Report No. ARB/EP-76001

EMISSIONS AND AIR QUALITY

ASSESSMENT

California Air Resources Board
Technical Resources Unit/Land Use Planning Program
Evaluation and Planning
1709 Eleventh Street
Sacramento, California 95814

April 1976

STATE OF CALIFORNIA
EDMUND G. BROWN JR., Governor

AIR RESOURCES BOARD
09--11th STREET
SACRAMENTO 95814

APR 8 1976

All APCDs
All RTPAs
All AQMP Task Forces
William Schaefer, Acting Chief, DOTP, CalTrans
George Hill, Chief, CalTrans Transportation Lab

Gentlemen:

Subject: Motor Vehicle Emissions Estimates

The Air Resources Board (ARB) has in the recent past suggested use of the report "Interim Estimates of Emissions from Mobile Sources in California" (IEE) as the basis for estimating mobile source emissions. At that time, the staff felt the IEE reflected California vehicle emission rates more accurately than data from other sources. However, in December 1975, EPA released Supplement 5 to its report, "Compilation of Air Pollutant Emission Factors". Supplement 5 contains more recent data for estimating mobile source emissions. The most significant differences between IEE and Supplement 5 are in estimates of heavy duty vehicle emissions with Supplement 5 indicating higher emissions in future years. Based on this more recent information, the ARB has decided to use Supplement 5 with minor modifications as the basis for ARB emissions assessments for motor vehicles. Free copies of Supplement 5 are available to government agencies and non-profit organizations through the Air Pollution Technical Information Center, Research Triangle Park, N.C. 27711.

Supplement 5 data, with minor modifications to characterize the data for California, will be incorporated into a California Department of Transportation computer program named "EMFAC". EMFAC presently contains IEE data. ARB staff expects to have EMFAC updated and on-line with Supplement 5 data by mid-April. The minor modifications being made to Supplement 5 data reflect the implementation schedule for emissions standards in California and consider vehicle population distributions specific for California. These

modifications will be documented and made available concurrent with the incorporation of Supplement 5 data in EMFAC. Questions regarding the status of the EMFAC program update should be addressed to Andy Ranzieri (916-445-9798).

Sincerely,

Thomas C. Austin

Tom Austin
Deputy Executive Officer -
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EMISSIONS AND AIR QUALITY ASSESSMENT

PREFACE

This report, "Emissions and Air Quality Assessment", is intended to serve as an introduction to major technical considerations and to provide the necessary baseline data and information for quantifying emissions and air quality impacts. "Emissions and Air Quality Assessment" has been developed for individuals who do not have a strong background in the technical areas relevant to air quality planning. However, some familiarity with the physical sciences and, more importantly, an interest in the subject matter are assumed. This report is part of a process of documenting emissions and air quality assessment methodologies for this audience. This process will continue, and this material will be revised to reflect new information and the comments of various user groups.

The discussion of certain topics is quite detailed; other topic areas are treated at the lay public level. This non-uniform treatment reflects both the priorities of the authors and the state-of-the-art of the technical data bases for these areas. The text is extensively referenced for further reading in areas of interest or priority.

In recent years, there has been considerable effort to integrate air quality considerations into ongoing land use and transportation planning processes. This activity includes both the policy/institutional areas and the technical areas. The magnitude of this effort is demonstrated by the number of references in this report, which by no means represents an extensive literature search. For these reasons, this report is not intended to replace or supersede existing works. Rather, it is intended that this report be used in a complementary manner with other documents covering these subjects. The "Air Quality/Land Use Planning Primer for California" presently being developed by Air Resources Board staff treats the policy/institutional considerations of interest in California. The Primer is a complement to the technical material presented in "Emissions and Air Quality Assessment."

It is recommended that those individuals/agencies who will be involved in air quality planning activities establish an air quality technical library. A majority of the documents referenced in the bibliography are available from the Air Pollution Technical Information Center (APTIC) or the National Technical Information Service (NTIS). The documents available from APTIC are free of charge to non-profit organizations. Documents obtained from NTIS must be purchased.

With regard to the format of this report, each section was developed as a separate element. References are indicated by numbers in brackets [ ] and are listed at the end of each section. Appendices for each section are also placed at the end of the section.

Comments and suggestions regarding this document should be directed to:

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EMISSIONS AND AIR QUALITY ASSESSMENT

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1. INTRODUCTION

1.1 PHYSICAL PROCESSES/CARRYING CAPACITY

By and large, the ways in which pollutants are created and released into the atmosphere are understood from a scientific standpoint. However, why they continue to be released, often to the detriment of human beings, involves considerations which are based upon factors other than those embraced by the domain of science and technology. They include the economic, political, and psychological motivations that traditionally influence human decisions. A schematic representation [1] of those factors impacting on air quality is shown in Figure 1.1.

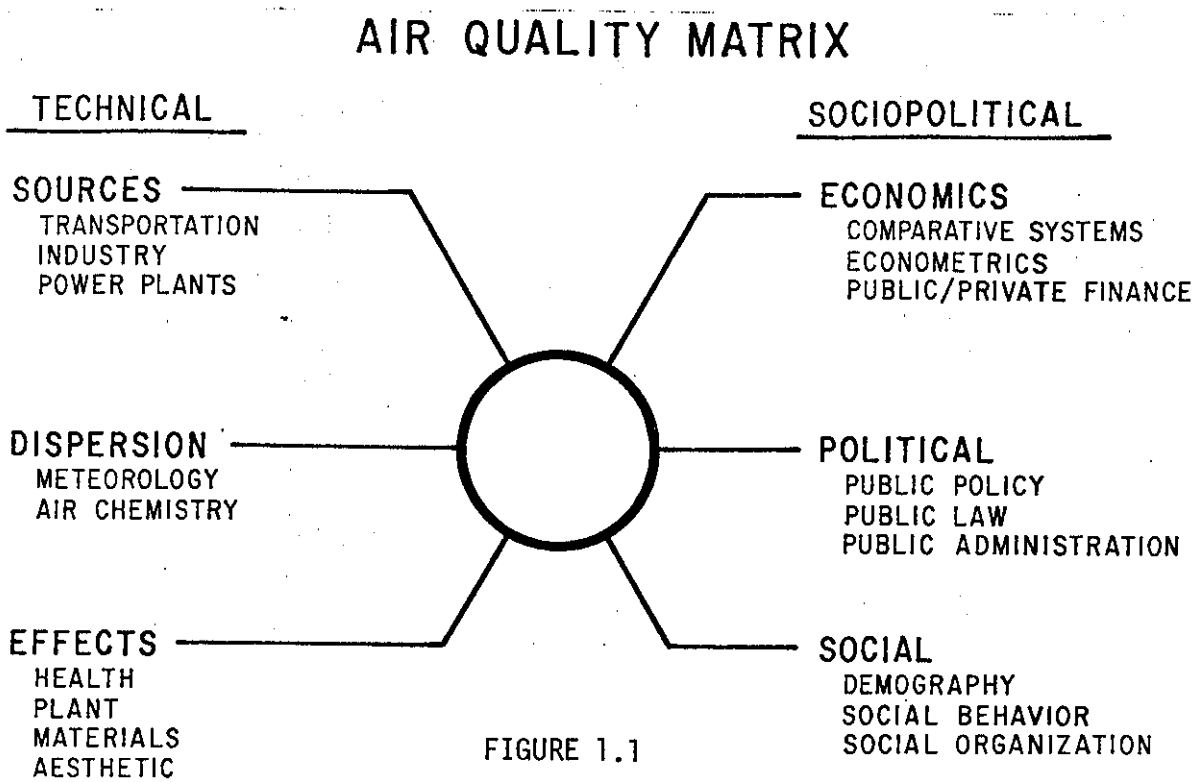


FIGURE 1.1

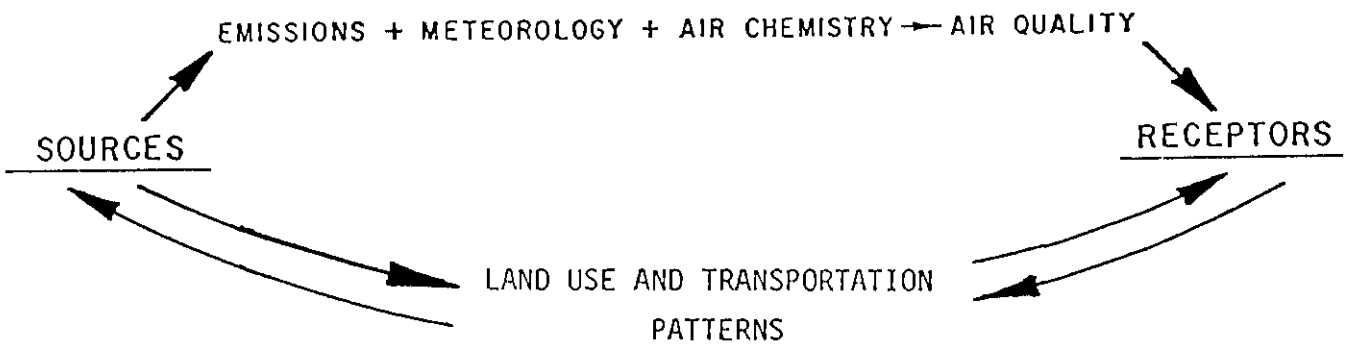
If solutions are to be found to alleviate the problem of air pollution, they must necessarily recognize the complex nature of the causes. Individual initiative to date has not solved the problem, so governments at various levels have shouldered the responsibility of initiating pollution controls.

It is often suggested that substantial advances will be forthcoming only if there is a social or political about-face from which develops a greater dependence by citizens upon mass transportation, more efficient use of our energy resources, and control over population growth. It is not the purpose to discuss these aspects of the air pollution problem. Certainly many novel social, political, and legal concepts must be introduced to meet the demands that citizens now make for cleaner air. But solutions to the problem of air pollution will not be found unless the *physical* nature of the phenomenon is understood [2]. It is this physical nature of air quality planning that will be emphasized in this report.

In discussing the relationships of planning to future air quality and the associated technical areas, we should start by establishing a mutual understanding of the physical factors involved. A conceptual representation of the major physical factors to be considered in an air quality planning process is shown in Figure 1.2. This representation indicates the linkages between sources of air pollutants and receptors, i.e., those things affected by air pollution such as humans, animals, vegetation, and materials.

FIGURE 1.2

Physical Processes in Air Quality Planning



Sources and receptors are simultaneously linked by two paths. One path is a one-way path involving the physical processes of pollutant emissions, chemical transformation, dispersion, and transport. The sources shown in the model represent all sources of pollutants in a study area. The emissions associated with these sources are acted upon by meteorological processes resulting in the transport and dispersion of the emissions.

The pollutants participate in physical and chemical processes resulting in the air quality for the study area. This air quality then impacts on the receptors.

The other path linking sources and receptors is a two-way path involving the location and intensities of land use activities and transportation facilities. It is this two-way path of land use/transportation patterns where planning can be expected to influence air quality and the impact of air quality on receptors. The quantity and location (i.e., the spatial distributions) of emissions are a function of land use/transportation patterns. Since these patterns are a result of planning activities, the spatial distributions of emissions and the associated air quality are also a result of planning activities. Changes in these spatial distributions can be made that consider the physical process, and in this way minimize the associated air quality impacts.

Historically, the specification of land use has been comparatively insensitive to air quality considerations. Recent public concern for environmental quality has fostered attempts to improve air quality through direct control of the sources of air pollution. Specifically, the current focus of these attempts is on technology-based emissions control and more efficient fuel utilization. However, this type of approach does not by itself address the broad-based problems of planning for long term air quality. Consequently, such emphasis will not provide for healthful air quality for certain areas of the State.

The inadequacy of technology-based controls is identified in a report on recommended air quality standards [3] to the Air Resources Board by the since-dissolved Technical Advisory Committee.

In some instances the standards which are designed to assure freedom from injury to health cannot be attained by the application of technical methods available now or in the foreseeable future. This incompatibility can be resolved only by drastic changes of life patterns in the most heavily populated areas.

For example, The drastic changes which must occur will have direct and jarring effects on residents of the South Coast Air Basin. Some or all of the following actions are necessary if the air quality of the South Coast Air Basin is to meet the proposed air quality standards.

1. Limit the number and use of automobiles, trucks, and aircraft permitted in the basin.

2. Reduce emissions from these sources to levels below those now proposed.

3. Remove or make essentially emission-free all industries and fossil-fuel power plants in the basin.

4. Develop a comprehensive non-polluting urban transport system.

5. Limit population growth by sharply restricting subdivision and residential expansion in the basin.

6. Limit commercial and industrial growth to zero-emission facilities.

7. Restrict emissions from commercial, agricultural, domestic and recreational sources.

The impact of these requirements staggers the imagination. They stem from the concept that each basin has a limited resource of air, into which the emission of a specific maximum quantity of particulates, nitrogen oxides, carbon monoxide and hydrocarbons can be permitted if the air quality standards are to be met. Once this maximum quantity is reached, no further activity which adds air contaminants to the basin can be permitted if the objective of the air quality standards is to be met and maintained.

The maximum permissible quantity of each category of air contaminants should serve as a guide to the planning, growth and development of each basin where air quality is now at lower levels than the standards, and as a similar guide for the reduction of contaminant emissions in basins where the air quality is above the standards.

The "maximum permissible quantity" is a function of the carrying capacity of an air basin and is just one determinant of air quality. The air quality of an urban environment depends upon:

1. The ability of the environment to disperse, transform, and remove pollutant loadings generated by urban land use activities, i.e., the carrying capacity.

2. Pollutant source characteristics.

3. Background pollutant concentrations.

The capacity of the air basin over a region to disperse, transform and remove atmospheric pollutants depends upon a variety of factors, including the amount and type of pollutants emitted, and meteorological and topographical characteristics of the region.

Pollutant source characteristics include the quantity of emissions and the physical location and configuration of sources. Sources are generally described as point, line and area sources. Point sources represent major, identifiable sources within a region, such as industry or municipal incinerators. Line sources represent emissions from motor vehicles along principal highways and emissions from aircraft. Area sources represent clusters of small, individual sources within a region such as emissions from heating plants in residences and small buildings. Distinctions are also drawn between direct and indirect sources of pollution. Direct sources are those which emit pollutants as a result of activities inherent in their operations (e.g., industrial facilities, housing facilities, etc.). Indirect sources represent major facilities that spawn various emission sources, such as transportation-related activity at an airport or shopping center.

Source emissions are determined by land use category or source type, level of activity or process rate, type and amount of fuel used, source controls and activity schedules. These elements may be specified to

greater detail depending on the type of land use or source type involved. For example, for a given industry, its stack height and smoke temperature would be specified. A source, such as a highway, may be additionally defined as elevated, depressed or at-grade. Each of these parameters contributes to the determination of pollutant source characteristics.

Land use encompasses not only the type of activity intended for land areas, but the physical interrelationship between and among various activities and the type of ground cover on the land. Therefore, land use affects both pollutant source characteristics and the ability of the environment to disperse pollutants.

Background air pollution may be defined as that portion of the measured ambient levels of a pollutant that does not result from anthropogenic activities. Background concentrations may be relatively constant over the planning area, or they may vary significantly within it. It is generally not possible to determine future background pollutant levels with a high degree of accuracy. Consequently, it is necessary to have air quality data available with which to assess the air quality impact of planning decisions relative to projected background air pollutant levels.

1.2 COMPONENTS OF AN AIR QUALITY PLANNING PROCESS

A fundamental determinant of emissions levels, and therefore air quality levels, over which organizational/institutional control can be exercised is the specification of land use. Land use activities, including specific emission sources, can be associated with a rate of pollution discharge. Specification of the types and amounts of residential, commercial, industrial and transportation activity will determine the location, types and quantity of emissions. When these emissions levels are consistent with air quality objectives, the original composition of land use/transportation activities is also consistent with air quality objectives. This linkage of land use/transportation/emissions/air quality forms the basis for an iterative methodology for identifying alternate urban configurations which are compatible with acceptable levels of air quality.

In this way, planning for air quality will be simultaneously a constraint and a directive for planning new development. Though air quality considerations represent a limit on the freedom to designate amounts, types and locations of land uses, it is expected that air quality impacts of development will be considered simultaneously with other planning criteria in designating future land use activities. This simultaneous consideration of air quality can provide for meeting social/economic goals while ensuring that health-protective levels of air quality will be attained and maintained.

In order to achieve such an equitable and realistic level of air resources management, it is necessary to define, develop, and implement the following components within the air quality planning process:

1) a methodology for identifying and evaluating alternate urban configurations for their air quality impacts:

2) guidelines, criteria, and standards which reflect applicable laws and regulations and the priorities of the planning jurisdiction;

3) the corresponding analytical tools to be utilized in the methodology; and

4) the data bases needed to support the analytical tools.

The specific steps within a methodology for assessing the air quality impacts of alternate urban configurations are a function of a myriad of variables including the organizational/institutional responsibilities in the planning jurisdiction, the resources and time available, and the severity of the air quality problem. Many generalized methodologies have been proposed. The steps in these methodologies differ, but they all have the common feature of an iterative procedure in which the air quality impact of an alternative is not known until the assessment methodology is completed. Another common feature is that some systematic procedure for introducing planning and program alternatives is present.

Two of these methodologies are shown below. Figure 1.3 is from the U.S. Environmental Protection Agency's Guidelines series for Air Quality Maintenance Planning [5]. This proposed methodology emphasizes the regulatory aspects of air quality management. Figure 1.4 shows a different methodology [2] which emphasizes the planning activities of air quality management. It should be stressed that these approaches are not mutually exclusive; both conceptual models could be implemented simultaneously. The major point is that it would be pretentious to present an idealized approach to air quality planning with an inference that this is the approach. Rather, it is hoped that each governmental entity will develop its own optimal orientation/methodology/participation in air quality management activities.

The guidelines, criteria, and standards utilized in the evaluation process are a combination of externally-determined and internally-generated parameters (external and internal to the planning jurisdiction). The National Ambient Air Quality Standards established by the U.S. Environmental Protection Agency, which are discussed in Section 2, are examples of externally-determined evaluation parameters.

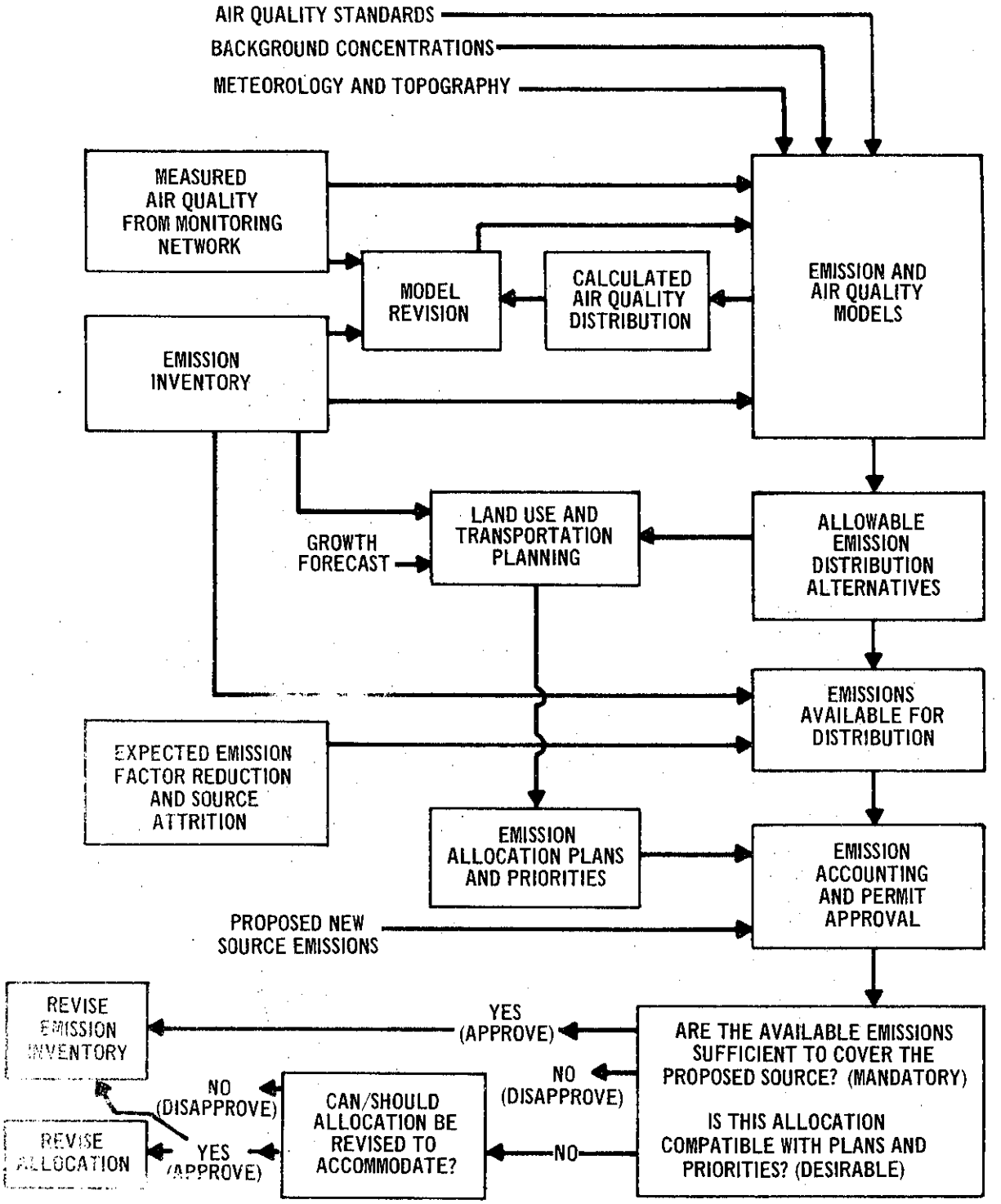


FIGURE 1.3

AIR QUALITY MAINTENANCE PROCESS

From [5]

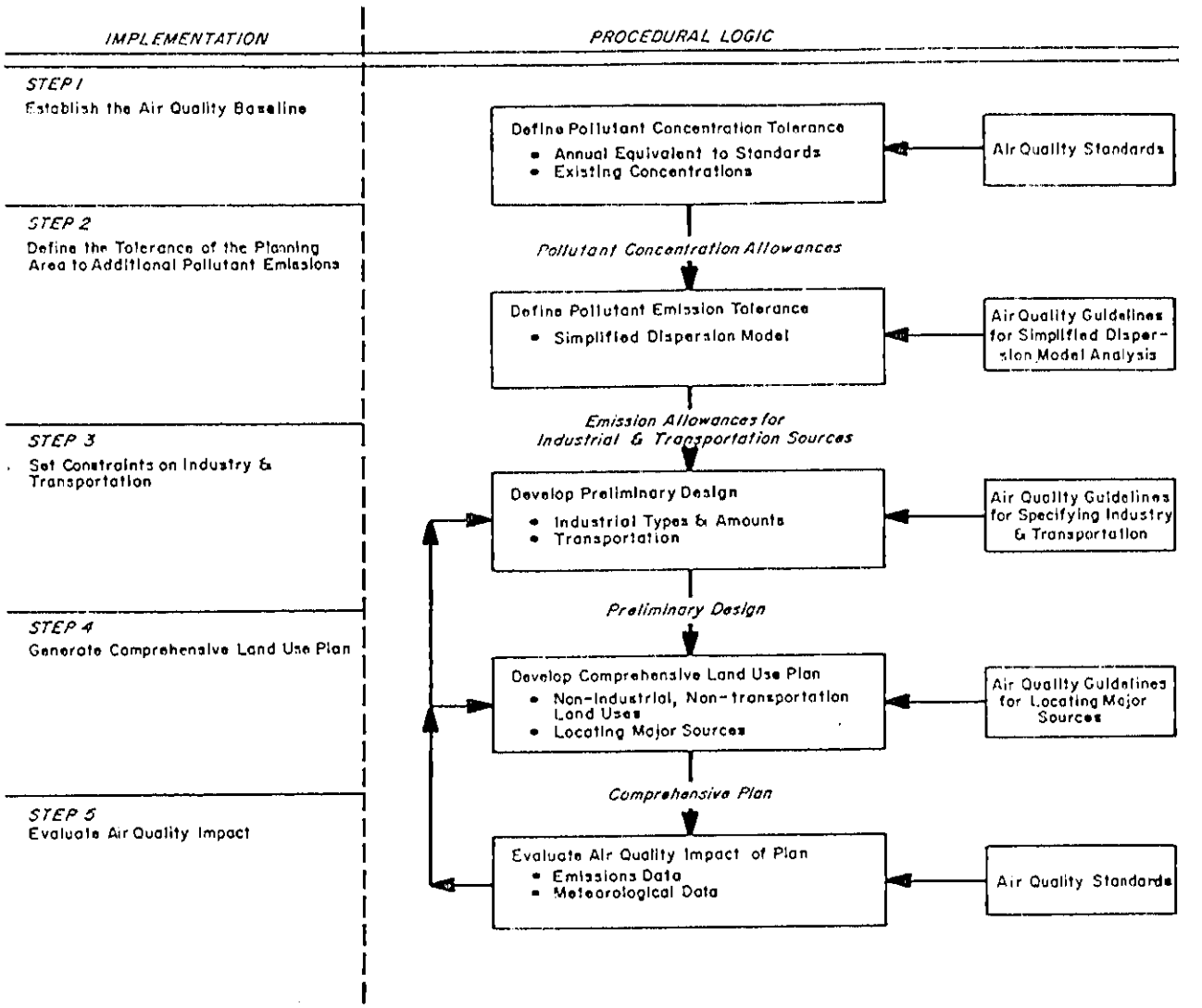


FIGURE 1.4

AIR QUALITY IMPACT - LAND USE PLANNING PROCESS

From [4]

Internally-generated evaluation parameters might include measures of mobility such as transit travel times for certain services, percentage of open space, or specific air quality impact assessment criteria. While seemingly unrelated at first, these parameters do interact in the total system of the urban planning process. Examples of different air quality impact assessment criteria are maximum concentration criteria and total regional dosage criteria. Historically, air quality control strategies have been evaluated by the maximum concentration which would result from their implementation. This approach considers the air quality only at one location in the planning area. An alternate approach would be to consider the air quality for the entire planning area. This approach would quantify the total population dosage through a parameter based on (exposure time X pollutant concentration X population). Such an approach would require identification of the simultaneous geographical distributions of population and air quality.

The basic set of analytical tools needed in any air quality planning methodology is the same; however, the sophistication, complexity, and resource requirements of these tools vary significantly as a function of the methodology. The physical processes shown in Figure 1.2 determine the elements of this basic set:

1) Identification and quantification of source activity,

2) Emissions assessment,

3) Air quality modeling, and

4) Receptor impact assessment.

The data base requirements for these tools also vary significantly as a function of the methodology. An important consideration is that the data base requirements must be within resource and time constraints. These data base requirements and the application of the associated analytical tools become even more difficult, not to mention less accurate, for

future years. For this reason, confidence levels for emissions assessments and air quality estimates should be identified where possible. Unfortunately, the data base for identifying such confidence levels is very limited and this topic is not covered in this edition of this report.

With regard to areas of air quality technical knowledge which need to be improved, we must establish another common understanding. The utility of improved technical information in the planning process depends to a large extent on the philosophy of the planners and the level of accuracy required in technical data and information. If we compare air quality engineering tests and measurements with conventional engineering tests and measurements (e.g., direct current electrical measurements), we find that conventional engineering measurements and tests are defined with very tight limits of accuracy in adopted standards such as those of the American Society of Testing and Materials and the U.S. Bureau of Standards.

At the present time, many air quality engineering tests and measurements do not have such high levels of accuracy. It is unlikely that such accuracy is probable or even possible in the near future. However, there have been significant changes and improvements in the technical information available in the air quality planning process. This information base will continue to evolve as data acquisition and research programs continue.

Two implications of these factors should be emphasized. The technical information base available now and in the foreseeable future provides for good relative quantitative air quality assessments but not good absolute assessments. Also, the information base is in constant evolution and the results of previous studies should be evaluated in light of the most recent information. A specific example of this is the increasing evidence that the number of vehicle trips is more significant than vehicle miles traveled in determining future-year motor vehicle emissions due to cold start and hot soak emissions characteristics of future-year vehicles.

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[1] Samuelsen, G.S., "Air Quality - Who is Responsible?", California Air Environment. Statewide Air Pollution Research Center, v2 n4, October 1971.

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[4] Epstein, A.H.; Leary, C.A.; McCandless, S.T., A Guide For Considering Air Quality in Urban Planning, Contract 68-02-0567 prepared by Environmental Research & Technology, Inc. for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. March 1974. EPA-450/3-74-020.

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SECTION 2. AIR POLLUTANTS AND THEIR SOURCES

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2.1 POLLUTANTS OF INTEREST TO PLANNERS

2.1.1 Definition of Air Pollutant

The term "air pollutant" has many possible definitions. A useful one is to regard an air pollutant as a substance or substances added directly or indirectly to the atmosphere by an act of man, in such amounts as to affect humans, animals, vegetation, or materials adversely. What is classified as a pollutant therefore depends upon the recognition of which substances cause adverse effects. It is an ever-changing definition. Many centuries ago only soot and odorant gases were considered pollutants. Now we recognize that pollutants can cause more subtle effects than the soiling of clothing or disagreeable odors. Some gaseous pollutants are colorless and odorless, and particles too small to be seen can adversely affect man. Even carbon dioxide may be considered a pollutant.

At the outset it would be well to dispel some confusion concerning the difference between a *pollutant* and a *contaminant*. The current tendency is to regard a contaminant as anything added to the environment that causes a deviation from the geochemical mean composition, i.e., what is normally present. Thus contaminants are introduced both by *natural sources*, such as volcanic eruptions and forest fires, and by *anthropogenic sources*, those associated with man's activities. Dust and pollen are generally considered contaminants. Either could be classified a pollutant if it had even an indirect anthropogenic origin and were present in sufficient amounts to have an adverse effect. A deviation from the natural composition of the environment need not cause adverse effects, and therefore the label "contaminant" does not always carry the odious connotation associated with the word "pollutant." In many contexts, however, the words are synonymous [1].

2.1.2 Ambient Air Quality Standards

The pollutants of concern for land use planners are those for which ambient air quality standards have been established and other toxic

TABLE 2.1

AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Time	California Standards [1]		National Standards [2]		
		Concentration [3]	Method [4]	Primary [3, 5]	Secondary [3, 6]	Method [7]
Oxidant (Ozone)	1 hour	0.10 ppm (200 ug/m^3)	Ultraviolet Photometry	160 ug/m^3 (0.08 ppm)	Same as Primary Std.	Chemiluminescent Method
Carbon Monoxide	12 hour	10 ppm (11 mg/m^3)	Non-Dispersive Infrared Spectroscopy	–	Same as Primary Standards	Non-Dispersive Infrared Spectroscopy
	8 hour	–		10 mg/m^3 (9 ppm)		
	1 hour	40 ppm (46 mg/m^3)		40 mg/m^3 (35 ppm)		
Nitrogen Dioxide	Annual Average	–	Saltzman Method	100 ug/m^3 (0.05 ppm)	Same as Primary Standards	Proposed: Modified J-H Saltzman (O_3 corr.) Chemiluminescent
	1 hour	0.25 ppm (470 ug/m^3)		–		
Sulfur Dioxide	Annual Average	–	Conductimetric Method	80 ug/m^3 (0.03 ppm)	–	Pararosaniline Method
	24 hour	0.04 ppm (105 ug/m^3)		365 ug/m^3 (0.14 ppm)	–	
	3 hour	–		–	1300 ug/m^3 (0.5 ppm)	
	1 hour	0.5 ppm (1310 ug/m^3)		–	–	
Suspended Particulate Matter	Annual Geometric Mean	60 ug/m^3	High Volume Sampling	75 ug/m^3	60 ug/m^3	High Volume Sampling
	24 hour	100 ug/m^3		260 ug/m^3	150 ug/m^3	
Sulfates	24 hour	25 ug/m^3	AIHL Method No. 61	–	–	–
Lead	30 Day Average	1.5 ug/m^3	AIHL Method No. 54	–	–	–
Hydrogen Sulfide	1 hour	0.03 ppm (42 ug/m^3)	Cadmium Hydroxide Stractan Method	–	–	–
Hydrocarbons (Corrected for Methane)	3 hour (6-9 a.m.)	–	–	160 ug/m^3 (0.24 ppm)	Same as Primary Standards	Flame Ionization Detection Using Gas Chromatography
Ethylene	8 hour	0.1 ppm	–	–	–	–
	1 hour	0.5 ppm				
Visibility Reducing Particles	1 observation	In sufficient amount to reduce the prevailing visibility to less than 10 miles when the relative humidity is less than 70% (8)		–	–	–

NOTES:

1. California standards are values that are not to be equaled or exceeded.
2. National standards, other than those based on annual averages or annual geometric means, are not to be exceeded more than once per year.
3. Concentration expressed first in units in which it was promulgated. Equivalent units given in parentheses are based upon a reference temperature of 25°C and a reference pressure of 760 mm of mercury. All measurements of air quality are to be corrected to a reference temperature of 25°C and a reference pressure of 760 mm of Hg (1,013.2 millibar); ppm in this table refers to ppm by volume, or micromoles of pollutant per mole of gas.
4. Any equivalent procedure which can be shown to the satisfaction of the Air Resources Board to give equivalent results at or near the level of the air quality standard may be used.
5. National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health. Each state must attain the primary standards no later than three years after that state's implementation plan is approved by the Environmental Protection Agency (EPA).
6. National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Each state must attain the secondary standards within a "reasonable time" after implementation plan is approved by the EPA.
7. Reference method as described by the EPA. An "equivalent method" of measurement may be used but must have a "consistent relationship to the reference method" and must be approved by the EPA.
8. Prevailing visibility is defined as the greatest visibility which is attained or surpassed around at least half of the horizon circle, but not necessarily in continuous sectors.

substances emitted by specific industrial sources. The principal pollutants and the corresponding federal and state air quality standards are shown in Table 2.1.

Air quality standards are of two categories:

1. Standards based on health. These standards are based on research studies which quantitatively relate air pollution exposure to detrimental health effects.

2. Standards based on aesthetic values and the protection of property. These standards are to a certain degree subjective and must reflect the judgments of the community in which they are applied.

There are a number of potentially harmful substances for which no standards can be recommended at present because of insufficient knowledge. In two instances, particulates and visibility, standards have been adopted despite severe limitations of knowledge because they are of such great and immediate concern to the public; additional studies in these and other fields are urgently needed.

There are two types of federal air quality standards, primary and secondary. Primary standards are established for the protection of the public health. Secondary standards are established for the protection of the public welfare, including protection against (known or anticipated effects of air pollution on property, materials, climate, economic values, and personal comfort). The federal primary standards were required to be achieved by May 1975. A two-year extension to 1977 has been granted for selected Air Quality Control Regions (AQCRs) in the nation. The federal secondary standards are to be achieved "within a reasonable time." The California State air quality standards were set as air quality goals with no specified date for achievement.

There are two commonly used systems of units for air quality standards. The California Air Quality Standards for gaseous pollutants are given in terms of parts of pollutant per million parts of air (ppm) or parts of pollutants per hundred million parts of air (pphm). This is a volume per

unit volume measurement. The National Ambient Air Quality Standards are given in terms of micrograms of pollutant per cubic meter (ug/m^3) of air. This is a mass per unit volume measurement. Both the ppm and ug/m^3 measures are appropriate indicators of gaseous pollutant concentrations. However, particulate matter has other characteristics which are important that are not conveyed by a "ppm" reference. Particle size, chemical composition and synergistic effects are examples. Consequently, both state and federal standards for particulate matter are in terms of ug/m^3).

The following equation converts the concentration of gaseous pollutants recorded in micrograms per cubic meter to parts per million by volume based on a reference temperature of 25° C. and pressure of 760 mm of mercury (standard atmospheric conditions).

$$ppm = \mu g/m^3 \frac{(0.0245)}{M.W.}$$

Where,

ppm = Concentration of pollutant in parts per million by volume

$\mu g/m^3$ = Concentration of pollutant in micrograms per cubic meter

M.W. = Molecular weight of the pollutant

$1\ \mu g/m^3 = 10^{-6}\ gms/m^3$

The process for establishing an air quality standard at the federal level includes documentation of effects of the pollutant, relevant research activities, and monitoring techniques in a publication entitled Air Quality Criteria. Air Quality Criteria documents for photochemical oxidants, carbon monoxide, hydrocarbons, particulate matter, sulfur oxides, and nitrogen oxides have been published and are available from the

Environmental Protection Agency [2]. Complementary documents on control techniques for these pollutants are also available [3].

The air quality standards are based on the dosage concept of air pollutant exposure. The dosage of an air pollutant experienced by a receptor depends on the duration and the concentration of the air pollutant. For example, each standard is given in terms of a certain average concentration of pollution experienced for a given duration (See Table 2.1). The air quality standards consider the dosage levels (i.e., the time and concentration) for the respective pollutants at which detrimental effects have been documented. The federal standards include safety margins in that the dosage levels of the standards are below that at which effects have been documented.

The present levels specified in the primary National Ambient Air Quality Standards have been the source of tremendous controversy. One area of this controversy concerns whether the standards represent the "true" levels of air pollution that are damaging to the public health. A study by the National Academy of Sciences [4] specifically addressed this question. The following excerpts are from that study.

> Due to the limitations of present knowledge, it is impossible at this time to establish an ambient air concentration of any pollutant--other than zero--below which it is certain that no human beings will be adversely affected.
>
> Present knowledge of health effects appears to afford no compelling basis for suggestions to either raise or lower the currently mandated primary air quality standards at this time.
>
> The present standards rest upon the best judgments which could be made of effects observed under far from ideal observing or experimental conditions. The impressions gained from the collective presentations and attitudes of those who participated in the conference is that, from the standpoint of health considerations, it would be prudent to retain the present standards until a substantial body of research provides much better evidence than any currently available to indicate that the primary air quality standards should be either relaxed or made more stringent. This conservative view is fostered by emerging data that suggest that

> observed adverse health effects may arise in considerable part not only from interactions of body tissues with the primary pollutants but with unidentified reaction products generated by complex chemical events in the atmosphere or indeed within the lung.

The present body of knowledge supports the current primary standards and thus places air quality planners in a position unique to environmental planners. The air quality standards provide an absolute quantitative parameter which planners can use to evaluate alternate land use/transportation patterns. The evaluation process is a multi-step, complex procedure that is undergoing constant evolution but the end result is a number which allows comparison of alternatives against a predetermined objective.

2.1.3 Air Pollutant Categories

There are several distinctions made in the identification of air pollutants. One distinction is between primary pollutants and secondary pollutants. Primary pollutants are those pollutants that are emitted directly from sources. Carbon monoxide, hydrocarbons (organic gases), oxides of nitrogen, sulfur dioxide, and particulate matter are primary pollutants. Secondary pollutants are those pollutants formed by chemical and photochemical reactions in the atmosphere. Both primary and secondary pollutants participate in these reactions. Photochemical oxidants and nitrogen dioxide (NO_2) are the principal secondary pollutants. Some particulate matter and hydrocarbon (organic gas) species are also generated by photochemical reactions in the atmosphere and are secondary pollutants.

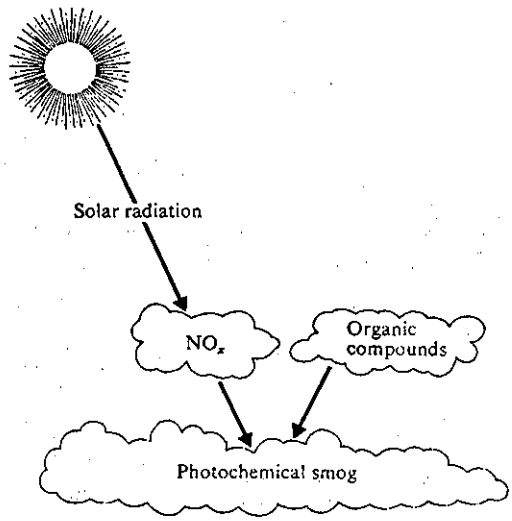
Another distinction in air pollutants is made between stable and unstable pollutants. Stable pollutants are those that do not participate to a significant extent in chemical or photochemical reactions in the atmosphere. Carbon monoxide and most particulate matter are considered to be stable pollutants. Unstable pollutants participate in chemical or photochemical reactions in the atmosphere. Oxides of nitrogen (principally NO and NO_2), photochemical oxidants, and most hydrocarbons and considered

to be unstable pollutants. (Stable and unstable pollutants are sometimes described as conservative and nonconservative pollutants) respectively.

The photochemical reactions mentioned above are part of a complex, multi-step process through which primary and secondary pollutants, in the presence of ultraviolet radiation (sunlight), produce photochemical oxidants. A very simplified representation of this process is shown in Figure 2.1.

Figure 2.1

Ingredients of Photochemical Process



Photochemical oxidant is the designation given to a wide variety of products of photochemical processes. Photochemical oxidants include ozone (O_3), members of the peroxyacyl nitrate family (PAN), hydrocarbon radicals, and certain aerosols. Ozone is by far the largest component of photochemical oxidants.

The organic compounds shown in Figure 2.1 represent the hydrocarbon species that participate in the process. However, the term hydrocarbon is not completely correct. "Hydrocarbon" usually refers to a compound comprising only hydrogen and carbon atoms. Some hydrocarbon species that participate in the photochemical process contain oxygen atoms in addition to their hydrogen and carbon atoms. These compounds are called oxygenated hydrocarbons. Two oxygenated hydrocarbons that are very reactive in photochemical processes are the aldehydes and ketones. The alcohols are examples of oxygenated hydrocarbons which are not important in the atmospheric photochemical process since they are not emitted in comparatively great quantities into the atmosphere.

The term "hydrocarbons" is commonly used to mean all organic compounds but because of possible misunderstandings, the term "organic compounds" or "organic gases" is being used more frequently.

The reactivity of organic gases in photochemical processes is another criteria for categorizing pollutants. Not all organic gases participate at the same rate or to the same extent in the process. As a result, a distinction is made in the reactivity of organic gases. In a summary of emissions for study areas, emissions of organic gases are usually given in terms of total organic gases (TOG) and reactive organic gases (ROG). This emissions summary may also be given in terms of total hydrocarbons (THC) and reactive hydrocarbons (RHC) but again, with this latter terminology, the possibility of a misunderstanding exists.

The reactivity of organic compounds is a very important consideration in emissions assessment and strategy development. If all organic gas emissions from a given source or source category were nonreactive, there would be no value in controlling those emissions if the objective was to reduce photochemical oxidants. If there were two principal source categories in a study area (e.g., mobile and stationary sources), it is important to know the proportion of reactive organic gases emitted by each source category in order for regulatory and planning agencies to develop optimal strategies.

Reactivity factors have been developed for the more common source categories used in emissions assessments. (There are many more source categories than just the mobile and stationary categories given in the example above.) A reactivity factor that considers the characteristics of each category is used to determine what percentage of the total organic gas emissions are reactive. The ROG and TOG emissions are then summed for all the source categories to give the total ROG and TOG emissions for the study area. A more detailed discussion of reactivity of organic gases is presented in Section 3.1.2.

A summary table of acronyms for pollutants and chemical compounds is given in Table 2.2 for future reference.

TABLE 2.2

ACRONYMS AND SYMBOLS FOR
POLLUTANTS AND COMPOUNDS

OG	-	Organic Gases
TOG	-	Total Organic Gases
ROG	-	Reactive Organic Gases
THC	-	Total Hydrocarbons
RHC	-	Reactive Hydrocarbons
NO_x	-	Oxides of Nitrogen
NO	-	Nitric Oxide
NO_2	-	Nitrogen Dioxide
SO_x	-	Oxides of Sulfur
SO_2	-	Sulfur Dioxide
TSP	-	Total Suspended Particulates
PM	-	Particulate Matter
O_x	-	Oxidants
O_3	-	Ozone
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
P_b	-	Lead
H_2S	-	Hydrogen Sulfide
H_2SO_4	-	Sulfuric Acid
XSO_3/XSO_4	-	Organic and Inorganic Sulfates
PANs	-	Peroxyacyl Nitrates (A Family of Pollutant Types)
PPN	-	Peroxypropionyl Nitrate
PB_zN	-	Peroxybenzoyl Nitrate
PAN	-	Peroxyacetyl Nitrate

2.2 SOURCE TYPES AND ASSOCIATED EMISSIONS

2.2.1 Anthropogenic and Natural Sources and Emissions

It is a popular misconception that almost everything present in the earth's atmosphere, except nitrogen, oxygen, and a few inert rare gases, is an air pollutant or the remnant of pollution activities. This is not the case. There are sources in the natural environment of a wide variety of gaseous and particulate materials which are commonly classed as air pollutants when they are emitted by anthropogenic (man-made) sources. In addition, the atmosphere possesses a number of mechanisms which act to remove, sometimes at a quite rapid rate, most if not all of the materials emitted into it.

It is also obvious that while these atmospheric scavenging and dispersion mechanisms are quite effective, they can be overburdened by excessive emissions occurring in relatively short periods of time or in limited geographical areas. The gradual accumulation of carbon dioxide in the atmosphere is a case where the available global environmental scavenging mechanisms are significantly lagging behind the pollutant emission rate. On a much smaller scale, the air pollution problems in major urban areas are examples of situations where the pollution emission rate seriously overburdens the scavenging and dispersion processes within these urban areas [5].

On a relative scale, natural emissions of most pollutants are much greater than emissions from anthropogenic sources. Table 2.3 indicates that global emissions related to man's activities are less than global natural emissions for all pollutants considered except for sulfur dioxide (SO_2) and carbon monoxide (CO).

TABLE 2.3

SUMMARY OF SOURCES, CONCENTRATIONS, AND MAJOR REACTIONS OF ATMOSPHERIC TRACE GASES

Emission Estimates are Global Summaries in Tons/Year

CONTAMINANT	MAJOR ANTHROPOGENIC SOURCES	NATURAL SOURCES	ESTIMATED EMISSIONS		ATMOSPHERIC BACKGROUND CONCENTRATIONS	CALCULATED ATMOSPHERIC RESIDENCE TIME	REMOVAL REACTIONS AND SINKS	REMARKS
			Anthropogenic Sources	Natural Sources				
SO_2	Combustion of coal and oil	Volcanoes	146×10^6 tons	None	0.2 ppb	4 days	Oxidation to sulfate by ozone, or after absorption, by solid and liquid aerosols	Photochemical oxidation with NO_2 and HC may be the process needed to give rapid transformation of $SO_2 \rightarrow SO_4$
H_2S	Chemical processes, sewage treatment	Volcanoes, biological action in swamp areas	3×10^6 tons	100×10^6 tons	0.2 ppb	2 days	Oxidation to SO_2	Only one set of background concentrations available
CO	Auto exhaust and other combustion	Forest fires	275×10^6 tons	75×10^6 tons	0.1 ppm	<3 yr	None known, but large sink necessary	Ocean contributions to natural source probably low
NO NO_2	Combustion	Bacterial action in soil (?)	53×10^6 tons	NO 430×10^6 tons NO_2 658×10^6 tons	NO: 0.2 - 2 ppb NO_2: 0.5 - 4 ppb	5 days	Oxication to nitrate after sorption by solid and liquid aerosols, hydrocarbon photochemical reactions	Very little work done on natural processes
Hydrocarbons	Combustion exhaust, chemical processes	Biological processes	88×10^6 tons	430×10^6 tons	CH_4: 1.5 ppm non CH_4: <1 ppb	16 yr (CH_4)	Photochemical reaction with NO/NO_2, O_3; large sink necessary for CH_4	"Reactive" hydrocarbon emissions from pollution = 27×10^6 tons
CO_2	Combustion	Biological decay release from oceans	1.4×10^{10} tons	10^{12} tons	320 ppm	2-4 yr	Biological absorption and photosynthesis, absorption in oceans	Atmospheric concentrations increasing by 0.7 ppm per year

Source: Stanford Research Institute, Sources, Abundance and Fate of Gaseous Atmospheric Pollutants - Supplemental Report, SRI Project PR-6755, April 1971

2.2.2 Classification Systems and Statewide Emissions Summary

The classification system used to identify source categories depends on the objectives and methodologies of the emissions assessment and also the agency performing the assessment. If the emission assessment is being prepared for air quality modeling purposes, sources are classified by their physical configuration such as point, line and area sources. The classification systems used by most regulatory agencies are based on the division between stationary and mobile sources.

Classification system differences, while rarely significant, do create compatibility problems with different emissions data bases. The source categories used by the Air Resources Board are shown in Table 2.4, which presents an emission assessment summary for the State of California for 1973.

The relative contributions of pollutants from these different categories are given for the State for 1973 in Figure 2.2.

2.2.3 Mobile Sources

2.2.3-1 Motor Vehicles

The motor vehicle category comprises light duty trucks and passenger vehicles, gasoline-powered heavy duty vehicles, diesel-powered heavy duty vehicles, and motorcycles. Motor vehicles are major contributors of three of the five pollutants, as shown in Figure 2.2 and Table 2.4.

The pollutants of interest emitted by motor vehicles are: organic gases (OG), also called hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx), particulates and oxides of sulfur (SOx). Hydrocarbons and carbon monoxide emissions result primarily from incomplete combusion of the fuel. Hydrocarbons are also emitted by evaporation from the fuel system and by the passage of combustion gases by the piston rings to the crankcase during the compression stroke. The vapors are then released

TABLE 2.4
CALIFORNIA SUMMARY
AVERAGE EMISSIONS OF POLLUTANTS-1973
(TONS PER DAY)

FEB. 26, 1976 PRELIMINARY DATA - SUBJECT TO REVISION

STATIONARY SOURCES	POG	TOG	PART	NOX	SO2	CO
PETROLEUM						
PRODUCTION		366		2.0	4.5	
REFINING		131	11.1	49.2	129	123
MARKETING		377		10.0		
SUBTOTAL		874	11.1	61.2	133	123
ORGANIC SOLVENT USERS						
SURFACE COATING		426	14.3			
DRY CLEANING		63.1				
DEGREASING		138				
OTHER		319	9.0			
SUBTOTAL		947	23.3			
CHEMICAL		61.8	62.7	12.8	215	678
METALLURGICAL		0.4	23.4	3.0	76.5	6.0
MINERAL		2.6	469	7.7	34.3	22.1
FOOD AND AG PROCESSING		10.5	93.3			5.3
PESTICIDES		44.0				
WOOD PROCESSING		3.0	41.2			
COMBUSTION OF FUELS						
POWER PLANTS		15.3	46.2	357	291	41.1
OTHER INDUSTRIAL		63.0	71.5	528	327	675
DOMESTIC AND COMMERCIAL		22.8	39.1	133	3.6	93.3
ORCHARD HEATERS		29.2	6.4	0.1	2.2	3.7
SUBTOTAL		130	163	1020	623	814
WASTE BURNING						
AGRICULTURAL DEBRIS		172	72.5	8.0	2.1	280
FOREST MANAGEMENT		43.9	18.6	2.0	0.1	71.9
RANGE IMPROVEMENT		77.2	32.8	3.3	0.5	126
DUMPS		9.5	4.8	2.5		22.5
CONICAL BURNERS		30.5	32.5	5.4		345
INCINERATORS		3.3	3.7	1.8	0.2	13.1
OTHER		21.3	10.4	1.5	0.7	51.8
SUBTOTAL		358	175	24.5	3.6	910
MISCELLANEOUS AREA SOURCES						
WILD FIRES		135	102	6.2		452
STRUCTURAL FIRES		52.4	39.5	2.2		172
FARMING OPERATIONS			323			
CONSTR. AND DEMOL.			37.3			
UNPAVED ROADS			103			
UTILITY EQUIP:MOWERS,ETC		43.6	0.8	2.9		308
SUBTOTAL		231	605	11.3		932
TOTAL, STATIONARY		2660	1670	1140	1090	3490
MOBILE SOURCES						
MOTOR VEHICLES-ON ROAD						
LIGHT-DUTY VEHICLE EXH		1020	155	1280	37.2	11200
HEAVY DUTY VEHICLE EXH		300	22.5	285	6.9	2330
HEAVY-DUTY DIESEL EXH		52.0	18.4	440	31.7	263
MOTORCYCLE EXH		60.6	0.8	0.7	0.1	194
EVAPORATION		487				
CRANKCASE		44.5				
SUBTOTAL		1960	197	2000	75.9	14000
JET AIRCRAFT		63.2	30.1	49.4	8.8	171
PISTON AIRCRAFT		50.8	2.7	6.8	0.5	410
RAILROADS		33.6	9.7	114	18.0	41.0
SHIPS		8.6	8.9	84.6	71.2	42.0
OTHER OFF-ROAD VEHICLES		162	21.6	227	34.2	1210
TOTAL, MOBILE		2290	270	2480	209	15900
TOTAL, ALL SOURCES		4950	1940	3620	1290	19400

Reference: Air Resources Board Emissions Inventory Unit

TABLE 2.4
CALIFORNIA SUMMARY
AVERAGE EMISSIONS OF POLLUTANTS-1973
(TONS PER DAY)

FEB. 25, 1976 PRELIMINARY DATA - SUBJECT TO REVISION

STATIONARY SOURCES	ROG	TOG	PART	NOX	SO2	CO
PETROLEUM						
PRODUCTION		366		2.0	4.5	
REFINING		131	11.1	49.2	129	123
MARKETING		377		10.0		
SUBTOTAL		874	11.1	61.2	133	123
ORGANIC SOLVENT USERS						
SURFACE COATING		426	14.3			
DRY CLEANING		63.1				
DEGREASING		138				
OTHER		319	9.0			
SUBTOTAL		947	23.3			
CHEMICAL		61.8	62.7	12.8	215	578
METALLURGICAL		0.4	23.4	3.0	76.5	6.0
MINERAL		2.6	469	7.7	34.3	22.1
FOOD AND AG PROCESSING		10.5	93.3			5.3
PESTICIDES		44.0				
WOOD PROCESSING		3.0	41.2			
COMBUSTION OF FUELS						
POWER PLANTS		15.3	46.2	357	291	41.1
OTHER INDUSTRIAL		63.0	71.5	528	327	675
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ORCHARD HEATERS		29.2	6.4	0.1	2.2	3.7
SUBTOTAL		130	163	1020	623	814
WASTE BURNING						
AGRICULTURAL DEBRIS		172	72.5	3.0	2.1	280
FOREST MANAGEMENT		43.9	18.6	2.0	0.1	71.9
RANGE IMPROVEMENT		77.2	32.8	3.3	0.5	126
DUMPS		9.5	4.8	2.5		22.5
CONICAL BURNERS		30.5	32.5	5.4		345
INCINERATORS		3.3	3.7	1.8	0.2	13.1
OTHER		21.3	10.4	1.5	0.7	51.8
SUBTOTAL		358	175	24.5	3.6	910
MISCELLANEOUS AREA SOURCES						
WILD FIRES		135	102	6.2		452
STRUCTURAL FIRES		52.4	39.5	2.2		172
FARMING OPERATIONS			323			
CONSTR. AND DEMOL.			37.3			
UNPAVED ROADS			103			
UTILITY EQUIP:MOWERS,ETC		43.6	0.8	2.9		308
SUBTOTAL		231	605	11.3		932
TOTAL,STATIONARY		2660	1670	1140	1090	3490
MOBILE SOURCES						
MOTOR VEHICLES-ON ROAD						
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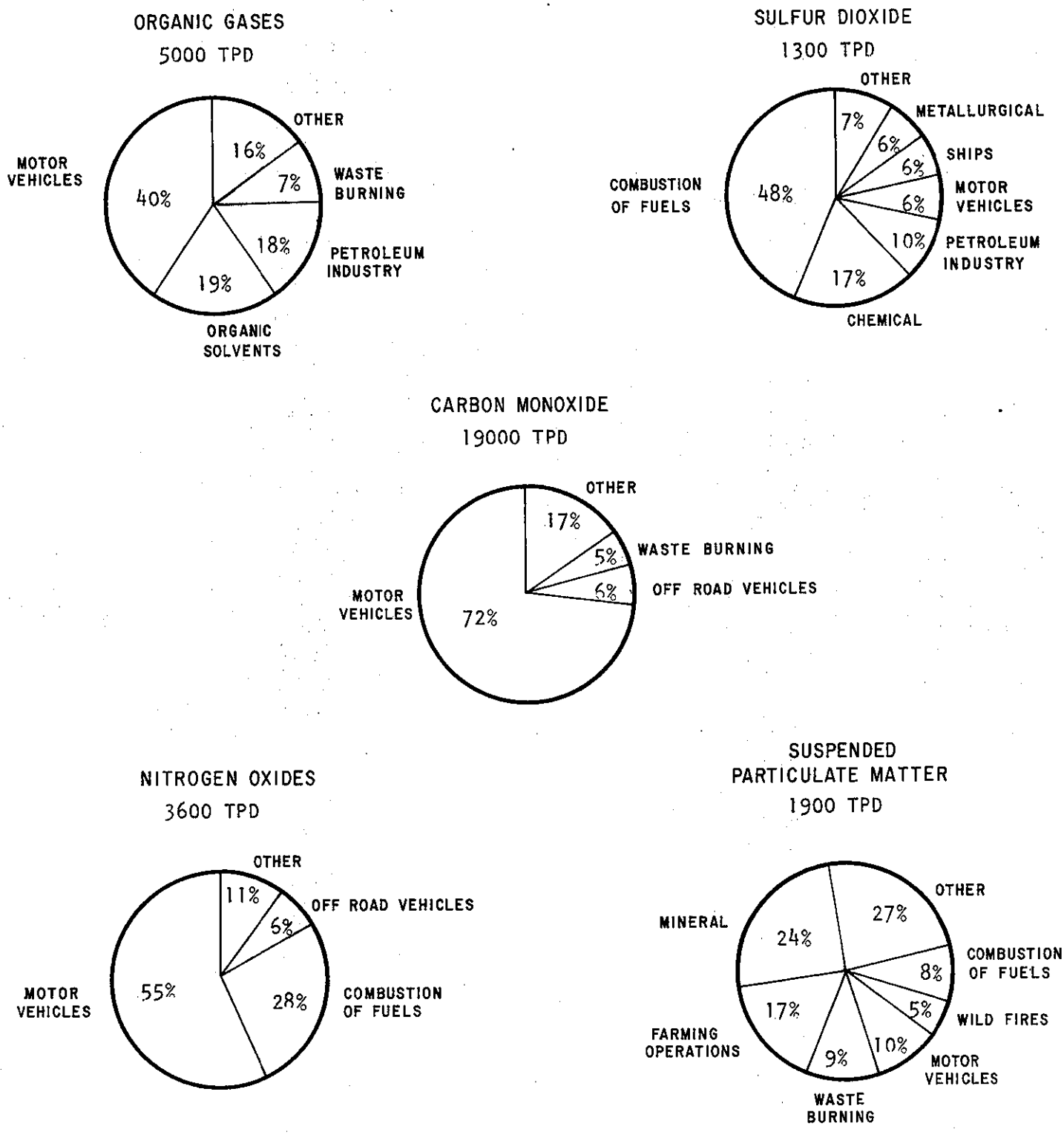
HEAVY DUTY VEHICLE EXH		300	22.5	285	6.9	2330
HEAVY-DUTY DIESEL EXH		52.0	13.4	440	31.7	263
MOTORCYCLE EXH		60.6	0.8	0.7	0.1	194
EVAPORATION		487				
CRANKCASE		44.5				
SUBTOTAL		1960	197	2000	75.9	14000
JET AIRCRAFT		63.2	30.1	49.4	8.8	171
PISTON AIRCRAFT		50.8	2.7	6.8	0.5	410
RAILROADS		33.6	9.7	114	18.0	41.0
SHIPS		8.6	8.9	84.6	71.2	42.6
OTHER OFF-ROAD VEHICLES		162	21.6	227	34.2	1210
TOTAL, MOBILE		2290	270	2480	209	15900
TOTAL, ALL SOURCES		4950	1940	3620	1300	19400

Figure 2.2

STATE OF CALIFORNIA PERCENTAGE OF EMISSIONS BY SOURCE CATEGORY FOR 1973



Source: Emission Inventory Unit, California Air Resources Board, February, 1976.

into the atmosphere from the crankcase. Crankcase emissions are assumed negligible for 1963 and later light duty vehicles due to the Positive Crankcase Ventilation (PCV) valve control device installed on these vehicles. Emissions of oxides of nitrogen result when the nitrogen (N_2) in the atmosphere breaks down at the high temperatures experienced in the combustion chamber of an engine, and reacts with oxygen (O_2) to form nitric oxide (NO) within the combustion chamber. The lead anti-knock compounds added to gasoline cause the majority of the particulate mass-emissions from gasoline engines. The emissions of oxides of sulfur are a function of the sulfur content of the fuel. Control techniques utilizing catalysts result in emissions of sulfates instead of SO_2. The basic combustion process causes the fuel sulfur to be oxidized to SO_2. Control techniques utilizing catalysts result in some of the SO_2 being further oxidized to sulfate. The impact of these emissions is currently under investigation.

2.2.3-2 Aircraft

The aircraft category includes piston-engine powered aircraft and turbine-powered aircraft. The pollutants from piston-powered aircraft are the same type and relative concentrations as gasoline-powered motor vehicles. Turbine-powered aircraft emit the same pollutants but with greater relative emissions of oxides of nitrogen.

2.2.3-3 Off-Road Mobile Sources, Trains and Ships

Off-road mobile sources comprise snowmobiles, dune buggies, farm equipment, off-road motorcycles, and off-road construction equipment. The pollutants emitted by these sources (except for construction equipment) are those typical of gasoline-powered internal combustion engines. Construction equipment is usually diesel or fuel oil powered and has higher relative emissions of particulates and oxides of nitrogen. The majority of rail locomotives are also diesel powered and have the same emission characteristics of high particulate and oxides of nitrogen emissions as

diesel powered motor vehicles. Fuel oil is the primary fuel used in vessels powered by inboard engines. Steamships are ships with steam turbines driven by external combustion engines (boilers). Motor ships have internal combustion engines usually operated on the diesel cycle.

2.2.4 Stationary Sources

2.2.4-1 Point Sources

Point sources are those sources which are considered on an individual basis due to the quantity or nature of their emissions. The majority of air pollutants from stationary sources are emitted by point sources. Examples of point sources are petroleum refineries, cement factories, power generating facilities, and steel mills. Power generating facilities are normally dealt with as a special type of stationary source.

Point sources can emit significant quantities of any of the five major primary pollutants and also other toxic materials. The emission characteristics of individual facilities vary widely and each facility must be examined individually to determine its contribution to an area's pollution problem. Table 2.5 lists several major point source categories, identifies the related processes which result in emissions and indicates the major pollutants emitted by each type of facility.

As outlined in the Federal Register, November 25, 1971, 51.1(K), the U.S. Environmental Protection Agency has defined a point source as:

> (a) any stationary source causing emissions in excess of 100 tons (90.7 metric tons) per year of any pollutant for which there is a national standard in a region containing an area whose 1970 "urban place" population, as defined by the U.S. Bureau of Census, was equal to or greater than 1 million, or (b) any stationary source causing emissions in excess of 25 tons (22.7 metric tons) per year of any pollutant for which there is a national standard in a region containing an area whose 1970 "urban place" population, as defined by the U.S. Bureau of Census, was less than 1 million, or (c) without regard to amount of emissions, stationary sources such as those listed in Appendix C to this part.

TABLE 2.5

MAJOR POINT SOURCE TYPES AND
ASSOCIATED POLLUTANTS

SOURCE	EMISSIONS PRODUCING PROCESS	MAJOR POLLUTANTS
1. Power Plants	Fuel Combustion-Boilers/ Turbines	NOx, SOx, OG, TSP
2. Refineries	Fuel Combustion-Boilers Storage & Distribution	NOx, SOx, TSP, CO OG
3. Cement Production	Fuel Combustion-kilns Rock Crushing	NOx, SOx, TSP TSP
4. Organic Solvent Usage	Storage/Distribution/ Use-Evaporation	OG
5. Steel/Metal Production	Fuel Combustion-Hearths Metal Formation	NOx, SOx, CO, TSP TSP
6. Glass Production	Fuel Combustions-Melter	NOx, SOx, TSP
7. Ceramics/Clay Production	Fuel Combustion-kilns Clay Mining	NOx, SOx, TSP TSP

Also included in a definition of point sources are the sources included in a permit or registration system already maintained by an air regulatory agency.

In California, most local air pollution control districts utilize a lower cut-off level such as 25 tons per year to identify point sources. In several districts such as the Los Angeles County Air Pollution Control District, sources emitting only one ton per year are classified as point sources.

2.2.4-2 Power Generating Facilities

Only power generating facilities which utilize fossil-fuels contribute significantly to the air pollution problem in California. Geothermal facilities can emit considerable quantities of hydrogen sulfide (H_2S) but the impact is usually localized. The direct effect of nuclear and hydroelectric facilities on air quality is minor.

Fossil fuel-fired facilities burn natural gas, oil or coal. When combusted, all of these fuels produce significant amounts of pollutants. Fuel oil and coal contain varying amounts of ash (0-11%) and sulfur (0.1-4%) which are emitted as particulate matter and sulfur oxides upon combustion of the fuel. Depending on the pollution controls utilized, generating facilities using these fuels can be major sources of oxides of sulfur and particulates. The combustion of all three types of fuel results in the emissions of large amounts of oxides of nitrogen. The nitrogen oxides are formed in power plants by the same mechanism as in motor vehicles. The nitrogen (N_2) in the atmospheric air used to combust the fuel breaks down at the high temperatures experienced in the combustion chamber of a boiler, and reacts with oxygen (O_2) to form nitric oxide (NO) within the boiler. In addition to the N_2 in atmospheric air, substantial NO may be formed from organic nitrogen contained within some fuels [6]. This nitrogen is called fuel-bound nitrogen.

To date only natural gas and oil-fired plants have operated in California. Until recently California's natural gas supplies have been sufficient to satisfy much of the demand of the State's utilities. In the last several years, however, there has been a significant decrease in the supplies of natural gas available for use in California. The utilities now must rely on low-sulfur fuel oil for the majority of their operation. Current projections suggest that very little natural gas will be available for power production. In future years the availability and cost of low-sulfur fuel oil is also in question. Given the uncertainties of the State's supplies of oil, the possibility exists that coal fired generating facilities may be built in California. Coal-fired facilities are currently supplying power to California but are presently located outside of the State.

2.2.4-3 Area Sources

Area sources are groups of sources which individually do not emit significant amounts of pollutants but which, upon aggregation, make an appreciable contribution to an area's emissions. Area sources include both mobile sources and stationary sources. Examples of area sources are motor vehicles operating on surface streets, residential home heating, forest fires, and agricultural operations. Table 2.6 lists several types of area sources along with their principal emissions.

Typical area source emissions are organic gases, particulates and oxides of nitrogen in significant quantities and carbon monoxide and sulfur oxides in relatively minor amounts. In highly industrialized and urbanized areas, point sources are the dominant sources of pollutants. In the San Francisco Bay Area Air Basin, point sources contribute approximately 80% of the stationary source emissions of particulate matter, while point sources in the San Joaquin Valley Air Basin emit approximately 50% of the particulate matter due to stationary sources.

2.2.5 Indirect Sources

An indirect source is defined as a facility, building, structure or installation which attracts or may attract mobile source activity that

TABLE 2.6

MAJOR AREA SOURCE TYPES AND
ASSOCIATED POLLUTANTS

Source	Major Pollutants
1. Motor Vehicles	OG , NO_x, CO, SO_x, TSP
2. Agricultural Operations	TSP*
3. Unpaved Roads	TSP*
4. Residential Home Heating	OG ; NO_x
5. Fires	OG ; CO; TSP
Agricultural Forest Structural	
6. Pesticides	OG
7. Utility Equipment	OG , NO_x, CO, TSP
8. Construction and Demolition	TSP*

*Does not include related vehicular emissions

results in emissions of pollutants. The major sub-categories identified by the Environmental Protection Agency in their efforts to implement the indirect source regulations [7] are highways, airports, and facilities with parking facilities. These regulations have since been suspended by the Environmental Protection Agency. However, from an air quality/land use/transportation planning perspective, their significance is well recognized and extends beyond the three categories mentioned above. The definition and categories first identified by the EPA [8] give a better indication of the significance of indirect sources which were defined as:

> A facility that has or leads to secondary or adjunctive activity which emits or may emit a pollutant for which there is a national standard. These sources include, but are not limited to:
>
> (1) Shopping centers:
> (2) Sports complexes:
> (3) Drive-in theaters;
> (4) Parking lots and garages:
> (5) Residential, commerical, industrial, or institutional developments;
> (6) Amusement parts and recreational areas;
> (7) Highways;
> (8) Sewer, water, power, and gas lines
>
> and other such facilities which will result in increased emissions from motor vehicles or other stationary sources. (Emphasis added.)

Within the broader definition of an indirect source, it is seen that the pollutants associated with an indirect source depend on the sub-category and that these sub-categories cover all the source types previously discussed.

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[1] Williamson, Samuel J., Fundamentals of Air Pollution, Addison-Wesley Publishing Co., Menlo Park, CA 1974.

[2] [3] The Air Quality Criteria and Control Techniques documents and reports in the AP series of reports issued by the Environmental Protection Agency.

AP reports are available free to Federal employees, current contractors and grantees, and nonprofit organizations - as supplies permit - from the Air Pollution Technical Information Center, Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

AIR QUALITY CRITERIA

AP-049 Air Quality Criteria for Particulate Matter. 1/69. FS 2.93/3:49. Price $1.75. PB 190-251

AP-050 Air Quality Criteria for Sulfur Oxides. 4/70. FS 2.93/3:50. Price $1.50. PB 190-252

AP-062 Air Quality Criteria for Carbon Monoxide. 3/70. HE 20.1309:62. Price $1.50. PB 190-261

AP-063 Air Quality Criteria for Photochemical Oxidants. 3/70. HE 20.1309.63. Price $1.75. PB 190-262

AP-064 Air Quality Criteria for Hydrocarbons. 3/70. HE 20.1309:64. Price $1.25. PB 190-489

AP-084 Air Quality Criteria for Nitrogen Oxides. 1/71. EP 4.9:84. Price $1.50. PB 197-333

CONTROL TECHNIQUES

AP-065 Control Techniques for Carbon Monoxide Emissions from Stationary Sources. 3/70. HE 20.1309:65. Price $0.70. PB 190-263

AP-066 Control Techniques for Carbon Monoxide, Nitrogen Oxides and Hydrocarbon Emissions from Mobile Sources. 3/70. HE 20.1309:66. Price $1.25. PB 190-264

AP-067 Control Techniques for Nitrogen Oxide Emissions from Stationary Sources. 3/70. HE 20.1309:67. Price $1.00. PB 190-265

AP-068 Control Techniques for Hydrocarbons and Organic Solvent Emissions from Stationary Sources. 3/70. HE 20.1309:68. Price $1.00. PB 190-266.

AP-051 Control Techniques for Particulate Air Pollutants. 1/69. FS 2.93/3:51. Price $1.75. PB 190-253

AP-052 Control Techniques for Sulfur Oxide Air Pollutants. 1/69. FS 2.93/3:52. Price $1.25. PB 190-254

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Prepared for the Committee on Public Works, United States Senate. November 1973, Series No. 93-13, pp. 7-10.

[5] Stanford Research Institute, Sources, Abundance, and Fate of Gaseous Pollutants - Supplemental Report, SRI Project PR-6755, April 1971.

[6] Bartz, D.R.; Arledge, K.W., Gabrielson, J.E., Hays, H.G.; Hunter, S.C., "Control of Oxides of Nitrogen from Stationary Sources in the South Coast Air basin." Prepared for California Air Resources Board by KVB, September 1974.

[7] Federal Register, V 38, N 116, June 18, 1973, pp. 15834-7.

[8] Federal Register, V 39, N 45, March 8, 1973, pp. 6279-80.

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3. ASSESSING AIR POLLUTANT EMISSIONS

3.1 ESTIMATING SOURCE EMISSIONS

3.1.1 Introduction

The identification of sources of air pollutants and the estimation of their emissions, coupled with local meteorological and air quality data provide the basis for a plan of action for improvement of air quality. The emissions assessment is a vital element in the abatement of emissions and in subsequent improvements in air quality.

Since an emissions assessment defines the sources of air pollution relatively and quantitatively, it is one of the most important planning tools available in air quality planning. The assessment provides information concerning source emissions and defines the location, magnitude, frequency, duration, and relative contribution of these emissions. It can be used to measure the success of implemented control strategies and to point to future requirements. An emission assessment can be used to assist in the design of an air sampling network, to aid in predicting ambient air quality, to aid in the design, evaluation, or modification of a control program, and, in conjunction with a source permit or registration system, to provide up-to-date information on major sources of pollution.

The optimal emission control strategy for a specific air pollution problem is dependent upon an adequate assessment of the nature and extent of the pollution in the region involved. This assessment includes an evaluation of existing levels of control and the probable increase in source emissions resulting from urban and economic growth. THE EMISSIONS ASSESSMENT INDICATES THE MAJOR CONTRIBUTORS (MOTOR VEHICLE, INDUSTRIAL, ETC.) AND THIS INFORMATION, IN TURN, DIRECTS THE THRUST OF CONTROL EFFORTS. After the control strategies have been developed, they can be tested with the aid of an air quality simulation model or other systematic, quantitative procedures to determine which strategies are capable of bringing about acceptable air quality as defined by national or state ambient air quality standards [1].

Section 3. outlines methodologies for estimating base year and future year emissions of air pollutants. Technical assumptions and factors affecting emission assessments are discussed.

The air pollutants considered in the methodologies are total organic gases, reactive organic gases, carbon monoxide, oxides of nitrogen, oxides of sulfur, and particulate matter. The categories of emission sources considered are listed in Table 3.1. Table 3.1 also lists some parameters and types of emission factors which can be used to estimate emissions from each source category.

Since there are usually several different parameters for most sources and some sources have alternate parameters, the methodology for each principal source category is described separately in the following subsections.

The available resources did not provide for the development and refinement of methodologies, techniques, and emission factors specific for long-range (20-year) emission estimates. Consequently, only currently available techniques are identified in this report. These techniques were not developed for long-range emission estimates but for short-term (5-10 year) estimates. They are appropriate for long-range projections at this time in the absence of more specific and appropriate long-range factors. Current methodologies need to be modified to provide improved long-range estimates of emissions for a variety of reasons. Some significant reasons are: 1) the inability of current methodologies to identify, quantify and forecast the impact of technological developments on emissions; 2) the inability of current methodologies to accommodate significant shifts in the utilization of alternate transportation modes in a pollutant specific fashion, e.g., private automobile to mass transit (bus or heavy rail); and 3) shifts in the costs and availability of scarce natural resources (e.g., fossil fuels, other mineral resources) which may cause fundamental changes in affected industries, the economy, and society at large.

TABLE 3.1

Emission Source Categories and Parameters for Future Year Emissions Assessments

SOURCE CATEGORY	Parameter for Estimating Source Activity	Emission Factor	Alternate Parameter for Estimating Source Activity	Emission Factor
MOBILE SOURCES				
Motor Vehicles				
Light Duty Passenger Cars	Vehicle Miles Travelled From Transportation Studies	Grams/Mile	Registrations and Average Annual Mileage	Grams/Mile
Light Duty Trucks	Vehicle Miles Travelled From Transportation Studies	Grams/Mile	Registrations and Average Annual Mileage	Grams/Mile
Gasoline-Powered, Heavy Duty Vehicles	Vehicle Miles Travelled From Transportation Studies	Grams/Mile	Registrations and Average Annual Mileage	Grams/Mile
Diesel-Powered, Heavy Duty Vehicles	Vehicle Miles Travelled From Transportation Studies	Grams/Mile	Registrations and Average Annual Mileage	Grams/Mile
Motorcycles	Vehicle Miles Travelled From Transportation Studies	Grams/Mile	Registrations and Average Annual Mileage	Grams/Mile
Aircraft	Landing and Take-Off (LTO) Cycles	Pounds/LTO	Population	Per Capita[1] Emission Factor
Off-road Mobile Sources	Population	Per Capita Emission Factor[1]	--	--
Ships	Population	Per Capita Emission Factor[1]	--	--
Trains	Population	Per Capita Emission Factor[1]	--	--
STATIONARY SOURCES				
Power Plants-Fossil Fueled	Energy Production	Pounds/BTU	Population	Per Capita Energy Generation and Pounds/BTU
Other Stationary Sources	Earnings Growth Projections	Emissions Growth From Base Year Emissions Levels	Population	Per Capita[1] Emission Factor

[1] The per capita emission factors are developed from base year emissions assessments and population data.

The development of techniques responsive to these and additional requirements will necessitate a continued effort by individuals involved in land use/air quality planning. It is the intent of this report to identify the current methodologies and reference materials that will provide the starting point for the development of these techniques.

3.1.2 Organic Gas Reactivity

Organic gas emissions in addition to oxides of nitrogen (NOx) are precursors to photochemical smog. Certain organic gases such as methane react very slowly in the photochemical processes while other organics such as olefins react more rapidly. Trijonis and Arledge offer the following comments [41]:

> Organic emission reactivity refers to the potential of an organic to participate in atmospheric reactions which result in photochemical smog. The particular smog symptom of interest here is photochemical oxidant for which a short-term National Ambient Air Quality Standard has been established. Oxidant producing potential is known to vary widely among specific organic compounds. This variation is significant because it introduces the option of selective organic emission control as a possibly advantageous alternative to the less flexible approach of indiscriminate control.

The question of relative reactivities of organic compounds has been researched and debated vigorously in recent years. On October 10, 1975 the Air Resources Board established an ad hoc committee of scientists to review and report recommendations on various reactivity schemes proposed by ARB staff. As a result of the Committee's work and public comments the Air Resources Board adopted "for the purpose of inventory and planning" the three class classification scheme depicted by Table 3.2. The three classes are [52]:

Class I:	low reactivity	organic compounds yielding little, if any ozone under urban conditions.
Class II:	moderate reactivity	organic compounds which give an intermediate yield of ozone within the first day of solar irradiation.
Class III:	high reactivity	organic compounds which give very high yields of ozone within a few hours of irradiation.

The ARB Emission Inventory Unit has initiated an effort which will result in an emissions inventory delineating organic gas emissions by classes defined in Table 3.2. The initial effort will rely heavily on the work done by Trijonis and Arledge [41]. The percent of total organic gas emissions in each of these classes for each ARB emission source category is shown in Table A.3.17. This scheme is presently being being used by the ARB. These percentages may be applied to the Total Organic Gas (TOG) column of ARB inventories to estimate the disaggregation of TOG into Class I, Class II and Class III reactivity categories. For example, Table 3.7 indicates 21.0 tons per day TOG emissions from Petroleum Marketing in Orange County. In order to apply the percentages of Table A.3.17, the marketing emissions must be disaggregated into terminal and storage losses and auto filling losses. The ARB Emissions Inventory Unit can provide this information for most areas in the state; in some cases, the local air pollution control districts may be capable of providing such information. According to the ARB Emissions Inventory Unit [16], in 1973 in Orange County, terminal and storage emissions accounted for 11.8 tons per day TOG and auto tank filling for 9.2 tons per day TOG. Applying Table A.3.17 factors results in the disaggregation indicated in Table 3.3.

Although the ARB has adopted a reactivity scheme and this scheme is recommended for use by planners, it is not the only reactivity scheme available. Both the ARB and EPA have prepared several other schemes during the last two years. A recent publication of the San Diego Air Quality Planning Team titled Three Reactivity Classification Schemes and Their Effect on Control Tactics, January 1976 [40] discusses various reactivity classification schemes considered by the ARB and EPA.

TABLE 3.2

AIR RESOURCES BOARD
REACTIVITY CLASSIFICATION OF ORGANIC COMPOUNDS

Class I (Low Reactivity)	Class II (Moderate Reactivity)	Class III (High Reactivity)
C_1-C_2 Paraffins	Mono-tert-alkyl-benzenes	All other aromatic hydrocarbons
Acetylene	Cyclic Ketones	All Olefinic hydrocarbons (including partially halogenated)
Benzene	Alkyl acetates	Aliphatic aldehydes
Benzaldehyde	2-Nitropropane	Branched alkyl Ketones
Acetone	C_3+ Paraffins	Cellosolve acetate
Methanol	Cycloparaffins	Unsaturated Ketones
Tert-alkyl alcohols	n-alkyl Ketones	Primary & secondary C_2+ alcohols
Phenyl acetate	N-methyl pyrrolidone	Diacetone alcohol
Methyl benzoate	N,N-dimethyl acetamide	Ethers
Ethyl Amines	Alkyl Phenols*	Cellosolves
Dimethyl formamide	Methyl phthalates**	Glycols*
Perhalogenated Hydrocarbons		C_2+ Alkyl phthalates**
Partially halogenated paraffins		Other Esters**
Phthalic Anhydride**		Alcohol Amines**
Phthalic Acids**		C_3+ Organic acids + di acid**
Acetonitrile*		C_3+ di acid anhydrides**
Acetic Acid		Formin** (Hexa methylene-tetramine)
Aromatic Amines		Terpenic hydrocarbon
Hydroxyl Amines		Olefin oxides**
Naphthalene*		
Chlorobenzenes*		
Nitrobenzenes*		
Phenol*		

*Reactivity data are either non-existent or inconclusive, but conclusive data from similar compounds are available; therefore, rating is uncertain but reasonable.

**Reactivity data are uncertain.

Source: [52]

TABLE 3.3

1973 ORANGE COUNTY PETROLEUM
MARKETING ORGANIC GAS EMISSIONS

Emissions Source	Organic Gas Emissions (Tons per Day)			
	TOG	Reactivity Class		
		Class I	Class II	Class III
Petroleum Marketing				
Terminal and Storage	11.8	0.7	8.3	2.8
Auto Tank Filling	9.2	0.2	6.2	2.8
Total	21.0	0.9	14.5	5.6

3.1 ESTIMATING SOURCE EMISSIONS

3.1.3 Motor Vehicles

3.1.3-1 Quantification of Motor Vehicle Emission

The motor vehicle category comprises light duty trucks and passenger vehicles (automobiles), gasoline-powered heavy duty vehicles (trucks), diesel-powered heavy duty vehicles (trucks), and motorcycles. The quantification and regulation of motor vehicle emissions in California dates from 1959 when the State Department of Public Health was mandated to develop emission standards for light duty motor vehicles. The Motor Vehicle Pollution Control Board was formed in 1960 to implement these standards. Crankcase emissions control requirements for controlling hydrocarbon emissions from this source were implemented in 1963 and exhaust emissions standards for hydrocarbons and carbon monoxide were first implemented in 1966.

The federal government established light duty vehicle emission standards in 1968 that were identical to the California standards. However, the California emission standards for 1970 through 1976 have been generally more stringent than the federal standards. The Clean Air Act Amendments of 1970 provide that California is the only state permitted to adopt motor vehicle emission standards more stringent than the federally adopted emission standards. Such action requires the approval of the U.S. Environmental Protection Agency. California received waivers for the state standards for 1970-1976. California recently exercised this prerogative by adopting more stringent standards for 1977 light duty vehicles [2].

Originally, the implementation schedule for the federal motor vehicle emissions control program called for the most stringent standards (as required by the Clean Air Act of 1970) to be achieved by 1975 and later

model year automobiles. The emission standards for 1975 and later would be uniform throughout the nation. However, after an assessment of the practicality and feasibility of achieving the 1975 standards for HC and CO and the 1976 standard for NOx, the Environmental Protection Agency, based on information obtained through Congressional hearings, postponed the date for achievement of these standards by two years and established two sets of interim standards, one for California based on a request of the ARB and the other for the rest of the United States. The interim standards for California are stricter than the interim standards for the rest of the nation.

In subsequent actions, the EPA has delayed achievement of the statutory standards until 1978 and has also recommended that achievement of the standards be delayed even further [3]. However, California has received approval of more stringent emission standards for 1977 light duty vehicles [2].

A summary of the emission standards is shown in Table 3.4. Standards are given for HC (organic gases), CO, and NOx and are based on three different certification test cycles. No valid and accepted formula exists to quantitatively compare "7-mode" cycles with CVS cycles but a reasonable correlation between CVS-72 and CVS-75 exists. Table 3.4 is included in the handbook for information purposes only. The table is not directly used for development of either emission factors or emission estimates.

The emissions of air pollutants from motor vehicles are dependent on a myriad of independently variable parameters, e.g., the ambient temperature, the temperature of the engine, the fuel, the driver, the type of trip, altitude, the effectiveness of emission control devices (if any), etc. To compare emissions from different vehicles, a driving cycle or test cycle is used to provide a common basis for comparison.

The two most familiar test cycles are the 7-mode test cycle developed by California in 1960 [4] and the Constant Volume Sampling (CVS) test cycle developed by the Environmental Protection Agency in 1970 [5,6]. Both of

TABLE 3.4

NEW VEHICLE STANDARDS SUMMARY

Increasingly stringent emission standards for new vehicles have been imposed by State and Federal law. The summary of regulations is printed below:

Passenger Cars and Light Duty Trucks

YEAR		STANDARD	COLD START TEST	HYDROCARBONS	CARBON MONOXIDE	OXIDES OF NITROGEN
Prior to controls			7-mode	850 ppm	3.4%	1000 ppm
			7-mode	(11 gm/mi)	(80 gm/mi)	(4 gm/mi)
			CVS-75	8.8 gm/mi	87.0 gm/mi	3.6 gm/mi
1966-1967		Calif.	7-mode	275 ppm	1.5%	no std.
1968-1969		Calif. or Federal	7-mode			
			50-100 CID	410 ppm	2.3%	no std.
			101-140 CID	350 ppm	2.0%	no std.
			over-140 CID	275 ppm	1.5%	no std.
1970		Calif. & Federal	7-mode	2.2 gm/mi	23 gm/mi	no std.
1971		Calif.	7-mode	2.2 gm/mi	23 gm/mi	4 gm/mi
		Federal	7-mode	2.2 gm/mi	23 gm/mi	–
1972		Calif.	7-mode or	1.5 gm/mi	23 gm/mi	3 gm/mi
			CVS-72	3.2 gm/mi	39 gm/mi	*3.2 gm/mi
		Federal	CVS-72	3.4 gm/mi	39 gm/mi	–
1973		Calif.	CVS-72	3.2 gm/mi	39 gm/mi	3 gm/mi
		Federal	CVS-72	3.4 gm/mi	39 gm/mi	3 gm/mi
1974		Calif.	CVS-72	3.2 gm/mi	39 gm/mi	2 gm/mi
		Federal	CVS-72	3.4 gm/mi	39 gm/mi	3 gm/mi
1975	**PC	Calif.	CVS-75	0.9 gm/mi	9.0 gm/mi	2.0 gm/mi
	**PC	Federal	CVS-75	1.5 gm/mi	15 gm/mi	3.1 gm/mi
	**LDT	Calif.	CVS-75	2.0 gm/mi	20 gm/mi	2.0 gm/mi
	**LDT	Federal	CVS-75	2.0 gm/mi	20 gm/mi	3.1 gm/mi
1976	**PC	Calif.	CVS-75	0.9 gm/mi	9.0 gm/mi	2.0 gm/mi
	**PC	Federal	CVS-75	1.5 gm/mi	15 gm/mi	3.1 gm/mi
	**LDT	Calif.	CVS-75	0.9 gm/mi	17 gm/mi	2.0 gm/mi
	**LDT	Federal	CVS-75	2.0 gm/mi	20 gm/mi	3.1 gm/mi
1977	**PC	Calif.	CVS-75	0.41 gm/mi	9.0 gm/mi	1.5 gm/mi
	**PC	Federal	CVS-75	1.5 gm/mi	15 gm/mi	2.0 gm/mi
	**LDT	Calif.	CVS-75	0.9 gm/mi	17 gm/mi	2.0 gm/mi
	**LDT	Federal	CVS-75	NOT	ESTABLISHED	
1978	**PC	Federal	CVS-75	0.41 gm/mi	3.4 gm/mi	0.4 gm/mi

The values in parentheses are approximately equivalent values by 7-mode test.
ppm - parts per million concentration
gm/mi – grams per mile
7-mode – is a 137 second driving cycle test.
CVS 72 – is a Constant Volume Sample cold start test.
CVS-75 – is a Constant Volume Sample test which includes cold and hot starts.
* – hot 7-mode
** – PC – Passenger Cars LDT – Light Duty Trucks

TABLE 3.4 (continued)

Heavy-duty Vehicles Over 6,000 lbs.

YEAR	STANDARD	HYDROCARBONS	CARBON MONOXIDE	OXIDES OF NITROGEN
*1969-1971	State-gasoline	275 ppm	1.5%	no std.
1972	State-gasoline	180 ppm	1.0%	no std.
1973-1974	State-gasoline & diesel	HC + NOx = 16 gm/BHP hr. CO = 40 gm/BHP hr.		
1975-1976	State-gasoline & diesel	HC + NOx = 10 gm/BHP hr. CO = 30 gm/BHP hr.		
1977 Alternate – Either →	State-gasoline & diesel	HC + NOx = 5 gm/BHP hr. CO = 25 gm/BHP hr.		
OR →	State-gasoline & diesel	1.0 gm/BHP hr.	25 gm/BHP hr.	7.5 gm/BHP hr.

gm/BHP hr. grams per brake horsepower-hour

* Federal standards remained at this level through 1973. The Federal Government adopted standards for heavy-duty gasoline and diesel vehicles for 1974 and subsequent model years which are identical to California's 1973-74 standards.

State Smoke Standards for Heavy-Duty Vehicles

1971 and later vehicles may discharge smoke no darker than Ringelman 1 or 20 percent opacity for up to 10 seconds.

Vehicles sold before 1971 may discharge smoke not darker than Ringelman 2 or 40 percent opacity for up to 10 seconds.

Crankcase Emissions

On all new vehicles manufactured for sale in California after January 1, 1964, crankcase emissions are virtually zero. Comparable Federal standards became effective in 1968 for light-duty vehicles, and 1970 for heavy-duty vehicles.

Evaporative Emissions

Evaporative emissions of hydrocarbons have been 6 gms/test for light-duty vehicles since 1970 and 2 gms/test since 1972 by the carbon trap approval test procedure. The evaporative emission requirements for 1978 light-duty vehicles will be 6 gm/test by the SHED (Sealed Housing for Evaporative Determinations) test procedure. Heavy-duty gasoline-powered vehicles are 2 gms/test by engineering evaluation effective 1973.

Motorcycle Emissions Standards

New motorcycles manufactured for sale in California on or after January 1, 1978, will be required to meet a hydrocarbon (HC) exhaust emission limit of 10.0 grams per kilometer. The limit will be reduced to 5.0 gm/km on January 1, 1980, and 1.0 gm/km on January 1, 1982.

Estimated CVS-75 emissions from CVS-72 tests are [53]:

$$HC_{CVS-75} = (.88)(HC_{CVS-72})$$
$$CO_{CVS-75} = (.73)(CO_{CVS-72})$$
$$NOX_{CVS-75} = (1.03)(NOX_{CVS-72})$$

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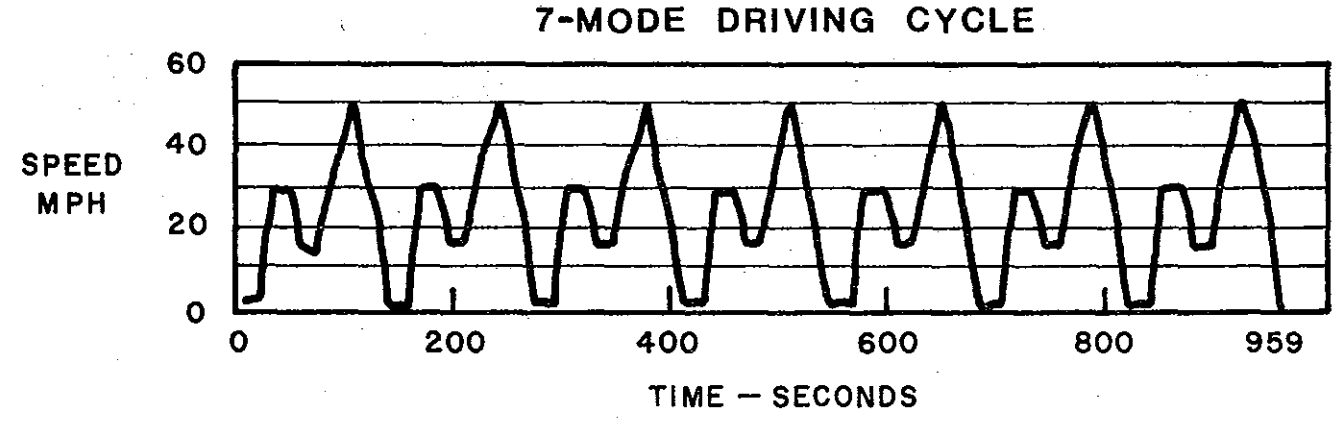
these test procedures have hot start and cold start variations, i.e., hot start means the engine is warmed up to operating temperature and cold start means the engine is at ambient temperature. A graph of vehicle speed versus time is shown for the test cycles in Figures 3.1 and 3.2.

The 7-mode procedure requires that a vehicle follow a specified time-speed plot seven times. Emission data is collected for certain modes for six of the seven cycles (data for the fifth cycle is not collected). Using various weighting factors, vehicle parameters, and specified computation procedures [7], an emission factor for that test cycle is obtained. There is no difference in the operation of the test procedure for a hot start or a cold start test.

The CVS test procedure also has a specified time-speed plot that must be followed. However, emission data is collected during the entire test cycle, not just for select modes as in the 7-mode test cycle. During the CVS-72 test cycle, which was used to quantify emission rates for the 1972, 1973, and 1974 model year light duty vehicles, a small portion of the vehicle exhaust is diverted into one plastic bag. After the test cycle, the pollutant concentrations in the bag are measured, and using certain computation procedures, mass emission values are calculated [5].

During the CVS-75 test cycle, used to quantify emission rates for 1975 and later light duty vehicle, a small portion of the vehicle exhaust is diverted into three plastic bags. The three bags cover separate segments of the test cycle. (See Figure 3.2). A computation procedure similar to the CVS-72 methodology is used to establish the emission rate. However, for the CVS-75 procedure, different weighting factors are used for the three different bags [6].

The principal differences in the CVS-72 and CVS-75 test procedures are 1) the CVS-75 test uses three bags, and 2) the CVS-75 test includes a hot start. Looking at Figure 3.1, the CVS-72 test includes a cold start


7-MODE DRIVING CYCLE
SPEED MPH
60
40
20
0
0
200
400
600
800
959
TIME — SECONDS

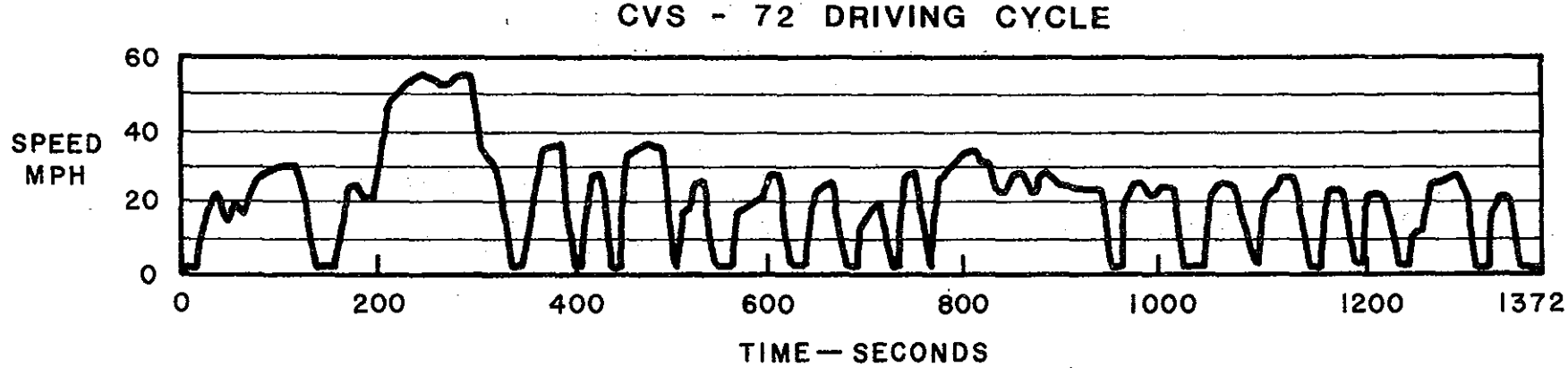

CVS - 72 DRIVING CYCLE
SPEED MPH
60
40
20
0
0
200
400
600
800
1000
1200
1372
TIME — SECONDS

FIGURE 3.1

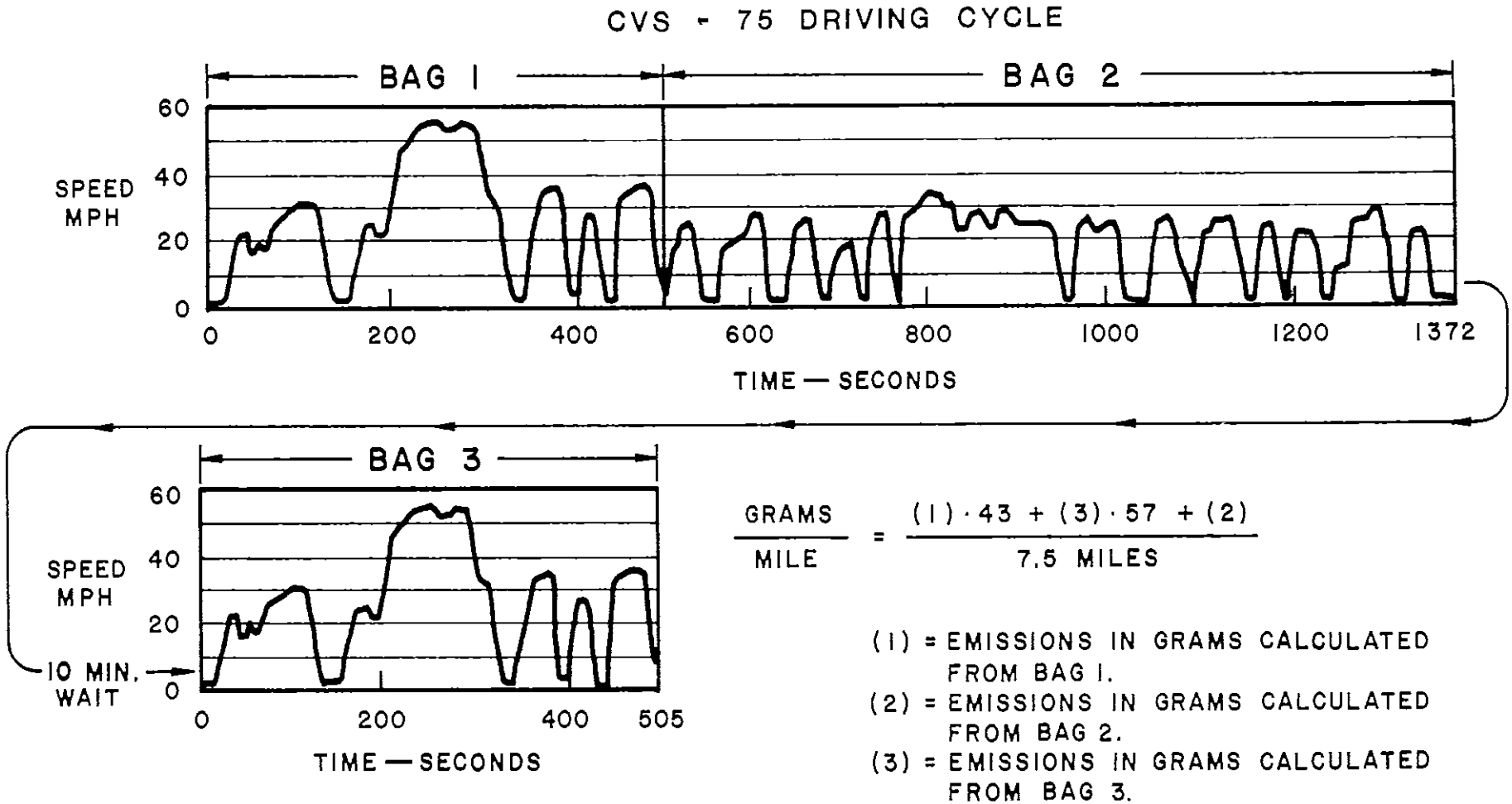

CVS - 75 DRIVING CYCLE
BAG 1
BAG 2
SPEED MPH
60
40
20
0
0
200
400
600
800
1000
1200
1372
TIME — SECONDS
BAG 3
SPEED MPH
60
40
20
10 MIN. WAIT
0
0
200
400
505
TIME — SECONDS
GRAMS / MILE = (1) · 43 + (3) · 57 + (2) / 7.5 MILES
(1) = EMISSIONS IN GRAMS CALCULATED FROM BAG 1.
(2) = EMISSIONS IN GRAMS CALCULATED FROM BAG 2.
(3) = EMISSIONS IN GRAMS CALCULATED FROM BAG 3.

FIGURE 3.2

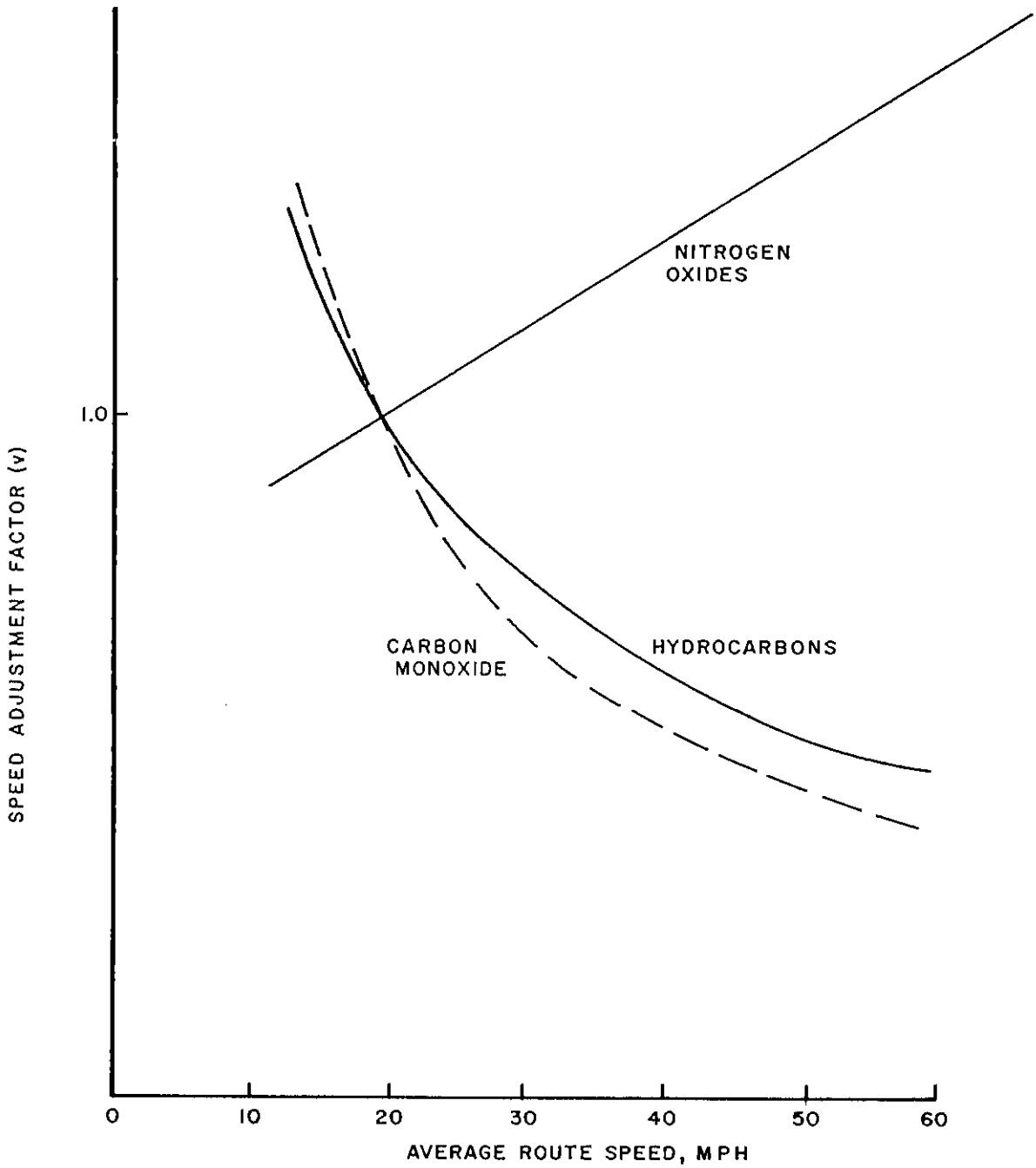
transient period of about 500 seconds and a stabilized (warmed-up) period of about 900 seconds. The total test cycle is about 1400 seconds long. Samples of emissions from both periods are collected in one bag. Looking at Figure 3.2, the CVS-75 procedure also includes a cold start transient period of about 500 seconds and a stabilized period of 900 seconds. In addition, 10 minutes after the stabilized operation period has been completed, a hot start period that duplicates the speed-time plot of the first period is completed. Samples of emissions for each of these three periods are collected in three separate bags and weighted with different factors using the previously mentioned procedure.

3.1.3-2 Additional Considerations in Quantifying Motor Vehicle Emissions

Separate from the numerical calculations involved in quantifying emissions from motor vehicles, the question of which speed-time plot is representative of the driving habits of the general public must be considered. Since no one test cycle and the resulting emission factors can be considered representative of all motor vehicle operations, several procedures for manipulating the test cycle emission data have been developed.

One of the earliest procedures related average route speed and emission rates using relationships developed by Rose and McMichaels [8]. These relationships shown in Figure 3.3, indicate a direct relationship between NOx emissions and speed and inverse relationships between CO and HC emissions and speed. The speeds given in Figure 3.3, represent average route speeds, where acceleration, deceleration, idle, and constant speed modes are averaged. The speed adjustment factors have been normalized to give a value of 1.0 at a base line speed equal to the average route speed of the CVS-72 driving cycle.

It must be noted, however, that the emissions measurement techniques utilized by Rose and McMichaels in 1963 differ from the current Federal Test Procedure (CVS) and the procedures EPA is currently utilizing to characterize speed-emissions relationships. The applicability of the Rose and McMichaels speed-emissions relationships to other test data is questionable.



SPEED VARIATION OF AVERAGE ROUTE SPEED ADJUSTMENT FACTORS

FIGURE 3.3

Average route speeds are not representative of certain operations such as constant speed. Nordseick [9] developed relationships between constant speed operation and emission rates indicating that the constant-speed emission rate for a given speed is significantly lower than the corresponding average-route-speed emission rate. Again, the reader is cautioned as to the applicability of the Nordseick developed relationships to current test data.

The quantification of emissions from non-constant speed operation still requires the identification of a time-speed plot representative of the area of interest. Since the driving cycles used by the Air Resources Board and the Environmental Protection Agency are assumed representative of "typical" driving patterns, they cannot be used in specific instances, i.e., a particular segment of a particular roadway at a particular time [10,11,12]. In order to estimate emissions under a specific set of conditions, modal emission factors for idle, constant speed, acceleration and deceleration are required. Since all driving patterns can be divided into one of these four modes, emissions rates for a specific driving pattern (e.g., a given time-speed plot) can be determined by summing the modal emissions for that driving pattern [11,12].

Since the beginning of the vehicle emissions surveillance testing in 1971, the EPA has been steadily accumulating emissions test data to support advanced emissions modeling techniques. These advanced techniques will allow the user to consider the following parameters and their effects on motor vehicle emissions:

1. average vehicle speed (including idles and various mixes of idles, accelerations, decelerations, and steady-speed cruises);

2. cold start/hot start operations;

3. VMT (vehicle miles traveled) mix by vehicle type (light duty trucks and passenger vehicles, gasoline-powered and diesel-powered heavy duty vehicles, and motorcycles);

4. ambient temperature;

5. high altitude and low altitude operation.

Supplement 5 to "Compilation of Air Pollutant Emission Factors" [12] describing these advanced techniques has been recently released by EPA (December 1975). While great promise is shown for these techniques, considerable effort will be required to utilize these techniques correctly. Ambient temperature and cold start/hot start correction functions presented in Supplement 5 introduce considerable adjustment to Federal Test Procedure (CVS-75) emission rates, especially for catalyst equipped vehicles. For example, the CO temperature adjustment factors for catalyst-equipped vehicles for various ambient temperatures are shown below.

Ambient Temperature	Adjustment Factor
20° F	5.1
30° F	4.4
40° F	3.6
50° F	2.9

This means that the CVS-75 based emission factor presented in AP-42 Supplement 5 must be multiplied by 3.6 to account for an ambient temperature of 40° F. From Supplement 5, the first year CO emission rate for a light duty vehicle certified for California's 1976 CO standard of 9 grams per mile is estimated at 5.4 grams per mile. At an ambient temperature of 40° F, the catalyst equipped vehicle will be emitting at approximately 3.6 times that rate or over 19 grams per mile. In areas such as Lake Tahoe, where relatively low ambient temperatures exist during winter months, the temperature correction factor becomes very important.

Adjustment factors to account for different percentages of cold start and hot start vehicle operations than those percentages implicit in the CVS-75 test procedure are also developed in AP-42 Supplement 5. The cold start/hot start adjustment factors development is quite technical and involved and should be applied only by individuals with expertise in motor vehicle emissions assessment. Ambient temperature adjustment factors must be used concurrent with cold start/hot start adjustment factors. It is, however, appropriate to use only the ambient temperature adjustment factor.

The motor vehicle emission factors and assessment methodologies presented in this report do not explicitly consider ambient temperature or cold start/hot start adjustment factors. AP-42 Supplement 5 provides the necessary information for considering these variables. The material in this report is appropriate for the majority of situations requiring an assessment of motor vehicle emissions. If a situation requires special considerations, individuals with expertise in motor vehicle emissions assessment should be consulted.

This discussion of additional considerations in quantifying emissions from motor vehicles was included to show the state of the art and to indicate the direction of developing procedures towards increasing accuracy and increasing complexity. The modal emission factor approach is in a state of development. The constant speed emission factors have been applied in a few select project studies completed by the California Department of Transportation (CalTrans). Speed-dependent emission factors based on average route speed are used by CalTrans in the micro-scale analyses of specific projects [13]. CalTrans has developed a computer program for generating geocoded emission inventories based on transportation simulation model outputs. This computer program considers the peak period and off-peak period speeds for each link in calculating emissions.

3.1.3-3 Variables for Estimating Motor Vehicle Emissions

Numerous methodologies for estimating emissions from motor vehicles have been developed and documented [10,11,12,19,53] in recent years. All of these approaches consider the following variables: motor vehicle population distribution by model year, average annual mileage by model year, vehicle types, emission factors, and, in some approaches, deterioration factors and speed adjustment factors.

The motor vehicle population distribution used by the ARB is based on 1973 registration data obtained from the Department of Motor Vehicles [22]. The distributions for light duty vehicles and heavy duty vehicles are assumed to be representative of future ownership patterns and vehicle attrition rates.

The values of average annual mileage used by the ARB for light duty vehicles are based on data obtained from the California Highway Patrol roadside inspection programs [14]. Values for heavy duty vehicles are based on national surveys of commercial vehicle operations [15]. Motorcycle usage for this report has been determined using nationwide data from EPA [12]. Use of this data is described in an ARB technical support document [23].

The vehicle types considered in the ARB emission assessment are light duty vehicles (automobiles and trucks), heavy duty gasoline-powered vehicles (trucks), heavy duty diesel-powered vehicles (trucks), motorcycles, and off-road mobile sources. The light duty vehicles are further identified as light duty passenger vehicles and light duty trucks in the ARB assessment.

Current emission rates are derived from data generated as part of various vehicle test programs conducted by EPA and its contractors. Emission rates for future vehicles are based on prototype test data and best estimates. Any vehicle degradation effects that might be expected are incorporated into the emission factors.

Emission rates for light duty trucks, passenger vehicles and motorcycles are derived from CVS-75 test cycle data [12]. Gasoline-powered and diesel-powered heavy duty vehicle emission rates are derived from San Antonio Road Route test data [17,18].

3.1.3-4 Development of Composite Emission Factors

The approach presented in this report is based on the calculation of a composite emission factor (CEF) that is representative of the average vehicle in use. All data used to generate the CEFs are based on [12]:

Light duty vehicles (This includes light duty passenger vehicles and light duty trucks. A light duty vehicle is any vehicle with a gross vehicle weight of 6,000 pounds or less).

Heavy duty vehicles, gasoline-powered

Heavy duty vehicles, diesel-powered, and

Motorcycles

The general equations [10,11,12,19] for calculation of these CEFs are as follows:

$$e_{npstwx} = \sum_{i-n-k}^{n} c_{ipn}\, m_{in}\, v_{ips}\, z_{ipt}\, r_{iptwx}$$

where,

e_{npstwx} = Composite emission factor in grams per mile (g/km) for calendar year (n), pollutant (p), average speed (s), ambient temperature (t), percentage cold operation (w), and percentage hot start operation (x).

c_{ipn} = The Federal Test Procedure (FTP) mean emission factor for the i^{th} model year vehicles during calendar year (n) and for pollutant (p).

m_{in} = The fraction of annual travel by the i^{th} model year vehicles during calendar year (n).

v_{ips} = The speed adjustment factor for the i^{th} model year vehicles for pollutant (p), and average speed (s). This variable applies only to CO, HC, and NOx.

z_{ipt} = The temperature adjustment for the i^{th} model year vehicles for pollutant (p) and ambient temperature (t). (Applied to light-duty vehicles only).

r_{iptwx} = The hot/cold vehicle operation adjustment factor for the i^{th} model year vehicles for pollutant (p), ambient temperature (t), percentage cold operation (w), and percentage hot start operation (x). (Applied to light-duty vehicles only).

k = The number of specific vehicle model years to be considered in calculations. 12 has been used as k by others [10,11,12,19], however, any number of model years may be considered if sufficient data are available. The ARB presently considers 17 separate model years.

In addition to exhaust emission factors, the calculation of hydrocarbon gasoline motor vehicle emissions involves evaporative and crankcase hydrocarbon emission rates. Evaporation and crankcase emissions can be determined using:

$$f_n = \sum_{i=n-k}^{n+1} h_i \, m_{in}$$

where,

f_n = the combined evaporative and crankcase hydrocarbon emission factor for calendar year n

h_i = the combined evaporative and crankcase emission rate for the i^{th} model year

m_{in} = the weighted annual travel of the i^{th} model year during calendar year n

k = the number of specific vehicle model years to be considered in calculations.

A value of 1.0 was used for the speed adjustment factor for all the exhaust CEFs in this report. Note that the hydrocarbon evaporative and crankcase emission factors do not have a speed adjustment factor. These emissions are assumed to be independent of speed and the efficiency of the control devices are assumed to be constant.

3.1.3-5 Alternate Approaches for Estimating Emissions

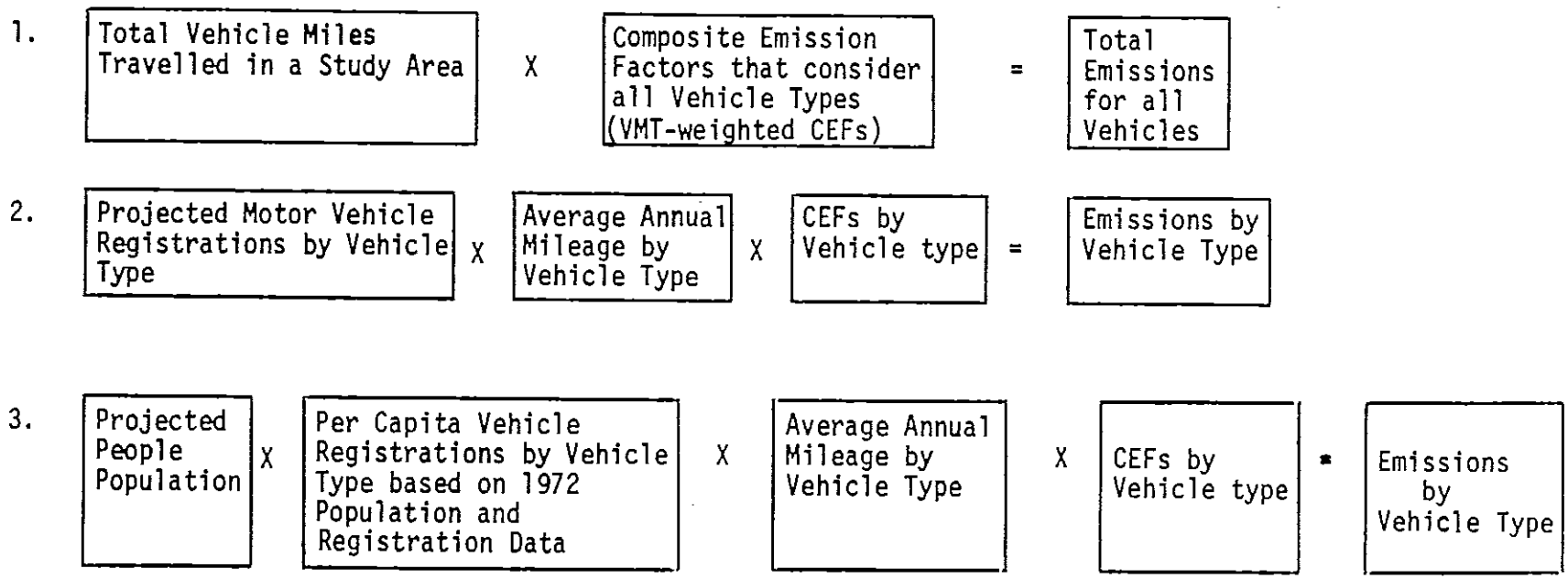
The emissions from motor vehicles can be estimated using several different sets of parameters. Three approaches are shown in Figure 3.4. The independent variable in each approach is the variable on the far left of the equations.

Approach 1 - Vehicle Miles Traveled

The total vehicle miles traveled (VMT) for a study area are used in conjunction with a composite emission factor representative of total vehicle activity. VMT estimates for a study area are developed from transportation studies using data from origin-destination surveys or transportation models. VMT estimates for specific projects can be developed using trip generation rates (trip ratios) based on traffic surveys. Trip generation rates are given in terms of trips per unit parameter characteristic of the project of interest, e.g., trips per parking space or trips per 10,000 square feet of leasable floor space for shopping center; trips per student or trips per staff member for colleges. District 4 (San Francisco) and District 11 (San Diego) of the California Department of Transportation have several reports on trip generation rates for facilities such as office buildings, colleges, shopping centers, and marinas [20,21]. While the generation rates are specific for the original area, they can be used in conjunction with data on trip lengths to develop comparative estimates of VMT for project alternates.

FIGURE 3.4

Three Approaches For Estimating Emissions From Motor Vehicles



Total VMT estimates are usually not broken down into VMT by vehicle type. A percentage of VMT from heavy duty vehicles can be calculated based on traffic survey data. However, usually no distinction is made between diesel-powered or gasoline-powered heavy duty vehicles. Also, motorcycle VMT is typically not estimated.

Since these vehicle types all have different emission factors, source adjustment of the composite emission factor must be made. This adjustment is based on the percent of statewide total VMT for each vehicle type for 1973 shown in Table A.3.2. This adjustment assumes that the percentage of total VMT by vehicle type remains constant through time and is applicable to specific study areas. The following example is for 1975 for carbon monoxide:

Vehicle Type	(1) % of Total VMT (From Table A.3.2)	(2) 1975 CO CEF (From Table A.3.6)	(1)x(2) / 100
LD Vehicle	86.8	47.7 gm/mile	41.4 gm/mile
Gasoline-Powered Heavy Duty Vehicle	8.3	207.2 gm/mile	17.2 gm/mile
Diesel-Powered Heavy Duty Vehicle	4.1	28.7 gm/mile	1.2 gm/mile
Motorcycle	0.8	30.6 gm/mile	0.3 gm/mile

1975 VMT - weighted CEF for carbon monoxide = 60.1 gm/mile

This VMT-weighted composite emission factor of 60.1 grams of carbon monoxide per vehicle mile is used with the estimate of VMT to calculate the total emissions of carbon monoxide. The same procedure is used to calculate the VMT-weighted CEFs for the other pollutants. It should be noted that the VMT-weighted CEFs are used only when the VMT for a study area or project is not broken down into VMT by vehicle type. Also, if the development in the study area indicates different percentages of vehicle activity than the statewide average, different percentages

should be used in calculating the VMT-weighted CEFs. As an example, for most residential development, the heavy duty vehicle activity could be negligible. If the study area comprises only industrial areas, the heavy duty vehicle activity could be much greater than the statewide average.

Approach 2 - Vehicle Registrations

The ARB Emissions Inventory Unit has analyzed data from various sources to determine average annual mileages by vehicle type, in-use vehicle populations, and annual vehicle population increases [23]. These data are presented in Appendix A in Tables A.3.1 and A.3.2. Using Table A.3.1, in-use motor vehicle populations for any year may be estimated. Once the projected motor vehicles in use by vehicle type is determined, the values for average annual mileage by vehicle type are used to calculate annual VMT. Then the CEFs are used to calculate annual emissions (grams/year) and a units conversion factor used to obtain the desired units, typically tons/day.

The following example is for Orange County in 1985 for carbon monoxide (CO):

Determine vehicle populations for 1973 and 1985 from Table A.3.1

	Ⓐ Vehicles In Use 1973	Ⓑ Annual Increase (% 1973)	Vehicles In Use -- 1985 $Ⓐ + \frac{12ⒶⒷ}{100}$
Light Duty Passenger	801,953	4.63	1,247,520
Light Duty Truck	132,726	4.63	206,470
Total Light Duty	934,679		1,453,990
Heavy Duty Gas	47,884	6.64	86,040
Heavy Duty Diesel	5,233	6.64	9,400
Total Heavy Duty	53,117		95,440
Motorcycles	48,592	5.73	82,000

Annual VMT by vehicle type may now be calculated using the Annual Average Mileages given in either Table A.3.2 or Table A.3.12.

Light Duty Vehicles VMT (1985) = (1,453,990) x (8,317)
= 12.09×10^9 miles

Heavy Duty Vehicles VMT (1985) = (95,440) x (15,944)
= 1.52×10^9 miles

Motorcycles VMT (1985) = (82,000) x (1,570) = 0.13×10^9 miles

The Composite Emission Rates from Table A.3.12 are now applied to obtain emissions per vehicle type.

Light Duty Vehicles CO emissions (1985) = $(12.09 \times 10^9) \times (7.2)$
= 8.705×10^{10} grams/year

Heavy Duty Vehicles CO emissions (1985) = $(1.52 \times 10^9) \times (106.3)$
= 16.158×10^{10} grams/year

Motorcycle CO emissions (1985) = $(0.13 \times 10^9) \times (30.6)$
= 0.398×10^{10} grams/year

Sum all vehicle types to obtain CO emissions for all on-road vehicles in Orange County in 1985.

$$\begin{array}{r} 8.705 \times 10^{10} \\ 16.158 \times 10^{10} \\ \underline{0.398 \times 10^{10}} \end{array}$$

Total CO emissions from on-road vehicles in Orange County in 1985 = 25.26×10^{10} grams/year

Convert grams/year into units of tons/day

$(25.26 \times 10^{10}$ grams/year) x $(3.02 \times 10^{-9}$ tons-year/grams-day)
= 763 Tons Per Day CO

When estimating hydrocarbon emissions, crankcase and evaporative emissions must also be calculated. In this example, we could easily calculate these emissions using the calculated vehicle populations and average annual mileages from Table A.3.12 in Appendix A.

Light Duty Vehicles HC evaporative emissions (1985)
= (1,453,990) x (8,317) x (0.79) = 9.553×10^9 grams/year
= 28.9 Tons Per Day HC

To determine reactive hydrocarbons, apply appropriate reactivity factor from Table A.3.17 in Appendix A.

Light Duty Vehicles Reactive HC evaporative emissions (1985)
= 28.9 x 0.035 (Class I)
= 1.0 Tons Per Day Class I Reactive
= 28.9 x 0.564 (Class II)
= 16.3 Tons Per Day Class II Reactive
= 28.9 x 0.401 (Class III)
= 11.6 Tons Per Day Class III Reactive

Approach 3 - Vehicle Registrations Per Capita

The 1973 values for average number of vehicles in use by county (Table A.3.1) and county population data (Table B.3.1) are used to calculate per capita vehicles in use by vehicle type. Future year population projections (Tables B.3.2 and B.3.3) are then used with the per capita values to estimate the number of future year vehicles. Once future year vehicles are estimated, the procedure is the same as that outlined in Approach 2 above.

The following example is for Orange County in 1985:

Determine the amount of projected motor vehicles by vehicle type by using Tables A.3.1, B.3.1 and B.3.2.

From previous example

Orange County Light-Duty Vehicles (1973) = 934,679
Orange County Heavy-Duty Vehicles (1973) = 53,117
Orange County Motorcycles (1973) = 48,592

Applying the 1985 growth factor from Table B.3.4.

Orange County Light-Duty Vehicles (1985) = (934,679) x (1.402)
= 1,310,420
Orange County Heavy-Duty Vehicles (1985) = (53,117) x (1.402)
= 74,470
Orange County Motorcycles (1985) = (48,592) x (1.402) = 68,130

Once these future year vehicle populations are calculated, then the remaining calculations are identical to those described in the example above for Approach 2.

A comparison of the vehicle populations as determined by Approach 2 and Approach 3 is appropriate.

	Approach 2	Approach 3
Orange County Light-Duty Vehicles (1985)	1,453,990	1,310,420
Orange County Heavy-Duty Vehicles (1985)	95,440	74,470
Orange County Motorcycles (1985)	82,000	68,130

It can be seen that Approach 2 consistently yields higher vehicle populations than Approach 3. The reason for this is that DMV projections used in Approach 2 project future growth using both

population projections (D-100 series similar to those found on Table B.3.2) and vehicle per capita growth projections (based on historical trends between fiscal years 1961-62 and 1971-72). Approach 3 assumes that vehicle per capita ratios will remain constant at 1973 levels and growth is attributed solely to population growth. In this respect, the two approaches may be used to establish a range of possible future values. Approach 2 would depict the continued growth at the high levels achieved during the prosperous 1960's and Approach 3 would describe a slowed growth indicative of present economic activity.

All three approaches utilize assumptions as to the applicability of statewide and countywide data to specific study areas. These assumptions, or at least the clearly visible ones, are minimized when the basis for emission estimates is an estimate of VMT from transportation studies in the study area. These VMT estimates are regionally specific since local preferences through origin-destination surveys and transportation system configurations are considered in the transportation modeling process.

3.1.4 Aircraft

3.1.4-1 Classification Systems and Emission Factors

There are two major categories of aircraft: piston engine powered and gas turbine powered. Turbine aircraft and piston engine aircraft are further divided into sub-categories depending on the size of the aircraft and the most commonly used engine for that sub-category. A commonly used classification system is shown in Table 3.5.

An operating cycle, called the landing-takeoff (LTO) cycle, is used to quantify emissions from aircraft. The emissions cycle for aircraft includes aircraft emissions during an approach from an altitude of 3,500 feet, landing, taxiing, and engine warmup, takeoff, and climbout to 3,500 feet. It should be made clear that the term "operation" used by the Federal Aviation Administration to describe either a landing or a takeoff is not the same as the LTO cycle. Two operations are involved in one LTO cycle. The LTO cycle incorporates the ground operations of idle, taxi, landing run, and takeoff run and the flight operations of takeoff and climbout to 3,500 feet and approach from 3,500 feet to touchdown.

Each class of aircraft has its own typical LTO cycle. In order to determine emissions, the LTO cycle is separated into five distince modes: (1) taxi-idle, (2) takeoff, (3) climbout, (4) approach, (5) landing, and (6) taxi-idle. Each of these modes has its share of time in the LTO cycle. Using modal emission factors for the most common engine of a certain aircraft class, the typical LTO cycle emissions factor can be calculated. This is the approach used in AP-42 [10]; the resulting emission factors are shown in Table 3.6. The 1975 emission factors represent the uncontrolled emission rates for aircraft.

TABLE 3.5

Aircraft Classifications[a]

Aircraft class	Representative aircraft	Engines per aircraft	Engine commonly used
Jumbo jet	Boeing 747	4	Pratt & Whitney JT-9D
	Lockheed L-1011	3	
	McDonald Douglas DC-10	3	
Long-range jet	Boeing 707	4	Pratt & Whitney JT-3D
	McDonald Douglas DC-8	4	
Medium-range jet	Boeing 727	3	Pratt & Whitney JT-8D
	Boeing 737	2	
	McDonald Douglas DC-9	2	
Air carrier turboprop	Convair 580	2	Allison 501-D13
	Electra L-188	4	
	Fairchild Hiller FH-227	2	
Business jet	Gates Learjet	2	General Electric CJ610
	Lockheed Jetstar	4	Pratt & Whitney JT-12A
General aviation turboprop	—	—	Pratt & Whitney PT-6A
General aviation piston	Cessna 210	1	Teledyne-Continental Ø-200
	Piper 32-300	1	Lycoming Ø-320
Piston transport	Douglas DC-6	4	Pratt & Whitney R-2800
Helicopter	Sikorsky S-61	2	General Electric CT-58
	Vertol 107	2	
Military transport			Allison T56A7
Military jet			General Electric J-79
			Continental J-69
Military piston			Curtiss-Wright R-1820

a) From [10,11]

TABLE 3.6

EMISSION FACTORS PER AIRCRAFT LANDING-TAKEOFF CYCLE
(lb/engine)

Aircraft	Solid particulates				Sulfur oxides				Carbon monoxide				Hydrocarbons[b]				Nitrogen oxides (NO_x as NO_2)			
	pre-1981	1985	1990	1995	pre-1981	1985	1990	1995	pre-1981	1985	1990	1995	pre-1981	1985	1990	1995	pre-1981	1985	1990	1995
Jumbo jet	1.30	1.30	1.30	1.30[a]	1.82	1.82	1.82	1.82	46.8	34.0	21.2	8.4	12.2	8.8	5.3	1.8	31.4	26.2	20.9	15.7
Long range jet	1.21	1.01	0.81	0.61[a]	1.56	1.56	1.56	1.56	47.4	34.4	21.4	8.5	41.2	29.6	17.9	6.2	7.9	6.6	5.3	4.0
Medium range jet	0.41	0.34	0.28	0.21[a]	1.01	1.01	1.01	1.01	17.0	12.4	7.8	3.1	4.9	3.52	2.13	0.74	10.2	8.5	6.8	5.1
Air carrier turboprop	1.1	1.1	1.1	1.1	0.40	0.40	0.40	0.40	6.6	5.3	4.0	2.6	2.9	2.12	1.35	0.58	2.5	2.3	2.2	2.0
Business jet	0.11	0.11	0.11	0.11	0.37	0.37	0.37	0.37	15.8	12.6	9.4	6.3	3.6	2.64	1.68	0.72	1.6	1.5	1.4	1.3
General aviation turboprop	0.20	0.20	0.20	0.20	0.18	0.18	0.18	0.18	3.1	2.5	1.9	1.2	1.1	.81	0.51	0.22	1.2	1.2	1.1	1.0
General aviation piston	0.02	0.02	0.02	0.02	0.014	0.14	0.14	0.014	12.2	10.2	8.2	6.1	0.40	0.36	0.32	0.28	0.047	0.047	0.047	0.047
Piston transport	0.56	0.56	0.56	0.56	0.28	0.28	0.28	0.28	304.0	253.4	202.8	152.0	40.7	36.6	32.6	28.5	0.40	0.40	0.40	0.40
Helicopter	0.25	0.25	0.25	0.25	0.18	0.18	0.18	0.18	5.7	5.7	5.7	5.7	0.52	0.52	0.52	0.52	0.57	0.57	0.57	0.57
Military transport	1.1	1.1	1.1	1.1	0.41	0.41	0.41	0.41	5.7	5.7	5.7	5.7	2.7	2.7	2.7	2.7	2.2	2.2	2.2	2.2
Military jet	0.31	0.31	0.31	0.31	0.76	0.76	0.76	0.76	15.1	15.1	15.1	15.1	9.93	9.93	9.93	9.93	3.29	3.29	3.29	3.29
Military piston	0.28	0.28	0.28	0.28	0.14	0.14	0.14	0.14	152.0	152.0	152.0	152.0	20.4	20.4	20.4	20.4	0.20	0.20	0.20	0.20

Source: Pre-1981 factors from AP-42, Compilation of Air Pollutant Emission Factors, Environmental Protection Agency, April 1973.
1985 and 1990 factors developed from linear interpolation of 1980 and 1995 factors.
1995 factors are based on 1975 factors and the percentage reductions expected from implementation of the emission standards. [25]

[a] Assumed 50% reduction.

[b] Total hydrocarbons equivalent to Total Organic Gases.

The Environmental Protection Agency has promulgated [24] emission standards for aircraft that have a time-phased implementation schedule similar to the motor vehicle standards. Fuel venting regulations are presently in effect and exhaust emissions standards first become effective in 1981. It was assumed in Table 3.6 that 1975 emission factors approximate 1980 factors. The determination of 1985 and 1990 emission factors (lb/LTO/engine) requires data on the attrition rate, replacement rate, and purchase rate of the different aircraft categories. Also, a quantitative relationship between the test cycle emission rates and the emissions for an actual LTO cycle is needed. There were inadequate data to complete the calculations and as a result 1985 and 1990 emission factors were determined through linear interpolation of 1980 and 1995 factors. For 1995, it was assumed that the emissions from aircraft would correspond to the emission standards. As more data becomes available on aircraft fleet operation the emission factors for 1980, 1985, 1990, and 1995 will be refined.

3.1.4-2 Estimating Emissions from Aircraft

For a given study area, the emissions from aircraft are a function of the number of airports, the types of aircraft using the airport, and the number of LTOs by different aircraft classes. While a given study area may not have an airport within its boundaries, portions of LTO cycles of an airport may occur over a study area.

Emissions from aircraft for all years can be estimated using projections of LTOs by aircraft classes and the appropriate emission factors in Table 3.6. If projections of LTOs for future years are not available, future year emissions can be projected using population growth factors applied to base year LTOs. These population growth factors should be based on the population of the area served by the airport.

The following hypothetical example illustrates the described techniques.

Two airports in Orange County supplied the following estimates of Federal Aviation Administration's (FAA) operations in 1975.

Aircraft Classification	Average Engines Per Craft	Daily FAA Operations
Medium-range jet	2.5	368
General aviation piston	1.5	1,642
Helicopter	1	38

Unfortunately, no data were available for future year operations. Assume that carbon monoxide (CO) emissions estimates are required for 1975 and 1995.

Determine 1975 emissions by applying 1975 emission factors from Table 3.6 to each aircraft classification. Note that the operations estimates provided by the airports are for FAA operations; to determine LTOs, assume one LTO for every two FAA operation.

Emissions from medium-range jets (1975) = (368/2) x (2.5) x (17)
= 7,820 Pounds Per Day CO

Emissions from general aviation pistons (1975) = (1642/2) x (1.5) x (12.2)
= 15,020 Pounds Per Day CO

Emissions from helicopters (1975) = (38/2) x (1) x (5.7)
= 110 Pounds Per Day CO

Sum all aircraft types to obtain CO emissions for 1975.

(7,820) + (15,020) + (110) = 22,950 Pounds Per Day CO
= 11.5 Tons Per Day CO (1975)

To estimate emissions for 1995, apply 1995 population growth factors for Orange County to the 1975 LTO estimates. This assumes the service area of the two airports to be Orange County.

From Table B3.4: 1975 population growth factor = 1.064
1995 population growth factor = 1.663

LTOs medium-range jets (1995) = (368/2) x (1.663/1.064)
= 288 LTOs Per Day

LTOs general aviation pistons (1995) = (1642/2) x 1.663/1.064)
= 1,283 LTOs Per Day

LTOs helicopters (1995) = (38/2) x (1.663/1.064) = 30 LTOs Per Day

Calculate emissions by applying 1995 emission factors to the projected LTOs (assume same average engines per craft as in 1975).

Emissions from medium-range jets (1995) = (288) x (2.5) x (3.1)
= 2,230 Pounds Per Day CO

Emissions from general aviation pistons (1995) = (1,283) x (1.5) x (6.1)
= 11,740 Pounds Per Day CO

Emissions from helicopters (1995) = (30) x (1) x (5.7)
= 170 Pounds Per Day CO

Sum all aircraft types to obtain CO emissions for 1995.

(2,230) + (11,740) + (170) = 14,140 Pounds Per Day CO = 7 Tons Per Day CO

In the event that LTO information is unattainable, a gross emission estimate may be made by applying population growth factors to a base year estimate of total aircraft emissions. The ARB estimates emissions by county as shown in Table 3.7 for Orange County. A 30% across the board emissions reduction has previously been assumed by the ARB for 1980 [26].

Detailed methodologies for assessing emissions from aircraft are available [27,28] and should be reviewed if aircraft emissions are significant in a given study area.

TABLE 3.7
AVERAGE EMISSIONS OF POLLUTANTS-1973
ORANGE COUNTY
SOUTH COAST AIR BASIN
(TONS PER DAY)

FEB. 26, 1976 PRELIMINARY DATA - SUBJECT TO REVISION

STATIONARY SOURCES	TOG	PART.	NOX	SO2	CO
PETROLEUM					
PRODUCTION	7.2			4.5	
REFINING					
MARKETING	21.0				
SUBTOTAL	28.2			4.5	
ORGANIC SOLVENT USERS					
SURFACE COATING	11.7				
DRY CLEANING	3.0				
DEGREASING	5.3				
OTHER	12.0				
SUBTOTAL	32.0				
CHEMICAL		0.1	0.3		
METALLURGICAL		0.1			
MINERAL		1.0	0.9	1.5	15.1
FOOD AND AG PROCESSING					
PESTICIDES	2.9				
WOOD PROCESSING					
COMBUSTION OF FUELS					
POWER PLANTS	0.6	2.7	11.8	17.9	
OTHER INDUSTRIAL	0.1	0.6	5.0	0.1	0.5
DOMESTIC AND COMMERCIAL	0.7	1.6	7.6	0.1	1.7
ORCHARD HEATERS					
SUBTOTAL	1.4	4.9	24.4	18.1	2.2
WASTE BURNING					
AGRICULTURAL DEBRIS	0.1				0.2
FOREST MANAGEMENT					
RANGE IMPROVEMENT					
DUMPS					
CONICAL BURNERS					
INCINERATORS	0.1	0.1	0.1		0.2
OTHER					
SUBTOTAL	0.2	0.1	0.1		0.4
MISCELLANEOUS AREA SOURCES					
WILD FIRES	2.5	1.9	0.1		8.1
STRUCTURAL FIRES	4.4	3.3	0.2		14.3
FARMING OPERATIONS		1.4			
CONSTR. AND DEMOL.		1.4			
UNPAVED ROADS		2.0			
UTILITY EQUIP:MOWERS,ETC	2.2	0.1	0.2		15.3
SUBTOTAL	9.1	10.1	0.5		37.7
TOTAL,STATIONARY	73.8	16.3	26.2	24.1	55.4
JET AIRCRAFT	0.7	0.1	0.6	0.1	1.3
PISTON AIRCRAFT	0.4		0.1		8.4
RAILROADS	0.4	0.1	1.5	0.2	0.5
SHIPS					
OTHER OFF-ROAD VEHICLES	8.9	0.6	6.5	1.0	39.9

Reference: Air Resources Board Emissions Inventory Unit

3.1.5 Off-Road Mobile Sources, Trains, and Ships

Off-road mobile sources comprise snowmobiles, dune buggies, farm equipment, off-road motorcycles, and off-road heavy duty equipment. The quantification of the emissions from these sources for any year, past or future, is difficult because of the lack of adequate data on the number of sources, operations, and emission rates. Consequently, it was felt that future year emissions could best be estimated by multiplying the 1973 emissions from these sources by population growth factors. Similarly, the emissions from trains and ships are projected using population growth factors. The use of per capita emission factors is based on the implicit assumptions that the emission rate is constant over time. This approach does not consider the possibility of increased per capita use or decreased emissions per operation of the source.

For these three source categories, the emissions tabulated in the 1973 ARB Emission Inventory are multiplied by the population growth factor for the year of interest. Population growth factors for C-150 and E-0 population growth rates, shown in Tables B.3.5 through B.3.21 in Appendix B have been normalized to the base year of 1973. Table B.3.4 describes methodology to develop series D-100 based population growth factors.

As an example from Table 3.7, the emissions of carbon monoxide (CO) in Orange County from these sources in 1973 are:

Off-Road Mobile Sources	39.9 tons/day
Trains	0.5 tons/day
Ships	Negligible
	40.4 tons/day of CO

From Table B.3.4, the D-100 1985 population growth factor for Orange County is 1.402. (40.4 tons/day)x(1.402) = 56.6 tons/day.

The emissions of CO from off-road mobile sources, trains, and ships in 1985 in Orange County are estimated to be 56.6 tons/day.

3.1 ESTIMATING SOURCE EMISSIONS

3.1.6 Fossil Fuel Power Plants

3.1.6-1 Introduction

Fossil fuel power plants presently meet the bulk of California's electrical energy demands; it is likely that fossil fuels will continue to generate significant quantities of energy through the year 2000. The combustion processes of these power plants and the associated high pollutant emissions make it necessary that the location or potential location of power plants be determined as accurately as possible when forecasting future air quality impacts. Typical lead times for fossil fuel power plants are approximately 6 to 8 years; nuclear power plants have typical lead times of 7 to 10 years [29]. This means that the short term planner (5 to 10 years) will normally be able to determine power plant location and design well in advance of power plant start-up. However, the long term planner is faced with the dilemma of knowing that additional energy will be required but not knowing what the source, location, or fuel type will be. To add to this uncertainty, recent state and federal stationary source regulations have made air quality a priority consideration in future year power plant construction. The regulations require that air pollution control agencies deny a permit to construct for any project that would interfere or prevent the attainment or maintenance of any primary National Ambient Air Quality Standards [30]. The federal regulations in themselves are not a source of uncertainty, but the still-developing implementation process at the federal, state, and local level is very much an unknown quantity. A more detailed discussion of new rules and regulations may be found in Section 3.2.1.

Determining the size and location or planned location of a power plant is only half the battle. In order to determine air quality impacts, the planner must estimate the use characteristics of the plant. Fuel type and sulfur content of fuels used may vary seasonally according to supply of preferred fuels. Power plant efficiency and emission rate

may vary according to power generation rate. The complicated network of power transmission lines in and out of California allows the delivery of energy to opposite ends of the State, thereby dislocating emissions from the area of power use. This type of energy use information is often difficult to obtain or estimate.

The following sections delineate sources of information and emissions estimating methodologies. An attempt is made to provide insight into the difficulties associated with evaluating air quality impacts of power plants.

3.1.6-2 Sources of Information

There are presently two State agencies involved in power plant siting: the Public Utilities Commission (PUC) and the newly formed State Energy Resources Conservation and Development Commission (State Energy Commission). Both of these commissions can supply valuable information for future emissions estimates.

The PUC has in the past handled all power plant siting activities at the State level. Its function was to review applications and grant certificates of public convenience and necessity, which are required before a power plant construction permit may be obtained. The enactment of the Warren-Alquist State Energy Resources Conservation and Development Act (AB 1575, 1974) in January of 1975 transferred primary power plant siting responsibility from PUC to the State Energy Commission. However, the Act did allow for some 42 individual planned power plants with a total generating capacity of over 14,000 megawatts (see note) to be exempt from review by the State Energy Commission [31]. The planning and construction of these power plants will be done under

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Note: A megawatt is one million watts. A kilowatt is one thousand watts. A kilowatt-hour is the amount of electricity needed to light 10 one-hundred-watt light bulbs for one hour.

(10 light bulbs) (100 watts/light bulb) (1 hour) = 1 kilowatt hour

the auspices of PUC to allow for a smoother transition of power plant siting authority. Construction of all exempt power plants is expected to commence before January, 1978.

The State Energy Commission was formed in recognition of the need for a cohesive process of energy conservation and development. The Energy Commission has exclusive power to certify all power plant sites and related facilities. In addition, the Warren-Alquist Act requires that beginning January 1, 1977 and every two years thereafter, the Energy Commission submit to the Governor and Legislature a comprehensive report identifying trends of energy supply, demand, conservation and health and safety factors for each year in forthcoming 5, 10, and 20 year periods. These reports should be useful tools for planners in estimating air quality impacts. The Energy Commission's reports will be based on information from local public utilities with evaluation and modification by the Commission. The public utilities themselves may be used as an additional information sources.

Information from the public utilities will likely be more area specific and may be more useful to the planner. Often, the local utility will be able to supply information in advance of PUC or the State Energy Commission. However, reports from the latter sources may represent more comprehensive evaluation of total State needs. Anyone using information from either local public utilities, the State Energy Commission, or PUC should evaluate the consistency of the data obtained (e.g., growth rates) and determine the most appropriate source of information for the specific planning task.

Table A.3.18 lists the generating capacity available to California as of December 31, 1972. For each plant, it includes the location of power plants, power plant names, the names of the utilities operating plants, maximum generating capacity and type of fuel normally used. Table A.3.19 is a summary of projections for new plants up to 1991 based on 1972 projections. Tables A.3.20 and A.3.21 delineate the location and capacity

of specific power plants already planned. The tables should be used only when making first attempts to identify location and size of power plants. Specific power plant information should be obtained from one of the sources previously mentioned.

3.1.6-3 Methodologies for Estimating Emissions from Electric Utilities

The specific method used for estimating air quality impacts of power plants is directly dependent on the availability of information. As already mentioned, in the short term (5-10 years), relatively accurate information is available; however, long term estimates (10-20 years) are usually very speculative. The possibility that no new fossil fuel fired power plants will be constructed in air quality maintenance areas should be considered. These areas are identified in Revision 5 of the State Implementation Plan [32]. In addition, local air pollution districts have specific regulations (e.g., Los Angeles Zone Southern California APCD Rule 20.1) forbidding construction of large new sources which will interfere or prevent the attainment and maintenance of any National Ambient Air Quality Standards. Direct contact with local districts is necessary to clarify legal implications of local future growth of power plants.

Method A - Per Capita Based Estimates

The first approach to estimate future power plant/air quality relationships is based on the projection of electrical generation demand on a per capita basis. The principal requirement for this kind of estimate is to obtain population projections for the future years of interest. Several sets of per capita energy demand values are given in Table 3.8. These values are based on the 3 scenarios developed by Rand [29] and the population projections of the California Department of Finance. These per capita values reflect statewide averages. For a description of the scenarios and assumptions used, the reader is referred to the Rand report [29]. The per capita demand values may be combined with population projection data to determine future electrical generation require-

TABLE 3.8
PROJECTIONS OF PER CAPITA ENERGY GENERATION
(KWH X 10^4/Year/Capita)

Scenario	Statewide Electrical Energy Generation[1] (Billions of KWH/Year)					Per Capita Energy Generation[2] (KWH X 10^4/Year/Capita)				
	1975	1980	1985	1990	1995	1975	1980	1985	1990	1995
Base Case (medium production, medium use)	160	205	258	323	408	0.75	0.90	1.06	1.24	1.47
Lower Limit (medium production, low use)	160	197	239	286	338	0.75	0.87	0.98	1.10	1.22
Upper Limit (low production, high use)	160	225	289	377	487	0.75	0.99	1.19	1.44	1.76

[1] Source: Energy Alternatives for California: Paths to the Future, Prepared for California State Assembly by Rand, R-1793-CSA/RF. December 1975.

[2] Based on Department of Finance population projections, D-100 series, June, 1974. The values were determined by dividing the projected Statewide Electrical Energy Generation by the projected statewide population.

ments. Emissions estimates may then be calculated by identifying electrical generation potential according to fuel type and applying appropriate emission factors.

Tables 3.9a,b,c provide information to disaggregate power generated according to fuel type for years between 1975 and 1995. The numbers provided are for statewide energy production estimates based on three scenarios developed by Rand [29] and should be used with appropriate values from Table 3.8. Once the energy sources have been identified, then emission factors may be applied to the fossil fuel power plants: natural gas, fuel oil and coal. It is assumed that coal fired power plants will be built outside of California and emissions from these sources will not directly affect California.

Table 3.10 presents emission factors to be used in this estimating methodology. There are several implicit assumptions in these factors such as plant efficiency and fuel heating value which may not be appropriate for the study area. However, these assumptions are appropriate when using Tables 3.8 and 3.9a,b,c.

As an example of using Method A for estimating future year emissions, calculations for a study area of 1 million people and for the year 1985 are shown below:

From Table 3.8 for Base Case-1985 an Electrical Generation of 1.06 KWH x 10^4/Year/Capita is estimated.

1.06 KWH x 10^4/Year/Capita x 1,000,000 people = 1.06 x 10^{10} KWH Per Year
= 10.6 x Million MWH Per Year

From Table 3.9a for 1985, electrical generating fraction of 0.136 from Gas and 0.298 from Fuel Oil

(10.6) x (0.136) = 1.44 Million MWH Per Year from natural gas-fuled power plants

(10.6) x (0.298) = 3.16 Million MWH Per Year from fuel oil-fueled power plants

TABLE 3.9a
HYPOTHETICAL POWER GENERATING MIX 1975-1995[1]
Base Case (Medium production, medium use)

Energy Source	Fraction of Total				
	1975	1980	1985	1990	1995
Hydroelectric	0.219	0.171	0.140	0.111	0.088
Geothermal	0.025	0.078	0.120	0.142	0.150
Coal[2]	0.100	0.107	0.116	0.093	0.074
Nuclear	0.081	0.161	0.190	0.288	0.488
Gas[3]	0.125	0.098	0.136	0.108	0.061
Oil	0.450	0.385	0.298	0.257	0.140
TOTAL[4]	1.000	1.000	1.000	0.999	1.001

[1]Source: Energy Alternatives for California Paths to the Future, Prepared for California State Assembly by Rand, R-1793-CSA/RF. December 1975
[2]Coal fired powerplants outside of California.
[3]Includes synthetic and natural gas.
[4]Totals may not add to 1.000 due to rounding.

TABLE 3.9b
HYPOTHETICAL POWER GENERATING MIX 1975-1995[1]
Lower Limit (Medium production, low use)

Energy Source	Fraction of Total				
	1975	1980	1985	1990	1995
Hydroelectric	0.219	0.178	0.151	0.126	0.107
Geothermal	0.025	0.081	0.130	0.161	0.180
Coal[2]	0.100	0.112	0.126	0.105	0.089
Nuclear	0.081	0.168	0.205	0.283	0.352
Gas[3]	0.125	0.102	0.205	0.178	0.148
Oil	0.450	0.360	0.184	0.147	0.124
TOTAL[4]	1.000	1.001	1.001	1.000	1.000

[1]Source: Energy Alternatives for California Paths to the Future, Prepared for California State Assembly by Rand, R-1793-CSA/RF. December 1975
[2]Coal fired powerplants outside of California.
[3]Includes synthetic and natural gas.
[4]Totals may not add to 1.000 due to rounding.

TABLE 3.9c
HYPOTHETICAL POWER GENERATING MIX 1975-1995[1]
Upper Limit (Low production, high use)

Energy Source	Fraction of Total				
	1975	1980	1985	1990	1995
Hydroelectric	0.219	0.156	0.125	0.095	0.074
Geothermal	0.025	0.071	0.107	0.122	0.125
Coal[2]	0.100	0.098	0.118	0.119	0.152
Nuclear	0.081	0.147	0.170	0.334	0.429
Gas[3]	0.125	0.000	0.000	0.000	0.000
Oil	0.450	0.529	0.481	0.329	0.220
TOTAL[4]	1.000	1.001	1.001	0.999	1.000

[1]Source: Energy Alternatives for California Paths to the Future, Prepared for California State Assembly by Rand, R-1793-CSA/RF. December 1975
[2]Coal fired powerplants outside of California.
[3]Includes synthetic and natural gas.
[4]Totals may not add to 1.000 due to rounding.

Table 3.10

Emission Factors for Emissions from Fossil Fuel Electric Generating Plants in Tons Per Day/Million MWH Per Year

Pollutant	Fuel Type		
	Gas (Natural and Synthetic)	Fuel Oil	Coal
Oxides of Nitrogen (NO_x)	2.04	3.98	9.45
Particulate Matter (PM)	0.14	0.72	1.35
Sulfur Dioxide (SO_2)	0.54	14.58(S) where (S) represents sulfur content of fuel in %; e.g. 0.5% yields a factor of 7.29. Use 1% if no information available.	16.20
Total Organic Gases (TOG)	0.01	0.18	0.17
Carbon Monoxide (CO)	0.23	0.27	0.56

Source: Internal ARB report by W. V. Loscutoff, Evaluation and Planning, March 24, 1976.

Applying emission factors from Table 3.10 for oxides of nitrogen (NOx) yield emissions for 1985.

$$\text{Natural gas} = 1.44 \text{ Million MWH Per Year} \times \frac{2.04 \text{ Tons Per Day NOx}}{\text{Million MWH Per Year}}$$

$$= 2.94 \text{ Tons Per Day NOx}$$

$$\text{Fuel oil} = 3.16 \text{ Million MWH Per Year} \times \frac{3.98 \text{ Tons Per Day}}{\text{Million MWH Per Year}}$$

$$= 12.6 \text{ Tons Per Day NOx}$$

A cautionary note on Method A is that all tables and assumptions are based on statewide trends. It is quite possible that a given study area would not exhibit typical per capita energy demands due to implementation of energy conservaton techniques. It is also possible power plants may not exist within a study area with power being transmitted from outside sources. Finally, the emission rates may not reflect actual conditions due to the influence of variables discussed previously. To improve on Method A estimates, better information and more resources are essential. Method B, described next, outlines areas of possible improvement of emission estimates.

Method B - Area Specific Estimates

In order to provide area specific forecasts of power plant emissions, the following parameters must be delineated for existing and planned power plants: location, fuel type, critical design parameters, and use characteristics. Tables A.3.18, A.3.19, A.3.20, and A.3.21 in Appendix A may be used to identify some of these parameters; however, it is suggested that the tables be used only to familiarize the planner with power plants in his study area before contacting the local public utility or State agencies for more specific information.

The type of information obtained will vary and the estimating technique will vary accordingly. The minimum amount of information obtained for each plant in the study area should be an estimate of projected year of

operation, energy production per year and expected fuel type. The production per year could then be converted into the units of million megawatt hours (MWH) per year, and the emission rates from Table 3.10 may be applied. Assumptions were made in developing the emission rates in Table 3.10 regarding thermal efficiency and fuel heating value. It is suggested that the planner seek technical assistance from the ARB or local districts if such engineering parameters are available.

Most power plants do not operate at a constant efficiency and some may use substitute fuels during certain modes of operation. These variations should be explored and a judgment made as to the most appropriate data to be employed. Note that most power plants will operate at peak generation rates during the mid-summer months when air conditioners are used and during mid-winter months when heating systems operate. Unfortunately, it is during mid-summer and mid-winter that meteorological air pollution potentials are greatest for secondary and primary pollutants respectively. If monthly resolution of power generation is available, then the emission factors in Table 3.10 can be modified by multiplying the factors by 12. For example, 3.98 tons per day/million MWH per year = 47.76 tons per day/million MWH per month. This could be taken one step further for a daily resolution, however, it is doubtful that forecasts are very accurate at that level of temporal resolution.

An example of typical calculations for 1985 using Method B are shown below:

Information from public utility for planned power plant within study area:

1. Fuel to be used - fuel oil
2. Projected operating date - June 1978
3. Total capacity - 500 megawatt
4. Anticipated yearly generation rate - 2 million MWH

Suppose that the utility disaggregates the yearly 2 million MWH generation rate into monthly rates of 0.2 million MWH for the six summer and winter months and 0.13 million MWH for the six spring and fall months. It would be appropriate to apply a monthly emission factor.

$$3.98 \frac{\text{Tons Per Day NOx}}{\text{Million MWH Per Year}} \times \frac{\text{12 Months}}{\text{Year}} = 47.76 \frac{\text{Tons Per Day NOx}}{\text{Million MWH Per Month}}$$

The emissions are then calculated to be,

$$47.76 \frac{\text{Tons Per Day NOx}}{\text{Million MWH Per Month}} \times 0.2 \text{ Million MWH Per Month}$$

= 9.6 Tons Per Day NOx during critical months (summer & winter)

The local public utilities may also be able to provide estimates of total fuel usage in future years. In this situation the reader may use emission factors directly from AP-42 [10,11] or the factors promulgated by EPA for new sources [33]. These emission factors are given in terms of pounds of pollutants per quantity of fuel consumed or in terms of pounds of pollutants per BTU released (see NOTE). In the latter situation, some estimate of fuel heating value is necessary such as BTU per pound of fuel. Some utilities may have developed future year emission rates for planned and existing power plants.

It should be recognized that the estimating techniques described do not completely address the periodic nature of power plant operation. In any given month, the energy demand placed upon a plant will be similar to that shown in Figure 3.5. The temporal dependence of energy demand appears to be significant even at an hourly resolution. How this dependence affects emission rates and fuel use is not well documented. It is quite possible for example, that the minimum night energy demand

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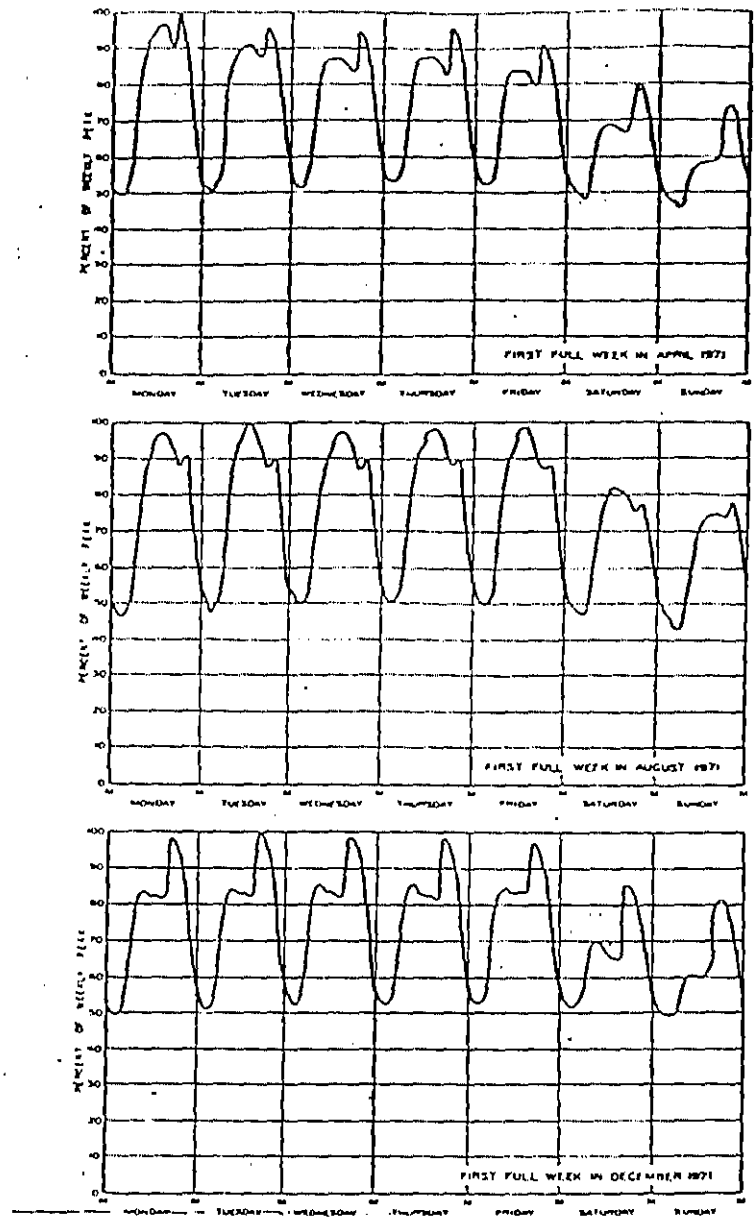
NOTE: A BTU is a British Thermal Unit. It is an energy unit equivalent to 2.93×10^{-4} kilowatt hours. Thermal energy conversion efficiency is a measure of the power plants ability to convert thermal input energy into electrical output energy. A 100% efficiency means that each BTU inputted is converted into exactly 2.93×10^{-4} kilowatt hours. A 35% efficiency means that each BTU is converted into $(.35)(2.93 \times 10^{-4}) = 1.03 \times 10^{-4}$ kilowatt hours.

FIGURE 3.5



HOURLY LOAD CURVES,
CITY OF LOS ANGELES

Source: Los Angeles Department of Water and Power

results in excessive emissions being emitted during early morning hours as steam generators are brought up to speed to meet mid-day peak energy demands. It is obvious that the estimating methodologies described do not consider such a situation.

3.1.7 Other Stationary Sources

3.1.7-1 Introduction

Emissions from stationary sources other than power plants are an important component of the air pollution problem in California. As motor vehicle controls become more stringent in the future, emissions from stationary sources will become increasingly important. This section describes the process of estimating stationary source emissions.

Emissions from these sources may be projected on an individual or aggregate basis. In the first case, each individual point source is treated separately. Forecasting future emissions requires projection of future activity and expansion of each source. Aggregate forecasting requires classification of individual sources into activity categories. Total future emissions are then projected by category instead of individual source.

The decision to forecast by either individual and/or aggregate source emissions is dependent on the information available. In either case, it is necessary and useful to adhere to a step by step procedure. First, it is important to classify emissions according to some activity scheme such as economic or industrial activities. Second, it is necessary to estimate current or baseline emissions from which projections may be made. Third, projections of source or activity growth must be made with the best available information. Finally, the activity or source growth must be used to determine future emissions from either the individual sources or source categories.

3.1.7-2 Source Classification Systems

There are several classification systems that may be used to classify emission sources. The following is a brief description of the scope,

structure and usefulness of several such systems in emissions inventories and forecasting.

Standard Industrial Classification (SIC) System

The SIC was developed to classify industrial, commercial, business and governmental activities by the type or economic activity in which they are engaged [34]. The SIC categories encompass all types of economic activity. The SIC is intended to facilitate the collection, tabulation, presentation, and analysis of statistical economic data by providing a uniform system for data reporting and presentation.

The SIC assigns a four-digit code number to various economic activities. The first two digits of the SIC code identify broad categories of economic activity (e.g., manufacturing); the third digit identifies a more specific group of activities within the broad category (e.g., agricultural chemicals); and the fourth digit elaborates further on the specific group identified by the third digit (e.g., pesticides). All establishments primarily engaged in the same type of economic activity are classified by the same four-digits regardless of their ownership.

The following principles have been used in deriving the SIC:

1) The SIC conforms to the structure of American industry.

2) Each establishment is classified according to its primary activity.

3) To be recognized as an industry, a group of establishments must be statistically significant in terms of number of employees, value of activity, etc.

The SIC classification system has gained wide acceptance as a method of classifying industrial activities. Its wide application has made it useful in emission inventory and projection procedures. Some local

agencies and the federal government project economic activity by SIC categories. A wide variety of information on current production, employment, and related indices of economic activity are grouped to form major classifications. The SIC categories closely correspond to most emission classification schemes. Because of this close agreement, information arranged by SIC classification can often be utilized in emission forecasting and inventories with only slight modification.

National Emissions Data System Source Classification Code

The National Emissions Data System (NEDS) [1] was developed by EPA to provide a uniform method for assembling emissions and source data. NEDS includes a uniform coding system, the Source Classification Code (SCC), for identifying source types. Sources are divided into point and area sources.

For the purpose of data collection, the emission factors and control equipment efficiencies have been identified by the individual process or activity that might be defined as a point source. A series of point source classification codes (SCCs) has been developed for those sources for which emission factors are available. Four levels of identification are used. These four levels define a general source category and subcategories within the general category. The subcategories define classification as to fuels, industrial processes, products, equipment types used, etc. The classification system is flexibile, and new or revised emission factors may be added easily [1]. It should be noted that the classification is not always internally consistent. The more specific codes (third and fourth digit combinations) will indicate different subclassifications for various general classifications.

An eight digit number in the form of 1-01-001-01 is used to identify each source category. The first digit identifies the source process category (e.g., 1 is an external combustion boiler) the next two digits identify the industrial classification (e.g., 01 is electric generation). The middle three digits further specify the process utilized (e.g., 001

for anthracite coal). The last two digits then identify the particular process utilized (e.g., 01 for a boiler producing more than 100 BTUs utilizing pulverized coal) [1].

The SCC is a specific coding system the use of which is limited to the NEDS. It is much more detailed than the SIC and bears no direct relation to other classification systems. It has not gained acceptance outside of this application and is only of interest to NEDS users. Appendix C of Supplement 4 to AP-42 [11] includes a listing of NEDS source classification codes and corresponding emission factors.

State and Local Classification Systems

Various source classification schemes are utilized in California by the ARB and local APCDs. The ARB uses a system (Table 3.7) which categorizes emissions by process categories. A process category is a group of industrial operations which have common air pollution emission characteristics. A single point source may have emissions in two or three separate categories (e.g., solvent evaporation, fuel combustion and chemical process emissions for a chemical plant).

Most APCDs use a source classification system which closely resembles the system utilized by the ARB. Some of the larger APCDs, such as Los Angeles County and the Bay Area APCDs, have developed their own coding systems to identify and classify sources.

It is beyond the scope of this Handbook to describe each individual APCD classification system. The user should consult directly with the local APCD in his study area for a description of each individual system.

3.1.7-3 Sources of Information on Current Emissions

An estimate of current emissions is necessary to establish a projection baseline. The EPA is in the process of establishing an emissions data system which will be continuously updated and accessible to any state or local agency. In addition, the State Air Resources Board and local air pollution control districts can normally supply county emissions estimates. The following is a description of these sources of information.

National Emissions Data System (NEDS)

The National Emissions Data System (NEDS) [1] is an extremely detailed emissions inventory of each air quality control region (AQCR) being developed for EPA. The NEDS will provide information concerning stationary point sources emitting greater than 100 tons per year of any pollutant. The data included in the NEDS for a given stationary source will be:

1) A description by Standard Industrial Code (SIC) and Source Classification Code (SCC).
2) Magnitude of emissions in tons/year.
3) Frequency and duration of operation in terms of hours/day, days/week and months/year.
4) Type of control equipment and their estimated efficiencies.
5) Location by Universal Transverse Mercator (UTM) zone and coordinates and by AQCR, county and city.

Area source emissions will also be included in the NEDS files. These emissions will be aggregated to the county level, and will contain the following information for each area source: 1) emission estimates in hundreds of tons per year for the county, and 2) type and amount of fuel consumed, solid waste disposed, mobile source activity, etc. The area source inventory will not include information on the specific emissions factor utilized or any detailed information on how the basic input data is generated.

When the NEDS System is completed, any state or local agency may request data from NEDS by telephone, mail, or by terminal access to the computer at the Research Triangle Park National Environmental Research Center. All data will be stored in computers to facilitate rapid retrieval. The inventories will be updated from year to year. Generally, three categories of data will be available: summaries, which will be most commonly used; sorting, a useful tool to be developed after summary techniques to arrange data into useful formats; and special analysis, that will necessitate both terminal and programming capability. Each category is discussed below.

1) Summaries

A number on programs are under development that will provide the following summaries:

a) Nationwide inventory - by county (3,300), AQCR (247), state and territories (54), and the nation (1).

b) Area sources - by county (3,300).

c) Point sources - individually (40,000) by county, and calculated emissions of pollutants, trace elements and compounds.

Two types of summary requests may be made:

Simple Summary Data Requests - Very brief data requests will be answered from monthly summaries or from the summaries output on the last day of the year (annual summaries). Annual summaries will be maintained for Automated Data Processing (ADP) and in computer printout form, stored on microfiche in National Source Inventory Section (NSIS). Monthly summaries will only be maintained on computer tape for ADP.

Comprehensive Summary Data Requests - More complicated requests will probably require access of the computer by NSIS. This request may be made by telephone, mail or computer terminal access. EPA hopes to provide quick response for each request (within one week).

2) Sorting

A number of programs will be developed that will enable sorting and ranking of data. The methods for answering these requests will be the same as for comprehensive requests of summary data, except that sorting and/or ranking operations will be included.

3) Special Analysis

No programs will be developed for these operations; therefore, users must have their own programming capability until this need can be met by increased resources in NSIS.

The NEDS system in California is presently operational. Data from many sources emitting less than 100 tons per year has been included thus making the California NEDS more complete in some respects than required by EPA. However, there is some question regarding accuracy of current input data. EPA has also funded development of the Comprehensive Data Handling System (CDHS) [35]. The Comprehensive Data Handling System is intended to aid state and local air pollution control agencies in performing their daily operations. The CDHS has an Emissions Inventory Subsystem (EIS) which will allow local agencies to readily code their present emission inventory information onto a computer data handling system. The EIS provides for output in either the original information input format or in NEDS format. The ARB has operationalized the EIS computer program. Data for California which was inputted into NEDS is also available through EIS. Some update of input information has occurred in the last year. Even with the updated information, EIS outputs should be evaluated for accuracy before use. The ARB is presently informing local districts of EIS input data requirements through seminars and direct discussions. It is anticipated that input data quality will improve through these efforts. Operational experience gained in the next year should also identify input data improvement needs.

County Emission Inventories

The ARB and all major APCDs maintain county emission inventories. The ARB estimates are usually developed from local APCD data with slight modifications to make the data fit ARB categories and assumptions. Table 3.7 is a typical ARB county emission inventory. Similar information is available from the ARB for all counties in the state. County or APCD inventories generally fit the ARB categories reasonably well. There is, however, a great deal of variety in specific inventory structures. The planner is directed to the APCD in his area of interest for detailed information.

The reliability of data from either local agencies or the ARB is also variable because of several factors. Some districts develop inventories from operating permits which may not reflect real use situations. It is also possible that major sources may have been incompletely characterized or perhaps not identified at all. Additionally, assumptions made by either the ARB or the local districts may not be appropriate for a specific study. It is suggested that the planner investigate the limitations and the applicability of emission inventory data for the intended usage. It may be necessary to allocate resources to modify or improve the data. The specific amount of resources allocated is largely dependent on funds available, planning tasks to be performed, and the applicability of the available emissions data.

Establishing a representative emissions baseline is important; however, developing and refining an emissions inventory is usually a major undertaking. Consequently, it is best to utilize existing information whenever it is available and appropriate.

The ARB last published an official emission inventory in 1970 [36]. This document is outdated and a preliminary 1972 inventory was used for development of the ARB's Revision 5 to the State Implementation Plan. A final, official, 1973 inventory is expected to be published shortly and

will be available from the ARB through the public information office. Local APCDs should be contacted directly for information developed by them. The large districts publish emissions data annually.

3.1.7-4 Methods of Predicting Stationary Source Activity and Location

Once an emission inventory baseline is established, some method of predicting source activity is necessary before an emission forecast may be attempted. The federal government provides economic activity projections, state and local governments provide population projections and local governments and private enterprises may also provide economic activity projections. These projections can be applied to either individual sources or to aggregated source categories. The following is a description of projections useful for determining future emission source activities.

OBERS Projections of Economic Activity

Projections of income, employment and population from 1970 to 2020 have been prepared by the Bureau of Economic Analysis [37,39,49]. These projections are are known as OBERS projections. (U.S. Department of Commerce Office of Business Economics (OBE) and U.S. Department of Agriculture Economic Research Service (ERS). The OBE is now called the Bureau of Economic Analysis.) These projections were developed for use in water quality management plans but can also aid the air quality planner. OBERS projections have been made for each of the country's 253 Standard Metropolitan Statistical Areas (SMSAs) which include 70 percent of the U.S. population. Seventeen SMSAs exist in California and contain approximately 90% of the state's population in 24 counties. OBERS projections for non-SMSA areas are also available.

The OBERS projections comprise two different sets of projections based on "Series C" and "Series E" population growth rates [37,49]. The total fertility rate per 1,000 women assumed to be obtained by the year 2000 are 2,800 for the Series C and 2,100 for the Series E. The Series E

projections are therefore a "replacement level fertility" rate leading to zero population growth. General assumptions incorporated into the OBERS projections are delineated in Figure 3.6. Specific differences between the Series C and Series E projections are identified in Figure 3.7.

Although these projections contain significant inaccuracies, they can be very useful in projecting future year source activity. The use of OBERS projections is particularly suited to predicting emissions from industrial sources because statistical data are disaggregated into industrial groupings for about 20 categories which closely correspond to emission inventory categories. Table 3.11 presents a relationship between the ARB emission categories and the industrial groupings used in the OBERS projections. The relationships between the industrial groupings used by OBERS and Standard Industrial Codes (SIC) are identified in Table 3.12.

Projections of production growth indices based on Series C projections were developed by the U.S. Bureau of Economic Analysis [39]. These indices were normalized to the base year of 1970. Similar indices were not developed for the Series E projections; however, methodologies for developing such indices are presented [49]. Tables B.3.5 through B.3.21 of Appendix B present both Series C and Series E indices for the seventeen California SMSAs. These indices are normalized to a base year of 1973. their use in estimating emissions is explained in Table B.3.22 of Appendix B.

The difference between Series C indices and Series E indices presented in Appendix B is considerable. Had the same economic data been used for both sets of projections with a change only in birth rate, then the Series E projections would consistently yield lower future estimates than Series C. However, Series E projections include economic data from 1970 and 1971 in addition to the pre-1970 data used for Series C. This difference and others identified in Figure 3.7 result in Series E

FIGURE 3.6

GENERAL ASSUMPTIONS INCORPORATED INTO OBERS PROJECTIONS

Series C

(1) Growth of population will be conditioned by a decline of fertility rates from those of the 1962–1965 period.

(2) Nationally, reasonably full employment, represented by a 4 percent unemployment rate, will prevail at the points for which projections are made; as in the past, unemployment will be disproportionately distributed regionally, but the extent of disproportionality will diminish.

(3) No foreign conflicts are assumed to occur at the projection dates.

(4) Continued technological progress and capital accumulation will support a growth in private output per manhour of 3 percent annually.

(5) The new products that will appear will be accommodated within the existing industrial classification system, and, therefore, no new industrial classifications are necessary.

(6) Growth in output can be achieved without ecological disaster or serious deterioration, although diversion of resources for pollution control will cause changes in the industrial mix of output.

The regional projections are based on the following additional assumptions:

(1) Most factors that have influenced historical shifts in regional "export" industry location will continue into the future with varying degrees of intensity.

(2) Trends toward economic area self-sufficiency in local-service industries will continue.

(3) Workers will migrate to areas of economic opportunities and away from slow-growth or declining areas.

(4) Regional earnings per worker and income per capita will continue to converge toward the national average.

(5) Regional employment/population ratios will tend to move toward the national ratio.

References [37] and [49]

Series E

(1) Growth of population will be conditioned by a fertility rate which represents "replacement level fertility."

(2) Nationally, reasonably full employment, represented by a 4 percent unemployment rate, will prevail at the points for which projections are made. As in the past, unemployment will be disproportionately distributed regionally, but the extent of disproportionality will diminish.

(3) The projections are assumed to be free of the immediate and direct effects of wars.

(4) Continued technological progress and capital accumulation will support a growth in private output per manhour of 2.9 percent annually.

(5) The new products that will appear will be accommodated within the existing industrial classification system, and, therefore, no new industrial classifications are necessary.

(6) Growth in output can be achieved without ecological disaster or serious deterioration, although diversion of resources for pollution control will cause changes in the industrial mix of output.

The regional projections are based on the following additional assumptions:

(1) Most factors that have influenced historical shifts in regional "export" industry location will continue into the future with varying degrees of intensity.

(2) Trends toward economic area self-sufficiency in local-service industries will continue.

(3) Workers will migrate to areas of economic opportunities and away from slow-growth or declining areas.

(4) Regional earnings per worker and income per capita will continue to converge toward the national average.

(5) Regional employment/population ratios will tend to move toward the national ratio.

FIGURE 3.7

DIFFERENCES BETWEEN OBERS SERIES C AND SERIES E PROJECTIONS

Significant population, personal income and cropland harvested differences between the "Series C" and "Series E" projections for the year 2000 are shown in the following table.

Item	"Series C"	"Series E"	Change	Percent difference
	Year 2000 projections (millions)			
Population (domestic)	306.8	263.8	−43.0	−14.0
Total personal income (domestic) (1967 dollars)	2,542,849	2,154,266	−388,583	−15.3
Cropland harvested (acres)	309.7	271.9	−37.8	−12.2

These differences are caused primarily by changes in the national population growth rate assumptions. However, the following additional changes also contributed to differences in the two reports.

- The hours worked per year are projected to decline at the rate of 0.35 percent per year. The "Series C" report used a 0.25 percent rate.
- The projected rate of increase in product per man per hour in the private economy is lowered from 3.0 percent to 2.9 percent.
- Earnings per worker in the individual industries at the national level are projected to converge toward the all-industry rate more slowly than in the "Series C" report.
- Income data for 1970 and 1971 and total employment data for 1970 have been included in this report. Use of this additional information, which was not available for the first report, has caused significant changes in some area projections.
- On the basis of the President's 1974 budget message to Congress, a smaller military establishment has been assumed.
- The method for projecting population as a function of projected employment has been revised to treat each of three age groups separately.
- Projections have been included for standard metropolitan statistical areas (SMSA's) and for non-SMSA portions of BEA economic areas and water subareas.
- Employment projections by industry, included in the previous report, are excluded from this one because the information contained in the 1970 Census is not directly comparable with that of previous censuses. Comparable data are now being prepared and will be available.
- Indexes of production are excluded from this report to avoid disclosure of confidential information; directions for calculating such indexes are provided.

The OBERS projections do not reflect the current energy problem, recent changes in agricultural exports, and recent changes in conservation and environmental activities. With no adequate historical base for these matters, their effects can be estimated best through the use of economic impact analysis.

Excerpted from Foreword to reference [49]

Table 3.11
Emission Source Category and Corresponding
Growth Indicator Category

EMISSION SOURCE CATEGORY	GROWTH INDICATOR CATEGORY[1]
PETROLEUM	
Production	Mining-crude petroleum and natural gas
Refining	Manufacturing - petroleum refining
Marketing	Population[2]
ORGANIC SOLVENT USERS	
Surface Coating	Manufacturing - composite index
Other	Population[2]
Degreasing	Manufacturing - composite index
Dry Cleaning	Population[2]
CHEMICAL	Manufacturing - chemical and allied products
METALLURGICAL	Manufacturing - primary metals
MINERAL	Mining - non-metallic, except fuels
FOOD & AGRICULTURAL PROCESSING	Manufacturing - food and kindred products
PESTICIDES	Agriculture
WOOD PROCESSING	Manufacturing - lumber products & furniture
COMBUSTION OF FUELS	
Power Plants[3]	------
Industrial	Manufacturing - composite index
Domestic and Commercial	Population[2]
Orchard Heaters	Agriculture
WASTE BURNING	
Agricultural Debris	Agriculture
Forest Management	Forest and fisheries
Range Improvement	Agriculture

(continued)

Table 3.11
(continued)

Emission Source Category and Corresponding
Growth Indicator Category

EMISSION SOURCE CATEGORY	GROWTH INDICATOR CATEGORY[1]
WASTE BURNING (cont.)	
Dumps[4]	------
Conical Burners	Manufacturing - lumber products & furniture
Incinerators	Population[2]
Other	Population[2]
MISCELLANEOUS AREA SOURCES	
Wild Fires	Constant
Structural Fires	Population[2]
Farming Operations	Agriculture
Construction and Demolition	Contract construction
Unpaved Roads	Population[2]
Other	Population[2]

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[1] Growth indicator based on earnings or production data from [37,39,49] unless otherwise specified. Specific indices may be found in Tables B.3.5 through B.3.21 of Appendix B. A specific example of relating emission source category to growth indicator category is presented in Table B.3.22 of Appendix B.

[2] Population growth factors based on projections of California Department of Finance, D-100 series.

[3] Special study - Please refer to section on Fossil Fuel Electric Generating Plants.

[4] Future emissions are assumed negligible.

TABLE 3.12

INDUSTRIAL GROUPINGS WITH STANDARD INDUSTRIAL CLASSIFICATION CODES

All-industry total:	
Agriculture, forestry and fisheries:	
Agriculture	01, 07.
Forestry and fisheries	08, 09.
Mining:	
Metal	10.
Coal	11, 12.
Crude petroleum and natural gas	13.
Nonmetallic, except fuels	14.
Contract construction	15-17.
Manufacturing:	
Food and kindred products	20.
Textile mill products	22.
Apparel and other fabric products	23.
Lumber products and furniture	24, 25.
Paper and allied products	26.
Printing and publishing	27.
Chemicals and allied products	28.
Petroleum refining	29.
Primary metals	33.
Fabricated metals and ordnance	34, 19.
Machinery, excluding electrical	35.
Electrical machinery and supplies	36.
Motor vehicles and equipment	371.
Transportation equipment, excluding motor vehicles	37 except 371.
Other manufacturing	21, 30-32, 38, 39.
Transportation, communications, and public utilities:	
Railroad transportation	40.
Trucking and warehousing	42.
Other transportation and services	41, 44, 47.
Communications	48.
Utilities (electric, gas, sanitary)	49.
Wholesale and retail trade	50, 52-57, 59.
Finance, insurance and real estate	60-67.
Services:	
Lodging places and personal services	70, 72.
Business and repair services	73, 75, 76.
Amusement and recreation services	78, 79.
Private households	88.
Professional services	80, 81, 82, 84, 86, 89.
Government:	
Civilian government:	
Federal government	91 except Fed. military.
State and local government	92, 93.
Armed forces	Part of 91.

Source: Executive Office of the President, Bureau of the Budget, Standard Industrial Classification Manual, 1967.

Reference [37]

projections generally being lower but containing a few exceptions. This can clearly be seen in Table B.3.9 in Appendix B for Orange County. Most of the Series E indices are lower as exemplified by the Series E Manufacturing year 2000 index which is nearly 40 percent lower than the corresponding Series C index (259 for Series E versus 412 for Series C). However the Series E projections yield higher indices for the Agriculture, Textile Mill Products, and Motor Vehicle and Equipment categories. The recommended procedure for projecting future emissions is to use both Series C and Series E indices in order to establish a range of values. If only one set of emission projections is to be made, it is suggested that Series E projections be used due to the more recent economic data base used to develop the indices.

State and Local Population Forecasts

Population forecasts are useful for projecting emissions for a number of emission categories. Emissions from dry cleaning operations, waste disposal, lawn and garden equipment operations, etc. are likely to grow at the same rate as population because the source activity in these categories is more directly related to population.

Population forecasts are developed and maintained at the State level by the California Department of Finance [38]. Forecasts are available by county by 5-year increments until the year 2020. Four series of projections are available from the Department. Each series utilizes different assumptions concerning mortality, fertility, and net migration of population for the State. Each of the series results in significantly different projected county populations. Before utilizing any of these projections, the user should examine the basic assumptions for each series and decide which series is most valid for the area of interest.

In addition to the State forecasts, many local and regional agencies maintain estimates of future population. In recent years there has been substantial coordination between the California Department of Finance

and local planning agencies. As a result, there is often close agreement between their respective projections. Local agency projections are useful in that they often provide projections down to the city or neighborhood level, and may be more accurate than the Department of Finance estimates, especially in the short term.

It is beyond the scope of this report to describe each of the various local projections which are available. The users will no doubt be familiar with the resources available within their study area and should consult them directly.

Local Economic Forecasts

There are several possible sources of local economic activity data. These include Council of Governments (COGs), Chamber of Commerce, Economic Development Districts and county governments. The projections obtained from these sources would include employment, land use, business development, and source expansion plans. Any information projecting activities for the categories listed in Table 3.11 may be valuable.

Private Economic Forecasts

In California, several large financial institutions maintain forecasts of economic activities. These forecasts may be useful in predicting regional or local source activity. Additionally, large corporations may also prepare economic projections. These sources of information should be explored, keeping in mind the emission source categories listed in Table 3.11.

3.1.7-5 Projecting Source Emissions

The following section presents two methods for projecting source emissions for the "Other Stationary Source" category. Power plants

are not included in this category. These methods provide the link between emissions baseline, projections of economic activity and emission projections.

Method 1 for "Other Stationary Sources"

The approach described here is a slight modification of the one utilized by the Air Resources Board in a recent analysis of future year air quality as a part of the Air Quality Maintenance Area designation process.

Future year stationary source activity and the subsequent emissions can be a function of the industry type and geographical location. In order to project stationary source emissions, it is necessary to have indicators of future year stationary source activity. The approach described here is based on the projections of the Bureau of Economic Analysis (BEA), U.S. Department of Commerce [37,39,49], which project income, employment, and population from 1950 to 2020 for the various Standard Metropolitan Statistical Areas and AQCRs throughout the nation. If suitable long-term projections exist at the local level and appear to be more valid than the BEA factors, they should be used.

Projections of total earnings and production contained in the BEA reports are used as indicators of growth for industrial activity and the associated emissions. Production indices were matched with the stationary source categories used in the 1973 ARB Emission Inventory. The source categories and the corresponding growth indicator categories are shown in Table 3.11. The projections of total earnings are made for entire SMSAs or AQCRs and are assumed to be applicable to sub-areas of these areas. If the study area is not within an SMSA, or an AQCR, Series D-100 population-based growth factors from Table B.3.4 are used. The normalized growth indices using C-150 and E-0 population growth rates for each area of the state are presented in Appendix B, Tables B.3.5 through B.3.21.

To project future year emissions from "Other Stationary Sources" for a study area, an emission inventory for the base year should be compiled for that study area. Since this is a considerable undertaking, an alternative is to disaggregate countywide emissions based on population using the emission levels contained in the most recent ARB Emissions Inventory. The equation for this disaggregation is:

$$\text{Emissions from Study Area for Other Stationary Sources in the Base Year} = \text{Emissions in County for Other Stationary Sources in the Base Year} \times \frac{\text{(Population of Study Area)}}{\text{(Population of County)}}$$

Once the base year emissions have been determined, the growth factors (for SMSAs or AQCRs) are multiplied times the base year emissions to estimate future year emissions for each source category.

As an example, the emissions in Orange County from the "Mineral" source category are estimated as shown below:

	Particulate Matter	Oxides of Nitrogen	Sulfur Dioxide	Carbon Monoxide
1973 Emissions (From ARB Emissions Inventory Table 3.7)	1.0 $T/_D$	0.9 $T/_D$	1.5 $T/_D$	15.1 $T/_D$
1985 Total Earnings Indicator for "Mining - Non-metallic except fuels" (From Table B.3.9):				
----- Series C	1.40	1.40	1.40	1.40
----- Series E	1.31	1.31	1.31	1.31
1985 Emissions:				
----- Series C	1.4 $T/_D$	1.3 $T/_D$	2.1 $T/_D$	21.1 $T/_D$
----- Series E	1.3 $T/_D$	1.2 $T/_D$	2.0 $T/_D$	19.8 $T/_D$

A similar procedure is followed for the remaining source categories and pollutants. Then, emissions by pollutants are summed to give total emissions from "Other Stationary Sources." The Series C projections would constitute the upper limit of emissions projections while the Series E projection would reflect lower limit emission projections.

Method 2 for "Other Stationary Sources"

The second method described requires far more specific information. For this reason the methodology is presented in outline form. The methodology is presented for individual point sources and for source categories. In each case, a methodology is described for existing and new sources.

Emissions from Existing Stationary Point Sources

a) Estimate current emissions by Standard Industrial Classification category for stationary sources from county, ARB, or NEDS inventories.

b) Utilize county source files to identify significant point sources of emissions.

c) Determine productive capacity of point sources and actual percentage of that capacity utilized in the base year.

d) Estimate emission factors for each point source for each projection year using information gathered from local APCDs or AP-42.

e) Estimate plant retirement as a percentage of original capacity for each projection year. This can be done by:

   1) Contacting individual point sources and interviewing managers; or

   2) Using retirement rates in Table A.3.22 for each type of source.

f) Determine if any proposed rule changes are likely to affect emissions from existing sources and for which projection years the regulations will apply.

g) Determine if the future industrial activity is expected to utilize all existing capacity. If plants are not expected to operate at full capacity, estimate the percentage of capacity that will be utilized for each individual point source.

h) Estimate emissions from existing sources for each projected year using the following formula:

$$E_{FY} = (Cap_{FY}) \times (\%Cap_{FY}) \times (EF_{FY}) \times (EA_{FY})$$

Where:

E_{FY} = Emissions in the future year
Cap_{FY} = Production capacity in the future year
$\%Cap_{FY}$ = Percent capacity utilization expected in the future year
EF_{FY} = Emission factor future year
EA_{FY} = Emission adjustment due to stricter rules or regulations

i) Make seasonal allocation of emissions if information can be gained on seasonal operational plans by SIC or individual plans.

The following example outlines the application of this methodology:

Step a) - Accomplished using the ARB and APCD inventory. Industrial fuel combustion shown to be a significant source of emissions.

Step b) - Using the county source files, the Ajax Chemical Company's Steam Plant was determined to be a significant emission source for SO_2 and NOx.

Step c) - This step was accomplished through a plant interview. The boiler capacity is 8×10^8 BTU/Hr. Normal plant operation is 7 days a week, 24 hours per day for 50 weeks per year. Total annual capacity is thus

$(8 \times 10^8$ BTU/Hr.) x (24 Hr./Day) x (7 Days/Week) x (50 Weeks/Year)
$= 6.7 \times 10^{12}$ BTU/Year

In the base year (1974), the entire plant was shut down for 3 months by a strike. For the rest of the year, the plant operated at 80% of capacity. Total utilization in base year:

$(6.7 \times 10^{12}$ BTU/Year) x (0.80) x (9 months/12 months) $= 4 \times 10^{12}$ BTU/Year

Fuel use in base year = 1.92×10^8 Meters^3 of natural gas. No fuel oil was used.

Step d) - The emission factors for the base year were obtained from AP-42 from factors for natural gas fuel combustion.

Natural gas NOx emission factor = 3700 Kg/10^6M^3
Natural gas SO_2 emission factor = 9.6 Kg/10^6M^3

For future years the plant is expected to operate on fuel oil as natural gas supplies decrease. Again from AP-42.

Fuel oil NOx emission factor = 9.6 Kg/10^3 Liters
Fuel oil SO_2 emission factor = 19(S) Kg/10^3 Liters

Where S is the percent sulfur in the fuel by weight. Assume that S will be 0.5% because current APCD rules limit the sulfur content of fuels.

Step e) - Consultation with the source operator yielded an estimate of 15 years additional life for the plant. Thus no emission estimate needs to be made for 1995.

Step f) - No rule changes are anticipated that will affect emissions from these sources. Existing regulation will, however, limit the sulfur content of fuel to 0.5 percent by weight.

Step g) - By 1985 the plant expects to utilize the full present capacity. It was estimated that actual full capacity is 95% of rated capacity.

Calculation of capacity - 6.7×10^{12} BTUs/Year x 0.95
$= 6.4 \times 10^{12}$ BTUs/Year

Calculation of capacity fuel use:

Heating value of fuel oil = 4.1×10^{4} BTUs/Liter

Anticipated fuel use:

$$\left(\frac{6.4 \times 10^{12} \text{ BTUs}}{\text{Year}}\right)\left(\frac{\text{Liter}}{4.1 \times 10^{4} \text{ BTUs}}\right) = 1.56 \times 10^{8} \text{ Liters/Year}$$

Step h) - Emissions are estimated for two study years, 1974 and 1985. for 1974:

$$E_{74_{NOx}} = (1.92 \times 10^{8} M^{3} \text{ Natural Gas/Year}) \times (3700 \text{ Kg}/10^{6} M^{3})$$
$$= 7.1 \times 10^{5} \text{ Kg/Year NOx}$$
$$= 710 \text{ Metric Tons/Year NOx}$$
$$E_{74_{SO_2}} = (1.92 \times 10^{8} M^{3} \text{ Natural Gas/Year}) \times (9.6) \text{ Kg}/10^{6} M^{3})$$
$$= 1.8 \times 10^{3} \text{ Kg/Year}$$
$$= 1.8 \text{ Metric Tons/Year}$$

for 1985:

$$E_{1985_{NOx}} = (1.56 \times 10^8 \text{ Liters/Year}) \times (9.6 \text{ Kg}/10^3 \text{ Liters})$$
$$= 1.50 \times 10^6 \text{ Kg/Year}$$
$$\simeq 1500 \text{ Metric Tons/Year of NOx}$$

$$E_{1985_{SO_2}} = (1.56 \times 10^8 \text{ Liters/Year}) \times 19(0.5) \text{ Kg}/10^3 \text{ Liters}$$
$$= 1.48 \times 10^6 \text{ Kg/Year}$$
$$\simeq 1500 \text{ Metric Tons/Year of } SO_2$$

Step i) - In the base year the plant was closed from February through April. The rest of the year the operation was relatively stable.

Emissions per day - 1974
February through April=0 for NOx and SO_2
Rest of the year =

$$E_{NOx} = \frac{710 \text{ Metric Tons}}{\text{Year}} \times \frac{1 \text{ Year}}{365 \text{ Days}} \times 9 \frac{12 \text{ Months}}{\text{Months operation}}$$

$$= 2.6 \text{ Metric Tons/Day}$$

$$E_{SO_2} = 1.8 \text{ Metric Tons/Year} \times \frac{1 \text{ Year}}{365} \times \frac{12}{9}$$

$$= 0.007 \text{ Metric Tons/Day}$$

Emissions per day - 1985
Operation steady for 50 weeks = 350 Days/Year

$$E_{NOx} = (1500 \text{ Metric Tons/Year}) \times \frac{1 \text{ Year}}{350 \text{ Days}}$$

$$= 4.3 \text{ Metric Tons/Day}$$

$$E_{SO_2} = (1500 \text{ Metric Tons/Year}) \times \frac{1 \text{ Year}}{350 \text{ Days}}$$

$$= 4.3 \text{ Metric Tons/Day}$$

Note that 1 metric ton = 2,204.6 pounds.

Emissions from New Stationary Point Sources

(a) Project source activity for each individual plant using information derived from BEA factors, local economic studies or direct contact with existing sources.

(b) For each projection year, determine the percent of estimated activity that will be supplied by sources constructed since the base year.

(c) Determine the effect of source permit requirements on new source constructions.

(d) Determine emission factors for new individual point sources using Table A.3.23 or information obtained from APCDs.

(e) Estimate emissions from new sources using the formula:

$$E_{FY_{NS}} = (Cap_{FY_{NS}}) \times (EF_{FY_{NS}})$$

Where:

$E_{FY_{NS}}$ = Emissions from new sources in the future year

$Cap_{FY_{NS}}$ = Production capacity of new sources in the future year

$EF_{FY_{NS}}$ = Emissions factors for new sources in the future year

(f) When necessary make seasonal allocation of emissions.

Emissions from Existing Sources by Source Category

(a) Estimate current emissions by Standard Industrial Classification category for stationary sources from county, ARB, or NEDS inventories.

(b) Using information presented in the section on point sources, subtract point source emissions from the county source file, thus yielding an estimate of emissions for each source category.

(c) Estimate retirement rate for each Standard Industrial Classification category as a percentage of original capacity for each projection year. This can be done by using retirement rates in Table A.3.22 for each Standard Industrial Classification category.

(d) Determine if any proposed rule changes are likely to affect emissions from existing source categories for the projection years the regulations will apply.

(e) Estimate emissions from existing sources in each category using the equation:

$$E_{FY} = (E_{BY}) \times \frac{(100-\%Ret_{FY})}{100} \times (EA_{FY})$$

Where:

E_{FY} = Emissions in any future year

E_{BY} = Emissions in base year

$\%Ret_{FY}$ = Percentage of Base Year Capacity expected to be retired by the future year (From Table A.3.22, e.g., Petroleum Production Retirement for 1985 = 35%)

EA_{FY} = Emission Adjustment due to stricter rules or regulations in the future year

(f) Make seasonal allocation of emissions in information can be gained on seasonal operational plans by SIC.

Emissions from New Sources by Source Cateogry

(a) Estimate current emissions by Standard Industrial Classification category for stationary sources from county, ARB, or NEDS inventories.

(b) Estimate the growth in activity for each projection year using information derived from BEA factors, local economic studies or direct contact with sources. For each projection year, determine the percent of estimated activity that will be supplied by sources constructed since the base year. Also estimate percent retirement for the projection year for each source category.

(c) Determine the effect of source permit requirements on new source construction.

(d) Determine emission factors for each SIC by scaling base year emissions to the estimated growth. Use Table A.3.23 to estimate if future emission factors are affected by more stringent new source performance standards.

(e) Estimate emissions from new sources in each source category using the formula:

$$E_{FY} = (E_{BY}) \times (\%G_{FY} - \%Ret_{FY}) \times (EA_{FY})$$

Where:

E_{FY} = Emissions in the future year
E_{BY} = Emissions in the base year
$\%G_{FY}$ = Estimate of percent growth in activity for each SIC (e.g., $\%G_{FY} = 105$)
%Ret = Estimate of percent retirement for each SIC
EA_{FY} = Emission Adjustment if more stringent rules are expected for new sources

(f) Make seasonal allocations of emissions if information can be gained on seasonal operation by SIC.

3.2 FACTORS AFFECTING CHANGES IN EMISSION RATES

3.2.1 More Stringent Rules and Regulations

The most important factor affecting future emissions will be the imposition of more stringent rules and regulations and their enforcement. More stringent emission limitations affect both existing and new sources. Existing sources may be required to utilize "add on" pollution control devices to reduce emissions, and new sources may have to utilize best available control techniques. Stringent control strategies to achieve and maintain ambient air quality standards may force some sources to close down or prevent others from being constructed. Stringent enforcement of regulations will induce the development of new technology once the need for emissions reductions is established.

The following regulations have been promulgated by the EPA which will affect future emissions from new sources:

a) Review of new source impact on ambient air quality. Enforcement of these regulations may prevent the construction of any new air pollution source if the source's emissions will result in the violation of any NAAQS.

b) New Source Performance Standards (NSPS). The NSPS specify emission limits which certain types of sources must meet in order to be constructed.

c) No Significant Deterioration Regulations. These regulations affect new source construction in two ways:

   (1) If a source's emissions would cause air quality to deteriorate beyond the limits established for an area, the source's construction is prohibited.

(2) Certain specified source categories will be required to control their emissions to the furthest extent technically and economically feasible. Thus, as new control technology is developed, it will have to be implemented.

On November 26, 1975, the ARB adopted guidelines for stringent review of new sources. Briefly, the new guidelines require review of any project, new source or modification which will emit either 15 pounds per hour or 150 pounds per day of any contaminant for which a state or national ambient air quality standard exists (150 pounds per hour or 1500 pounds per day for CO). There are exceptions and caveats to the guidelines which are explained in two documents available from the ARB [50,51]. The intent of the rules would be to prohibit construction of those sources reviewed whose emissions would prevent attainment or maintenance or cause violation of ambient air quality standards.

3.2.2 New Technologies

Future source emissions will also be affected to a large extent by changes in technology. Emission reductions may be affected either by (1) the development of new emission control strategies or (2) the development of new processing techniques which are less polluting than the processes they replace. The quantification of the effect on emissions of either of these developments is a difficult task.

The development of new emissions control technology will normally be induced by the need to comply with more stringent regulation. New processing technology may be developed in order to comply with air pollution regulation but is more often developed because of economic reasons.

Changes in industrial processes are a promising area for new technology. In such large industries as power generation, petroleum refining and steel manufacturing, the development of new process and control technologies offers the possibility of further emissions reductions.

At present we know of no comprehensive effort to identify and quantify the impact of technology on air pollutant emissions.

3.2.3 Fuel Changes

The effect of the energy crisis on our economy is still being evaluated. Two clearly identifiable impacts have been the shifts in present fuel use and a dramatic shift in the trends of fuel use. In the past, California has been fortunate in that ample supplies of inexpensive, relatively low polluting natural gas have been available. In 1970, California's fossil-fuel fired power plants consumed natural gas approximately 80% of the year. Today they have sufficient supply for only 10% of the year. In the future, very little natural gas is projected to be available for power generation.

These shifts directly affect the air pollutant emissions of California's industries. For example, a power plant burning coal typically emits 2 times more particulate matter than one combusting oil and 10 times more than a plant using natural gas. Although we cannot accurately quantify future changes in fuel supplies, it seems clear that "dirty" fuels will be substituted for relatively clean natural gas. The emissions most affected will be those of particulates, sulfur oxides, and oxides of nitrogen.

Although the anticipated shift in fuels will aggravate the air pollution problem, the decrease in fuel availability and subsequent increases in fuel prices will increase efforts in energy conservation. Industries will have more incentive to develop and utilize processes which are less energy demanding.

3.2.4 Mitigation Measures

Mitigation measures may be classified into two general categories: those affecting the source directly and those affecting source related activities.

Direct source mitigation measures alter either the time or mode of operation of a facility. For example, it may be desirable for a large power generating system serving a given region to preferentially load low emitting facilities to minimize air pollutant emissions. It might also be desirable to restrict process activity of a source and the attendant emissions, especially during periods of high air pollution potential. Quantification of the effects of either of these measures is difficult. The effect of operating at night instead of day is almost impossible to quantify since extensive knowledge of typical meteorological conditions is necessary. Operating at a restricted level may have a more significant effect since emissions may be reduced disproportionately. However, care should be taken in providing a complete analysis of effects because some facilities are designed to operate at specific levels; these source emissions may actually increase at lower operating levels.

Mitigation measures affecting mobile source related activities fall generally into the category of VMT or trip reduction measures such as:

1. Bus incentives; bus lanes, reduced fares.
2. Carpooling.
3. High density residential development which would shorten trips, increase utilization of transits, and increase use of bicycles.
4. Staggered working hours.
5. Disincentives for use of automobiles (increased parking fees, auto free zones, etc.).

Several attempts have been made to quantify the effects of these measures for certain areas in California [43,44,45,46]. The reader is referred to these information sources with the cautionary note that the studies were completed for specific areas and results may not be applicable to other areas in the state. Examples of VMT reductions from typical control measures are listed below [43]:

Strategy Description	Approx. Percent VMT Reduction
1. Much improved public transit	Approx. 3
2. Improved transit and tax on auto use	Approx. 4
3. Auto Free Zones (e.g., Los Angeles Central Business District)	Approx. 0.6
4. Increased Parking Cost	Negligible
5. Four-Day Work Week	Approx. 0.6
6. Exclusive Bus and Car Pool Lanes	Approx. 2.5
7. Exclusive Bus and Car Pool Lanes with 3¢/mile tax	Approx 3.2
8. Increased Commuter Car Pools to Achieve an Average Auto Occupancy of 1.5 on Freeway	Approx 4.4

It should be noted that the above VMT reductions are not additive, i.e., measures 7 and 8 implemented together would not necessary result in a 7.6 percent VMT reduction but probably a much lower figure.

3.2.5 Improved Enforcement of Regulations

State regulations delegate primary responsibility for the control of stationary sources to local air pollution control districts. Enforcement of regulations is therefore subject to county budgets and political conditions. The State, through their subvention program, has the authority to review local enforcement procedures. Recent reviews by ARB

staff of the then Los Angeles County Air Pollution Control District (LACAPCD) [47] and the San Francisco Bay Area Air Pollution Control District (BAAPCD) [48] identified several deficiencies in their enforcement programs. Additional reviews by the ARB of other local district operations are anticipated. The presently available ARB reviews and materials from the APCDs are suggested readings for planners desiring further information on the enforcement programs for these areas. If lax enforcement of existing regulations does occur, there is potential for greater than anticipated emissions from source categories ostensibly under control.

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APPENDIX A

Emission Factors, Vehicle Registrations, and Weighted Annual Travel Distributions for Motor Vehicles

SECTION 3 - ASSESSING AIR POLLUTANT EMISSIONS

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TABLE A.3.1
VEHICLES IN USE AND ANNUAL INCREASE
BY VEHICLE TYPE,
COUNTY, AND AIR BASIN

	VEHICLE TYPE									
	Light Duty Passenger		Light Duty Truck		Heavy Duty Gas		Heavy Duty Diesel		Motorcycles	
	Vehicles in Use 1973	Annual Increase (% 1973)	Vehicles in Use 1973	Annual Increase (% 1973)	Vehicles in Use 1973	Annual Increase (% 1973)	Vehicles in Use 1973	Annual Increase (% 1973)	Vehicles in Use 1973	Annual Increase (% 1973)
GREAT BASIN VALLEY AIR BASIN										
Alpine	292	3.27	48	3.27	53	0.41	6	0.41	15	4.63
Inyo	7,811	3.37	1,293	3.37	1,548	4.67	169	4.67	751	4.71
Mono	2,285	6.60	378	6.60	516	6.31	56	6.31	177	4.23
Basin Total	10,387	4.08	1,719	4.08	2,117	4.96	231	4.96	943	4.62
LAKE COUNTY AIR BASIN										
Lake	12,241	3.64	2,026	3.64	1,927	4.38	211	4.38	830	3.02
Basin Total	12,241	3.64	2,026	3.64	1,927	4.38	211	4.38	830	3.02
MOUNTAIN COUNTIES AIR BASIN										
Amador	6,416	3.59	1,062	3.59	1,336	5.19	146	5.19	577	5.29
Calaveras	6,533	3.40	1,081	3.40	1,363	4.78	149	4.78	481	5.11
El Dorado	24,440	5.66	4,045	5.66	3,746	6.09	409	6.09	1,832	5.47
Mariposa	3,255	3.90	539	3.90	625	4.64	68	4.64	247	5.62
Nevada	14,566	4.11	2,411	4.11	2,395	4.22	262	4.22	1,121	5.73
Placer	40,560	5.42	6,713	5.42	5,665	5.79	619	5.79	3,433	5.04
Plumas	6,282	3.84	1,040	3.84	1,340	2.95	146	2.95	430	4.87
Sierra	1,084	1.72	179	1.72	274	2.84	30	2.84	68	3.72
Tuolomne	10,964	3.35	1,815	3.35	2,126	4.53	232	4.53	873	4.31
Basin Total	114,099	4.72	18,884	4.72	18,869	5.11	2,062	5.11	9,061	5.16
NORTH CENTRAL COAST AIR BASIN										
Monterey	111,825	3.08	18,508	3.08	9,660	4.40	1,056	4.40	5,276	4.26
San Benito	8,128	2.46	1,345	2.46	1,384	3.33	151	3.33	418	6.61
Santa Cruz	71,770	4.09	11,878	4.09	6,839	4.81	747	4.81	3,632	3.19
Basin Total	191,723	3.43	31,731	3.43	17,883	4.47	1,954	4.47	9,325	3.95
NORTH COAST AIR BASIN										
Del Norte	6,926	3.01	1,146	3.01	1,094	0.82	120	0.82	466	0.26
Humboldt	45,971	2.80	7,608	2.80	6,972	3.85	762	3.85	3,207	3.97
Mendocino	24,505	3.58	4,056	3.58	4,343	3.46	475	3.46	1,771	5.30
Sonoma	14,158	0.72	2,343	0.72	1,612	0.82	176	0.82	865	0.52
Trinity	3,335	3.25	552	3.25	834	3.45	91	3.45	378	3.32
Basin Total	94,894	2.72	15,705	2.72	14,855	3.16	1,623	3.16	6,686	3.58

TABLE A.3.1 (cont'd)

VEHICLES IN USE AND ANNUAL INCREASE BY VEHICLE TYPE, COUNTY, AND AIR BASIN

	VEHICLE TYPE									
	Light Duty Passenger		Light Duty Truck		Heavy Duty Gas		Heavy Duty Diesel		Motorcycles	
	Vehicles in Use 1973	Annual Increase (% 1973)	Vehicles in Use 1973	Annual Increase (% 1973)	Vehicles in Use 1973	Annual Increase (% 1973)	Vehicles in Use 1973	Annual Increase (% 1973)	Vehicles in Use 1973	Annual Increase (% 1973)
NORTHEAST PLATEAU AIR BASIN										
Lassen	7,005	2.04	1,159	2.04	1,597	3.89	175	3.89	756	4.20
Modoc	3,231	0.55	535	0.55	973	0.93	106	0.93	155	0.67
Shasta	2,590	0.23	429	0.23	466	0.30	51	0.30	201	0.37
Siskiyou	15,105	2.64	2,500	2.64	3,577	3.46	391	3.46	1,033	4.51
Basin Total	27,931	2.02	4,623	2.02	6,612	2.97	723	2.97	2,146	3.73
SACRAMENTO VALLEY AIR BASIN										
Butte	50,846	3.39	8,415	3.39	7,606	4.57	831	4.57	4,209	3.85
Colusa	5,793	0.45	959	0.45	1,448	2.09	158	2.09	440	4.97
Glenn	8,636	3.60	1,429	3.60	1,987	3.07	217	3.07	676	2.10
Sacramento	328,764	3.27	54,412	3.27	31,518	5.24	3,444	5.24	20,014	5.27
Shasta	35,496	3.11	5,875	3.11	6,381	4.11	697	4.11	2,749	5.08
Solano	16,230	0.71	2,686	0.71	1,308	0.98	143	0.98	1,031	0.90
Sutter	19,716	2.65	3,263	2.65	3,215	4.64	351	4.64	1,615	2.71
Tehama	13,359	2.66	2,211	2.66	2,688	4.86	294	4.86	1,001	5.19
Yolo	41,365	3.85	6,846	3.85	5,714	4.73	624	4.73	2,814	4.40
Yuba	18,755	2.61	3,104	2.61	2,512	4.28	275	4.28	1,502	2.43
Basin Total	538,959	3.15	89,200	3.15	64,376	4.70	7,035	4.70	36,051	4.60
SAN DIEGO AIR BASIN										
San Diego	681,119	4.51	112,727	4.51	48,007	6.28	5,246	6.28	40,175	5.54
Basin Total	681,119	4.51	112,727	4.51	48,007	6.28	5,246	6.28	40,175	5.54
SAN FRANCISCO BAY AREA AIR BASIN										
Alameda	489,359	2.32	80,991	2.32	34,946	4.54	3,819	4.54	25,892	4.75
Contra Costa	277,253	3.47	45,887	3.47	18,705	5.13	2,044	5.13	15,580	5.05
Marin	108,269	3.61	17,919	3.61	5,762	4.88	630	4.88	5,421	5.59
Napa	40,056	3.58	6,629	3.58	4,104	4.01	448	4.01	2,530	6.03
San Francisco	257,696	0.36	42,650	0.36	18,569	1.28	2,029	1.28	8,319	5.47
San Mateo	301,541	2.96	49,907	2.96	18,461	4.83	2,017	4.83	12,408	4.55
Santa Clara	561,249	4.40	92,889	4.40	36,998	6.22	4,043	6.22	28,348	6.49
Solano	63,722	2.79	10,546	2.79	5,134	3.85	561	3.85	4,048	3.53
Sonoma	96,450	4.91	15,963	4.91	10,981	5.58	1,200	5.58	5,894	3.53
Basin Total	2,195,595	3.07	363,381	3.07	153,658	4.71	16,792	4.71	108,440	5.24

TABLE A.3.1 (cont'd)
VEHICLES IN USE AND ANNUAL INCREASE BY VEHICLE TYPE, COUNTY, AND AIR BASIN

	VEHICLE TYPE									
	Light Duty Passenger		Light Duty Truck		Heavy Duty Gas		Heavy Duty Diesel		Motorcycles	
	Vehicles in Use 1973	Annual Increase (% 1973)	Vehicles in Use 1973	Annual Increase (% 1973)	Vehicles in Use 1973	Annual Increase (% 1973)	Vehicles in Use 1973	Annual Increase (% 1973)	Vehicles in Use 1973	Annual Increase (% 1973)
SAN JOAQUIN AIR BASIN										
Fresno	194,236	2.87	32,147	2.87	34,377	4.25	2,664	4.25	11,548	4.16
Kern	130,023	2.20	21,519	2.20	17,660	3.70	1,930	3.70	11,041	4.52
Kings	26,880	2.42	4,449	2.42	3,853	3.81	421	3.81	2,333	3.82
Madera	18,638	3.24	3,085	3.24	3,522	4.24	385	4.24	1,230	7.37
Merced	45,844	3.52	7,587	3.52	6,809	4.43	744	4.43	2,965	5.82
San Joaquin	131,425	2.69	21,751	2.69	16,546	4.44	1,808	4.44	7,653	4.03
Stanislaus	94,333	2.85	15,613	2.85	13,116	4.95	1,433	4.95	6,203	2.31
Tulare	82,698	3.48	13,687	3.48	12,542	4.21	1,371	4.21	6,151	2.22
Basin Total	724,078	2.82	119,838	2.82	98,424	4.27	10,756	4.27	49,124	3.91
SOUTH CENTRAL COAST AIR BASIN										
San Luis Obispo	52,766	4.18	8,733	4.18	6,024	5.43	658	5.43	3,625	4.27
Santa Barbara	55,756	1.35	9,228	1.35	4,240	1.87	463	1.87	3,405	1.90
Basin Total	108,522	2.73	17,961	2.73	10,264	3.96	1,122	3.96	7,030	3.12
SOUTH COAST AIR BASIN										
Los Angeles	3,355,530	1.91	555,356	1.91	199,517	3.69	21,804	3.69	164,199	4.32
Orange	801,953	4.63	132,726	4.63	47,884	6.64	5,233	6.64	48,592	5.73
Riverside	160,070	2.79	26,493	2.79	14,942	3.47	1,633	3.47	9,628	3.51
San Bernardino	245,660	2.46	40,658	2.46	23,105	3.66	2,525	3.66	16,628	3.97
Santa Barbara	73,608	1.79	12,182	1.79	5,598	2.47	612	2.47	4,496	2.51
Ventura	188,912	4.86	31,266	4.86	14,296	5.39	1,562	5.39	11,811	4.85
Basin Total	4,825,733	2.53	798,681	2.53	305,341	4.20	33,368	4.20	255,354	4.53
SOUTHEAST DESERT AIR BASIN										
Imperial	33,430	3.75	5,533	3.75	5,080	3.36	555	3.36	1,658	5.46
Kern	20,641	0.35	3,416	0.35	2,803	0.59	306	0.59	1,753	0.72
Los Angeles	40,068	0.02	6,631	0.02	2,382	0.04	260	0.04	1,961	0.05
Riverside	67,302	1.17	11,139	1.17	6,282	1.46	687	1.46	4,048	1.48
San Bernardino	64,126	0.64	10,613	0.64	6,031	0.96	659	0.96	4,341	1.04
San Diego	1,228	0.01	203	0.01	87	0.01	9	0.01	72	0.01
Basin Total	226,796	1.12	37,536	1.12	22,666	1.49	2,477	1.49	13,832	1.51
CALIFORNIA STATE TOTAL	9,752,000	3.03	1,614,000	3.03	765,000	4.74	83,600	4.74	539,000	4.86

Reference: ARB, "Technical Support Document for Estimating Emissions from Mobile Sources in California," Division of Implementation and Enforcement, May 1975. See Emission Inventory Unit for specific details.

TABLE A.3.2

1973 Statewide Motor Vehicle Registrations, Average Annual Mileage, and Percent VMT by Vehicle Type
(Registrations are adjusted to give average number in use over entire year)

Vehicle Type	Average In Use	Average Annual Mileage (mi/yr)	Total Vehicle Miles Travelled (10^9 mi/yr)	Percent of Total VMT
Light Duty Passenger Vehicles	9,752,000	8,367	81.59	74.9%
Light Duty Trucks	1,614,000	8,016	12.94	11.9%
Combined Light Duty Vehicles	11,366,000	8,317	94.53	86.8%
Gasoline-Powered Heavy Duty Vehicles	765,000	11,820	9.03	8.3%
Diesel-Powered Heavy Duty Vehicles	83,600	53,685	4.49	4.1%
Combined Heavy Duty Vehicles	848,600	15,944	13.52	12.4%
Motorcycles (on-road)	539,000	1,570	0.85	0.8%
TOTAL	12,753,600	----	108.9	100.0%

Source: All vehicle population data from internal ARB report, "Total Number of Motor Vehicles In Use and Distribution According to Model Year", Division of Implementation and Enforcement, January, 1975. Motorcycle mileage from "Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975; AP-42, Supplement 5. All other vehicle mileages based on data and methodology described in ARB, "Technical Support Document for Estimating Emissions from Mobile Sources in California", Division of Implementation and Enforcement, May, 1975. For specific information regarding vehicle populations or mileages see ARB Emissions Inventory Unit.

Table A.3.3
1972 Composite Motor Vehicle Emission Rates and Average Annual Mileage

VEHICLE TYPE	POLLUTANT					
	Hydrocarbons HC (organics) (gm/mi)			Carbon Monoxide CO (gm/mi)	Oxides of Nitrogen NOx (gm/mi)	Annual Average Mileage (mi/yr)
	Exhaust	Evaporative	Crankcase			
Light Duty Passenger Vehicles	5.4	2.16	0.09	68.5	4.1	8,367
Light Duty Trucks	6.6	3.34	0.19	72.0	4.8	8,016
Combined Light Duty Vehicles	5.6	2.32	0.10	69.0	4.2	8,317
Gasoline-Powered Heavy Duty Vehicles	29.6	5.80	1.69	224.6	8.3	11,820
Diesel-Powered Heavy Duty Vehicles	5.2	0.00	0.00	28.7	20.9	53,685
Combined Heavy Duty Vehicles	21.5	3.88	1.13	159.6	12.5	15,944
Motorcycles (on-road only)	8.1	0.36	0.36	30.6	0.2	1,570

References:
Light and heavy duty vehicle data from "EMFAC3" motor vehicle emissions computer program output April, 1976.
EMFAC3 input is based on:
"Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975.
AP-42 - Supplement 5.
Supplement 5 emission factors were modified to reflect California specific data. All data assumes 14.20 percent light duty are trucks, and 9.85 percent heavy duty are diesel. All light duty data assumes ambient temperature of 75°, 20 percent cold start, and 27 percent hot start. For additional information see:
California Air Resources Board, "EMFAC3 - Technical Information Document", March 31, 1976.
Motorcycle emission rates are uncontrolled rates as presented in Supplement 5.

Table A.3.4
1973 Composite Motor Vehicle Emission Rates and Average Annual Mileage

VEHICLE TYPE	POLLUTANT					
	Hydrocarbons HC (organics) (gm/mi)			Carbon Monoxide CO (gm/mi)	Oxides of Nitrogen NOx (gm/mi)	Annual Average Mileage (mi/yr)
	Exhaust	Evaporative	Crankcase			
Light Duty Passenger Vehicles	4.9	2.06	0.06	59.0	3.9	8,367
Light Duty Trucks	6.0	3.28	0.14	62.8	4.7	8,016
Combined Light Duty Vehicles	5.1	2.23	0.07	59.5	4.0	8,317
Gasoline-Powered Heavy Duty Vehicles	27.5	5.80	1.41	219.6	8.9	11,820
Diesel-Powered Heavy Duty Vehicles	5.2	0.00	0.00	28.7	20.9	53,685
Combined Heavy Duty Vehicles	20.1	3.88	0.94	156.2	12.9	15,944
Motorcycles (on-road only)	8.1	0.36	0.36	30.6	0.2	1,570

References:
Light and heavy duty vehicle data from "EMFAC3" motor vehicle emissions computer program output April, 1976.
EMFAC3 input is based on:
"Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975.
AP-42 - Supplement 5.
Supplement 5 emission factors were modified to reflect California specific data. All data assumes 14.20 percent light duty are trucks, and 9.85 percent heavy duty are diesel. All light duty data assumes ambient temperature of 75°, 20 percent cold start, and 27 percent hot start. For additional information see:
California Air Resources Board, "EMFAC3 - Technical Information Document", March 31, 1976.
Motorcycle emission rates are uncontrolled rates as presented in Supplement 5.

Tabl A.3.5
1974 Composite Motor Vehicle Emission Rates and Average Annual Mileage

VEHICLE TYPE	POLLUTANT					
	Hydrocarbons HC (organics) (gm/mi)			Carbon Monoxide CO (gm/mi)	Oxides of Nitrogen NOx (gm/mi)	Annual Average Mileage (mi/yr)
	Exhaust	Evaporative	Crankcase			
Light Duty Passenger Vehicles	4.7	1.99	0.04	54.9	3.6	8,367
Light Duty Trucks	5.7	3.23	0.12	59.2	4.4	8,016
Combined Light Duty Vehicles	4.9	2.16	0.05	55.5	3.7	8,317
Gasoline-Powered Heavy Duty Vehicles	25.7	5.80	1.23	214.3	9.4	11,820
Diesel-Powered Heavy Duty Vehicles	5.2	0.00	0.00	28.7	20.9	53,685
Combined Heavy Duty Vehicles	18.9	3.88	0.82	152.7	13.2	15,944
Motorcycles (on-road only)	8.1	0.36	0.36	30.6	0.2	1,570

References:
Light and heavy duty vehicle data from "EMFAC3" motor vehicle emissions computer program output April, 1976.
EMFAC3 input is based on:
"Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975.
AP-42 - Supplement 5.
Supplement 5 emission factors were modified to reflect California specific data. All data assumes 14.20 percent light duty are trucks, and 9.85 percent heavy duty are diesel. All light duty data assumes ambient temperature of 75°, 20 percent cold start, and 27 percent hot start. For additional information see:
California Air Resources Board, "EMFAC3 - Technical Information Document", March 31, 1976.
Motorcycle emission rates are uncontrolled rates as presented in Supplement 5.

Table A.3.6
1975 Composite Motor Vehicle Emission Rates and Average Annual Mileage

VEHICLE TYPE	POLLUTANT					
	Hydrocarbons HC (organics) (gm/mi)			Carbon Monoxide CO (gm/mi)	Oxides of Nitrogen NOx (gm/mi)	Annual Average Mileage (mi/yr)
	Exhaust	Evaporative	Crankcase			
Light Duty Passenger Vehicles	4.2	1.92	0.03	46.7	3.3	8,367
Light Duty Trucks	5.3	3.19	0.11	54.2	4.6	8,016
Combined Light Duty Vehicles	4.3	2.09	0.04	47.7	3.5	8,317
Gasoline-Powered Heavy Duty Vehicles	23.5	5.80	1.05	207.2	9.9	11,820
Diesel-Powered Heavy Duty Vehicles	5.2	0.00	0.00	28.7	20.9	53,685
Combined Heavy Duty Vehicles	17.4	3.88	0.70	147.9	13.5	15,944
Motorcycles (on-road only)	8.1	0.36	0.36	30.6	0.2	1,570

References:
Light and heavy duty vehicle data from "EMFAC3" motor vehicle emissions computer program output April, 1976.
EMFAC3 input is based on:
"Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975.
AP-42 - Supplement 5.
Supplement 5 emission factors were modified to reflect California specific data. All data assumes 14.20 percent light duty are trucks, and 9.85 percent heavy duty are diesel. All light duty data assumes ambient temperature of 75°, 20 percent cold start, and 27 percent hot start. For additional information see:
California Air Resources Board, "EMFAC3 - Technical Information Document", March 31, 1976.
Motorcycle emission rates are uncontrolled rates as presented in Supplement 5.

Table A.3.7
1976 Composite Motor Vehicle Emission Rates and Average Annual Mileage

VEHICLE TYPE	POLLUTANT					
	Hydrocarbons HC (organics) (gm/mi)			Carbon Monoxide CO (gm/mi)	Oxides of Nitrogen NOx (gm/mi)	Annual Average Mileage (mi/yr)
	Exhaust	Evaporative	Crankcase			
Light Duty Passenger Vehicles	3.6	1.87	0.02	38.6	3.1	8,367
Light Duty Trucks	4.9	3.16	0.09	55.4	4.9	8,016
Combined Light Duty Vehicles	3.8	2.04	0.03	40.9	3.4	8,317
Gasoline-Powered Heavy Duty Vehicles	21.3	5.80	0.91	200.6	10.1	11,820
Diesel-Powered Heavy Duty Vehicles	5.2	0.00	0.00	28.7	20.9	53,685
Combined Heavy Duty Vehicles	16.0	3.88	0.61	143.5	13.7	15,944
Motorcycles (on-road only)	8.1	0.36	0.36	30.6	0.2	1,570

References:
Light and heavy duty vehicle data from "EMFAC3" motor vehicle emissions computer program output April, 1976.
EMFAC3 input is based on:
"Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975.
AP-42 - Supplement 5.
Supplement 5 emission factors were modified to reflect California specific data. All data assumes 14.20 percent light duty are trucks, and 9.85 percent heavy duty are diesel. All light duty data assumes ambient temperature of 75°, 20 percent cold start, and 27 percent hot start. For additional information see:
California Air Resources Board, "EMFAC3 - Technical Information Document", March 31, 1976.
Motorcycle emission rates are uncontrolled rates as presented in Supplement 5.

Table A.3.8
1977 Composite Motor Vehicle Emission Rates and Average Annual Mileage

VEHICLE TYPE	POLLUTANT					
	Hydrocarbons HC (organics) (gm/mi)			Carbon Monoxide CO (gm/mi)	Oxides of Nitrogen NOx (gm/mi)	Annual Average Mileage (mi/yr)
	Exhaust	Evaporative	Crankcase			
Light Duty Passenger Vehicles	3.0	1.83	0.01	31.9	2.8	8,367
Light Duty Trucks	4.5	3.14	0.05	56.6	5.1	8,016
Combined Light Duty Vehicles	3.2	2.01	0.01	35.3	3.1	8,317
Gasoline-Powered Heavy Duty Vehicles	19.3	5.80	0.78	194.3	10.4	11,820
Diesel-Powered Heavy Duty Vehicles	5.2	0.00	0.00	28.7	20.9	53,685
Combined Heavy Duty Vehicles	14.6	3.88	0.52	139.3	13.9	15,944
Motorcycles (on-road only)	8.1	0.36	0.36	30.6	0.2	1,570

References:
Light and heavy duty vehicle data from "EMFAC3" motor vehicle emissions computer program output April, 1976.
EMFAC3 input is based on:
"Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975.
AP-42 - Supplement 5.
Supplement 5 emission factors were modified to reflect California specific data. All data assumes 14.20 percent light duty are trucks, and 9.85 percent heavy duty are diesel. All light duty data assumes ambient temperature of 75°, 20 percent cold start, and 27 percent hot start. For additional information see:
California Air Resources Board, "EMFAC3 - Technical Information Document", March 31, 1976.
Motorcycle emission rates are uncontrolled rates as presented in Supplement 5.

Table A.3.9
1978 Composite Motor Vehicle Emission Rates and Average Annual Mileage

VEHICLE TYPE	POLLUTANT					
	Hydrocarbons HC (organics) (gm/mi)			Carbon Monoxide CO (gm/mi)	Oxides of Nitrogen NOx (gm/mi)	Annual Average Mileage (mi/yr)
	Exhaust	Evaporative	Crankcase			
Light Duty Passenger Vehicles	2.5	1.80	0.00	26.2	2.6	8,367
Light Duty Trucks	3.8	3.13	0.04	48.3	4.6	8,016
Combined Light Duty Vehicles	2.6	1.98	0.01	29.2	2.9	8,317
Gasoline-Powered Heavy Duty Vehicles	17.4	5.80	0.68	186.9	10.6	11,820
Diesel-Powered Heavy Duty Vehicles	5.2	0.00	0.00	28.7	20.7	53,685
Combined Heavy Duty Vehicles	13.4	3.88	0.45	134.4	14.0	15,944
Motorcycles (on-road only)	8.1	0.36	0.36	30.6	0.2	1,570

References:
Light and heavy duty vehicle data from "EMFAC3" motor vehicle emissions computer program output April, 1976.
EMFAC3 input is based on:
"Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975.
AP-42 - Supplement 5.
Supplement 5 emission factors were modified to reflect California specific data. All data assumes 14.20 percent light duty are trucks, and 9.85 percent heavy duty are diesel. All light duty data assumes ambient temperature of 75°, 20 percent cold start, and 27 percent hot start. For additional information see:
California Air Resources Board, "EMFAC3 - Technical Information Document", March 31, 1976.
Motorcycle emission rates are uncontrolled rates as presented in Supplement 5.

Table A.3.10
1979 Composite Motor Vehicle Emission Rates and Average Annual Mileage

VEHICLE TYPE	POLLUTANT					
	Hydrocarbons HC (organics) (gm/mi)			Carbon Monoxide CO (gm/mi)	Oxides of Nitrogen NOx (gm/mi)	Annual Average Mileage (mi/yr)
	Exhaust	Evaporative	Crankcase			
Light Duty Passenger Vehicles	2.0	1.77	0.00	21.3	2.4	8,367
Light Duty Trucks	3.2	3.09	0.04	40.0	4.1	8,016
Combined Light Duty Vehicles	2.2	1.95	0.01	23.8	2.6	8,317
Gasoline-Powered Heavy Duty Vehicles	15.8	5.80	0.60	178.1	10.9	11,820
Diesel-Powered Heavy Duty Vehicles	5.2	0.00	0.00	28.7	20.4	53,685
Combined Heavy Duty Vehicles	12.3	3.88	0.40	128.5	14.0	15,944
Motorcycles (on-road only)	8.1	0.36	0.36	30.6	0.2	1,570

References:
Light and heavy duty vehicle data from "EMFAC3" motor vehicle emissions computer program output April, 1976.
EMFAC3 input is based on:
"Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975.
AP-42 - Supplement 5.
Supplement 5 emission factors were modified to reflect California specific data. All data assumes 14.20 percent light duty are trucks, and 9.85 percent heavy duty are diesel. All light duty data assumes ambient temperature of 75°, 20 percent cold start, and 27 percent hot start. For additional information see:
California Air Resources Board, "EMFAC3 - Technical Information Document", March 31, 1976.
Motorcycle emission rates are uncontrolled rates as presented in Supplement 5.

Table A.3.11
1980 Composite Motor Vehicle Emission Rates and Average Annual Mileage

VEHICLE TYPE	POLLUTANT					
	Hydrocarbons HC (organics) (gm/mi)			Carbon Monoxide CO (gm/mi)	Oxides of Nitrogen NOx (gm/mi)	Annual Average Mileage (mi/yr)
	Exhaust	Evaporative	Crankcase			
Light Duty Passenger Vehicles	1.6	1.55	0.00	16.7	2.1	8,367
Light Duty Trucks	2.7	2.59	0.00	33.6	3.7	8,016
Combined Light Duty Vehicles	1.7	1.69	0.00	19.0	2.3	8,317
Gasoline-Powered Heavy Duty Vehicles	14.5	5.80	0.00	170.8	11.1	11,820
Diesel-Powered Heavy Duty Vehicles	5.2	0.00	0.00	28.7	20.3	53,685
Combined Heavy Duty Vehicles	11.4	3.88	0.00	123.6	14.1	15,944
Motorcycles (on-road only)	8.1	0.36	0.36	30.6	0.2	1,570

References:
Light and heavy duty vehicle data from "EMFAC3" motor vehicle emissions computer program output April, 1976.
EMFAC3 input is based on:
"Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975.
AP-42 - Supplement 5.
Supplement 5 emission factors were modified to reflect California specific data. All data assumes 14.20 percent light duty are trucks, and 9.85 percent heavy duty are diesel. All light duty data assumes ambient temperature of 75°, 20 percent cold start, and 27 percent hot start. For additional information see:
California Air Resources Board, "EMFAC3 - Technical Information Document", March 31, 1976.
Motorcycle emission rates are uncontrolled rates as presented in Supplement 5.

Table A.3.12
1985 Composite Motor Vehicle Emission Rates and Average Annual Mileage

VEHICLE TYPE	POLLUTANT					
	Hydrocarbons HC (organics) (gm/mi)			Carbon Monoxide CO (gm/mi)	Oxides of Nitrogen NOx (gm/mi)	Annual Average Mileage (mi/yr)
	Exhaust	Evaporative	Crankcase			
Light Duty Passenger Vehicles	0.6	0.76	0.00	5.7	1.4	8,367
Light Duty Trucks	1.2	0.99	0.00	16.2	2.6	8,016
Combined Light Duty Vehicles	0.7	0.79	0.00	7.2	1.6	8,317
Gasoline-Powered Heavy Duty Vehicles	10.1	5.80	0.00	144.9	11.7	11,820
Diesel-Powered Heavy Duty Vehicles	5.2	0.00	0.00	28.7	20.3	53,685
Combined Heavy Duty Vehicles	8.5	3.88	0.00	106.3	14.6	15,944
Motorcycles (on-road only)	8.1	0.36	0.36	30.6	0.2	1,570

References:
Light and heavy duty vehicle data from "EMFAC3" motor vehicle emissions computer program output April, 1976.
EMFAC3 input is based on:
"Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975.
AP-42 - Supplement 5.
Supplement 5 emission factors were modified to reflect California specific data. All data assumes 14.20 percent light duty are trucks, and 9.85 percent heavy duty are diesel. All light duty data assumes ambient temperature of 75°, 20 percent cold start, and 27 percent hot start. For additional information see:
California Air Resources Board, "EMFAC3 - Technical Information Document", March 31, 1976.
Motorcycle emission rates are uncontrolled rates as presented in Supplement 5.

Table A.3.13
1990 Composite Motor Vehicle Emission Rates and Average Annual Mileage

VEHICLE TYPE	POLLUTANT					
	Hydrocarbons HC (organics) (gm/mi)			Carbon Monoxide CO (gm/mi)	Oxides of Nitrogen NOx (gm/mi)	Annual Average Mileage (mi/yr)
	Exhaust	Evaporative	Crankcase			
Light Duty Passenger Vehicles	0.5	0.52	0.00	4.0	1.2	8,367
Light Duty Trucks	1.0	0.58	0.00	12.9	2.4	8,016
Combined Light Duty Vehicles	0.5	0.53	0.00	5.3	1.4	8,317
Gasoline-Powered Heavy Duty Vehicles	7.0	5.80	0.00	129.3	12.4	11,820
Diesel-Powered Heavy Duty Vehicles	5.2	0.00	0.00	28.7	20.3	53,685
Combined Heavy Duty Vehicles	6.4	3.88	0.00	95.9	15.0	15,944
Motorcycles (on-road only)	8.1	0.36	0.36	30.6	0.2	1,570

References:
Light and heavy duty vehicle data from "EMFAC3" motor vehicle emissions computer program output April, 1976.
EMFAC3 input is based on:
"Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975.
AP-42 - Supplement 5.
Supplement 5 emission factors were modified to reflect California specific data. All data assumes 14.20 percent light duty are trucks, and 9.85 percent heavy duty are diesel. All light duty data assumes ambient temperature of 75°, 20 percent cold start, and 27 percent hot start. For additional information see:
California Air Resources Board, "EMFAC3 - Technical Information Document", March 31, 1976.
Motorcycle emission rates are uncontrolled rates as presented in Supplement 5.

Table A.3.14
1995 Composite Motor Vehicle Emission Rates and Average Annual Mileage

VEHICLE TYPE	POLLUTANT					
	Hydrocarbons HC (organics) (gm/mi)			Carbon Monoxide CO (gm/mi)	Oxides of Nitrogen NOx (gm/mi)	Annual Average Mileage (mi/yr)
	Exhaust	Evaporative	Crankcase			
Light Duty Passenger Vehicles	0.4	0.51	0.00	3.7	1.2	8,367
Light Duty Trucks	0.9	0.54	0.00	11.8	2.3	8,016
Combined Light Duty Vehicles	0.5	0.51	0.00	4.8	1.4	8,317
Gasoline-Powered Heavy Duty Vehicles	6.2	5.80	0.00	122.2	12.4	11,820
Diesel-Powered Heavy Duty Vehicles	5.2	0.00	0.00	28.7	20.3	53,685
Combined Heavy Duty Vehicles	5.8	3.88	0.00	91.2	15.0	15,944
Motorcycles (on-road only)	8.1	0.36	0.36	30.6	0.2	1,570

References:
Light and heavy duty vehicle data from "EMFAC3" motor vehicle emissions computer program output April, 1976.
EMFAC3 input is based on:
"Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975.
AP-42 - Supplement 5.
Supplement 5 emission factors were modified to reflect California specific data. All data assumes 14.20 percent light duty are trucks, and 9.85 percent heavy duty are diesel. All light duty data assumes ambient temperature of 75°, 20 percent cold start, and 27 percent hot start. For additional information see:
California Air Resources Board, "EMFAC3 - Technical Information Document", March 31, 1976.
Motorcycle emission rates are uncontrolled rates as presented in Supplement 5.

TABLE A.3.15

Composite Motor Vehicle Emission
FACTORS FOR TOTAL SULFUR OXIDES (SO_x as SO_2) EMISSIONS
(grams/mile)

	Inventory Year		
Vehicle Type	1972-1977	1978-1979	1980-1995
Light Duty Passenger	0.13	0.13	0.12
Light Duty Trucks	0.18	0.18	0.17
Combined Light Duty Vehicles	0.14	0.14	0.13
Gasoline-Powered Heavy Duty Vehicles	0.36	0.36	0.28
Diesel-Powered Heavy Duty Vehicles	2.8	2.8	2.8
Combined Heavy Duty Vehicles	1.17	1.17	1.12
Motorcycles	0.028	0.027	0.024

Based on data from "Compilation of Air Pollutant Emission Factors, Supplement 5", December, 1975. AP-42, Supplement 5. Modified to reflect adopted ARB regulations [42] presented below:

Maximum Sulfur Content (Parts Per Million by Weight)	Effective Date of Limitation
500	January 1, 1976
400	January 1, 1978
300	January 1, 1980

Does not include anticipated fuel economy gains. Specific details delineated in internal ARB report by W. V. Loscutoff, April 5, 1976.

TABLE A.3.16
COMPOSITE MOTOR VEHICLE EMISSION
FACTORS FOR PARTICULATE EMISSIONS
(grams/mile)

Vehicle Type	Inventory Year											
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1985	1990	1995
Light Duty Passenger	0.54	0.54	0.54	0.49	0.44	0.40	0.36	0.33	0.31	0.26	0.25	0.25
Light Duty Trucks	0.54	0.54	0.54	0.54	0.50	0.47	0.42	0.38	0.35	0.27	0.26	0.25
Combined Light Duty Vehicles	0.54	0.54	0.54	0.50	0.45	0.41	0.37	0.34	0.32	0.26	0.25	0.25
Gasoline-Powered Heavy Duty Vehicles	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
Diesel-Powered Heavy Duty Vehicles	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86
Combined Heavy Duty Vehicles	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Motorcycles	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16

Based on data from: "Compilation of Air Pollutant Emission Factors, Supplement 5," December, 1975. AP-42-Supplement 5. Specific details delineated in internal ARB report by W. V. Loscutoff, April 2, 1976. Data do not reflect gasoline lead content regulations adopted by the Air Resources Board on February 19, 1976.

TABLE A.3.17

PERCENT ORGANIC GAS EMISSIONS BY CLASS

Source	Percentages by Class of Organic Gas Emissions		
	Class I	Class II	Class III
Petroleum			
Production	46.5	53.5	0.0
Refining	4.1	73.3	22.6
Marketing			
Terminal and Storage	5.7	70.0	24.3
Auto Tank Filling	2.3	67.4	30.3
Organic Solvent Users			
Surface Coating			
Heat Dried	3.7	28.0	68.3
Air Dried	9.2	53.4	37.4
Dry Cleaning			
Petroleum Based	0.0	94.3	5.7
Perchloroethylene	100.0	0.0	0.0
Degreasing			
Perchloroethylene or 1,1,1 - Trichloroethane	100.0	0.0	0.0
Trichloroethylene	0.0	0.0	100.0
Printing			
Rotogravure	6.0	69.0	25.0
Flexigraphic	15.0	10.0	75.0
Rubber, Plastic, Putty and Adhesive Mfg.	18.1	25.4	56.5
Pharmaceutical Mfg.	21.7	6.8	71.5
Misc. Organic Solvent Users	27.2	36.9	35.9
Chemical	0.0	0.0	100.0
Metallurgical	0.0	0.0	100.0
Mineral	66.2	10.3	23.5
Food and Agricultural Processing	0.0	0.0	100.0
Pesticides	0.0	30.0	70.0
Wood Processing	60.0	15.0	25.0
Combustion of Fuels			
Power Plants	2.6	53.1	44.3
Other Industrial	2.6	53.1	44.3
Domestic and Commercial Heaters	2.6	53.1	44.3
Orchard Heaters	2.6	53.1	44.3

(continued)

TABLE A.3.17

(continued)

PERCENT ORGANIC GAS EMISSIONS BY CLASS

Source	Percentages by Class of Organic Gas Emissions		
	Class I	Class II	Class III
Waste Burning			
Agricultural Debris	48.0	18.0	34.0
Forest Management	48.0	18.0	34.0
Range Improvement	48.0	18.0	34.0
Dumps	48.0	18.0	34.0
Conical Burners	48.0	18.0	34.0
Incinerators	48.0	18.0	34.0
Other Waste Burning	48.0	18.0	34.0
Miscellaneous Area Sources			
Wild Fires			
Structural Fires			
Utility Equip: Mowers, etc.	11.3	42.1	46.6
Gasoline Powered Vehicles			
Exhaust	11.3	42.1	46.6
Evaporative	3.5	56.4	40.1
Crankcase	7.2	49.7	43.1
Diesel Powered Vehicles	2.6	53.1	44.3
Aircraft			
Jet	2.0	47.6	50.4
Piston	14.4	41.4	44.2
Locomotives	2.6	53.1	44.3
Ships			
Steam	65.7	10.6	23.7
Diesel	2.6	53.1	44.3

Reference: Howard Linnard, Emission Inventory Unit, California Air Resources Board. Internal communication March 25, 1976. Based on data from Trijonis and Arledge [41].

TABLE A.3.18

GENERATING CAPACITY AVAILABLE TO CALIFORNIA[1] AS OF DECEMBER 31, 1972

BASE LOAD PLANTS

Utility	Plant Name	County	No. of Units	Capability MW
Gas- and Oil-Fired Steam Plants				
Southern California Edison Company	Alamitos	Los Angeles	6	1,950
	Cool Water	San Bernardino	2	146
	El Segundo	Los Angeles	4	1,020
	Etiwanda	San Bernardino	4	904
	Highgrove	San Bernardino	4	154
	Huntington Beach	Orange	4	870
	Long Beach No. 3	Los Angeles	2	212
	Mandalay	Ventura	2	430
	Ormond Beach	Ventura	1	750
	Redondo	Los Angeles	8	1,602
	San Bernardino	San Bernardino	2	126
	Yuma Axis	(State of Arizona)	1	25
			40	8,189
Pacific Gas and Electric Company	Avon	Contra Costa	1	46
	Contra Costa	Contra Costa	7	1,260
	Humboldt Bay	Humboldt	2	105
	Hunters Point	San Francisco	3	377
	Kern	Kern	2	180
	Martinez	Contra Costa	1	46
	Morro Bay	San Luis Obispo	4	1,002
	Moss Landing	Monterey	7	2,060
	Oleum	Contra Costa	2	87
	Pittsburg	Contra Costa	7	2,002
	Potrero	San Francisco	3	323
			39	7,488
Los Angeles Department of Water and Power	Harbor	Los Angeles	5	445
	Haynes	Los Angeles	6	1,593
	Scattergood	Los Angeles	1	179
	Valley	Los Angeles	4	517
			16	2,734
San Diego Gas and Electric Company	Encina	San Diego	3	325
	Silver Gate	San Diego	4	237
	South Bay	San Diego	4	713
	Station B	San Diego	4	96
			15	1,371
Imperial Irrigation District[2]	El Centro[3]	Imperial	4	180
	Yuma Axis	(State of Arizona)	1	25
			5	205
City of Pasadena	Broadway	Los Angeles	3	161
	Glenarm	Los Angeles	2	59
			5	220
City of Burbank	Magnolia	Los Angeles	4	74
	Olive	Los Angeles	2	104
			6	178
City of Glendale	Glendale	Los Angeles	5	160
	TOTAL GAS AND OIL PLANTS		131	20,545
Nuclear-Powered Steam Plants				
Pacific Gas and Electric Company	Humboldt Bay	Humboldt	1	63
Southern California Edison Company, San Diego Gas & Electric Company	San Onofre	San Diego	1	430
	TOTAL NUCLEAR PLANTS		2	493
Geothermal Steam Plants				
Pacific Gas and Electric Company	The Geysers	Sonoma	8	290
	TOTAL GEOTHERMAL PLANTS		8	290
Coal-Fired Steam Plants[4]				
Southern California Edison Company	Four Corners	(State of New Mexico)	2	768
Southern California Edison Company, Los Angeles Department of Water and Power	Mohave	(State of Nevada)	2	1,122
	TOTAL COAL-FIRED PLANTS		4	1,890
	TOTAL BASE LOAD PLANTS		145	23,218

PEAKING PLANTS

Utility	Plant Name	County	No. of Units	Capability MW
Hydroelectric Plants				
Pacific Gas and Electric Company	Alta	Placer	2	2
	Angels	Calaveras	1	1
	Balch No. 1	Fresno	1	34
	Balch No. 2	Fresno	2	105
	Belden	Plumas	1	125
	Black, James B.	Shasta	2	172
	Bucks Creek	Plumas	2	55
	Butt Valley	Plumas	1	40
	Caribou No. 1	Plumas	3	75
	Caribou No. 2	Plumas	2	120
	Centerville	Butte	2	6
	Chili Bar	El Dorado	1	7
	Coal Canyon	Butte	1	1
	Coleman	Shasta	3	13
	Cow Creek	Shasta	2	2
	Crane Valley	Madera	1	1
	Cresta	Butte	2	70
	Deer Creek	Nevada	1	6
	De Sabla	Butte	1	19
	Drum No. 1	Placer	4	54
	Drum No. 2	Placer	1	50
	Dutch Flat	Placer	1	22
	El Dorado	El Dorado	2	21
	Electra	Amador	3	92
	Haas	Fresno	2	144
	Halsey	Placer	1	11
	Hamilton Branch	Plumas	2	5
	Hat Creek No. 1	Shasta	1	9
	Hat Creek No. 2	Shasta	1	9
	Inskip	Tehama	2	6
	Kerckhoff	Fresno	3	38
	Kern Canyon	Kern	1	10
	Kilarc	Shasta	2	3
	Kings River	Fresno	1	52
	Lime Saddle	Butte	2	2
	Melones	Tuolumne	2	26
	Merced Falls	Merced	1	4
	Murphys	Calaveras	1	4
	Narrows	Nevada	1	12
	Phoenix	Tuolumne	1	2
	Pit No. 1	Shasta	2	57
	Pit No. 3	Shasta	3	70
	Pit No. 4	Shasta	2	95
	Pit No. 5	Shasta	4	156
	Pit No. 6	Shasta	2	80
	Pit No. 7	Shasta	2	112
	Poe	Butte	2	120
	Potter Valley	Mendocino	3	9
	Rock Creek	Plumas	2	110
	Salt Springs	Amador	2	44
	San Joaquin No. 1-A	Madera	1	1
	San Joaquin No. 2	Madera	1	3
	San Joaquin No. 3	Madera	1	4
	South	Tehama	1	5
	Spaulding No. 1	Nevada	1	7
	Spaulding No. 2	Nevada	1	4
	Spaulding No. 3	Nevada	1	6
	Spring Gap	Tuolumne	1	7
	Stanislaus	Tuolumne	1	92
	Tiger Creek	Amador	2	58
	Tule	Tulare	2	6
	Volta	Shasta	3	7
	West Point	Amador	1	15
	Wise	Placer	1	14
	Wishon	Madera	4	20
			112	2,532
Pacific Power and Light Company	Copco No. 1	Siskiyou	2	20[5]
	Copco No. 2	Siskiyou	2	27[5]
	Fall Creek	Siskiyou	3	2[5]
	Iron Gate	Siskiyou	1	18[5]
			8	67
Oroville-Wyandotte Irrigation District	Forbestown	Butte	1	36
	Kelly Ridge	Butte	1	10
	Woodleaf	Butte	1	55
			3	101
Yuba County Water Agency	New Colgate	Yuba	2	284
	New Narrows	Yuba	1	47
			3	331
Nevada Irrigation District	Chicago Park	Placer	1	42
	Dutch Flat No. 2	Nevada	1	26
			2	68
Sierra Pacific Power Company[2]	Farad	Placer	2	3
	Fleish	Placer	1	2
			3	5

(Data for peaking plants continued on next page)

TABLE A.3.18 (Continued)

GENERATING CAPACITY AVAILABLE TO CALIFORNIA 1/ AS OF DECEMBER 31, 1972 (Continued)

PEAKING PLANTS (Continued)

Utility	Plant Name	County	No. of Units	Capability MW
	Hydroelectric Plants (Continued)			
Southern California Edison Co.	Big Creek No. 1	Fresno	4	81
	Big Creek No. 2	Fresno	4	66
	Big Creek No. 2A	Fresno	2	96
	Big Creek No. 3	Fresno	4	138
	Big Creek No. 4	Fresno	2	91
	Big Creek No. 8	Fresno	2	58
	Bishop Creek No. 2, 3, 4, 5, and 6	Inyo	14	29
	Fontana	San Bernardino	2	2
	Kaweah No. 1, 2 and 3	Tulare	4	9
	Kern River - Borel	Kern	3	10
	Kern River No. 1	Kern	4	25
	Kern River No. 3	Kern	2	36
	Lundy	Mono	2	3
	Lytle Creek	San Bernardino	2	1
	Mammoth Pool	Madera	2	150
	Mill Creek No. 1, 2, and 3	San Bernardino	5	4
	Ontario No. 1 and 2	Los Angeles	4	1
	Poole	Mono	1	10
	Portal	Fresno	1	10
	Rush Creek	Mono	2	10
	San Gorgonio No. 1 and 2	Riverside	2	2
	Santa Ana No. 1, 2, and 3	San Bernardino	7	7
	Sierra	Los Angeles	2	1
	Tule River	Tulare	2	2
	Hoover	(State of Arizona)	4	277
	Parker	(Calif. & Ariz.)	4	17
			87	1,136
Sacramento Municipal Utility District	Camino	El Dorado	2	140
	Jaybird	El Dorado	2	140
	Robbs Peak	El Dorado	1	22
	Union Valley	El Dorado	1	38
	White Rock	El Dorado	2	223
	Loon Lake	El Dorado	1	78
			9	641
Placer County Water Agency	French Meadows	Placer	1	18
	Middle Fork	Placer	2	136
	Oxbow	Placer	1	7
	Ralston	Placer	1	86
			5	247
Turlock and Modesto Irrigation Districts	La Grange	Stanislaus	1	4
	New Don Pedro	Tuolumne	3	144
			4	148
Oakdale and San Joaquin Irrigation Districts	Beardsley	Tuolumne	1	11
	Donnells	Tuolumne	1	68
	Tulloch	Tuolumne	2	18
			4	97
City and County of San Francisco	Dion R. Holm	Tuolumne	2	150
	Robert C. Kirkwood	Tuolumne	2	85
	Moccasin	Tuolumne	2	104
			6	339
Merced Irrigation District	Exchequer	Mariposa	1	80
	McSwain	Mariposa	1	9
			2	89
East Bay Municipal Utility District	Pardee	Amador	2	19
Imperial Irrigation District 2/	Pilot Knob	Imperial	2	33
	Drop No. 2, 3, 4	Imperial	8	39
	Turnip & Double Weir	Imperial	2	1
	Parker	(Calif. & Ariz.)	4	53
			16	126
Los Angeles Department of Water and Power	Owens River Gorge	Mono	3	110
	Owens Valley Plants	Inyo	7	9
	Aqueduct Plants	Los Angeles	12	72
	Hoover	(Ariz. & Nev.)	6	548
	Castaic	Los Angeles	1	24
			29	763
Metropolitan Water District	Hoover	(State of Nev.)	3	260
	Parker	(Calif. & Ariz.)	1	50
			4	310

PEAKING PLANTS (Continued)

Utility	Plant Name	County	No. of Units	Capability MW
	Hydroelectric Plants (Continued)			
U. S. Bureau of Reclamation	Folsom	El Dorado	2	200
	Judge Francis Carr	Shasta	2	154
	Keswick	Shasta	3	90
	Nimbus	Sacramento	2	16
	O'Neill 6/	Merced	6	25
	San Luis 6/	Merced	4	202
	Shasta	Shasta	5	477
	Spring Creek	Shasta	2	192
	Trinity	Trinity	2	193
			28	1,479
California Department of Water Resources	Hyatt	Butte	6	781
	Thermalito	Butte	4	113
	San Luis 6/	Merced	4	222
	Devil Canyon	San Bernardino	1	60
			15	1,176
	TOTAL HYDROELECTRIC PLANTS		342	9,674
	Gas Turbine Plants			
Southern California Edison Company	Alamitos	Los Angeles	1	121
	Etiwanda	San Bernardino	1	121
	Garden State	Los Angeles	1	12
	Huntington Beach	Orange	1	121
	Mandalay	Ventura	1	121
			5	496
Los Angeles Department of Water and Power	Harbor	Los Angeles	4	80
Imperial Irrigation District 3/	Brawley	Imperial	2	23
San Diego Gas and Electric Company	Division	San Diego	1	20
	El Cajon	San Diego	1	21
	Encina	San Diego	1	20
	Kearny	San Diego	3	183
	South Bay	San Diego	1	22
	NTC	San Diego	1	20
	Point Loma Sewerage Plant	San Diego	1	2
	North Island	San Diego	2	49
	Miramar	San Diego	1	52
			12	389
City of Burbank	Magnolia	Los Angeles	1	21
	Olive	Los Angeles	1	24
			2	45
City of Glendale	Glendale	Los Angeles	1	24
	TOTAL GAS TURBINE PLANTS		26	1,057
	Diesel Plants			
Southern California Edison	Vernon	Los Angeles	5	20
Imperial Irrigation District 3/	Brawley	Imperial	8	12
Sierra Pacific Power Company	King's Beach	Placer	6	16
	Portola	Plumas	3	6
	TOTAL DIESEL PLANTS		22	54
	TOTAL PEAKING PLANTS		390	10,785

1/ Includes out-of-state capacity available to California on a firm basis.
2/ Not included in C.O. 131 reports.
3/ Fired by gas only; no oil.
4/ These coal-fired plants are shared by several utilities. Values listed represent capacity available to California utilities on a firm basis.
5/ Name plate rating.
6/ Jointly owned by USBR and CDWR. Ratings shown are USBR and CDWR shares respectively.

Source: Data in this table were compiled by the Calif. Public Utilities Commission. Except as noted, production capacity figures are based on filings by Pacific Gas and Electric Co., Southern California Edison Co., Pacific Power and Light Co., Sierra Pacific Power Co., Los Angeles Dept. of Water and Power, and San Diego Gas and Electric Co. in accordance with CPUC General Order No. 131.

TABLE A.3.19

SUMMARY OF UTILITY PROJECTIONS FOR NEW PLANTS (in megawatts)

	1972 - 1981					1982 - 1991					1972 - 1991		
	Northern Calif.	SCE	SDG&E	Southern Calif. Public Utilities [1]	Total New Capacity	Northern Calif.	SCE	SDG&E	Southern Calif. Public Utilities [1]	Total New Capacity	Total New Capacity	Retirements and Terminations	Net Increase of Capacity
Nuclear	7,517	2,964	456	595	11,532	15,390	11,700	2,250	0	29,340	40,872	0	40,872
Hydro	974 [2]	720	0	1,933	3,627	249	3,777	500	0	4,526	8,153	277 [3]	7,876
Coal	0	2,207	999	1,924	5,130	0	1,000	1,000	0	2,000	7,130	0	7,130
Gas & Oil (Steam)	735	2,410	579	461	4,185	0	0	0	0	0	4,185	1,103 [4/5]	3,082
Gas & Oil (Combined Cycle)	0	768	0	0	768	0	3,012	0	0	3,012	3,780	0	3,780
Gas & Oil (Gas Turbine)	150	680	669	282	1,781	0	1,046	502	0	1,548	3,329	0	3,329
Othermal	1,166	0	0	0	1,166	0	1,000	0	0	1,000	2,166	0	2,166
Undefined	0	0	0	148 [6]	148	5,650	500	0	5,541	11,691	11,839	0	11,839
TOTAL NEW CAPACITY	10,542	9,749	2,703	5,343	28,337	21,289	22,035	4,252	5,541	53,117	81,454	1,380	80,074
Less Retirements and Terminations	0	0	0	0	0	0	935 [3/5]	0	445 [4]	1,380	1,380		
Net Increase of Capacity	10,542	9,749	2,703	5,343	28,337	21,289	21,100	4,252	5,096	51,737	80,074		

1/ Cities of Los Angeles, Burbank, Glendale and Pasadena, and Imperial Irrigation District
2/ Includes 287 MW for New Melones, being the difference between 300-MW capacity of the new plant and the 13-MW capacity of Melones which will be retired in 1974.
3/ Agreement with SCE for Hoover units A5-8 terminates 1987 (277 MW). It is possible that this capacity will continue to serve California needs after that date.

4/ 5-unit LADWP Harbor Plant (445 MW) to be retired 1982-1991.
5/ Unspecified SCE gas- and oil-fired equipment (658 MW) to be retired 1987-1989.
6/ Glendale - 73 MW, Burbank - 30 MW, and Pasadena - 45 MW reported as "thermal".

Source: Reports to CPUC by PG&E, SCE, SDG&E and LADWP, March 1972.

TABLE A.3.20

FORECASTS OF NEW GENERATING UNITS, 1972-1991

SITE	CAPACITY (MW)
NUCLEAR[1]	
Rancho Seco	3,000
Diablo Canyon, Mendocino, Davenport, Montezuma, South Moss Landing, One PG&E unspecified location	16,000
San Onofre	5,570
Point Conception, Three SCE unspecified locations	11,752
Two LADWP unspecified locations	4,400
Sorrento, Border	1,500
TOTAL NEW CAPACITY 1972-1991	42,222
NET INCREASE IN INSTALLED CAPACITY DURING 1972	0
TOTAL NEW CAPACITY 1973-1991	42,222
HYDROELECTRIC[2]	
Castaic	1,275
Aqueduct	8
Devil Canyon	120
Terminal	50
New Melones (net increase)	287
Piru Creek	1,200
Helms Creek	687
Auburn	217
Marysville	40
Pumped Storage (SCE)	3,100
Conventional Hydroelectric (SCE)	677
Pumped Storage (SDG&E)	500
Changes in SWP and CVP	- 8
TOTAL NEW CAPACITY 1972-1991	8,153
NEW INCREASE OF INSTALLED CAPACITY DURING 1972	257
TOTAL NEW CAPACITY 1973-1991	7,896
COAL[3]	
Mohave (rerate) (Nevada)	281
Navajo (Arizona)	550
Kaiparowitz (Utah)	4,999
Arrow Canyon (Nevada)	1,300
TOTAL NEW CAPACITY 1972-1991	7,130
NEW INCREASE OF INSTALLED CAPACITY DURING 1972	202
TOTAL NEW CAPACITY 1973-1991	6,928

SITE	CAPACITY (MW)
GAS AND OIL	
Gas and Oil Steam Plants[2]	
Pittsburg	735
Ormond Beach	830
Encina	579
Glendale (rerate)	2
Scattergood	309
Fry Mountain or Huntington Beach	1,580
El Centro	150
TOTAL NEW CAPACITY 1972-1991	4,185
NET INCREASE OF INSTALLED CAPACITY DURING 1972	440
TOTAL NEW CAPACITY 1973-1991	3,745
Combined Cycle Plants[2]	
Long Beach Units 8R and 9[4]	320
Coolwater[4]	300
SCE - D	80
SCE - E	68
SCE (Second Decade)	3,012
TOTAL NEW CAPACITY 1972-1991	3,780
NET INCREASE OF INSTALLED CAPACITY DURING 1972	0
TOTAL NEW CAPACITY 1973-1991	3,780
Gas Turbines[2]	
Glendale	21
Olive	49
Harbor	80
Kearney	20
Miramar	48
North Island	48
El Centro	58
San Francisco	150
Not specified (SCE)	1,726
Not specified (SDG&E)	1,055
Not specified (Pasadena)	44
Not specified (Burbank)	30
TOTAL NEW CAPACITY 1972-1991	3,329
NET INCREASE OF INSTALLED CAPACITY DURING 1972	247
TOTAL NEW CAPACITY 1973-1991	3,082
GEOTHERMAL[5]	
The Geysers	1,696
Imperial Valley	710
Not specified	4,804
TOTAL 1973-1991	7,210

1/ For sources, see Table 10.
2/ PG&E, SCE, SDG&E, and LADWP reports to the CPUC, March 1972.
3/ Report on Ten-Year and Twenty-Year Forecasts of Electric Utilities' Loads and Resources, CPUC, July 25, 1972.
4/ SCE communication with State Power Plant Siting Committee, December 6, 1971.
5/ Department of Conservation, August 1972 (see Figure 14).

TABLE A.3.21

PROJECTION OF MAJOR THERMAL SITING FOR COMMERCIAL OPERATION THROUGH 1991

Project Name or Location	Fuel Type	Capacity (MW) 1982 (a)	Capacity (MW) 1991 (b)
Northern California			
Rancho Seco (SMUD)	Nuclear	900	3,000
Diablo Canyon (PG&E)	Nuclear	2,120	
Mendocino (PG&E)	Nuclear	-	
Davenport (PG&E)	Nuclear	-	16,000 (c)
Montezuma (PG&E)	Nuclear	-	
South Moss Landing (PG&E)	Nuclear	-	
Unspecified Location (PG&E)	Nuclear	-	
Southern California			
San Onofre (SCE & SDG&E)	Nuclear	2,710	6,000
Lucerne Valley (SCE)	Gas & oil	1,248	
Pt. Conception (SCE)	Nuclear	-	13,000
Unspecified Location (SCE) (e) (3 sites)	Nuclear	-	
Unspecified Location - (L.A. Public) (2 sites)	Nuclear	638	4,400 (d)
Sorrento (SDG&E)	Nuclear	-	1,500
Border (SDG&E)	Nuclear	-	
			TOTAL 43,900

(a) PG&E, SDG&E and LADWP Reports to the CPUC, March 1973 (Information of December 31, 1972).

(b) CPUC Report on Ten-Year and Twenty-Year Forecasts of Electric Utilities' Loads and Resources, July 25, 1972.

(c) PG&E letter to Resources Agency, April 4, 1973.

(d) LADWP letter to Resources Agency, March 27, 1973.

(e) The Eastern Desert site shown on Figure 16 is an approximate location. While not identified by name in the March 1973 submittal to the CPUC, intent to purchase two 770-MW high-temperature gas-cooled reactors was announced in 1972, and in March 1973, announcement was made of an investigation for a suitable site for the units in an area within 50 miles of the Colorado River adjacent to the aqueduct of the Metropolitan Water District of Southern California.

Table A.3.22

Expected Lifespan of Facilities in Various Emission Categories

Category	Typical Plant Lifespan (years)	Percent Retirement of Present Capacity In 1975	1980	1985	1990	1995
Petroleum						
Production	28	0	18	35	54	71
Refining	32	0	16	31	47	63
Marketing	32	0	16	31	47	63
Chemical Manufacturing	22	0	23	45	68	91
Mineral Operations						
Cement Manufacture	40	0	13	25	38	50
Glass and Glass Products	28	0	18	35	54	71
Stone & Clay (except cement)	30	0	17	33	50	66
Composite	33	0	15	30	45	61
Wood Processing						
Lumber and Wood Products	20	0	25	50	75	100
Paper and Allied Products	28	0	18	35	54	71
Composite	24	0	21	42	63	83
Food and Agriculture						
Food and Kindred Products	24	0	21	42	63	83
Grain & Grain Mill Products	34	0	15	29	44	59
Composite	29	0	17	34	52	69
Metallurgical						
Fabricated Metal	24	0	21	42	63	83
Primary (ferrous)	36	0	14	28	42	56
Primary (non ferrous)	28	0	18	35	54	71
Pesticides (same as chemical)	22	0	23	45	68	91
Combustion of Fuels						
Power Platns	56	0	9	18	27	36
Industrial	56	0	9	18	27	36
Commercial	--	--	--	--	--	--
Residential	--	--	--	--	--	--
Waste Burning	--	--	--	--	--	--

Based on data from "Depreciation - Guidelines and Rules," Revenue Procedure 62-21, U.S. Treasury Department, Internal Revenue Service Publication No. 456. Revised August 1964.

TABLE A.3.23

PROMULGATED NEW SOURCE PERFORMANCE STANDARDS
—GROUP 1 SOURCES[a]

Source category and pollutant	New Source Performance Standard (maximum 2-hr average)	AP-42 page reference
Municipal incinerators Particulates	0.18 g/Nm^3 (0.08 gr/scf) corrected to 12% CO_2	2.1-1
Portland cement plants Kiln—dry process Particulates	0.15 kg/MT (0.30 lb/ton) of feed to kiln	8.6-3
Kiln—wet process Particulates	0.15 kg/MT (0.30 lb/ton) of feed to kiln	8.6-3
Clinker cooler Particulates	0.050 kg/MT (0.10 lb/ton) of feed to kiln	8.6-4
Nitric acid plants Nitrogen oxides (as NO_2)	1.5 kg/MT (3.0 lb/ton) of 100% acid produced	5.9-3
Sulfuric acid plants Sulfur dioxide	2.0 kg/MT (4.0 lb/ton) of 100% acid produced	5.17-5
Sulfuric acid mist (as H_2SO_4)	0.075 kg/MT (0.15 lb/ton) of 100% acid produced	5.17-7

[a]Title 40 — Protection of Environment. Part 60—Standards of Performance for New Stationary Sources. Federal Register. *36* (247):24876, December 23, 1971.

TABLE A.3.23
(Continued)

PROMULGATED NEW SOURCE PERFORMANCE STANDARDS
–GROUP II SOURCES[a]

Source category and pollutant	New Source Performance Standard	AP-42 page reference
Asphalt concrete plants		
Particulates	90 mg/Nm^3 (0.040 gr/dscf)	8.1-4
Petroleum refineries: Fluid catalytic cracking units		
Particulates	60 mg/Nm^3 (0.026 gr/dscf)[b]	9.1-3
Carbon monoxide	0.050% by volume	9.1-3
Storage vessels for petroleum liquids		
"Floating roof" storage tanks		
Hydrocarbons	If true vapor pressure under storage conditions exceeds 78 mm (1.52 psia) mercury but is no greater than 570 mm (11.1 psia) mercury, the vessel must be equipped with a floating roof or its equivalent.	4.3-8
Secondary lead smelters		
Blast (cupola) furnaces		
Particulates	50 mg/Nm^3 (0.022 gr/dscf)	7.11-2
Reverberatory furnaces		
Particulates	50 mg/Nm^3 (0.022 gr/dscf)	7.11-2
Secondary brass and bronze ingot production plants		
Reverberatory furnaces		
Particulates	50 mg/Nm^3 (0.022 gr/dscf)	7.9-2
Electric induction furnaces		
Particulates	50 mg/Nm^3 (0.022 gr/dscf)	7.9-2
Blast furnaces		
Particulates	50 mg/Nm^3 (0.022 gr/dscf)	7.9-2
Iron and steel plants		
Basic oxygen process furnaces		
Particulates	50 mg/Nm^3 (0.022 gr/dscf)	7.5-5
Sewage treatment plants		
Sewage sludge incinerators		
Particulates	0.65 g/kg (1.30 lb/ton) of dry sludge input	2.5-2

[a]Title 40--Protection of Environment, Part 60--Standards of Performance for New Stationary Sources: Additions and Miscellaneous Amendments, Federal Register, *39* (47), March 8, 1974.

[b]The actual NSPS reads "1.0 kg/1000 kg (1.0 lb/1000 lb) of coke burn-off in the catalyst regenerator," which is approximately equivalent to an exhaust gas concentration of 60 mg/Nm^3 (0.026 gr/dscf).