AIR POLLUTION: IMPLICATIONS FOR TRANSPORTATION PLANNING

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The paper discusses the need to integrate air quality considerations into the long-range transportation planning process. Eight recommendations for incorporating air quality planning into the transportation planning process are given by using illustrations from the Washington, D.C., metropolitan area: Because air quality is a regional problem, solutions must be sought and implemented on regional and local scales, the kind of solution will vary depending on the time frame considered, the interaction between transportation and land use must be considered fully if correct solutions are to be found, central area parking policy should become an integral part of the transportation planning process, the benefits of alternative actions should be stated clearly and the impacts to private and public groups estimated, alternative land use policies and alternative transportation policies should be examined, a planning process that is responsive to evaluating alternative courses of action is required, and continuing process improvements, monitoring, and feedback are essential.

•THIS paper will discuss and illustrate, by using examples from the Washington, D.C., area, the need to integrate air quality considerations into the long-range transportation planning process. It is the central theme of this paper that air quality considerations are compatible with sound land use and transportation planning and that a viable planning process can be described that fully considers air quality as well as other social, economic, and environmental impacts. Such a process does not exist at the present time, but the framework for such planning has been established at the regional scale by land use and transportation planning programs required in urban areas and supplemented through A-95 review procedures.

AIR POLLUTION CONTROL OBJECTIVES

National objectives for the control of air pollution as pointed out in the Air Quality Act of 1967 are

1. To protect and enhance the quality of air,
2. To initiate and accelerate a national research and development program in this area,
3. To provide technical and financial assistance to states and local governments to achieve the preceding, and
4. To encourage and assist in the development and operation of air pollution control programs.

Studies have indicated that the motor vehicle is responsible for more than three-quarters of carbon monoxide emissions, more than half of hydrocarbon emissions, and nearly half of nitrogen oxide emissions. In addition, some pollutants combine to produce more harmful effects than the original emissions.

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Recently, plans for continued construction of urban freeway systems have been criticized on the basis that such facilities contribute to air pollution. Evaluating the need for such freeway facilities (PPM 20-8, DOT) requires that social, economic, and environmental effects be considered and that such environmental effects include consideration of air pollution. In addition, the National Environmental Policy Act requires that a study of the environmental impact of any federally funded action be included as part of any major action significantly affecting the quality of the environment. Such a study would include

1. Measurement of the environmental impact of the proposed action,
2. Identification of unavoidable adverse impacts,
3. Identification of alternatives, and
4. Study of the relation between short- and long-term uses of the environment.

A description of the kinds of studies needed to determine the effects of transportation system alternatives on air pollution follows.

GENERAL CONSIDERATIONS

Transportation system alternatives can include proposals for construction of freeways to provide more capacity and faster travel, improvements to existing facilities through reconstruction and traffic control, or alternative modes of travel such as improved bus service or construction of rail transit facilities. Alternatives may also contain more than one of these solutions.

In addition, and particularly in the short run to meet air quality standards by 1975, automobile restraints and pricing policies are being discussed.

The effect of transportation alternatives on air pollution can be properly measured by estimating the amount of emissions for each alternative proposed. Such an estimate should include the effect of alternative future emission standards such as those proposed by Congress. In addition, consideration must also be given to weather conditions, diffusion of pollution in the atmosphere, air quality standards, and number of people and kinds of property exposed to such emissions. At the present time, a comprehensive study considering all these factors has not been made in any urban area. Figure 1 shows the relation between alternative transportation systems and the effects on air pollution.

POLLUTION CONCENTRATIONS

Different amounts of pollution concentrations are formed at different scales of measurement. For example, the first scale at which any investigation of air pollution effects should be made is at the street level. Concentrations of pollutants at this level can be severe, with the intensity of pollution varying significantly with small changes in time or distance. At this scale, these concentrations are greatly influenced by facility design and location and traffic operation characteristics. Such effects are felt most in downtown areas, where large concentrations of people and vehicles exist throughout the business day. The effects of alternative transportation systems on air pollution in the central portion of the urban area are clearly of major concern.

A second scale would be that of the urban area as a whole. At this scale, the variation in effect occurs over many square miles and for hours, even days, at a time. Within the urban area, peak concentrations can occur in various parts of the region. These peaks within the region are caused by traffic concentrations on certain facilities and in certain areas and by meteorological characteristics. An important need in analyzing the effects of subregional pollution levels is to determine the distribution of the population exposed by time of day.

METHODOLOGY

Basic methodology for a study of the effects of alternative transportation systems on air pollution is shown in Figure 2.

Figure 1. Effect of transportation system on air pollution.

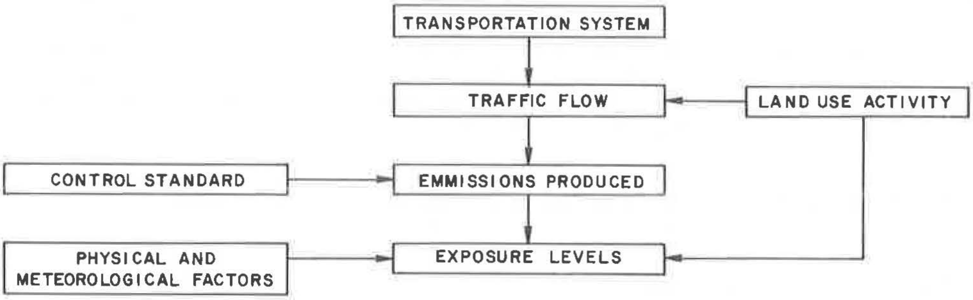
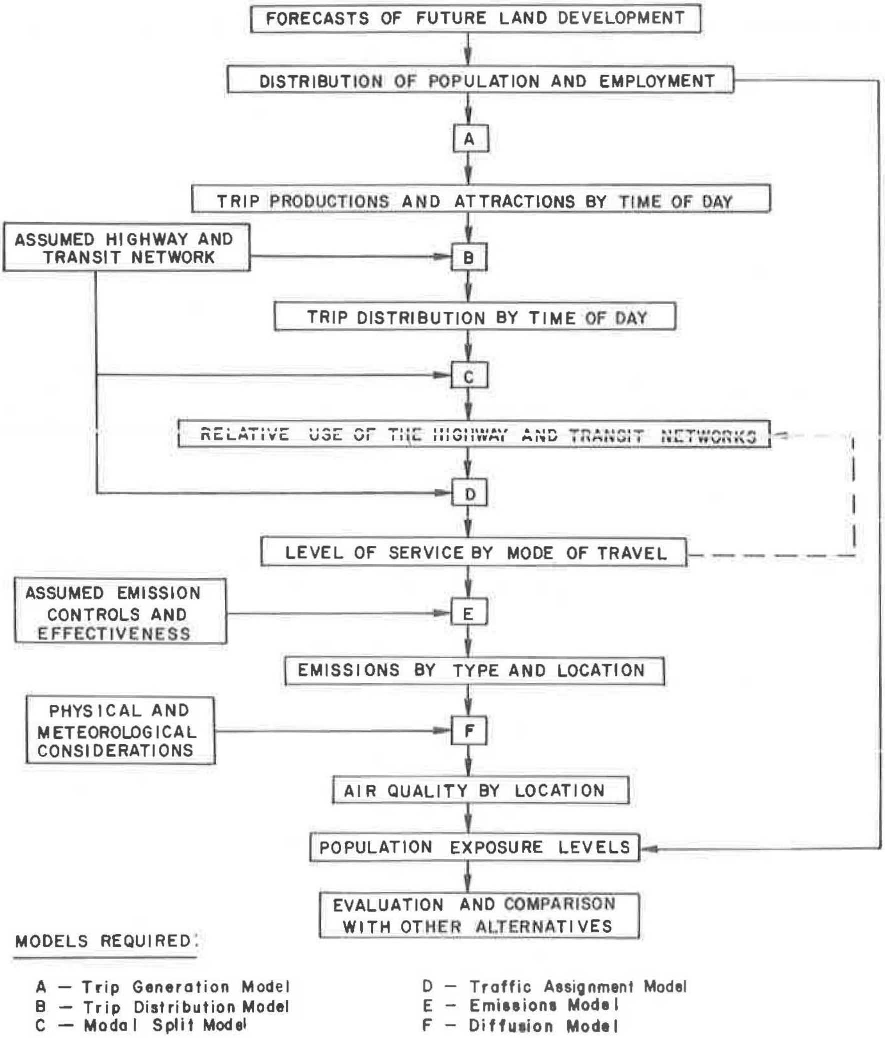


Figure 2. Methodology for study of effect of transportation system on air pollution.



It should be recognized that there are difficulties in both measurement and forecasting throughout the process and that many values are difficult to compute at the present time given the existing state of the art. These difficulties should not diminish the values of such a study, however, because each alternative tested would be subject to similar methodology.

As shown in Figure 2, land development and estimates of activity are converted to travel demands by time of day. Depending on the alternative transportation system being tested, the use of each part of the system is determined by forecasting both the distribution of travel and the use of each travel mode.

Comparisons of the amount of travel on highway facilities with capacity form a means to estimate system performance. Thus, performance measures (together with the use estimates by type of facility) form the required inputs to an emission model that determines emissions by type and area. Physical and meteorological considerations are then taken into account resulting in a determination of pollution levels by area. These levels, together with population distributions, are then used to determine the exposure levels under the different transportation plan alternatives tested. These exposure levels are then compared with acceptable standards.

The preceding paragraphs have described a more or less "ideal" technical process. Suffice it to say that such a methodology could be developed and integrated into an ongoing land use and transportation planning process. However, such a method would be expensive and time-consuming, and the results might not be available in time to influence decisions. Much is known already about these relations, however. Given the current state of the art, there may be other ways to integrate air quality considerations into the planning process in the short run. Existing data, forecasts, and methods could be used to provide policy guidance to decision-makers.

RECOMMENDATIONS

Eight recommendations for incorporating air quality planning into the land use and transportation planning process follow:

1. Because air quality is a regional problem, solutions must be sought and implemented at a regional as well as local scale.

Although EPA has required the states to prepare air quality implementation plans for urban areas, the problem is a regional one, requiring home-grown solutions. Thus, in the Washington, D.C., metropolitan area, it came as no surprise that one jurisdiction found no problem at all, another asked for a 2-year extension in meeting the standards, and the third recommended an immediate action program to reduce pollution by up to 55 percent. An analysis of the local situation reveals that the concentration of slow-moving traffic at high density in the region's core causes automobile emissions that are many times greater than the regional average. Further analysis quickly discloses that two out of every three vehicles bound for the CBD in peak hours originate in the suburbs.

It should be obvious that a regional approach must be taken if effective solutions are to be found. The suburbs also have an air pollution problem. The highest regional levels of oxidants have been recorded in Hyattsville, downwind from Washington, D.C. These levels have reached the "alert" stage all too frequently in past months.

2. The kind of solution will vary depending on the time frame considered. Both short- and long-range solutions are required.

It has been estimated that the 1970 level of carbon monoxide emissions from motor vehicle travel in the District of Columbia must be reduced by 55 percent in order to meet air quality standards by 1975. A recent study (1) has indicated that, even with fully effective control devices on new vehicles, this level of reduction could not be achieved by that time without major improvements to public transportation service. As more vehicles are equipped with emission control devices and as a large regional rail transit system becomes available, the chances of meeting air quality standards are enhanced.

Control strategy options available for meeting standards in the short run include retrofitting all vehicles with emission control devices or providing constraints or deterrents to automobile travel or both.

Substantial differences in the level of effort required to meet air quality standards exist even between 1975 and 1977.

In the short run, emission control devices coupled with improved transit services and equitable CBD parking charges may well meet the needs by 1977, if not by 1975. In the long run, however, a reduction in the rate of trip-making and travel by automobile might also be required as regional growth continues.

3. The interaction between transportation and land use must be considered fully if correct solutions are to be found.

No one can deny that the automobile is a major contributor to air pollution. Persons and agencies concerned with air quality have called for reduction in the use of the automobile, a halt to freeway construction, institution of automobile-free zones, and creation of vastly improved public transit systems. Are such solutions indicated? Would the public accept such actions? Would they have the desired effect?

To obtain answers to these questions, we must understand why the majority of people today travel by automobile and what types and magnitudes of change are required to reduce this travel. Also required is an understanding of the interaction between transportation and land development.

As shown in Figure 3, the number of daily person- and vehicle-trips made by a family residing inside the District of Columbia and Arlington (rings 1, 2, and 3) is much less than those made by families outside this area in the lower density suburbs. This points out that, although the total amount of travel generated is higher in high-density areas, the rate generated per family is less. Automobile ownership is also lower, and people can walk to destinations or use public transportation. Even when family size and income are taken into account, average automobile ownership is approximately one-half an automobile per household less in the District of Columbia. This lower level of automobile ownership results in less trip-making. Growth is now almost exclusively in the suburbs. Unless land use intensities and arrangements are created that approach those of the city, suburban travel and subsequent pollution will increase greatly. Creation of urban environments and reduction of automobile ownership and trip-making require that the suburban area be better served by public transportation and pedestrian systems.

In addition, mixed rather than segregated land uses are needed so that activities are closer together. New towns or communities having housing, shopping, recreational, and employment opportunities would contribute less total travel than would conventional suburban development.

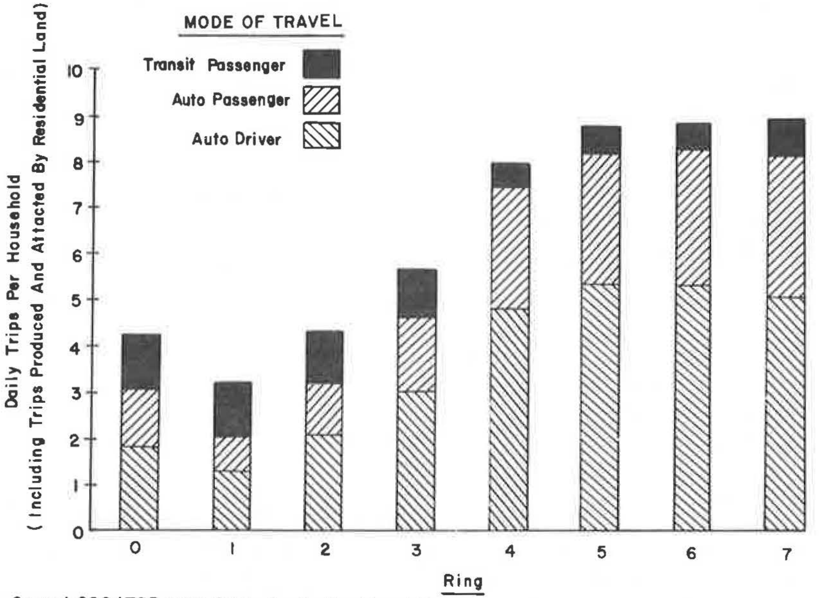
What about the question of improved highways?

It is generally believed that increases in the supply of highway facilities generate increased demands for automobile travel. Some claim that freeways increase travel faster than the new facility can absorb the increase, causing greater congestion than before. This view fails to take into account the fact that much of the so-called "generated" travel is really travel that has been removed from other routes and redirected away from other travel corridors. In addition, like transit facilities, freeways can channel land development, causing higher travel demands in the corridor. Must this necessarily be bad?

The effect of a major freeway on travel demands and on air pollution levels can be shown by forecasts of travel in the I-66 corridor in northern Virginia both with and without this freeway.

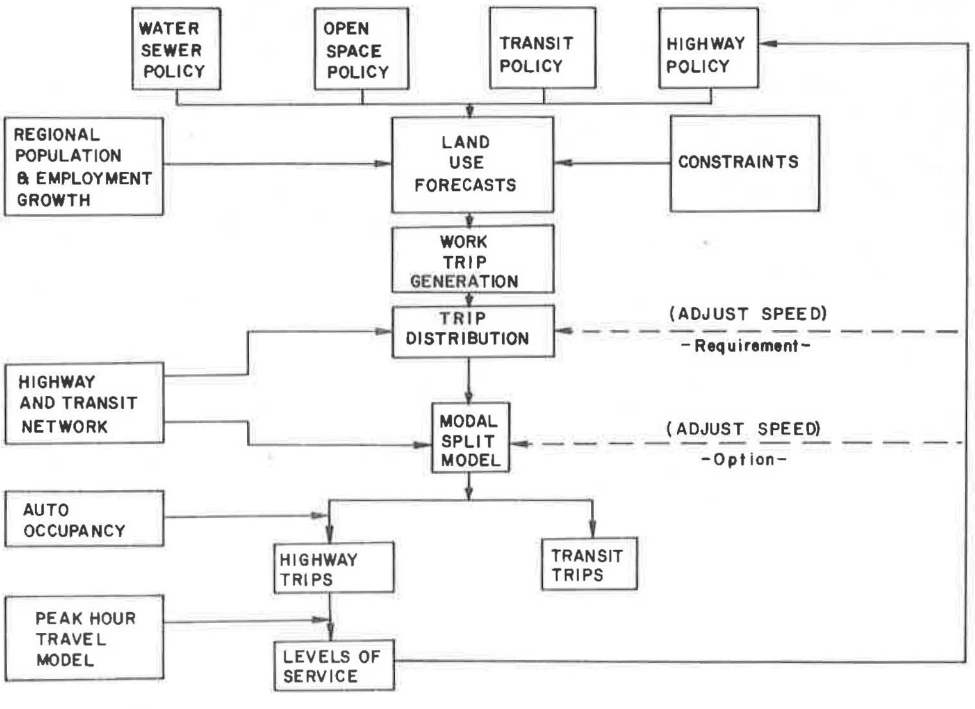
Forecasts of future travel demand by mode were made by using a series (or chain) of mathematical simulation models. The model system used is shown in Figure 4. Land activity forecasts by small area were made by inserting in the model a staged transportation alternative by time period. Other policies, such as water, sewer, and open space, were also introduced. The resultant distribution of land use activities was then converted to person work travel, distributed between origins and destinations, and split by mode (depending on the characteristics of the modal alternatives used). Automobile travel was converted to peak-hour travel demands and assigned to the highway network. The performance characteristics of the highway system were then determined, and the travel was redistributed between origins and destinations and among modes until a state of equilibrium was approximated. The results of this analysis indicated that the

Figure 3. Total person-trip ends per household, 1968.



Source: COG/TPB 1968 Origin Destination Travel Survey

Figure 4. Generalized traffic forecasting procedure (peak-hour travel).



provision of an interim transit facility in the right-of-way could absorb much of the increasing peak-period travel in the corridor in the short run and actually slightly reduce automobile travel in the corridor by 1976.

In the long run, the land use changes that would accompany the provision of the highway facility would also tend to encourage greater use of the parallel rail rapid transit line. This line also serves the corridor, and only moderate increases in automobile travel are forecast. The highway facility with its added capacity could then help relieve overcrowded conditions on parallel adjacent routes. Without the freeway, however, land use would be more dispersed, resulting in lower transit patronage. Although lower highway travel demands would also result, these demands would be accommodated at lower levels of service in the corridor with accompanying higher levels of automobile emissions. In addition, increased travel demand would occur, with little chance of increased public transportation, and regional air quality would suffer as well.

Major highway facilities, when accompanied by transit in the same corridor, may serve as a positive rather than a negative factor in reducing the amount of regional air pollution. Careful analysis of highway corridors, taking full account of the developmental effect of major facilities, should be undertaken.

4. Central area parking policy should become an integral part of the transportation planning process.

There is much talk about imposing automobile restraints or deterrents in the downtown area. So-called "modal split" or modal-choice relations developed from Washington, D.C., data have indicated that parking charges can have a substantial effect on the choice of travel mode. Such charges also affect the automobile occupancy rate and would encourage car-pool arrangements as well. Table 1 gives the percentage of people traveling to work who chose transit under differing levels of automobile and transit service for pay or free parking. The relative use of transit service from various distances is shown, for both pay and free parking. Based on the number of trips to the CBD from each area, Table 2 gives the total percentage of all CBD trips on transit in relation to pay and free parking. (The $1 average parking charge is actually created by nearly one-half the users paying up to $3 a day with the other half parking free.)

Because free parking attracts a larger percentage of automobile drivers, it can be shown that increases in the parking cost can influence drivers to use public transit if service is available. As shown, even assuming a minimal 5 percent increase in the modal choice percentages given in Table 1, the relative use of transit could increase from 36 to 41 percent with bus systems and from 46 to 51 percent with rail. These correspond to reductions in automobile use of 8 to 10 percent. A policy of improved transit and increased parking charges could have significant effects in reducing peak-period automobile travel to the CBD.

5. The benefits of alternative actions should be stated clearly and the impacts to public and private interests estimated.

The parking charge question, however, opens up other issues that should be explored. Why is there so much free parking in the downtown area? Why should government workers be subsidized to park in the area? Should the amount of parking spaces be reduced and zoning requirements changed? A rational, equitable parking policy could go a long way in shifting automobile users to public transit without increasing already high charges on those who do pay for parking. This will involve private as well as public interests. However, if parking charges are imposed or less parking is provided in the CBD, will not the CBD suffer and the alternative suburban development sites be benefited?

6. Alternative land use policies as well as alternative transportation policies should be examined.

The central area of Washington, D.C., is already substantially larger than most other U.S. cities. In 1968, the CBD contained nearly a quarter of the region's employment. If nearby Arlington is included, the core of the region contains more than one-third of the region's jobs. If pollution is a problem in the CBD, and if only one-half of all travel can be attracted to transit under the most optimistic forecasts, why continue to encourage employment to locate there? This question should also be raised when it is noted that most residential development is occurring outside the capital belt-

Table 1. Travel mode, time, and choice.

Distance From CBD (miles)	Equivalent Travel Time to CBD (min)		Work Trip Modal Choice (percent using transit)				
			Bus Versus Automobile		Rail Versus Automobile		
	Bus Versus Automobile	Rail Versus Automobile	$1 Parking Cost	Free Parking	$1 Parking Cost	Free Parking	Percentage of CBD Work Trips
4	+9	+6	45	30	50	35	50
8	+29	+9	30	20	45	30	30
12	+42	+16	25	15	40	25	15
16	+60	+22	20	10	35	20	5

Note: Equivalent travel time for walking, waiting, and transfer times weighted by a factor of 2½.

Table 2. Use of transit as related to parking costs.

Distance From CBD (miles)	Percentage of Trips to CBD Using Transit					
	Bus Versus Automobile		Rail Versus Automobile		Bus Versus Automobile, $2 Parking Cost	Rail Versus Automobile, $2 Parking Cost
	$1 Parking Cost	Free Parking	$1 Parking Cost	Free Parking		
4	22.5	15.0	25.0	17.5	25.0	27.5
8	9.0	6.0	13.5	9.0	10.5	15.0
12	3.75	2.25	6.0	3.75	4.5	6.75
16	1.0	0.5	1.75	1.0	1.25	2.0
Total	36.25	23.75	46.25	31.25	41.25	51.25

Table 3. Household and employment distribution by ring.

Ring	Existing Land Use Pattern (1968)		Future Land Use Pattern (1992)			
			Concentrated Employment Pattern		Decentralized Employment Pattern	
	Households	Jobs	Households	Jobs	Households	Jobs
0	1	19	—[a]	18	—[a]	13
1	5	17	1	13	1	13
2	16	14	7	11	7	11
3	20	11	11	8	11	9
4	30	19	20	15	20	17
5	15	9	17	10	18	12
6	9	8	20	13	20	13
7	4	3	12	7	12	7
8	—[a]	—[a]	11	7	10	5

[a]Less than 1 percent.

way, 10 to 12 miles away. Why continue to encourage such lengthy travel? Table 3 gives the imbalance between households and employment in each ring (rings are numbered outward from the center). With continued concentration in the region's core, it has been forecast that future highway travel will exceed current levels in that area, despite the completion of the rail system. In addition, future trip lengths will be substantially greater than they are today. Trip length and vehicle-miles of travel can be reduced by encouraging increased employment near the capital beltway. This decentralized employment pattern would redistribute 5 percent of regional employment out of the CBD and into satellite employment centers served by public transportation. A preliminary traffic analysis of this land use alternative shows significant reductions in trip length, travel time, and vehicle-miles of travel. Solutions to the air pollution problem can be found that are consistent with sound land use and transportation planning. The goals of such planning should be to minimize the number of vehicle-miles traveled and reduce traffic congestion.

7. A planning process that is responsive to evaluating alternative courses of action is required.

At a minimum, the planning process must be able to quickly produce forecasts of future conditions based on various land use and transportation alternatives and control schemes. These results should receive wide public distribution. Although the methods of determining these forecasts will necessarily vary, quantification of alternative courses of action is essential to sound decision-making.

8. Continuing process improvement, monitoring, and feedback are essential.

Although there is no shortage of traffic data, models, and forecasts (in Washington, D.C., if not in all U.S. cities), the corresponding data for automobile emissions and air quality are largely unavailable. Only a few control stations exist, and minimal ad hoc readings of pollutants are available. The conversion of vehicle-miles of travel and speed data to pollution values and the subsequent determination of air quality leave much room for continuing analysis and development. Monitoring and analysis, especially after control strategies are implemented, are essential to determine if standards are being met.

SUMMARY

Eight recommendations for incorporating air quality planning considerations into the land use and transportation planning process have been discussed. (Not discussed was the obvious need to consider the air quality implications of various land uses independently of traffic generation and resultant emissions.) A major need is to seek out transportation and land use planning strategies that can reduce the amount of vehicular emissions. It has been shown that the problem cannot be solved on a partial basis but that regional solutions must be sought and implemented. Public acceptance of such solutions can be attained if alternative courses of action are studied and evaluated.

These alternatives should consider various scales (CBD, corridors, and area-wide) and time frames (immediate, short range, and long range) with the benefit and impacts to the public clearly stated.

A planning process that can bring together affected groups and reconcile air quality, land use, and transportation (including central area parking policies) is needed. In most cities, it may be desirable to utilize the comprehensive transportation planning process for such work. The process should be responsive to meeting stated goals and objectives and evaluating the benefits and impacts of alternative policies and programs. Continuing monitoring and evaluation of strategies are essential to the process.

REFERENCE

1. Berwager and Wickstrom. Estimating Auto Emissions of Alternative Transportation Systems. For U.S. Department of Transportation, April 1972.