THE QUANTITATIVE AIR QUALITY REPORT

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A series of field observations and mathematical analyses are presented in an effort to answer certain questions posed in the preparation of an environmental impact statement. The significant primary pollutants (carbon monoxide, hydrocarbons, oxides of nitrogen, sulfur oxides, and particulates) produced from stationary as well as mobile sources are tabulated. Air quality standards based on results of investigations on the effects of pollutants are presented. The component parts of an air quality study are discussed. Transport and dispersion of pollutants depend on topography and meteorology, and the procedure to be adopted in their study is outlined. The use of a mathematical model in analyzing pollutant concentration in the microscale is described as is mesoscale analysis. Ambient air quality defines the background levels of pollutant concentration. Data gathering in ambient air quality studies is discussed. Guidelines on data presentation and summarization (written and tabular) and methods of graphical representation are provided. The need for research to quantify the various factors is stressed.

•CONCERN over the apparent deteriorating quality of the environment has resulted in the adoption of numerous new programs and requirements. In particular, the "environmental impact statement" requirements of the National Environmental Policy Act of 1969 are now familiar to those connected with the highway program. Further, in December 1970, Congress passed the Federal-Aid Highway Act of 1970, which directed that guidelines be prepared that will ensure that possible adverse economic, social, and environmental effects be considered on federal-aid highway projects.

Among other things, the Act stated that, "air, noise and water pollution be considered, and further, that all highways constructed under terms of the Act are consistent with implementation plans to attain ambient air quality standards for any air quality control region."

In order to properly evaluate the effects of air pollution from highways, one must perform necessary field studies and analyses leading to a quantitative air quality report. It is the purpose of this report to present an outline of the studies of the California Division of Highways in connection with the preparation of a quantitative air quality report.

AIR QUALITY PHENOMENA

Emissions contributing to air pollution are produced from stationary and mobile sources. The most significant primary pollutants from such sources are carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NO_x), sulphur oxides (SO_2), and particulates. Table 1 gives the estimated nationwide sources of the five major pollutants for 1968.

In the eastern United States, the most pervasive form of air pollution is a combination of sulfur dioxide and particulates derived from stationary industrial sources. Also, significant amounts of carbon monoxide, hydrocarbons, and oxides of nitrogen are emitted by mobile sources powered by internal-combustion engines.

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In the western United States, most large population centers do not have high sulfur dioxide levels but may be subjected to so-called photochemical smog that is composed of a large series of compounds derived from reactions of atmospheric oxygen with oxides of nitrogen and hydrocarbons in the presence of ultraviolet light. The conditions found in California, its cities built on flat lands surrounded by mountain ranges, a persistent inversion aloft, a large amount of sunlight (source of ultraviolet radiation), and a high concentration of automobiles in the principal urban areas, make it an ideal breeding ground for photochemical smog.

The principal factors affecting pollutant concentration are the downwind distance between the receptor and the source, the wind speed and associated turbulence, the source strength, and the mixing depth.

The greater the distance between the source and receptor is, the more chance there is for dispersion to occur and hence lessen the concentration. Higher wind speeds have the effect of increasing the amount of air into which the emitted pollutants are dispersed. In effect, this causes a greater dilution. Vertical turbulence, of course, promotes the dispersion of pollutants from a continuous line source such as a highway. The mixing depth directly affects the volume of clean air available to dilute the pollutants.

To properly define an air quality study for a highway line source, one must examine the manner in which the receptors perceive changes in air quality. It is convenient to look at these effects on two levels, microscale and mesoscale.

The receptor living immediately adjacent to the line source is affected when localized pollutant concentrations reach levels injurious to his health. This is the microscale effect, and it must be analyzed and quantified in terms of pollutant concentration. The mesoscale effect, as the term would imply, looks at the effect of the project over a much wider area than in the immediate highway corridor. A study of this level is quantified in terms of pollutant burden, that is, tons of pollutant per day per unit area of land surface. Pollutant burden, during episodic conditions, is directly related to ambient pollutant concentrations, and, although these concentrations never reach the levels of those found in the microscale situation, they may endure over a sufficiently long period to cause health problems in susceptible individuals.

The effects of the various pollutants on man have been investigated and delineated by epidemiologists. As a result of these investigations, ambient air quality standards have been published by the California Air Resources Board and the Environmental Protection Agency. These standards are given in Table 2. It should be noted that these standards were developed to protect those people who are especially susceptible to the effects of air pollutants. These susceptible individuals are primarily the very old, the very young, those with cardiac insufficiencies and anemia, and respiratory cripples.

COMPONENT PARTS OF AN AIR QUALITY STUDY

Air quality predictions resulting from an air quality study should cover a time period that begins with the present situation and covers approximately 20 years subsequent to the estimated time of completion of the improvement. For this period, air quality predictions must be made for two conditions. The first condition assumes that the transportation project is built, and the second assumes that the project has not been built.

Determination of pollutant concentrations in the microscale area will be confined, initially, to carbon monoxide, lead, and total particulates. Hydrocarbon concentration will not be predicted because it is not considered by epidemiologists to constitute a health hazard. The primary reason for the inclusion of hydrocarbons in the ambient air quality standards was to effect a control on the formation of secondary pollutants. Oxides of nitrogen will not be predicted in the microscale analysis because of the lack of suitable emission factors showing the variation of these emissions with respect to speed.

Secondary pollutants will not be considered in the microscale analysis because even low wind speeds are usually sufficient to move the reacting pollutant out of the microscale area before sizable quantities of secondary pollutant can be formed. Indeed, recent study has shown that ambient ozone within the microscale area is involved in the

Table 1. 1968 estimated nationwide emissions (in millions of tons).

Pollutant	Transportation	Fuel Combustions in Stationary Sources	Industrial Processes	Solid Waste Disposal	Other	Total	Percentage of Total by Motor Vehicle
Carbon monoxides	64	2	10	8	17	101	63
Hydrocarbons	17	1	5	2	9	34	52
Nitrogen oxides	8	10	0.2	1	2	21	39
Particulates	1	9	8	1	10	29	4
Sulfur oxides	1	24	7	0.1	1	33	2

Table 2. Ambient air quality standards applicable in California.

Pollutant	Averaging Time	California Standards		Federal Standards[a]		
		Concentration[b]	Method[c]	Primary[d]	Secondary[e]	Method[f]
Photochemical oxidants (corrected for NO_2)	1 hour	0.10 ppm (200 $\mu g/m^3$)	Neutral buffered KI	160 $\mu g/m^3$[g] (0.08 ppm)	160 $\mu g/m^3$[g] (0.08 ppm)	Chemiluminescent
Carbon monoxide	12 hours	10 ppm (11 mg/m^3)	Nondispersive infrared spectroscopy	—	—	Nondispersive infrared spectroscopy
	8 hours	—		10 mg/m^3 (9 ppm)	10 mg/m^3 (9 ppm)	
	1 hour	40 ppm (46 mg/m^3)		40 mg/m^3 (35 ppm)	40 mg/m^3 (35 ppm)	
Nitrogen dioxide	Annual average	—	Saltzman	100 $\mu g/m^3$ (0.05 ppm)	100 $\mu g/m^3$ (0.05 ppm)	Colorimetric using NaOH
	1 hour	0.25 ppm (470 $\mu g/m^3$)		—	—	
Sulfur dioxide	Annual average	—	Conductimetric	80 $\mu g/m^3$ (0.03 ppm)	60 $\mu g/m^3$ (0.02 ppm)	Pararosaniline
	24 hours	0.04 ppm (105 $\mu g/m^3$)		365 $\mu g/m^3$ (0.14 ppm)	260 $\mu g/m^3$ (0.10 ppm)	
	3 hours	—		—	1,300 $\mu g/m^3$ (0.5 ppm)	
	1 hour	0.5 ppm (1,310 $\mu g/m^3$)		—	—	
Suspended particulate matter	Annual geometric mean	60 $\mu g/m^3$	High-volume sampling	75 $\mu g/m^3$	60 $\mu g/m^3$	High-volume sampling
	24 hours	100 $\mu g/m^3$		260 $\mu g/m^3$	150 $\mu g/m^3$	
Lead (particulate)	30-day average	1.5 $\mu g/m^3$	High-volume sampling, dithizone	—	—	—
Hydrogen sulfide	1 hour	0.03 ppm (42 $\mu g/m^3$)	Cadmium hydroxide stractan	—	—	—
Hydrocarbons (corrected for methane)	3 hours (6 to 9 a.m.)	—	—	160 $\mu g/m^3$ (0.24 ppm)	160 $\mu g/m^3$ (0.24 ppm)	Flame ionization detection using gas chromatography
Visibility reducing particles	1 observation[h]	—	—	—	—	—

[a]Federal standards, other than those based on annual averages or annual geometric means, are not to be exceeded more than once per year.

[b]Concentration expressed first in units in which it was promulgated. Equivalent units given in parentheses are based on a reference temperature of 25 C and a pressure of 760 mm of mercury.

[c]Any equivalent procedure may be used that 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.

[d]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 3 years after that state's implementation plan is approved by EPA.

[e]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 EPA.

[f]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" to be approved by the EPA.

[g]Corrected for SO_2 in addition to NO_2.

[h]In sufficient amount to reduce the prevailing visibility to 10 miles. Prevailing visibility is defined as the greatest visibility that is attained or surpassed around at least half of the horizon circle, but not necessarily in continuous sectors.

oxidation of nitric oxide to nitrogen dioxide, thereby reducing the ambient levels of ozone in the immediate vicinity. In the future, as suitable emission factors become available, determination of NO_x concentrations within the microscale area will be made.

For the mesoscale, or total burden analysis, predictions will be confined, initially, to the two gaseous pollutants, carbon monoxide and hydrocarbons. Again, oxides of nitrogen will not be estimated because of the lack of suitable emission factors relating emission of NO_x to speed. Effects of lead and other particulates are usually limited to the microscale area because these pollutants, except for some amount in the submicron size range, are acted on by gravitational forces and are also removed by impaction with surrounding objects. Hence, they will not be considered in the mesoscale analysis. Initially, secondary pollutants resulting from photochemical reactions will not be quantified in the mesoscale analysis because of the lack of a fully validated mathematical model to predict the photochemical reactions. Sophisticated models are now becoming available, and, as soon as the validation requirements are satisfied, this capability will be added to our procedures.

In the future, we should gradually proceed toward a systems approach because the ambient air quality is a function of the interaction among all the various freeways and the surface traffic network. This is the subject of scheduled research.

It should be recognized at the outset that air quality predictions are somewhat tenuous at best. The predictions resulting from an air quality study are based on statistical analysis of meteorological conditions, statistical analysis of ambient air quality, and statistical analysis of traffic data. These data are then extrapolated perhaps 25 years into the future and are used to make air quality predictions. It should be obvious that the reliability of these predictions is not precise. However, the predictions are made by using recognized methods and the best available data. For this reason, no apology need be made concerning the adequacy of the predictions.

PROCEDURES FOR ANALYZING HIGHWAY IMPACT ON AIR QUALITY

The following outline describes a procedure for analyzing highway impact on air quality (Fig. 1):

1. The project description should be a short narrative statement of not more than a few paragraphs describing the proposed improvement in sufficient detail to allow a reviewer to obtain a mental picture of the work to be done.
2. The conclusions are presented early in the report to enable a cursory review by the person who does not desire to dig through the details. In the conclusions, the first thing to be discussed should be the answers to the questions for the environmental impact statement. Secondly, the written and tabular data summaries should be presented. The final portion of the conclusions, the graphic data presentations, can be interspersed with the written and tabular data summaries if desired.
3. The background discussion should provide a resume of all the historical data that were researched for the study. These data should be presented under the following general topics: topography (including a copy of the map discussed later in this paper), historical meteorology, historical air quality, principal existing point and line sources, existing and future land use, existing and future sensitive receptors, and research (previous studies).
4. The field studies should be fully described including the instrumentation used, calibration of that instrumentation, dates and locations where observations were made, and a discussion of the setups at the various points. This section should be divided into two subsections: meteorology, including data reduction and results; and ambient air quality, including data reduction and results.
5. The source of traffic estimates should also be given if data sources other than the California Division of Highways were used. These estimates should also be tied in with the discussion of the existing and future land use.
6. A brief discussion of the derivation of the emission factors should be presented in this section.

7. Mathematical analysis should cover the use of the mathematical model to estimate microscale concentrations and the various mesoscale analyses that were made.

8. A bibliography should list the sources of historical data and other information used in the report.

9. If desired, the reduced meteorological and ambient air quality data from the field studies may be attached to the report in appendix form. The appendixes should be attached only to those reports going to interested agencies such as the Air Resources Board and the Department of Public Health. The average reviewer will be interested only in the data summary.

CHARACTERIZATION OF SOURCE STRENGTH

A highway represents a continuous line source of pollutant emissions. The strength of this line source is dependent on two factors: the volume of pollutants coming from each individual vehicle and the number of these vehicles on the highway at any given time (1, 2).

The emission factors used in this approach vary with (Fig. 2) vehicle model and year mix, percentage of heavy-duty vehicles in the traffic stream, speed of traffic, and vehicle operating model (this is, in the simplest sense, whether the vehicle is on the freeway system or on the surface network).

Traffic data for source strength calculations in the microscale area consist of speed and volume information at the point where the analysis is being made (Fig. 3). This information must be supplied for the critical hours of the day. The critical hours may be determined by peak-hour traffic or adverse meteorological conditions. For the mesoscale, or pollutant burden analysis, total daily mileage and associated average speeds are needed for both freeway traffic and surface traffic (Fig. 3).

TRANSPORT AND DISPERSION OF POLLUTANTS

The transport and dispersion of air pollutants depends on topography and meteorology. The very important first step in any study of transport and dispersion is that of laying out and examining, on a topographical map, all the features that might affect the air quality study. This procedure is as follows:

1. Plot the location of all air quality data sources;
2. Plot the location of all meteorological data sources;
3. Delineate natural and man-made features that might affect wind flow;
4. Plot the location of the most sensitive receptors such as hospitals, schools, and rest homes as well as the features of medium sensitivity such as residential areas;
5. Plot the location of existing and future point sources of pollution such as factories and power plants;
6. Plot the location of areas with susceptible agricultural crops that are downwind of the project in the area where secondary pollutants might be expected to form;
7. If sufficient data are available from the plotted meteorological stations, prepare wind rose plots and superimpose these on the topographic map;
8. If sufficient data are available, prepare overlays showing wind streamlines for the typical meteorological regimes; and
9. Examine the plotted data and locate the areas where field studies will be required to obtain additional desired meteorological and air quality data.

A meteorological study (3) is an essential element of any air quality analysis (Fig. 4). Only in this manner can the transport and dispersion of pollutants be estimated. The first step is to locate all existing data for the area under study. These data should be analyzed and wind roses developed. The desirable parameters for this analysis are wind direction, wind speed, stability for various regimes, inversion heights or mixing depths, and, if data are available, wind streamlines.

There will be a few cases where the existing data fully satisfy the data requirements for the project. Normally, data will have to be developed for each individual project. These data will be developed in distinct phases. The first step will be to obtain data, using mechanical weather stations at desirable locations, to characterize wind speed

Figure 1. Procedure for analyzing highway impact on air quality.

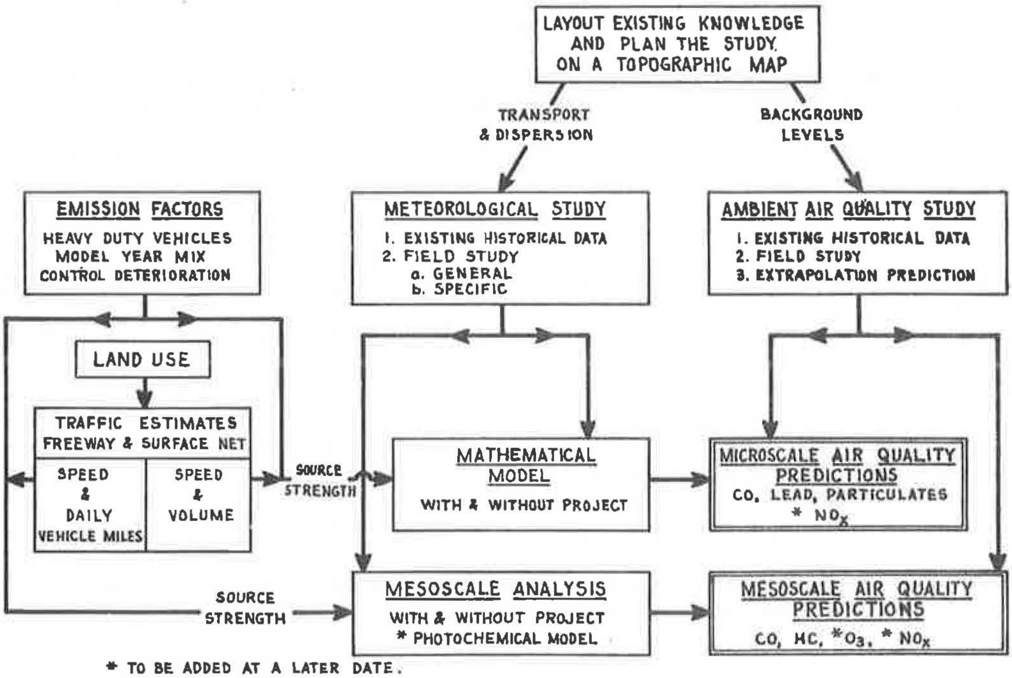


Figure 2. Emission factors.

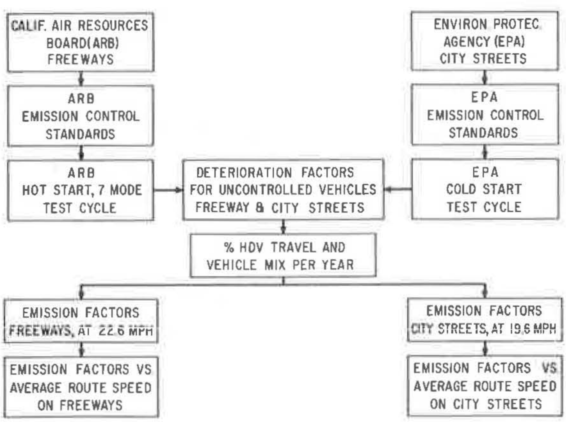


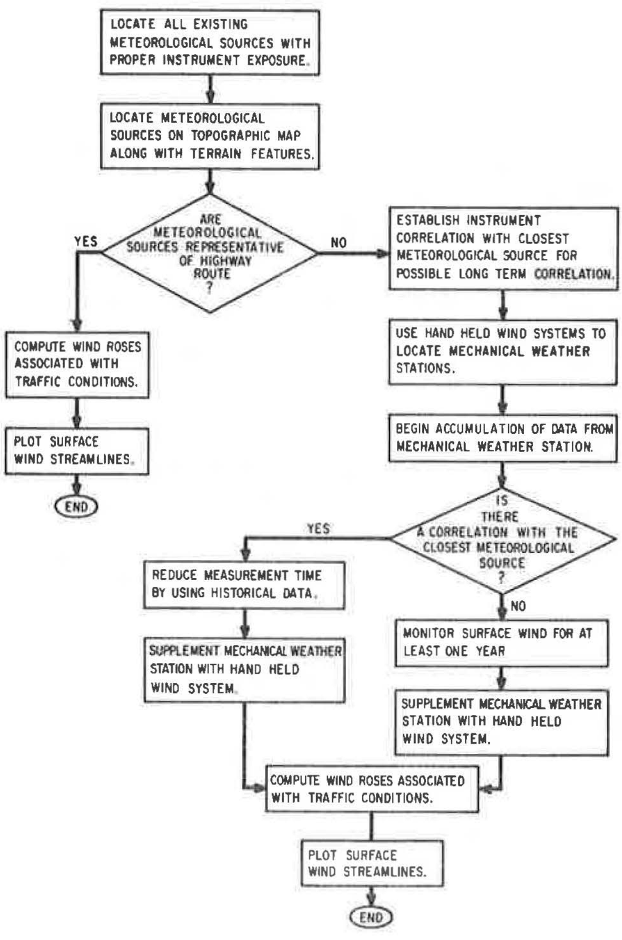
Figure 3. Traffic information matrix for air quality predictions.

TRAFFIC PARAMETERS		PROPOSED HIGHWAY FACILITY	SURFACE TRAFFIC* WITH NEW FACILITY	SURFACE TRAFFIC* WITHOUT NEW FACILITY
MESOSCALE AIR QUALITY	DAILY VEHICLE MILES	(①②④⑤⑥) ⑦ ⑧ ⑩	(②③④⑥) ⑦⑧⑩	(② ④⑥) ⑦⑧⑩
MESOSCALE AIR QUALITY	OVERALL SPEED	⑫ ⑬	⑪	⑪
MICROSCALE AIR QUALITY	PEAK HOURLY VOLUME	⑦ ⑧ ⑭ ⑮	⑯	
MICROSCALE AIR QUALITY	SPEED AT PEAK HOURLY VOLUME	⑫		

*Surface traffic for the mesoscale analysis is that traffic from all streets in the feeder area - This represents a grid source of pollutants which affect the burden in the air basin.

①Attracted Traffic (use for new facility)
②Existing Traffic (use for improved facility)
③Diminished Traffic (use for surface streets)
④Normal Traffic Growth
⑤Generated Traffic
⑥Development Traffic (based on existing land use plans)
(①–⑥: AASHO Definitions)
⑦Change in Traffic Due to Future Land Use Changes
⑧Change in Traffic Due to Urban Mass Transit Facility
⑩Percentage of Heavy Duty Vehicles (HDV)
(①–⑩: Daily Vehicle Miles)
⑪Average Trip Speed
⑫Average Peak Hour Trip Speed
⑬Average Trip Speed for Free-Running Facility
(⑪–⑬: Speed)
⑭Daily volume
⑮Hourly % of Daily Volume
(⑭–⑮: Volume)
⑯This information is not usually available - It would define surface traffic from arterials parallel and immediately adjacent to the proposed facility which would be strongly influenced by that improvement. These represent a line source of pollutants which has an effect on nearby receptors.

Figure 4. Meteorological flow chart.



and direction. Collection of these data might take as long as a year. Where possible, inversion heights for the various meteorological regimes should be taken simultaneously with the other measurements. If instrumentation is available, twice daily flights from a nearby airport would satisfy this requirement. Calibration of any instrumentation used is essential.

The second phase for developed data involves an examination of the temperature structure and turbulence in the lower atmosphere. This can be accomplished by locating a meteorological tower on previously selected sites for short periods under the various meteorological regimes. The towers to be used by the California Division of Highways contain two sets of wind speed and direction instruments separated by a distance of 10 m to examine wind shear. They also have instrumentation for measuring temperature change over the same interval. This instrumentation is self-contained and capable of operating without support for more than a week at a time.

In any areas where wind flow patterns vary considerably because of topographical influences, it is desirable to obtain meteorological data that will allow construction of wind streamlines. For the microscale situation, these streamlines can be constructed with the use of hand-held anemometers and direction indicatoes. For the mesoscale situation, the use of balloons and theodolites is recommended.

Evaluation of meteorological information will involve the "most probable" and "worst case" meteorological conditions. The probabilities of occurrence of these conditions must be estimated. For each of these conditions, a wind rose and stability analysis must be made. These analyses must be correlated with hours of peak traffic flow and any anomalous traffic situation that may give rise to an increase in source strength. Conversely, traffic data must be collected for the worst case meteorological conditions. Analyses made in this manner enable the evaluation of the most critical conditions.

MATHEMATICAL ANALYSIS

Analysis of pollutant concentration in the microscale area is made using a mathematical model (Fig. 5). Inputs to this model consist of traffic data, meteorological data, and emission factors (4). The output from this model is presented in terms of concentration of the pollutant being analyzed for a particular meteorological regime and a certain traffic condition. To these predictions must be added the ambient concentration of the pollutant in question.

The mesoscale analysis (Fig. 6) is primarily concerned with the total pollutant burden resulting from changes in the traffic network that accompanies the initiation of a new traffic facility. The item of greatest importance in this analysis is the change in the total amount of daily vehicle mileage in the affected traffic network and the average operating speeds at which that mileage is generated. Another aspect of mesoscale analysis is the import of primary and secondary pollutants from distant upwind sources into the study area and the export of primary and secondary pollutants generated within the study area to distant downwind receptors. The final aspect of a complete mesoscale analysis is the examination of the time history of oxidant concentration and the prediction of future trends based on correlation with future pollutant burden estimates.

Beaton et al. (4) describe in detail the various aspects of the microscale and mesoscale calculations.

AMBIENT AIR QUALITY

A study of ambient air quality serves to define the background levels of pollutant concentrations in the project area (5). Like the meteorological study, an ambient air quality study must begin with the collection and analysis of the existing or historical data (Fig. 7).

Because it is highly unlikely that sufficient data exist to define ambient air quality along a proposed route, particularly in areas along the route containing sensitive receptors, it is mandatory to perform an on-site survey. The first level of sophistication in such a survey is to obtain bag samples of air for later analysis. The only gaseous pollutant for which values can be obtained without some degree of degradation is carbon

Figure 5. Microscale corridor analysis.

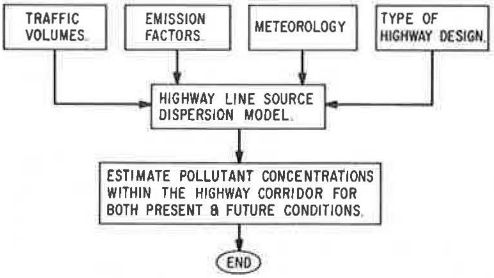


Figure 6. Mesoscale analysis.

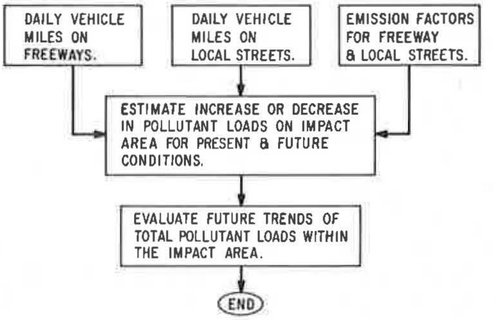
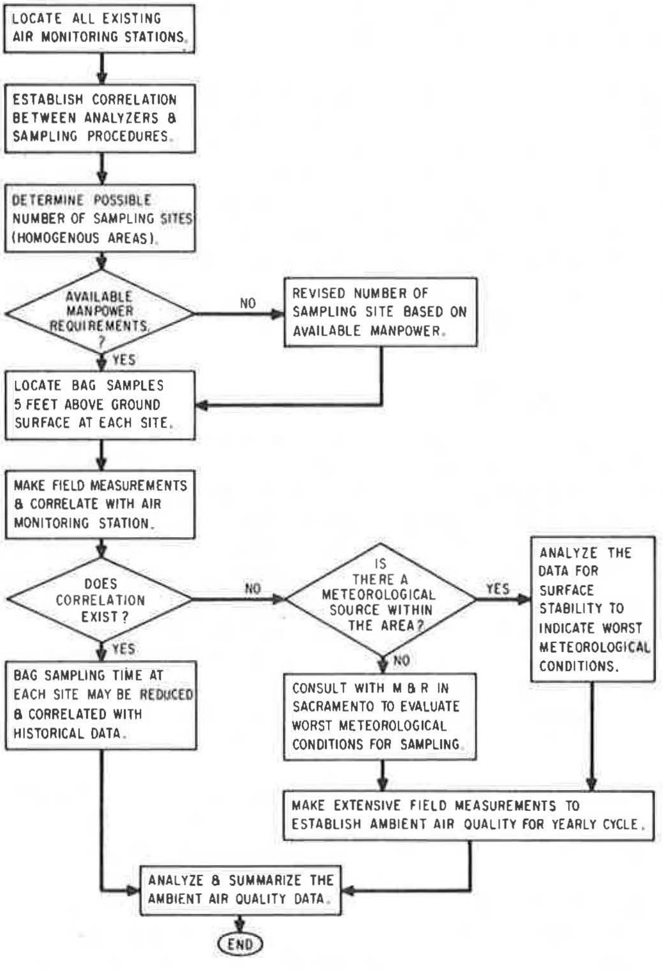


Figure 7. Flow chart for ambient air quality survey.



monoxide. The necessary equipment for this survey is a number of 12- by 18-in. Scotchpak bags, a battery-powered air pump, and a well-calibrated, sensitive, nondispersive infrared carbon monoxide analyzer. Lead and particulates can be sampled with a high-volume sampler, and subsequent analysis for lead can be performed with atomic absorption equipment. Continuous meteorological observations must be taken at the site during the gathering of any air samples.

The second stage of sophistication for an air quality survey involves the use of an instrumented van. The vans used by the California Division of Highways contain a long-path, nondispersive infrared analyzer for carbon monoxide, an ultraviolet absorption analyzer for ozone, a chemiluminescent analyzer for nitric oxide and nitrogen dioxide, and a high-volume sampler for lead and particulate samples. These minivans contain on-board power with a capability for connecting to house current. Each minivan has an on-board anemometer and wind direction indicator. Data are acquired graphically and on-board capability for calibration is maintained.

Data gathered during an ambient air quality study serve several purposes. The main purpose, naturally, is that of providing background air quality data. Secondary purposes involve the building of a data bank (this applies particularly to NO_x and O_3 data), mathematical model validation, and analysis of source strength predictions. Where NO_x and O_3 are traceable to upwind highways, traffic data should be obtained during sampling.

The periods during which ambient air quality data are gathered must be closely tied with the periods for the meteorological survey and the periods for which traffic data are estimated. Again, the object is to acquire data for the most probable conditions and the worst case conditions. Air quality data must be taken for periods corresponding with the various averaging times listed in the ambient air quality standards.

The final phase of the ambient air quality study is the prediction of future ambient air quality. This prediction can be based in part on an extrapolation of the correlation between historical pollutant burden and historical ambient air quality. To this extrapolation must be added the effects of future changes in land use and probable future point sources.

DATA PRESENTATION

One of the most difficult aspects of any report lies in the communication of the significant findings to other people. In the case of the air quality report, the findings will be incorporated into an environmental impact statement by another person. This statement will then be used as a basis for decision-making by still other people. It is very probable that the findings from the air quality study, in addition to being used in the environmental impact statement, will be used as a basis for discussions in a public hearing. It is, therefore, doubly important that the findings be communicated in a manner that promotes understanding and enables analysis by a reasonable layman.

It is entirely possible to address a report to two or three levels of understanding. The needs of the technically oriented person may be satisfied by presenting detail in the body of the report, whereas the reasonable layman, with the aid of written, tabular, and graphic data summaries, should be able to arrive at a full understanding of the findings.

The number of variables to be discussed in an air quality report taxes the ingenuity of the report writer who is attempting to communicate his findings. Air quality must be discussed in terms of the proposed project and without it. The most probable and worst case pollutant concentrations must be presented and the probabilities of their occurrence discussed. The time period for the study must begin with the existing situation and continue through the completion of the improvement and for 20 years thereafter. The effects of the pollutants must be discussed in terms of the distance between the receptor and the source. The pollutant concentrations must be discussed in terms of health standards; that is, the 1-, 8-, and 12-hour averages, yearly averages, and other averages as required must be presented for the pollutants to which they apply. Each pollutant requires a separate discussion, which increases the difficulty of the task.

WRITTEN AND TABULAR DATA SUMMARY

The following items should be presented in tabular form with sufficient written discussion for each item to fully explain the data (6).

1. Ambient air quality data should be shown in a form that will clearly indicate the existing air quality, the air quality at the end of the design life of the project, and the intervening trends. If the trends indicate a peak or a valley, both the poorest and the best air quality should also be indicated.
2. The pollutant burden and its variations over the same time period should be presented. A short discussion should cover the probability of episodic conditions and the effects of those conditions on the pollutant burden.
3. The import and export of pollutants, where applicable, should be discussed. The relative effect of these phenomena should be presented.
4. The oxidant trends with respect to time should be presented in terms of the number of adverse days, which might exceed the health standards, on a yearly basis over the period of the study.
5. Microscale pollutant concentrations should be shown for the most probable and worst case conditions. The respective probabilities of occurrence of these conditions should be indicated. Some detail should be presented with regard to areas where sensitive receptors are located. The data should also be presented in a manner that will indicate the variation in concentration with respect to the distance from the source.

VISUAL AIDS

One of the best avenues of communication between the engineer and the layman is that that utilizes visual aids such as charts, graphs, and sketches. This approach, however, is often abused and fails to achieve its purpose because of the amount of detail on any one chart that the eye is required to assimilate. Simple visual aids, with minimal detail and the bold use of color, are the epitome of good communication. The principal use of the visual aid should be to present trends and comparisons. The tabular and written summaries, discussed previously, are slightly more sophisticated and present some detail. The body of the report provides even finer detail and technical discussion for those who are interested.

Graphic presentation of trends, with time as the horizontal axis, can efficiently demonstrate changes in mesoscale pollutant burden, oxidant trends, and ambient air quality.

The mesoscale pollutant burden trends could be indicated with one color for the situation including the improvement and one color for the situation without the improvement. Horizontal limit lines could then be drawn with one line indicating the maximum acceptable pollutant burden under the most probable meteorological conditions and another limit line indicating the maximum acceptable burden under episodic conditions.

The trends in average ambient air quality can be indicated with a single line for each pollutant. However, because a comparison must be made with the averaging times specified by the health standards, several charts for each pollutant may be required. The applicable air quality standard should be indicated by a horizontal line on the appropriate charts.

Oxidant trends with respect to time can be appropriately visualized by two different colored lines on a chart representing the situation both with and without the improvement.

Contour maps may be an effective way of visualizing microscale pollutant concentrations. This could be done by using a plan view of the project and the surrounding community with perhaps three colors representing ranges of pollutant concentrations. One chart could thus indicate spatial variations in pollutant concentrations for the combination of a particular meteorological regime and source strength. The color red could be used to indicate those concentrations that exceed the health standards.

The question of pollutant transport may be dealt with by a two-color presentation that indicates the relative amounts of transported oxidant and oxidant formed from pollutants generated within the area.

RESPONSE TO QUESTIONS FOR THE ENVIRONMENTAL IMPACT STATEMENT

Response to the questions to which the environmental impact statement must address itself should be made in the air quality study. The statements must be quantified insofar as possible. This may be done by listing the changes in air quality in terms of tons per day or parts per million.

The ultimate effect of air pollution, however, as it applies to human health, agricultural losses, wear and soiling of clothing and other fabrics in the home, corrosion and wear of metals, paints, and susceptible materials, extra-industrial maintenance, aesthetic losses, degradation in work performance, decline in property values, and visibility reduction is very complex and cannot be estimated. If the changes in quantities and concentrations of air pollutants are very small, it should be pointed out that the effects on the air environment would be small also. If, however, the changes are substantial, it is best to leave the evaluation of the effects of the change up to competent epidemiologists, plant pathologists, and other such experts.

SUMMARY

The quantitative air quality report consists of a series of field observations and mathematical analyses that answer certain required questions posed in the writing of an environmental impact statement. Detailed micrometeorological and ambient air quality field observations over relatively long periods of time must be obtained. The analysis of the information must be coupled with traffic data and vehicle emission factors in order to estimate emission concentrations and dispersion.

It should be stressed that the subject is in a continuing state of flux, and a great deal of research is still required to properly quantify the various required factors.

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