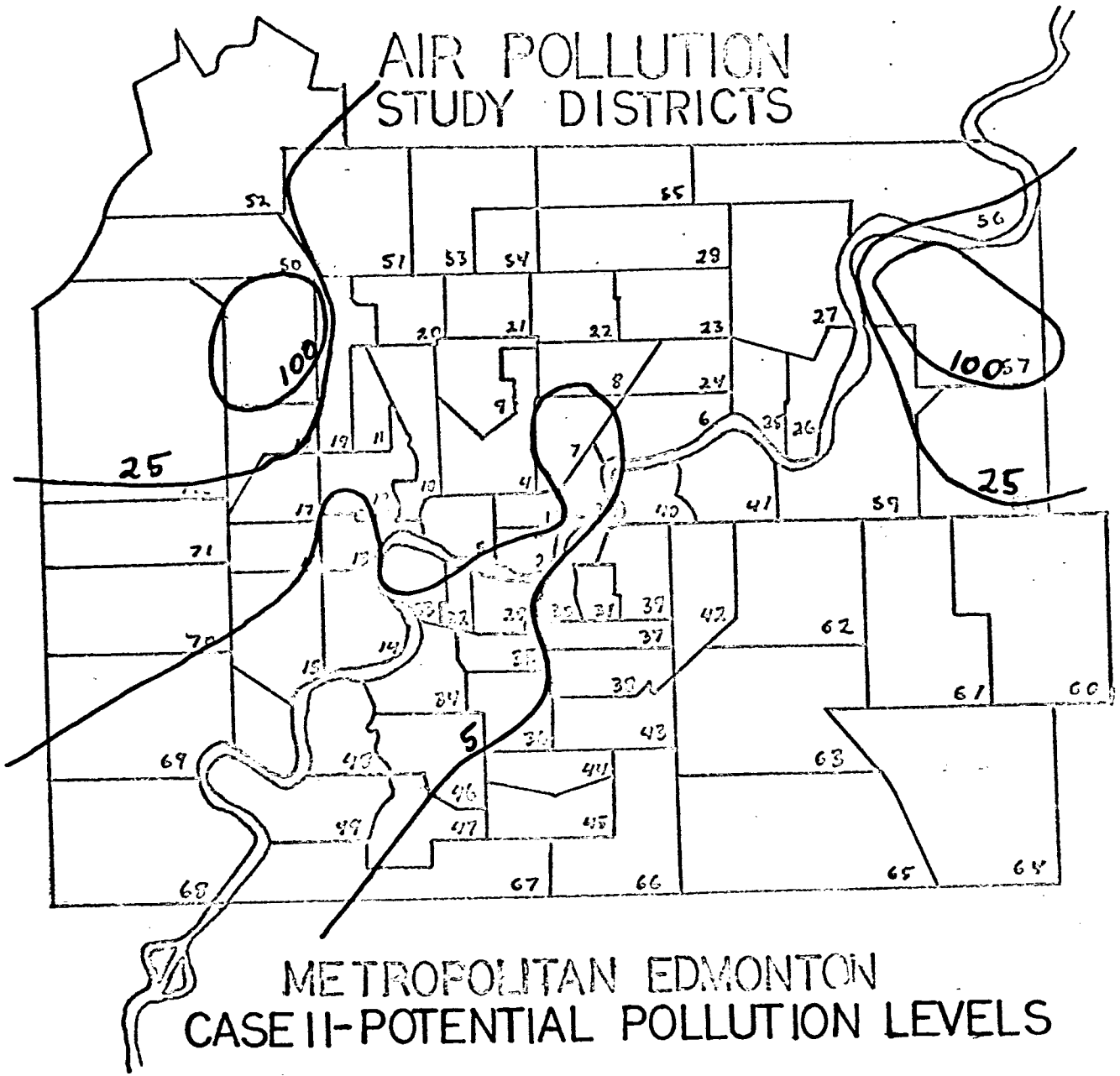
The Results. The results for the first case are shown on illustration III following this page. The south-west portion of the area had the lowest potential pollution level, which might be expected subjectively, but it was interesting that some central districts had


AIR POLLUTION
STUDY DISTRICTS
100
100
100
100
25
25
METROPOLITAN EDMONTON
CASE I - POTENTIAL POLLUTION LEVELS
MILES

higher potentials than ones right at the edge of the south-east industrial zone where the maximum potential existed. Since no subdivisions of the metropolitan industrial zone were taken into account, the picture is extreme. However, performance standards as such are not really enforced, and no use list is employed in the municipal zoning approval procedures so that it may not be far from reality.

Illustration IV, the second case, shows that the hypothesis is indeed valid, with the assumptions taken. It would appear that by locating air pollutant industries with meteorological factors in mind a drastic lowering of potential pollution levels could be achieved. Even if the present situation were left as it presently exists and new air pollutant industries were so located this would be true. Of course, restrictions within the other industrial zones were implied for new industry at least so that the hypothesis perhaps does not go sufficiently far.

The numbers listed in the Appendix representing potential pollution levels should not be interpreted as being too precise. In fact, air does not travel as a straight horizontal flow so that the illustration has greatly simplified a complex situation. The quantities presented can be compared relatively, but should not be taken to represent dramatic differences between districts even if one has a figure of 10.3 and another 28.4. What




METROPOLITAN EDMONTON
CASE II - POTENTIAL POLLUTION LEVELS

IV

is significant is the great drop in most districts from the first case to the second, and the validity of the air zoning concept.

Limitations. The method described would perhaps have a use in area source location control. It is not precise and one doubts that the meteorologist could accept it as it stands. However, there is every likelihood that a more sophisticated technique could be perfected. The concept was brought forward for illustration purposes only and does not purport to be a widely usable technique in area source location decisions. With it however, a crude picture was presented of the implications of such a decision on the metropolitan area as a whole. Atmospheric pollution levels depend on other factors such as emission quantitites of different sources, so that only a preliminary picture was illustrated.

Conclusion. Industrial location planning may be employed for the purpose of air pollution control. However, such planning is not a substitute for air pollution control through engineering abatement techniques, and it should be administratively integrated with the agency responsible for such control. The theoretical method conceptualized here has illustrated that such a programme would be both possible and purposeful.

# V. SUMMARY

Metropolitan Los Angeles has suffered from an air pollution problem and its control authority has explored various methods for abatement. The counties of California are responsible for air pollution control in that they have the right under law to create county-wide control districts. Planning control on the other hand is essentially a city function and is the responsibility of 70 jurisdictions within Los Angeles County. The Control District has advised two planning authorities on single source cases, but area source locational decision-making has not been successful. Mandatory air zoning at the County level was considered the answer, but was never enacted.

In the Edmonton metropolitan area as a contrast area-wide planning control has existed since 1958 and province-wide air pollution control since 1961. The Regional Planning Commission and Provincial Sanitary Engineer have integrated their control operations so far as new single sources are concerned. Area source location control has not been implemented, though considered as early as 1952. Pollution levels indicate that Edmonton has a problem greater than normal for a city its size, and that stricter abatement methods are needed.

The hypothesis was analyzed by means of a quanti-

fiable method, depending on wind direction and distance variables. Non-industrial sources were ignored in the study which illustrated relative potential pollution levels for 73 districts of the metropolitan area in two situations. The second situation created an M-4 air pollutant industry zone, and restricted emissions to within zone boundaries elsewhere. The results showed that through locating such industries according to meteorological criteria, potential pollution levels could be significantly lowered. The hypothesis did not go far enough in expressing the need for complementary engineering abatement controls.

# CHAPTER VI

# POLICY RECOMMENDATIONS

## I. INTRODUCTION

In the formulation of recommendations towards metropolitan atmospheric pollution control policies related to industrial location planning, it is first necessary to describe other locational factors. Second, an evaluation of the validity of the hypothesis and the methodology of its analytical inquiry is required. Third, various policy recommendations are presented to show the utility of the study in decision-making. Finally, a suggested method for implementation of these proposals is described.

## II. INDUSTRIAL LOCATION FACTORS

In the allocation of land for industrial use, the planner should consider many other criteria beyond air pollution control. The Lower Mainland Regional Planning Board, for example, undertook a study "to designate areas for industrial use within the next 15 years"[1] without any consideration of atmospheric pollution ramifications.

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[1] Lower Mainland Regional Planning Board, The Dynamics of Industrial Land Settlement (New Westminster: The Board, 1961), p. 1.

Economic and transportation factors were analyzed in terms of industrial plants needs.

Overall Locational Needs. One point of view is to regard an industrial zone as a work area which should be so located as to make it accessible to its labour force. Transportation facilities and mass public transit routes are of particular significance to certain industries. Utility services may also be so relevant as to make particular locations more desirable.

A slope of less than five per cent is another general locational determinant for industrial development. Also, a range of locations from the central core to the fringes should be provided for different types of manufacturing operations. Space requirements differ among the range of firm-types regarding parking, loading, and storage areas, the requirements having expanded because of the one storey plant having become the standard. Outlying locations have necessarily been favoured. Commuting time from residential areas may limit the amount of this decentralization, and many industries require central locations for marketing purposes to be close to their clientele.

Rezoning Factors. The planning authority, before increasing and extending industrial zoning must consider the amount of such land unused at the time. With a low

vacancy rate prices are raised due to the shortage, and development is discouraged. With the high land values industrial zoning creates, long-term holding before use becomes possible. In 1952, for example, one municipality's industrial area was undermined by old coal operations reducing the unused area from 46% to 20% of the total usable, and this was considered by the planners as undesirable.[2] An excess amount of industrial zoning, on the other hand, would encourage premature farm abandonment and speculation.

Other considerations include fragmentation of land, access, and slope. If the land were split into residential size lots rezoning for industrial use without consolidation would be impractical. Access includes road, rail, and utilities. Proximity to a large water supply would also be important for certain industry types. Slope may limit servicing and drainage as well as be excessive for large buildings.

One example of how the various factors were considered is illustrated in the Fort Saskatchewan Part of the Edmonton Regional Plan. The proposed heavy industrial area was considered to have

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[2]Edmonton District Planning Commission, Annual Report (Edmonton: The Commission, 1953), p. 11.

> the advantage of having rail access, access to River [sic] water, easy highway access, proximity to gas supply, ideal location for air pollution control, being in the direction of least frequent winds. Access from the residential area is easy and direct. 3

This 1,350 acre industrial area which included one glass, one ore reduction and three chemical plants had been directed in its growth by a general plan since 1954.

Other factors include the expansion of the local property tax base through diversification though this should not affect locational decisions unless the municipality's land area is deficient. In areas where water access is an important locational factor there may be potential conflicts between this critical need and highway transportation or air pollution control policies.

Conclusion. Air pollution control is only one consideration among many which the planning agency must consider in recommending an increase in the amount of industrially zoned land at a certain location. The objective should be the maximization of all the considerations when making the locational decision. Though this may be quite facile in the case of the smaller urban area, at the multi-jurisdiction metropolitan scale where large portions are only partially developed or where employment

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[3]Edmonton Regional Planning Commission, Background Information--Fort Saskatchewan Part Preliminary Regional Plan (Edmonton: The Commission, 1964), p. 10.

concentrations will overtax transportational facilities there may be considerable difficulty in achievement of all considerations. Control of air pollution through abatement methods should be a requirement of development in areas where pollution potentials would be seriously augmented in the process.

## III. ASSESSMENT OF THE HYPOTHESIS

The hypothesis is that the control of industrial location by all levels of government in a cooperative manner, taking into account the applicable meteorological factors, would significantly reduce potential atmospheric pollution. Each aspect of this statement is considered below.

Control of Industrial Location. The different objectives and methods of industrial location control have been described, the emphasis being on area source location control by means of air zoning. This is considered to be both practical and purposeful as a means to control area source location at the metropolitan or regional scale. Both methods of inducement and compulsion are available to reinforce this technique.

Government. Socio-economic objectives have been pursued by the senior governments in locating industry, whereas the local governments have tended to stress the

zoning by-law which controls physically the locational decision-making of industry. The senior governmental levels could utilize economic inducements to encourage desirable physical location relative to population concentrations. They could also do this directly using their own legal authority. Cooperative effort was exemplified by the Department of Public Health's integration into intermunicipal industrial development decision-making within the Edmonton area.

Meteorological Factors. The considerations which must be analyzed in order to locate industry for atmospheric pollution control purposes are of meteorological character. These were described at length, wind direction frequency as measured at certain time periods being the most important. Topographic modification of air movements was also stressed. The need for detailed air flow measurements at the micrometeorological level was illustrated as a prerequisite to locational decision-making. It was concluded that averages of a gross nature do give an indication of the general conditions.

Potential Pollution Levels. An inquiry was made into the effects of air zoning which showed that with certain assumptions a reduction in potential pollution level could be achieved. However, engineering abatement

methods must be employed in conjunction with area source location control. Since it is simply not possible to decentralize all industry, restricted emission zones are needed close to the central portions of urban areas where plant sites are desired by certain industry types.

Other Areas of Investigation. Transportation planning and air pollution control could be investigated and documented in a similar manner. There are probably conflicts between the solutions in transportation planning and those in industrial location planning, in that decentralization of industry, for example, would lead to longer periods of automobile exhaust emission. With more data, factor correlation would have been possible in the study presented in order to identify likely causal relationships. With more statistical knowledge in fact, more sophisticated potential pollution models could be constructed to aid in the process of locational decisions.

Conclusion. The hypothesis provided a needed focus to this subject which infringes upon so many professional disciplines. Other facets of air pollution control do exist which interest the planner, but it appears that control of the location of industrial pollution sources will become even more important in future with abatement of motor vehicle sources. The hypothesis appears to be a reasonable and practical

point of view with which to approach air pollution control and industrial location planning.

## IV. POLICY RECOMMENDATIONS

In the investigation of air pollution control and its importance and relevance to community and regional planning certain issues were presented. Policy considerations for all levels of government might be suggested to establish a high level of cooperative control. In water pollution control, for example, sewage treatment has been stressed with the Federal Government providing low-interest loans, the provinces the standards and impetus, and the local governments the responsibility and drive.[4] General recommendations for governmental policy are described below.

The Effects. The need for more research into the various effects of atmospheric pollution in order to identify specific contaminants has been established. The senior governments, the universities, and private enterprise should provide more financial and technical assistance in this area. The Federal Government is particularly urged to expand its Department of Health and Welfare grant programme.

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[4] T.V.Berry, Pollution Control in the Lower Mainland Communities of British Columbia (Vancouver: Greater Vancouver Water and Sewage and Drainage Districts, 1960), pp.8-9.

Engineering Abatement Methods. The need for research is very important in this area also, so that a similar recommendation may be made. Full use of the legal system is recommended in the passage of air pollution control regulations. Large areas of administrative jurisdiction are needed, and the Province itself would be most suitable. Performance standards within municipal zoning by-laws also depend upon further research into abatement techniques, and discovery of new, simple, and inexpensive methods.

Air Zoning. Locational control based on meteorological factors at the metropolitan and regional scale is recommended. Study of a micrometeorological nature is a necessary prerequisite of the delimitation of restricted emission zones. Many permanent data collecting stations are required. Refinement of pollution potential models would be another approach. Zoning is based on provincial legislation which should be tailored to provide for zoning as a technique of area source location control.

Integration. Abatement control and planning control agencies are recommended to integrate their operations administratively in order to achieve unity of approach. The achievement of an acceptable and continuing high standard of ambient air would be rendered possible. The actual method of integration depends on referral and joint action, but it may be quite different,

area to area. The meteorological agency should enlarge its activities to include a consultative function on area source location matters.

Land Use Planning. The planning process must have goals toward which it is directed. Clean air is undoubtedly one goal which should receive more recognition in community and regional planning. The various other interested professions would also possess this goal, as one of many. It is basically the health and welfare of people that is the main concern; the future societies which are to inhabit the large metropolitan industrial complexes should continue to have clean air to breathe.

## V. IMPLEMENTATION

Additional administrative organizations are needed in order to achieve the policies described above. New measures are necessary in both air pollution and planning control utilizing the resources of all three levels of government. The philosophy of cooperative federalism is reflected in the suggestions, as a joint approach is necessary in dealing with the air pollution problem.

The Canada Air Pollution Control Act. Federal Government leadership is recommended in the field by the passage of a Federal Act. Several features of the proposed Act should be stated:

1. The Department of Health and Welfare would be responsible for administration of the Act, and coordination of all aspects.
2. Research grants would be provided to universities, provincial governments, and other research agencies, the purpose being the establishment of a Canada Air Pollution Control Code.
3. Federal funds, delegated powers, and representatives would be assigned to provincially created Air Pollution Control Boards.[5]
4. None of the above would be assigned without certain common requirements being met by the Provinces.
5. If no Boards were created there would be provision for application of regulations in the federal jurisdiction such as railways, shipping and criminal law.
6. The Canada Air Pollution Control Code (or preliminary codified regulations) would be employed by each Board unless stricter standards were desired.
7. Incentives to industry would be provided in the manner of subsidies on control equipment and tax

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[5]This delegation became possible in 1952. See W.R. Lederman, The Courts and the Canadian Constitution (Toronto: McClelland and Stewart Ltd., 1964), p. 159.

incentives to locate in approved Air Zones might also be created in the various tax Acts.

8. Measurement of meteorological parameters would be left to the Department of Transport, but provision would be made for consulting work to metropolitan and provincial agencies, where special data was required.
9. Air pollutant level measurement would be under the direction of D.O.T. in conjunction with the Department of Health and Welfare, but authority would be under this Act, and actual measurement would be a provincial responsibility.

The Act would create a new interest in air pollution control and serve to provide a first step in a concerted effort to improve ambient air quality.

The Provincial Air Pollution Control Acts. Provincial action is also necessary to effect the programme since most sources could only be controlled within their jurisdictions. The following features are proposed for inclusion in the accompanying Provincial Act:

1. All municipal power to control air pollution would be revoked except for nuisance by-laws and industrial zoning performance standards.
2. An Air Pollution Control Board for the Province would be created with quasi-judicial and quasi-

legislative functions, and with provision for federal representation upon them.

3. The Canada Air Pollution Control Code would be adopted as regulations for the Board to administer, but provision would be made for the Board to adopt stricter regulations with the approval of the Cabinet.
4. Research into the effects of air pollution, its measurement, and its abatement control would be a responsibility of the Board's staff with co-ordination at the federal level.
5. A permit system would be established requiring approval of all new pollutant sources by the Board before construction commencement.
6. Any expansion of a source or major change in pollutant emission composition would require a permit from the Board.
7. Inducement subsidies on control equipment would be provided for by rebates on sales taxes and by not including them in value of property etc. (Tax incentives might also be used under the tax Acts to encourage location in approved air zones.)
8. Integration with planning authorities would be clearly set out in a formal manner requiring referral by them of development applications (of cases listed by the Board) and consultation

before industrial zone change decisions.

9. The Board would be responsible for air pollutant level measurement in accordance with national standards, and for maintaining and creating a network of data stations.

The Provincial Planning Acts. Planning should remain an area of provincial jurisdiction in which the province itself would play a direct part. Local government should continue to have some responsibilities in matters of local concern. It should also be stated that where the existing planning organization could accomplish these tasks it should be retained. The following proposals are only those which are related to air pollution control, so that a comprehensive Planning Act would require many more features:

1. Planning agencies, responsible for the delineation of major zoning categories would be created in all metropolitan and major urban areas, the area of jurisdiction depending on provincial planning policies.
2. These agencies would be responsible to the Cabinet and not local governments.
3. They would prepare regional zoning regulations for their areas, which would only be in force after Cabinet approval.

4. The usual procedures of public meetings for individual and municipal discussion and criticism would be required.
5. The regulations, once approved, would be binding on all municipalities, requiring conformance of their more detailed by-laws.
6. Air zoning would be included in the specified requirements set out by the Act.
7. Municipalities would still issue development permits but would be required to refer applications to the planning agency for interpretation and recommendation.
8. Referral of development applications to the Air Pollution Control Board would be required if the proposed use was found to be on the list provided by the Board.
9. Performance standards and detailed zoning requirements would be left to municipal authorities though the agency would be permitted to recommend on these matters (standards would necessarily have to be stricter than Board regulations).
10. Consultation with the Board would be required before zoning change decisions were recommended to the Cabinet by the agency.

Conclusions. The above descriptions of the

proposed method of implementation make explicit the view that Air Pollution abatement be considered so important that the Federal Government take the leadership. Boards in each Province would possess the administrative and quasi-legislative powers necessary to regulate the emission of atmospheric contaminants. Air would be recognized as an important natural resource that should be conserved as it is irreplaceable and fundamental to human life.

## VI. SUMMARY

There are several other factors besides air pollution control which should be taken into account in the allocation of industrial land. The needs of industry and the capacities of the metropolitan transportation network are of paramount importance. However, air pollution control must be considered in conjunction with these other factors in industrial land allocation decision making and not ignored or given less relative weight.

The hypothesis provided direction in the discussion and description of the air pollution problem from the community and regional planning viewpoint. The role of the three levels of government in influencing and directing locational decisions was presented.

Meteorology as the chief consideration in area source location control was described as the necessary prerequisite information. It was concluded that potential pollution levels may be significantly reduced by utilizing planning in conjunction with abatement methods.

General policy recommendations were outlined. Research into the effects of atmospheric pollution is required so that senior government support is needed. Abatement methods not only have to be devised, but given the necessary legal force in all parts of Canada. Air zoning based on a meteorological data collection programme is recommended as desirable in all metropolitan and major urban areas. Integration with the emission abatement agency is necessary to the total approach. Increased recognition of atmospheric pollution control objectives and clean air goals by community and regional planners is required, along with cooperation of other professionals.

The Federal Government should assume the leadership in this matter since it is of national importance. A Canada Air Pollution Control Act is recommended to implement the policies described above. Provincially created boards to control air pollution and to do research would be organized with federal funds, delegated powers, and representatives provided by the Act.

These boards would work in cooperation with metropolitan and major urban area planning agencies, directly responsible to the Provincial Cabinet. Local government would still control development in conformance with the agency's regional zoning regulations after they had been approved by the Cabinet. Air zoning would be included in the regulations and integration with the Air Pollution Control Board formally required.

The ultimate goal should be that the future society, living in the metropolitan and industrial complex, should have the right to breathe clean and pure air. It is hoped that this study aided in presenting the reasons, methods and aims of the physical planner in directing his plans towards that goal.

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# APPENDIX

# APPENDIX

The following sections list Edmonton meteorological data, derived potential pollution figures, and the formula employed in the inquiry into air zoning described in Chapter V:

## I. HOURS OF WIND 1938-1963

| | Total | N | NE | E | SE | S | SW | W | NW | C |
|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 19344 | 2099 | 1623 | 1622 | 1213 | 4401 | 2959 | 2685 | 2603 | 139 |
| Feb. | 17616 | 2096 | 1735 | 1786 | 1739 | 3870 | 2140 | 1975 | 2156 | 119 |
| March | 19344 | 2026 | 1628 | 1995 | 2895 | 4315 | 1888 | 1935 | 2592 | 70 |
| April | 18720 | 2145 | 1723 | 1807 | 3198 | 3649 | 1512 | 1778 | 2862 | 46 |
| May | 19344 | 2397 | 2179 | 1903 | 3024 | 2932 | 1430 | 1932 | 3502 | 45 |
| June | 18720 | 2225 | 1897 | 1722 | 2420 | 2568 | 1631 | 2825 | 3395 | 37 |
| July | 19344 | 2057 | 1436 | 1423 | 2011 | 2854 | 2124 | 3138 | 4244 | 57 |
| Aug. | 19344 | 1859 | 1439 | 1520 | 1910 | 3313 | 2421 | 3153 | 3641 | 82 |
| Sept. | 18720 | 2083 | 1090 | 1184 | 1848 | 3797 | 2159 | 2705 | 3789 | 65 |
| Oct. | 19344 | 1295 | 908 | 1025 | 2009 | 5254 | 2682 | 2713 | 3408 | 50 |
| Nov. | 18720 | 1431 | 1152 | 1465 | 1679 | 4590 | 2735 | 2705 | 2873 | 70 |
| Dec. | 19344 | 1493 | 1320 | 1440 | 1556 | 5192 | 3280 | 2640 | 2321 | 152 |

Source: Department of Transport, Edmonton Municipal Airport

## II. AVERAGE DIRECTIONAL FREQUENCY 1938-1963

| Direction | N | NE | E | SE | S | SW | W | NW |
|---|---|---|---|---|---|---|---|---|
| Percentage of Hours | 10 | 8 | 9 | 11 | 20 | 12 | 13 | 17 |

Source: Computed from above table

## III. POTENTIAL POLLUTION LEVELS

| Study District | Case I | Case II |
|---|---|---|
| 1 | 59.2 | 6.2 |
| 2 | 50.3 | 4.5 |
| 3 | 62.0 | 4.5 |
| 4 | 93.3 | 6.8 |
| 5 | 45.0 | 14.7 |
| 6 | 68.7 | 0 |
| 7 | 96.2 | 4.9 |
| 8 | 96.0 | 3.3 |
| 9 | 86.0 | 8.9 |
| 10 | 55.0 | 11.5 |
| 11 | 52.4 | 18.5 |
| 12 | 44.4 | 9.7 |
| 13 | 39.0 | 0 |
| 14 | 19.7 | 0 |
| 15 | 15.8 | 0 |
| 16 | 35.7 | 5.6 |
| 17 | 52.1 | 21.3 |
| 18 | 100.0 | 27.0 |
| 19 | 100.0 | 15.8 |
| 20 | 46.3 | 10.1 |
| 21 | 65.3 | 6.8 |
| 22 | 64.9 | 5.8 |
| 23 | 100.0 | 17.4 |
| 24 | 100.0 | 9.0 |
| 25 | 84.0 | 7.3 |
| 26 | 81.5 | 17.0 |
| 27 | 100.0 | 19.3 |
| 28 | 37.0 | 5.5 |
| 29 | 24.1 | 4.9 |
| 30 | 74.3 | 3.8 |
| 31 | 70.4 | 5.4 |
| 32 | 28.7 | 2.1 |
| 33 | 29.0 | 6.2 |
| 34 | 29.8 | 0 |
| 35 | 70.5 | 4.0 |
| 36 | 100.0 | 1.5 |
| 37 | 100.0 | 5.4 |
| 38 | 100.0 | 5.0 |
| 39 | 76.1 | 6.3 |
| 40 | 78.9 | 6.7 |
| 41 | 70.9 | 5.7 |
| 42 | 100.0 | 5.8 |
| 43 | 100.0 | 5.1 |
| 44 | 100.0 | 5.9 |
| 45 | 100.0 | 3.9 |
| 46 | 36.3 | 4.6 |

| Study District | Case I | Case II |
|---|---|---|
| 47 | 10.1 | 1.1 |
| 48 | 11.3 | 0 |
| 49 | 5.2 | 1.9 |
| 50 | 78.0 | 43.0 |
| 51 | 88.9 | 0 |
| 52 | 100.0 | 32.0 |
| 53 | 53.0 | 7.2 |
| 54 | 51.5 | 0 |
| 55 | 28.7 | 3.7 |
| 56 | 38.5 | 19.8 |
| 57 | 100.0 | 100.0 |
| 58 | 80.0 | 35.0 |
| 59 | 100.0 | 18.0 |
| 60 | 100.0 | 16.2 |
| 61 | 69.0 | 10.7 |
| 62 | 100.0 | 6.4 |
| 63 | 100.0 | 4.7 |
| 64 | 34.2 | 4.8 |
| 65 | 29.3 | 3.9 |
| 66 | 100.0 | 4.2 |
| 67 | 20.8 | 5.3 |
| 68 | 3.0 | 1.4 |
| 69 | 6.7 | 2.7 |
| 70 | 8.3 | 5.9 |
| 71 | 20.6 | 6.3 |
| 72 | 38.0 | 27.0 |
| 73 | 100.0 | 100.0 |

## IV. POTENTIAL POLLUTION LEVEL CALCULATION

The calculation of the potential pollution level for a particular study district is accomplished by the use of the following:

$$P.P.L. = \left(\frac{f}{d}\right)_N + \left(\frac{f}{d}\right)_{NE} + \left(\frac{f}{d}\right)_E + \left(\frac{f}{d}\right)_{SE} + \left(\frac{f}{d}\right)_S + \left(\frac{f}{d}\right)_{SW} + \left(\frac{f}{d}\right)_W + \left(\frac{f}{d}\right)_{NW}$$

f = percentage of hours of wind from that compass direction

d = distance in that direction to nearest industrial zone, this number assumed to be never less than one