CRW
CHASE, ROSEN & WALLACE, INC.
901 N. WASHINGTON ST. ALEXANDRIA, VA. 22314
TELEPHONE: AREA CODE (703) 836-7120

AIR POLLUTION CONTROL MEASURES FOR NORTHERN VIRGINIA

F I N A L R E P O R T

NORTHERN VIRGINIA TRANSPORTATION COMMISSION

CONSULTANTS: CHASE, ROSEN & WALLACE, INC.
901 North Washington Street
Alexandria, Virginia 22314

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FORWARD

The draft of this report was submitted on April 26, 1973. While the report was undergoing review and revision, there were several significant developments in the arena of control strategy development. Examples include the relaxation of auto emission standards, the Supreme Court's affirmation of the non-degredation ruling, and EPA's rejection of the control plan submitted by Virginia, Maryland and the District of Columbia.

In the preparation of the final report, mention has been made of these recent developments. Nonetheless, due to the rapid and continuing changes and modifications in the air quality requirements, this report may contain outdated sections by the time of printing or distribution.

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SUMMARY

Regulations adopted pursuant to the 1970 Clean Air Act established ambient air quality standards and required each state to formulate an implementation plan for achieving and maintaining the standards.

The implementation plan for Northern Virginia was drafted by the Virginia Air Quality Control Board, acting in concert with a regional Air Quality Planning Committee composed of representatives from the District of Columbia, Maryland and Virginia. It was found that the air quality problem in the Washington region is sufficiently severe to require extensive transportation control measures to reduce emissions produced by motor vehicles. Strategies proposed fall into the following major categories:

- Expansion of Mass Transit System
- Parking Disincentives
- Car Pool Locator Service
- Vehicle Inspection/Maintenance
- Retrofit of Light Duty Vehicles (Later Deleted)
- Eliminate Dry Cleaning Losses
- Reduce Gas Evaporative Losses at Service Stations
- Reduce Aircraft Emissions
- Restrict Delivery by Heavy Duty Gas Trucks

Details of the recommended strategies, as well as evaluations of their effectiveness are contained in the body of the report.

The plan submitted by Virginia was rejected by EPA, due to insufficient legal and implementation mechanisms. A revised plan is currently being developed with the cooperation of EPA and the Virginia State Air Pollution Control Board.

There is an important role to be filled as the planning and implementation agency for transportation control strategies in Northern Virginia. The Northern Virginia Transportation Commission (NVTC), responsible for the transportation interest of its member jurisdictions, is the agency best suited to assume this role. The opportunity exists for NVTC to assume a leadership role in the formulation and implementation of transportation policies which can improve ambient air quality in the National Capital Interstate Region. NVTC, which will be vitally concerned with the implementation of transportation control strategies, must be a forceful party to their development. The recommended program for NVTC is summarized in the following paragraphs. Details are provided in the body of the report.

NVTC should do all in its powers to ensure that transportation control strategies are:

- The results of comprehensive study.
- Flexible.
- Subject to periodic review.

More specifically, it is recommended that NVTC initiate the following actions to assume its leadership role in the development of environmentally sound transportation programs:

- Establish a sub-committee of the Commissioners to be responsible for environmental aspects of NVTC programs.
- Establish a staff function in environmental planning either in-house or through the use of a private consultant, to serve the needs of the sub-committee of the Commission. Using this new staff resource, interface with other public agencies and private interest groups for the promotion of clean air objectives in Northern Virginia.
- Investigate funding sources for the planning, design, and operation of transportation improvement programs to improve air quality.
- Sponsor a cost-effectiveness study of alternative control strategies, explicitly identifying costs to the agency and to the general public.

- Establish positions on elements of the proposed control strategy, based on the findings of the cost-effectiveness study.
- Sponsor transit improvement studies of busway facilities.
- Sponsor a study of the parking needs of Metro.

The program will permit NVTC to be responsive to the demands for clean air, as well as the transportation needs of Northern Virginia.

INTRODUCTION

One of the major public policy developments of recent years has been the emergence of environmental issues as major national and international concerns. International concern over the environment has recently been manifested in the United Nations Conference on the Human Environment held in Stockholm and in the attention focused on environmental issues by the Organization for Economic Cooperation and Development.

At the national level, the Congress of the United States has dealt with environmental issues through the National Environmental Policy Act of 1969, the 1970 Clean Air Act and pursuant regulations, the 1970 Federal Aid Highway Act, and other legislative programs.

A primary focus of national environmental concern has been the problem of air pollution in urban areas. The most promising measure for dealing with this problem has been the 1970 Clean Air Act, which is outlined in the following paragraphs.

1970 CLEAN AIR ACT

The passage of the 1970 Clean Air Act, more properly referred to as the Clean Air Act Amendments of 1970, created far stronger legal tools for air pollution control than had previously existed. Major provisions of the Act required the Administrator of the Environmental Protection Agency to establish national ambient

air quality standards and to set emission standards for stationary and mobile pollution sources. The Act also requires each state to formulate an implementation plan for achieving and maintaining the standards. If the states fail to act, the Administrator of EPA is authorized to enforce a plan to ensure compliance with the ambient air quality standards. (1)

Air Quality Standards

Based on the provisions of the Clean Air Act Amendments of 1970, EPA has established ambient air quality standards which specify acceptable pollution levels in terms of concentrations per unit of air. The national primary and secondary ambient air quality standards are summarized in Table 1. Each standard specifies an averaging time, frequency, and concentrations. The standards specify that the maximum concentrations are not to be exceeded more than once per year. Primary standards are to be sufficiently stringent to protect the public health, while secondary standards are designed to protect the public welfare.

TABLE 1

NATIONAL PRIMARY AND SECONDARY AMBIENT AIR QUALITY STANDARDS

Pollutants	Type of Standard	Averaging Time	Frequency Standard	Concentration μg/m³	Concentration ppm
Carbon monoxide	Primary and	1 hour	Annual maximum[a]	40,000	35
	Secondary	8 hour	Annual maximum	10,000	9
Hydrocarbons (nonmethane)	Primary and Secondary	3 hour (6-9 A.M.)	Annual maximum[a]	160	0.24
Nitrogen dioxide	Primary and Secondary	1 year	Arithmetic mean	100	0.05
Photochemical oxidants	Primary and Secondary	1 hour	Annual maximum[a]	160	0.08
Particulate matter	Primary	24 hour	Annual maximum[a]	260	---
		24 hour	Annual geometric mean	75	---
	Secondary	24 hour	Annual maximum[a]	150	---
		24 hour	Annual geometric mean	60	---
Sulfur dioxide	Primary	24 hour	Annual maximum[a]	365	0.14
		1 year	Arithmetic mean	80	0.03
	Secondary	3 hour	Annual maximum[a]	1,300	0.5
		24 hour	Annual maximum	260	0.1
		1 year	Arithmetic mean	60	0.02

[a] Not to be exceeded more than once per year.

Source: The Conservation Foundation, A Citizen's Guide to Clean Air, Washington, D.C., 1972.

Implementation Plans

Each state has been required to formulate an implementation plan to meet and maintain the ambient air quality standards in each air quality control region (AQCR) within its jurisdiction by 1975. If a state fails to submit a satisfactory plan, EPA has the authority to formulate and enforce a plan of its own for the attainment of national standards.

In order to meet EPA requirements, an implementation plan must include the following major components:

- Legal Authority - the state must present evidence that it has sufficient legal authority to produce and execute an implementation plan.
- Control Strategy - a combination of measures designed to achieve the aggregate reduction of emissions necessary for attainment and maintenance of a national standard.
- Compliance Schedules - each major source of pollution must prepare and follow a detailed schedule of measures it will take to bring it into accord with the implementation plan. Compliance schedules are negotiated between the state and each major source of pollution, at which time they become legally enforceable and are a part of the implementation plan.
- Emergency Episode Procedures - in heavily polluted areas, consideration must be given to the emergency measures needed when the pollution level threatens to reach or exceed the danger point.

- Surveillance Systems - state plans must include surveillance systems for monitoring ambient air quality levels and individual source emissions.
- Review of New Sources - each plan must contain legally enforceable procedures that will enable the state agency to prevent the construction or modification of any stationary source that would interfere with attainment or maintenance of a national standard.
- Resources - each plan must include a description of the manpower and funds needed to carry out the plan for five years.
- Interstate Cooperation - each plan must provide for the exchange of all necessary information among the responsible agencies in each control region encompassing more than one state.

Stationary and Mobile Source Emission Standards

The Act requires EPA to establish national standards of performance for certain new and modified stationary pollution sources. These standards are to be set for those types of pollution sources which contribute significantly to air pollution. The standards of performance are limited to new sources and to sources undergoing modification. The Act also requires EPA to prescribe regulations under which states must set emission standards

for pollutants from existing sources in each category for which a performance standard would apply if the source were new or modified. If a state fails to develop or enforce such standards for existing sources, EPA has the authority to develop and enforce them.

In addition to the standards of performance placed on stationary sources of pollution, the 1970 Clean Air Amendments established emission standards for motor vehicles. By 1975, emission rates for carbon monoxide and hydrocarbons were to be reduced to no more than ten percent of the 1970 partially controlled levels. By 1976, nitrogen oxide emissions were to be reduced to no more than ten percent of the 1970 uncontrolled levels. These standards must be maintained for a duration of five years or 50,000 miles, whichever comes first. These reductions translated to 1975 emission standards of 3.4 gm/mile and 0.41 gm/mile for carbon monoxide and hydrocarbons, respectively. The 1976 nitrogen oxide standard was set at 0.4 gm/mile, with a 1973 interim standard of 3.0 gm/mile (1).

The Environmental Protection Agency recently acceded to requests from the auto-makers to delay the aforementioned standards for one year. Standards for 1975 have thus been relaxed to limit emissions to 15 gm/mile and 1.5 gm/mile for carbon monoxide and hydrocarbons, respectively (2). Further, current reports indicate that EPA may be considering making the emission standards for nitrogren oxides less stringent (3).

Non-Degredation

A major judicial interpretation of the 1970 Clean Air Act has been the so-called non-degredation finding. The U.S. Supreme Court, on June 11, 1973, affirmed a lower court finding that the EPA must keep states from allowing any significant deterioration in the quality of air that is already cleaner than the federal standards (6). It is anticipated that further litigations will be forthcoming to define more explicitly the role of EPA in enforcing this decision.

The potential impact of the non-degredation issue on air quality implementation plans is very significant. Depending on continuing interpretations, it may be impossible to reduce air pollution hotspots by distributing activities over a wider area.

THE NEED FOR TRANSPORTATION CONTROLS

Motor vehicle emissions have been estimated to account for approximately 60 percent of the carbon monoxide emissions, 50 percent of the hydrocarbons, and 35 percent of the nitrogen oxides, on a national basis (4,5).

Although EPA has promulgated emission standards which will go a long way toward alleviating the air quality problem, in many urban areas the motor vehicle emission control program will be insufficient, in itself, to achieve national ambient air quality standards. Thus, it will be necessary to plan transportation programs with explicit attention paid to air pollution emissions, concentrations, and human exposure. Only by taking a comprehensive

approach, including stationary and mobile source emission controls, as well as transportation control strategies, can the air quality standards be achieved in cities with severe pollution problems.

Three major categories can be identified for reducing air pollution through transportation measures:

1. Reducing emissions at the source
2. Reducing concentrations of pollutants
3. Reducing vehicular traffic

Vehicle emissions can be reduced at the source through the application of source control technology or traffic flow improvements. Examples of source control technology would include retrofit devices to reduce the emission rate of uncontrolled and partially controlled vehicles, programs for the inspection and maintenance of vehicle components related to emissions, and converting to low pollution power sources. Traffic flow improvements, which reduce the amount of idling and facilitiate the movement of traffic can significantly reduce pollutant emissions. Typical of this type of improvement would be traffic responsive signal systems, reversible lanes and control of vehicle-pedestrian conflicts.

Techniques aimed at reducing the concentration of pollutants in time and space include staggered work hours, as well as design techniques to promote rapid dispersion.

The third group of techniques are those which actually reduce the number of vehicles on the streets. Included in this group are public transit improvements (occasioning a reduction in auto travel), pricing policy, which discourages motorists from using their vehicles by the imposition of various types of user charges, and regulation, which limits the amount or distribution of vehicle travel by law.

PURPOSE

The purpose of this report is to review and evaluate the control strategies developed for the Northern Virginia portion of the Washington, D. C. area and to recommend to the Northern Virginia Transportation Commission) e promotion of clean air in Northern Virginia, consistent with the goals of NVTC to provide necessary transportation services to the residents of the sub-region.

CONTROL STRATEGIES FOR NORTHERN VIRGINIA

An initial survey of this Air Quality Control Region indicated that for the Northern Virginia portion the levels of pollution were of marginal concern. The initial measurements of air quality indicated that Northern Virginia could meet the standards for hydrocarbons, nitrogen oxides, carbon monoxide, and photo-chemical oxidants, with only minor local measures.

However, more recent air quality data for hydrocarbons indicated a much more severe problem in Northern Virginia and in the entire Washington Area, requiring the adoption of transportation control measures as well as more stringent stationary source controls in order to attain acceptable ambient air quality. It was recognized that to be effective these measures had to be applied consistently with similar measures in the District of Columbia and adjacent areas of Maryland. The task of providing for coordinated, uniform transportation control measures throughout the National Capital Interstate Region was undertaken by a regional Air Quality Planning Committee, which developed and examined strategy packages keyed to achieving the national standards in the region in 1975, 1976, or 1977. After due consideration, they recommended the implementation of the 1975 package.

In a document prepared by the Virginia State Air Pollution Control Board in February 1973, the three packages evaluated by the Air Quality Planning Committee, as well as fourth and fifth options, were summarized (7). No strategy was recommended at that time. The material contained in this section is largely excerpted from that document.

AMBIENT AIR QUALITY IN THE NATIONAL CAPITAL INTERSTATE REGION

Ambient air sampling data for 1972 from monitoring sites in Montgomery, Prince George, Fairfax, and Arlington Counties, the City of Alexandria and the District of Columbia reveal that maximum one-hour average concentrations of .20 ppm total oxidants and maximum eight-hour average concentrations of 20 ppm carbon monoxide are representative of the worst ambient air quality over the NCI Region. National standards are .08 ppm and 9.0 ppm respectively. These "worst" case readings form the basis for computing emission reduction requirements according to EPA prescribed procedure.

The current nitrogen dioxide (NO_2) problem is uncertain to some extent, since the present annual arithmetic average is not yet known. All previous measurements of the NO_2 concentrations were by methods unacceptable to EPA. Measurements of NO_2 with acceptable methods were initiated in the summer of 1972. In spite of the lack of data at the time of plan preparation, it was anticipated the NO_2 standard could readily be attained through a combination of current Region 7 regulations and new auto emission controls.

Required Emission Reductions

In the overall development of plans to reach ambient air quality standards, EPA has presented guidelines for the States' use in developing implementation plans. These assumptions are used for this plan. First, it is assumed that photochemical oxidants are produced in the afternoon by sunlight reacting with oxides of nitrogen, and with non-methane hydrocarbons emitted between 6 and 9 A.M. Second, it is further assumed that the maximum oxidant reading and required hydrocarbon reduction relationship published by EPA in Air Quality Criteria document AP-84 is valid. These two assumptions facilitate evaluation in that hydrocarbon emission reductions can be estimated from fuels use and process description data while oxidant reductions must be measured over long periods of time. Thus, the largely unknown chemical reactions of actual formation of oxidants can be bypassed for purposes of strategies development. Using the relationship presented in AP-84, it was determined that a 67 percent reduction in hydrocarbon emissions is required to achieve photochemical oxidant standards.

Since carbon monoxide is a direct output of fuel consumption and is relatively inert, control strategies can be based on a proportional model.

The percentage reduction in carbon monoxide emissions required to achieve CO standards (9 ppm) is:

$$\frac{A-9}{A} \times 100, \text{ or } 55\% \text{ for } A=20 \text{ ppm}$$

Emission Inventory

Tables 2, 3, and 4 are the best available emission inventory data for carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NO_x) for the National Capital Interstate Region. Source emissions in tons per year were adjusted to tons per peak period (6 to 9 A.M. for HC; 6 A.M. to 2 P.M. for CO) by application of hourly factors. Table 5 portrays vehicle miles of travel (VMT) and vehicle trips. Data in these figures for 1975, 1976 and 1977 are based on the following assumptions:

- That auto manufacturers will meet all 1975 emission requirements for new cars set by EPA by the specified date.
- That all existing rules for HC control will be fully enforced by the specified dates.
- That rapid rail transit (METRO) and its supporting bus feeder system will go into operation as now planned.
- That no new freeways other than those now committed or under construction will be operational.
- That patterns of behavior of the general public with respect to transportation-related activities as observed in 1968 will continue through 1977 (e.g. new car purchasing habits, "normal" maintenance of autos, responses to transit service, etc.)
- That population growth will continue at present rates.

TABLE 2

NATIONAL CAPITAL INTERSTATE REGION HC EMISSIONS

EXISTING INVENTORY & PROJECTION

(with '75 Auto controls and Metro System as now planned)

Source	1972 TFY*	HRS. FACTOR	1972 TPP*	1975 TPP	1976 TPP	1977 TPP
Mobile						
Autos	(Note 1)		43.3	27.0	20.2	15.4
L. D. Trucks	6545	.145	2.6	1.2	0.9	0.8
Taxis	913	.200	0.5	0.3	0.2	0.1
H. D. Gas Trucks	6545	.145	2.6	2.2	2.1	2.0
Aircraft	9100	.130	3.2	3.3	3.4	3.4
Diesel & Ships	913	.125	0.3	0.3	0.4	0.4
Stationary						
Gas Handling	14985	.170	7.0	6.3	6.6	6.9
Gas Storages	1356	.125	0.5	0.3	0.3	0.3
Power Plants	1314	.125	0.5	0.5	0.5	0.5
Solid Waste	2299	.125	0.8	0.8	0.8	0.8
Heating & Industrial	2336	.125	0.8	0.9	0.9	0.9
Solvents	3358	.125	1.2	1.1	1.1	1.1
Totals			63.3	44.2	37.4	32.6

Note 1 - Computed only in tons per peak period (6-9 a.m.)

*TFY per year; TPP - tons per peak period (6-9 a.m.)

TABLE 3

NATIONAL CAPITAL INTERSTATE REGION CO EMISSIONS

EXISTING INVENTORY & PROJECTION

(with '75 Auto controls and Metro System as now planned)

Source	1972 TPY	1972 HRS. FACTOR	1972 TPP	1975 TPP	1976 TPP	1977 TPP
Mobile						
Autos	(Note 1)		867.8	570.0	432.5	334.7
L. D. Trucks	73460	.63	126.8	85.9	63.7	55.9
Taxis	9800	.70	18.8	8.5	5.7	3.0
H. D. Gas Trucks	34300	.63	59.3	55.8	53.9	53.7
Aircraft	33215	.44	40.1	49.1	52.5	56.2
Diesel & Ships	5100	.33	4.5	4.5	4.4	4.4
Stationary						
Gas Handling	-	-	-	-	-	-
Gas Storages	-	-	-	-	-	--
Power Plants	2900	.33	2.8	3.8	4.2	4.5
Solid Waste	6600	.33	5.9	5.9	5.9	5.9
Heating & Industrial	8400	.33	7.5	7.3	7.3	7.3
Solvents	-	-	-	-	-	-
Totals			1133.5	790.8	630.1	525.6

Note 1 - Computed only in tons per peak period (6 a.m. to 2 p.m.)

TABLE 4

NATIONAL CAPITAL INTERSTATE REGION NO_x EMISSIONS
EXISTING INVENTORY & PROJECTION

(with '75 Auto controls and Metro System as now planned)

Source	1972 TPP	1975 TPP	1976 TPP	1977 TPP
Mobile				
Auto	32.0	26.6	21.3	16.6
L. D. Trucks	2.4	2.0	1.6	1.3
Taxi	0.8	0.4	0.3	0.2
H. D. Gas Trucks	1.7	1.9	1.9	2.0
Off Highway	1.3	1.6	1.8	1.8
Aircraft	1.3	1.3	1.4	1.4
Diesel & Ships	2.0	2.2	2.5	2.7
Stationary				
Power Plants	29.9	28.7	28.3	27.8
Heating & Industrial	7.7	8.6	8.9	9.3
Totals	79.1	73.3	68.0	63.1

TABLE 5

NATIONAL CAPITAL INTERSTATE REGION
Vehicle Miles Travelled and Vehicle Trips
(Projection with Metro System as Now Planned)

thousands (000)

	1972	1975	1976	1977
6 am to 9 am Period				
All Trips, All Purposes				
VMT	6116	6531	6476	6384
Trips	614	663	644	601
To Core, Home to Work				
VMT	1279	1266	1126	900
Trips	113	112	98	74
6 am to 2 pm Period				
All Trips, All Purposes				
VMT	13479	14452	14354	14169
Trips	1619	1747	1697	1583
To Core, Home to Work				
VMT	1596	1571	1404	1123
Trips	141	140	122	92

Note: Core Area is Central Business District (Ring 0) plus surrounding area (Ring 1). Includes Pentagon, Fort Myer and Rosslyn.

Based on the rollback requirement of 67% HC and 55% CO, the reductions required by new transportation control measures to meet national standards in 1975, 1976 or 1977 are shown in Table 6.

It will be noted that as a result of Federal 1975 new auto emission controls and other factors, CO is very nearly within limits by 1977, and that HC reductions required for achievement of standards by 1977 are half those required for achievement by 1975.

Achievement of the allowable HC total is governing and, among the strategies considered, will provide more than enough reduction in CO emission.

PROPOSED STRATEGIES

The transportation control plan of AQCR 7 was submitted in March of 1973 and is described in the following paragraphs.

1. Transportation

   a. Expansion of Mass Transit System

In addition to presently planned METRO rapid rail and associated bus feeder systems:

- Add nine new bus ways (seven contra-flow lanes and two exclusive rights of way).
- Expand service by adding about 1300 new buses in 1975 (or alternatively 880 new buses in 1976 or 400 in 1977).
- Expand fringe parking, provide bus shelters and adequate public information.
- Provide subsidies as required to maintain fares at an appropriate level in comparison with costs of operating autos for work trips.

TABLE 6

NATIONAL CAPITAL INTERSTATE REGION

Emission Reduction to Meet National Air Quality Standards by Various Dates

Hydrocarbons (tons 6 to 9 am)

	1972	1975	1976	1977
Existing Inv. & Proj.	63.3	44.2	37.4	32.6
67% Reduction	42.4	--	--	--
Allowable Emissions	20.9	20.9	20.9	20.9
Required Reduction	42.4	23.3	16.5	11.7

Carbon Monoxide (tons 6 am to 2 pm)

	1972	1975	1976	1977
Existing Inv. & Proj.	1133.5	789.8	630.1	525.6
55% Reduction	623.4	--	--	--
Allowable Emission	510.1	510.1	510.1	519.1
Required Reduction	623.4	280.7	120.0	15.5

b. Parking Disincentives

- Eliminate on-street, long-term parking spaces available for commuters.
- Eliminate, to the extent feasible, provision of free parking to employees, by both private and public sector employers.
- Impose a $2.00 surcharge on long-term commuter parking in both Core and in non-Core areas.
- Increase the enforcement of and fines for parking violations and adopt reciprocal fine-payment agreements among local governments.
- Restrict provision of additional parking spaces through zoning, building permits, land use controls, etc.

c. Car Pool Locator Service

- Establish a region-wide computer data file on employees' home addresses, work addresses, and working hours.
- Design and operate an automated information system to match employees with similar characteristics.
- Disseminate potential car pool information on a request basis.
- Through public information and advertising, promote car pooling and preferential treatment through exclusive lanes and parking incentives.

2. Vehicle Inspection/Maintenance

[Annual emission inspection of all gasoline powered road vehicles registered in the region.]

In order to minimize emissions from faulty engine adjustment and/or defective engine components, a regionwide emission inspection program would be established to isolate malfunctioning vehicles and to require necessary maintenance to meet emission standards. All road vehicles registered in the Virginia jurisdictions of the NCI Region would be tested once per year at appropriately equipped inspection stations.

The following criteria are suggested for the first year's inspection cycle:

Model Year	Pollutant Standards	
	Hydrocarbons	Carbon Monoxide
pre-1968	700 ppm	6%
1968-70	400 ppm	5%
1971-74	300 ppm	3%

(These standards fall between New Jersey 1972 standards and more stringent Clayton Idle-Emission Standards.)

Those vehicles failing the test would be required to undergo corrective maintenance within a specified period. A diagnostic procedures chart would be given to the owner to assist his mechanic in correcting the vehicle's problems.

3. Retrofit of Pre-1975 Automobiles and Light Duty Trucks

- Model years 1974-68 registered in the NCI Region would be required to install by June 1975 (or alternatively 1976 or 1977) an oxidizing catalytic converter emission control device which reduces emissions by at least 50%.
- Pre-1968 model year vehicles registered in the region would be required to install by June 1975 (or alternatively 1976 or 1977) a mechanical device and/or engine modifications which reduce emissions by 25%.

In 1975, the 1968-74 model year automobiles are expected to produce 79% of the HC and CO emissions from all automobiles while 1975 models will produce 2.0% and pre-1968 models 21%. The 1968-74 vehicles emit less pollution per mile than vehicles produced before 1968, but they are considerably more prevalent and are driven more miles than the older vehicles. The high total emission from the 1968-74 vehicles and their longer life expectancy make it appropriate that this portion of the fleet be fitted with the most effective and more costly devices.

A number of emission control devices have been developed for pre-1968 automobiles and three have been certified by the California Air Resource Board and by EPA. All three and other certified devices would be approved and selection would be left to the owner based on cost, convenience and secondary benefits (i.e. increased gas mileage). The three retrofit devices are the "GM Kit" produced by General Motors, the "Purepower Kit" produced by Air Quality Products, Inc., and the "Retronox Kit",

produced by the Perfect Circle Division of the Dana Corporation. At present, the only catalytic converter which is available is the "Mini-Verter" manufactured by Universal Oil Products.

This strategy will necessitate the availability of unleaded gasoline coincident to installation of catalytic converters.

4. Eliminate Dry Cleaning Losses

[Control emissions from dry cleaning establishments to encourage their switching to non-photochemically reactive hydrocarbons (e.g. perchloroethylene).

Emissions of reactive hydrocarbons can be virtually eliminated by the strict enforcement of regulations similar to Virginia Rule 4.705.03(g) throughout the Washington Metropolitan Region by 1975. Such a rule calls for 85% control of sources of photo-chemically reactive hydrocarbons of incineration, absorption or other approved methods. Stringent enforcement of this regulation would have the effect of causing users to switch to non-photochemically reactive hydrocarbons and thus provide complete (viz. 85%) saving in dry cleaning emissions as calculated by inventory. A Virginia rule change would be involved to the extent of lowering the applicability limit from 40 pounds of solvent per day to perhaps five pounds per day.

5. Reduce Gas Evaporative Losses at Service Stations

. Install by June 1975 (or alternatively 1976 or 1977) at all new and old gasoline service stations vapor collection systems to reduce by 90% losses during filling of underground storage tanks.

. Install by June 1975 (or alternatively 1976 or 1977) at all new and old gasoline service stations vapor collection systems to reduce by 90% losses during filling auto tanks.

Current rules control only 30% of stationary source gasoline evaporative emissions. The remaining 70% occurs at the service stations. Rules similar to the above recently enacted by San Diego have triggered extensive development activity in gas station controls. Implementation of this strategy involves consideration of:

(1) life cycle of underground tanks,

(2) fleet stations and jobbers handling small daily quantities, and

(3) nozzle/auto tank interface aspects of unleaded gasoline required for 1975 catalytic converters.

6. Reduce Aircraft Emissions

[Reduce emissions during taxiing operations.]

At the two major airports in the region, National and Dulles, emissions of HC and CO from aircraft can be significantly reduced since ground based operations of aircraft account for the majority of total emissions. It has been estimated that the total aircraft

emissions can be reduced by 50% for hydrocarbons and 60% for carbon monoxide with the use of tow vehicles for taxiing operations. In a recent report for the FAA, the EPA has recommended similar strategies to reduce aircraft emissions commencing in 1979. It is proposed to implement this procedure in 1975, (or alternatively in 1976).

7. Restrict Delivery by Heavy Duty Gas Trucks

[No deliveries by heavy duty gasoline powered trucks during daylight hours, i.e. 6 A.M. to 6 P.M. (1975 only).]

By restricting operation of heavy duty gas powered trucks the emissions from such vehicles are virtually eliminated from the peak pollution hours. This strategy would also help relieve congestion on streets during the high demand daylight hours. Heavy duty trucks are those over 6000 pounds gross vehicle weight. This strategy is omitted from the 1976 and 1977 achievement date packages.

Strategy Options

To facilitate comparison, the 1975, 1976 and 1977 strategies packages are designated Options #1, #2 and #3 respectively.

Option #4, developed by the State Air Pollution Control Board, is simply a rebalancing of the 1976 strategies package (Option #2) to yield the required HC reduction with less margin. This rebalancing would require a complete computer re-run for second order effect on other strategies of a smaller VMT reduction through adoption of less expensive mass transit improvements.

The emission reductions to be achieved by each of the foregoing strategies are shown in Table 7 for the four options (1975, 1976, 1977 and the 1976 variant).

Corresponding capital investment costs and annual operating costs are shown in Table 8.

Percentage cost effectiveness of the four options is shown in Table 9.

A fifth strategy option is proposed in addition to the four options described in the basic proposal. It is intended to reduce the VMT (Vehicle Miles Traveled) by the control of gasoline sales. Several methods of accomplishing this have been advanced and include increased cost of gasoline, increased tax on gasoline, and gasoline rationing. Of these, gasoline rationing is considered the most equitable, i.e. the effect is the same regardless of income bracket, and therefore it was decided to proposed this method as a fifth option.

There are two general approaches to implementation of a gasoline rationing strategy - the substitution of rationing for one or more of the strategies in Options #1 through #4, or the substitution of rationing for all of the strategies and gain the total required reduction solely through rationing. No attempt is made here to choose or recommend any one or combination of strategies, but rather to present some information on which the public and responsible officials may come to a decision.

TABLE 7

EFFECTIVENESS OF STRATEGY PACKAGES

Option	Reductions (TPP) #1	#2	#3	#4	Reductions (TPP) #1	#2	#3	#4
Year of Achievement	1975	1976	1977	1976	1975	1976	1977	1976
Strategies								Note 1
1. Transportation	7.1	3.7	1.6	1.7	21	10	4	4
a. Expanded Mass Transit Sys.								
b. Parking Disincentives								
c. Car Pool Locator Svc.								
2. Vehicle Insp./Maint.	1.5	1.3	1.1	1.5	47	37	30	43
3. Retrofit of Pre-75 Vehicles	7.1	5.8	3.8	5.7	211	162	101	159
4. Eliminate Dry Cleaning Losses	1.1	1.1	1.1	1.1	-	-	-	-
5. Control Evap. Losses at Gas Stations	4.6	5.1	5.8	5.1	-	-	-	-
6. Reduce Aircraft Emissions	1.6	1.7	x	1.7	30	32	x	32
7. Restrict Delivery by H.D. Trucks	2.2	x	x	x	56	x	x	x
Totals	25.2	18.7	13.4	16.8	365	241	135	238
Req'd Reductions	23.2	16.5	11.7	16.5	281	120	16	120
Margin(HC)	9%	13%	15%	2%				

x - omitted

Note 1 - Figures illustrate rebalancing. When calculated by computer may vary slightly from those shown.

TABLE 8

COSTS OF STRATEGY PACKAGES

(Capital Outlay and Annual Operating Costs)

Costs in Million — Option	#1 1975		#2 1976		#3 1977		#4 1976	
	Cap.	Ann.	Cap.	Ann.	Cap.	Ann.	Cap.	Ann.
Strategies								
1. Transportation	74.9	21.6	51.2	12.6	23.8	2.1	25.2	2.2
a. Expanded M…angit Sys.								
b. Parking Di…tives								
c. Car Pool Loca… Svc.								
2. Vehicle Insp./Mai…	3.6	14.8	3.7	15.2	3.8	15.7	3.7	15.2
3. Retrofit of Pre-… ehicles	113.2	10.8	97.0	9.1	82.3	8.7	97.0	9.1
4. Eliminate Dry Cle… ng Losses	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
5. Cont. Evap. Losses … t Gas Stations	4.8	n.e.	4.9	n.e.	5.0	n.e.	4.9	n.e.
6. Reduce Aircraft E… sions	n.e.	n.e.	n.e.	n.e.	x	x	n.e.	n.e
7. Restrict Delivery … H.D. Trucks	n.e.	n.e.	x	x	x	x	x	x
…tals	196.5	47.2	156.8	36.9	114.9	26.5	130.8	26.5

x - omitted

n.e.- not estimated

TABLE 9

PERCENT COST EFFECTIVENESS OF STRATEGY PACKAGES

(HC Red. and Capital Outlay Cost)

Option	#1 1975		#2 1976		#3 1977		#4 1976	
Percentages	**Red.**	**Cost**	**Red.**	**Cost**	**Red.**	**Cost**	**Red.**	**Cost**
Strategies								
1. Transportation	28	38	20	33	12	21	10	19
a. Expanded Mass Transit Svc.								
b. Parking Disincentives								
c. Car Pool Locator Sys.								
2. Vehicle Insp./Maint.	66	2	7	2	8	3	9	3
3. Retrofit of Pre-75 Vehicles	28	58	31	62	29	72	34	74
4. Eliminate Dry Cleaning Losses	4	n.e.	6	n.e.	8	n.e.	7	n.e.
5. Cont. Evap. Losses at Gas Stations	18	2	27	3	43	4	30	4
6. Reduce Aircraft Emissions	7	n.e.	9	n.e.	x	x	10	n.e.
7. Restrict Delivery by H.D. Trucks	9	n.e.	x	x	x	x	x	x
Totals	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

x - omitted
n.e.- not estimated

Any system of rationing must be guided by the results expected. Obviously, much more stringent requirements must be promulgated to gain the total reduction required (67%) than to replace the proposed retrofit of pre-1975 vehicles (30%) or the replacement of restricted delivery by heavy duty trucks (10%). Therefore, if this option is chosen for implementation the choice must include the degree of replacement desired. As a very rough approximation one could assume that if a 67% reduction in emissions during the peak period (6 to 9 A.M.) is required, then a reduction of 67% of the gasoline used would result in a corresponding reduction in emissions, and similarly for 50% or 10% reduction desired. Admittedly, these figures leave much to be desired, but in the absence of more definitive numbers and the lack of time to develop them for this proposal, one can use them as a base from which to decide and proceed.

Such a severe measure as gasoline rationing confronts us with many problems, but it appears to be the only measure implemented in the last fifty years which has been able to reduce VMT and increase transit ridership goals we are currently trying to reach. Some of the features which make gasoline rationing an attractive control strategy are:

- Relatively high adaptability for use as a seasonal control strategy.
- Very flexible. Can easily and quickly be implemented or terminated.
- Adjustable. Degree of control can be easily adjusted for changing conditions or circumstances.
- Does not rely on unproven or non-existent technology.
- Induces increased car pooling and transit use.
- Rapid response. Time lag for experiencing air quality improvement is less than most other programs.

There are, however, a number of real obstacles and problems to be expected if such a program were to be implemented. Some of these are:

- Administrative Problems. There were significant administrative problems encountered in World War II program.
- Enforcement Problems. Black markets, bootlegging and counterfeiting of coupons were problems during WW II and could be even more of a problem now.
- Micro-economic Problems. Any massive rationing program will significantly affect the economy of the region.
- Acceptability Problems. It is doubtful if much public and institutional support could be mustered for a gasoline rationing program.
- Legal Problems. It is not clear if legal authority exists to implement such a program.

On April 11, 1973, Virginia filed a change to the above Air Quality Implementation Plan and at the same time applied for a two year extension for achieving the national ambient air quality standards in AQCR VII. To summarize the plan briefly, it is the same as Option 1 described above with the following exceptions:

(1) Retrofitting of vehicles of model year 1969 through 1971 is not required. The technology for successful retrofitting of these vehicles has been judged inadequate to meet the 1975 deadline.

(2) Heavy duty gasoline trucks will not have their delivery hours restricted. This measure is considered impractical and unworkable.

(3) The addition of buses to the existing fleet is still recommended. However, reservations are expressed as to the exact number needed. It appears to be impractical to acquire and then sell-off 1300 buses in such a short time span. One thousand buses are mentioned as a more realistic upper limit to the expansion which could be achieved.

Discussions of these control strategies and other possible control measures are given in the following chapters.

EPA's Response

On June 15, 1973, the Environmental Protection Agency rejected the clean air plans submitted by the District of Columbia, Maryland and the Northern Virginia suburbs (8). EPA announced it would impose its own clean air plan on the region this summer, requiring a ten to fifteen percent reduction in automobile travel throughout the area by July 1, 1975. While details have not been completed, it was reported that the plan will include limitations on on-street parking, a system of car pooling, and the purchase of 1300 new buses for the region. It is anticipated that Washington will not be required to meet the national standards until 1977.

Maryland was one of two states where EPA found plans to be almost completely inadequate, although state officials apparently are preparing a more detailed plan for EPA. Plans for the District of Columbia and Northern Virginia were sufficient but did not include the necessary legal procedures for insuring plan implementation.

In announcing the plans, Acting EPA Administrator Robert W. Fri acknowledged that the standards contained in the 1970 Clean Air Act may be too strict and that Congressional review of the Act provisions is a certainty.

EVALUATION OF SURFACE TRANSPORTATION CONTROL STRATEGIES

This section contains an evaluation of the transportation elements of the control strategies.

MASS TRANSIT

Four items are included in the transportation control measures proposal under the category of mass transit expansion. These are:

- Expand service by adding about 1300 new buses in 1975.
- Add nine new busways.
- Expand fringe parking, provide bus shelters and adequate public information.
- Provide subsidies as required to maintain fares at an appropriate level in comparison with costs of operating private autos for work trips.

Each of these items will be dealt with individually in the review. In addition, a section on other desirable transit improvements will be included.

Add 1300 New Buses in 1975

This number of buses was apparently arrived at based on the amount of additional bus service required to provide for the level of transit passenger usage that is required to meet the 1975 air quality standards. It must be emphasized that providing this additional service without any other changes in the transportation system might produce only a small fraction of the required increase in transit usage. Experiments with increases

in bus service on a smaller scale have been conducted in many cities. Without exception the result of such experiments has been that increases in the quantity of bus service (frequency and coverage) have produced additional usage, but at a rate much lower than the increase in quantity of service. For example, a 50% increase in quantity of service might be expected to produce only a 10% increase in ridership. There is no reason to expect that an expansion in the quantity of bus service on a regional basis would produce results different than those obtained in the smaller scale experiments.

Most travelers select a travel mode largely on the basis of travel time. A transit system that does not provide travel times competitive with the automobile will not be able to attract a significant fraction of travel. It appears that the only area in which conventional bus and rail systems offer travel time competitive with the automobile is that of travel to the core area. For example, over 60% of transit travel is to the Washington CBD while less than 30% of all travel is to this area. Factors of service frequency and cost only tend to reinforce this conclusion. The core area is the only place where sufficient concentrations of travel exist so that adequate service frequencies can be supplied to a large part of the region without undue cost. The core is also the only area in which the transit rider has a significant out of pocket cost advantage due to parking costs.

Notwithstanding these constraints on the potential effectiveness of a transit expansion program, such a program is still a necessary and desirable part of the air pollution control strategy.

However, certain practical problems exist with the rapid increase in bus operations proposed closely followed by a phase-down of bus operations as Metro opens. Three areas of concern exist:

- The provision of sufficient buses for the expansion.
- The need for additional bus garages.
- The need for additional drivers and service personnel.

WMATA is operating 1740 buses acquired from the four private bus companies that it took over. It is preparing to order 620 buses. A large bus purchase is a normal procedure for any newly formed publicly-owned transit agency, as usually the fleet inherited from private operators has a large proportion of overage buses in poor condition. As there have been no other public purchases of major systems this year, this bus order should have a minimal effect on manufacturing capacity and be delivered in a reasonable time. This is true, even though it represents approximately 21% of all the buses purchases in 1972 in the United States.

In the near future, however, the availability of buses may become very constrained. It is unclear at this time whether the capacity to manufacture buses will be able to keep up with the demand, over the next few years.

Table 10 shows the effects of a probable strategy for bus service expansion during the period from 1973 to 1979. It is based on expansion of all transit service (bus and Metro) to the level implied by the 1300 buses required in the 1975 proposal. It assumes that buses that would otherwise be retired up to 1975 would be stored for use in the 1975-1976 period.

From this table, it can be seen that the earliest date that the high level of transit service that is desired can not be attained until in 1976, and that this is true with or without Metro. The bus fleet returns to a stable condition with respect to purchases, retirements and age of buses when Metro is complete in 1979. With a generally satisfactory condition being reached by 1977 when the major Metro routes to Silver Spring and National Airport are opened. In order to reduce the maximum age of the bus fleet to thirteen years by 1979, thirty additional buses would be required in 1976 and 184 in 1977.

To operate a peak of 2900 buses in 1976, five additional garages would be required, for a total of thirteen garages. By 1979, four of these garages would become surplus, if bus operations are scaled down with the opening of Metro.

TABLE 10

BUS SERVICE EXPANSION - EFFECTS OF A PROBABLE STRATEGY

YEAR	BUSES ON HAND	PURCHASES	RETIREMENTS	TOTAL	REQUIRED FOR SERVICE	BUSES UNDER 15 YEARS OLD	OLDEST BUS IN SERVICE
1973	1740	620	0	2360	1850		13
1974	2360	250	0	2610	1950		13
1975	2610	250	0	2860	3050		27
1976	2860	220	180	2900	2900	2438	21
1977	2910	0	500	2400	2400	2233	16
1978	2410	0	200	2200	2400	2233	16
1978	2410	0	200	2200	2200	2130	16
1979	2210	0	200	2000	2000	2000	15

Also, in 1976, an additional 1750 drivers would be required. By 1979, only 400 additional drivers would be needed, again assuming bus service is scaled down with the opening of Metro. It is estimated, based on 1969 Metro employment estimates, that only about 400 of the drivers can be absorbed into the Metro operation. The remainder of the operating department employees of Metro as estimated in 1969 are supervisory personnel or station attendants and janitors. Employment in these latter categories is most likely substantially overstated, based on recent development in automation of these functions.

In order to be able to hire the 950 drivers who could not be absorbed into the permanent system, some type of early retirement plan will undoubtedly be necessary for current Metro employees to be used as employment is phased down in the 1977-1979 period.

While NVTC will not have direct operating responsibility of the expanded bus system, some part of the financing of the additional buses may be part of the NVTC program. It is anticipated that the bus fleet in the Virginia part of the region will grow from 550 buses at present to approximately 1050 at the 1976 peak, and then decline to approximately 750 by 1979, as much of the service provided by buses is taken over by Metro trains.

A more direct contribution to the bus service expansion program may be required in the location and establishment of additional bus garages. Of the three Metrobus garages in Virginia, two, the former WV&M garage in Arlington and the Royal Street garage in Alexandria, are not desirable as permanent facilities.

Two additional bus garages will be acquired for the 1976 peak service level. The two new garages, plus the former AB&W Four Mile Run garage will then be adequate for the post 1979 operations.

Locations for the new garages should be in the outer part of the area, preferably near the outer ends of the two Metro trunk lines. The southern garage should be relatively easy to locate, with the industrial area adjacent to the RF&P and the Southern Railway being a logical place. The northern garage is a more difficult location problem with no specific area being obviously suitable for this land use.

Add Nine New Busways

This proposal appears to be inadequate. Of the nine busways proposed, only three would be in Virginia. These are George Washington Parkway/Route 1 to Alexandria, Arlington Boulevard, and George Washington Parkway west to Chain Bridge Road. In addition, the Shirley Highway bus lanes would give a total of four exclusive bus facilities. At least four more radial arterials appear to warrant exclusive bus facilities. These are Lee Highway, Wilson Boulevard, Columbia Pike and a route between the Parkway and Shirley Highway, possibly Mount Vernon Avenue. In addition, it is likely that some portion of streets feeding into the radials should have exclusive bus facilities established. For example, portions of Duke Street, Leesburg Pike and Chain Bridge Road may be valuable for this purpose.

While is is not possible to be more specific about the location of exclusive bus facilities without further study, it is appropriate to give some suggestion about the design of such facilities.

Two types of design have proved to be effective in providing an adequate degree of separation between buses and general traffic. The most effective is a true contra-flow system. This system is of limited usefulness in Northern Virginia, as it requires the establishment of pairs of one-way streets. In this system buses operate in a direction opposite to the flow of general traffic on an otherwise one-way street. Turn interference is minimized without restrictions on turns. Positive traffic separation can be provided by means of a barrier. If bus stops are desired, the buses are in a curb lane so that no special provisions are required. However, since one-way streets are required, application seems to be limited to Alexandria, Rosslyn and Washington CBD.

The other effective system is the use of a center lane for the bus roadway. In this system the bus roadway separates the two directions of general traffic movement. Left turn conflicts are avoided by having a separate left turn signal cycle, where space is available for left turn lanes, or by having left turn traffic use a jughandle arrangement or go around a block. If bus stops are desired, they may be provided by the use of islands. This system requires a minimum of five usable lanes, except on limited access facilities with shoulders where a single lane in the minor

direction of movement is acceptable. It is most suited to use on divided highways, where bus movements in the peak direction and general traffic in the reverse direction can use one roadway, while peak direction general traffic can use the other roadway. On undivided highway, small barriers delimiting the bus lane are recommended in order to prevent turns across the roadway.

Either system can be adopted for both non-stop operation or operation with local stops. The contra-flow system is more suited to operation with stops, while the center lane system is more suited to non-stop operation. A mixture of express and local service can be provided under either system if a second bus lane can be made available in the bus stop areas. If there is insufficient room for a second lane, an alternate stop arrangement can be used to speed up local service in the exclusive lane area.

The commonly used practice of designating a curb lane for buses operating in the same direction as general traffic is definitely not recommended. This approach does not solve the problem of right turn conflicts as turning vehicles must be permitted in the bus lane. As positive separation can not be provided because of the need to permit right turns, the lane is often blocked by loading or other stopped vehicles.

It may be desirable in some cases to provide exclusive lanes in both directions of movement in order to provide for rapid return movements of empty buses and thus increase bus utilization. The contra-flow exclusive lanes are generally set up for two

direction movement. The center roadway exclusive lanes are most often designed as reversible lanes operating only in the peak direction of movement. Where space is available, the provision of two center lanes, one for each direction of bus movement, is recommended.

Expand Fringe Parking, Provide Bus Shelters and Adequate Public Information

The importance of an adequate fringe parking program can not be overstated in producing increased transit usage. To provide service to the large low density areas in the suburbs, it is either necessary to substantially expand the coverage and frequency of service, or to provide parking at outlying locations with express service to the core area. An expansion of bus service will not provide the high quality of service needed to attract the auto driver in large numbers, as overall speeds will still be low, as a result of extensive operations on local streets with frequent stops. In addition, to provide adequate coverage and frequency, average passenger loads will be quite low, and thus the service will be very expensive to provide. The provision of express service with adequate parking will produce both a more attractive service and a more economical operation.

Experience with rail lines, both rapid transit and commuter, in other cities has borne this out. Parking facilities have generally been quite successful, with the usual problem being that demand for parking has been underestimated. In contrast

feeder bus operations have been generally unsuccessful in suburban areas. Such services exist in suburban New York, Philadelphia and Boston and have received only minimal use.

Another important reason for providing parking areas at the end of express services or express zones is that there will be a strong desire for commuters to park at these locations. If parking areas are not provided or are of inadequate size, there will be substantial use made of curb space on adjacent local streets and of the parking provided by nearby commercial establishments for commuter parking, despite attempts to discourage this practice.

The location of these parking areas can not be determined without further study. However, Metro has planned 11,000 spaces at nine stations in Virginia. If these parking areas were developed in advance of Metro construction a substantial part of the parking demand would be satisfied. However, the ultimate requirement for fringe parking, based on experience in the New York and Philadelphia areas, is likely to be upwards of 30,000 spaces in Northern Virginia. The experience of the PATCO rail line in the New Jersey suburbs of Philadelphia is illuminating in this respect. This line provides parking for 7,500 cars, or one car for every 2.4 riders.

Bus shelters are desirable, but of themselves have not proved to have a substantial effect on ridership. With the provision of improved service, however, a shelter program could aid in making a deeper penetration into the ranks of the automobile users.

Improved information service is necessary to develop usage of new or expanded services. Information systems should be designed to acquaint potential users of such new or expanded services. With a fully developed system, information service is again desirable convenience, but is of substantial benefit mostly to the occasional user rather than the regular commuter.

Provide Subsidies to Maintain Fares at a Competitive Level in Comparison with Auto Operating Costs

Some level of operating subsidy is undoubtedly required, at least until Metro is complete, in order to provide the expanded transit services necessary to meet the 1975 air quality standards. The expanded services will most likely be less efficient than existing service, in terms of revenue/cost ratios. This is a natural result of having to provide a less efficient service to maximize its attractiveness to the user.

There will be some public pressure to reduce fares to a minimal level. While such action will undoubtedly increase transit usage and would be very popular (everyone likes to get something for nothing), it would do little to reduce automobile use. The increased transit usage would largely come from people who presently walk for short distances and by increased trip making among people (largely children) without access to an automobile.

Service quality, rather than cost, will be the major influence on the choice of mode of work trips. With proposed reductions in free parking at trip destinations, transit service at current or even slightly higher fare levels should be very competitive with the automobile provided service quality is improved.

It is also important to keep control of the level of subsidy in order to prevent the transit system from becoming an excessive drain on the resources of the region. This can occur in several ways. One is by allowing wage levels in the transit system to rise at a faster rate than wage levels for comparable jobs in other positions of the economy. Another is for inefficient operating and maintenance practices to become prevalent. A third way is to operate large amounts of lightly patronized service. This form of inefficiency is perhaps the most undesirable, since not only wages, but other resources are wasted. The operation of underutilized bus service will add to rather than reduce the pollution level.

Other Transit Improvements

Relatively little has been specified concerning the types of service to be provided in the transit expansion of radial express services to suburban areas. The possibility of additional service to non-core areas having high trip end densities was mentioned. The potential for service of this type has already been examined, and it appears unlikely that much non-core oriented service would be successful.

Only a very limited amount of service on the former AB&W routes penetrates into the CBD north of Pennsylvania Avenue. Thus a majority of the Virginia bus service does not have direct access to the commercial portions of the CBD, and serves only the Federal office areas. The former WV&M routes, operating mostly via the Key Bridge and K Street provide much better coverage of the CBD. However, it has been necessary to provide a separate Southwest Mall service on most of these routes during peak hours. It is suggested that it would be a substantial service improvement to increase the CBD coverage of the former AB&W routes. A possible means of doing this would be to through route former AB&W and WV&M services so that buses would operate, for example, inbound via the 14th Street Bridge and then serve routes that operate outbound via the Key Bridge.

The other area of expanded service would be service to high density portions of the core outside of the Washington CBD. Included would be expanded service to Crystal City, Rosslyn and the Pentagon. In most cases, this would require new peak hour routes. There is no service from the former AB&W territory to Rosslyn, although most former WV&M routes serve this area. Service to Crystal City is even more limited, being available only from the south along Lee Highway. In addition to routes from Virginia, it might be desirable to experiment with direct services to these areas from areas north of the Potomac with high demand potential. Such service has been impractical in the past due to the separation of operating rights among four private companies.

PARKING DISINCENTIVES

One part of the transportation control strategy is a series of parking disincentives. These include:

- Elimination of on-street, long term parking spaces available for commuters.
- Elimination, to the extent feasible, of provision of free parking to employees.
- Imposition of a two dollar surcharge on long term computer parking in core areas.
- Increasing the fines for and enforcement of parking violations and adoption of reciprocal fine payment agreements among local governments.
- Restriction of the provision of additional parking spaces through land use control measures.

The parking disincentive package is based on the conditions to be found in densely urbanized area. For such a package to be successful two conditions found only in densely developed areas must apply. One is that an adequate alternative to automobile travel must be available. In other words, an adequate transit system must exist before parking disincentives can be employed without causing substantial damage to the economy of the affected area. Such a transit system must provide an acceptable level of service from the areas where most employees reside.

The second condition is that parking must be a scarce resource subject to effective control. This condition implies that land must be scarce, and be of relatively high value. It is nearly impossible to create an artificial shortage, as is proposed in the parking disincentives program, when the natural condition is one of adequate supply. For example it is difficult to envision an effective ban on all day street parking in an area where the street space would have no other use.

As a result, it appears that the parking disincentive program would only be applicable in the core area, where these two conditions are met. Even in this area, it would have to be very carefully applied, so as to develop public acceptance and minimize evasion.

For example, a flat surcharge on long term parking may be easily evaded by use of two parking facilities at short term rates, thus leading to the great lunchtime car switch. A more effective control measure would be a requirement that all parking facilities charge a uniform hourly rate.

To insure that on-street space is not available to commuting workers, it will most likely be necessary to restrict parking completely, with towaway enforcement on all affected street segments during a sufficient portion of at least one peak (up to 10 A.M. or after 3 P.M.) so that meter feeding is not a practical means of evading the restriction.

The restriction of the provision of additional parking by means of land use controls can take several forms. One is the repeal of existing requirements for off-street parking as part of zoning and building codes. Restriction on the construction of new parking facilities where such facilities are a voluntary action of the developer would be difficult to apply without radically altering the location of development. Such action would tend to move much new development from the center to the periphery of the region, with decided undesirable consequence.

CAR POOLING

It has been proposed as part of the strategy for meeting the 1975 air quality standards that car pooling be encouraged by means of a locator service, promotional activities and preferential treatment of car pools.

As the Administrator of the EPA wistfully remarked (9):

> "The rate of occupancy of cars during peak load periods is down to 1.2 persons per vehicle and falling steadily, a condition that prompted a facetious critic to predict that by 1980 one of every three cars will be tooling along without a driver. Improbable, perhaps, but not much more absurd than the present practice of encasing one man in 5000 pounds of steel, adding 400 horses, and then making him creep along at five miles per hour breathing a combination of synergistic poisons."

There are, however, many problems to be overcome in significantly increasing the number of car pools. The ingredients for extensive car pooling have existed for many years, yet there is very little such activity. A member of a car pool can reduce his commuting costs by up to 75%, and in many cases eliminate the need for a second car, yet there are a negligible number of car pools.

One obstacle to the formation of car pools is the difference in policy among the members' employers with respect to actual, as opposed to nominal, working hours, holidays, and severe weather conditions.

A practical problem in any car pooling service is the potential for invasion of privacy. Thus, general circulation of employees home addresses should be avoided, and all contacts made through the work address.

Another potential problem concerns legal liability. Such an experiment should be conducted only after adequate legal advice as to the liability of the locator service, and of the members of the car pool. In particular, liability may be a significant problem if a charge is made for the locator service. The legal advisability of accepting non-drivers as members, particularly if a charge is collected from the non-driver by the driver members, must also be explored.

The primary unanswered question with regard to car pooling is the degree of public acceptance that it will achieve. The use of a car pool produces some inconvenience and reduces the flexibility of travel arrangements for the commuter. It also reduces the flexibility of work schedulings available to the employer. To date, the cost advantages of car pooling do not appear to have overcome these disadvantages. It is possible that the additional inducement of general public benefit, i.e. a sense of participation in a socially useful activity, may aid in making car pools more prevalent. Thus a skillful, extensive promotion effort, based on such public benefits could be a valuable aid to encouraging an increase in car pooling.

Another inducement of high potential is the use of preferential traffic treatment for car pools. Preferential treatment could take the form of reserved lanes for car pools, reduced parking charges for high-occupancy vehicles, or other incentives.

In spite of the problems inherent in car pool operations, the potential for reduction in congestion and pollution is significant and worthy of further study, preferential inducements and promotion. In particular car pooling should be encouraged in areas where they would be complementary rather than competitive with scheduled mass transit service.

NVTC's efforts to promote car pooling in Northern Virginia should be continued.

INSPECTION AND MAINTENANCE OF EMISSION RELATED COMPONENTS

It is generally recognized that mechanical malfunctions of automobiles, especially those affecting the induction system, ignition system, and valves, can lead to abnormally high exhaust emissions.

A program requiring the periodic inspection and maintenance of emission control devices, as well as other components that influence emission rates could significantly reduce air pollution from mobile sources. On a regional basis, emission reductions of ten percent for carbon monoxide and hydrocarbons appear reasonable (10).

However, the institutional obstacles are considerable. Although Virginia and the District of Columbia both have vehicle safety inspection regulations, they do not include an emission test. Maryland does not even have a safety inspection program and the state legislature has shown considerable reluctance to initiate one.

While impacts on the general public would be very significant, implementation costs would likely be moderate in comparison to other alternatives; therefore, the measure appears worthy of further consideration.

RETROFIT

One of the most controversial proposals has been the required retrofitting of pre-1975 automobiles and light duty trucks with devices to reduce their emission of harmful pollutants. Specifically:

- Model years 1968-1974 registered in the NCI Region would be required to install an oxidizing catalytic converter, which reduces emissions by at least 50 percent.
- Pre-1968 model year vehicles registered in the region would be required to install a mechanical device and/or engine modifications which reduce emissions by 25 percent.

Although there is considerable uncertainty over the effectiveness of various retrofit devices, it appears that the current state of the art technology would permit reductions of 20 percent and 60 percent for hydrocarbons and carbon monoxide, respectively, for pre-1972 vehicles. For model years 1972-1974, reductions in the 60 to 70 percent range appear likely for both pollutants. Reductions of nearly 50 percent in nitrogen oxide emissions are attainable for all model years (11, 12).

Words of caution are appropriate in evaluating the potential effectiveness of retrofit as indicated by these figures. First, these estimates do not include the possibility of deterioration with age, nor do they include the effects of uncontrolled heavy duty vehicles, and vehicles from outside the region, all of which would moderate the effectiveness of retrofit, when applied

on a regional scale. Thus, reductions on a regional scale of 20 percent in carbon monoxide and hydrocarbons, and 15 percent in nitrogen oxides are more realistic. Another important consideration of a retrofit program is its relatively short term effectiveness. By 1985 the contribution of pre-1975 vehicles to the emissions total will be very small, rendering the effectiveness of retrofit programs as rather minor in the long run.

The unit cost of implementing such a program would likely be on the order of $150-200. While this appears to be a modest price in view of the emission reductions achieved, its cost-effectiveness when compared to other control strategies is by no means self-evident.

While retrofit definitely is worthy of further study, it would seem to be premature to recommend its wide-scale application without a cost-effectiveness evaluation.

TRUCK DELIVERIES

A restriction was initially proposed on the operation of heavy duty gasoline powered trucks during daylight hours. This restriction was proposed to be applied only during 1975 and to be dropped as soon as the effect of longer term pollution control measures was felt in 1976.

The ammended Transportation Control Plan dropped this restriction and we support this change. The nature of such a ban, being imposed on gasoline powered but not diesel powered vehicles, would impact some truck operators severely and others not at all.

Operators of heavy trucks using gasoline engines are mostly the smaller firms. The large fleet operator, with ample access to capital, his own maintenance base, and his own fueling facilities can take advantage of the greater operating economies of the diesel engine. The smaller operator has to rely on outside maintenance and has to purchase fuel at service stations. Such facilities are largely lacking for diesel powered vehicles in the core areas of the region. Thus the ban on daylight use of heavy gasoline powered trucks would fall most heavily on the small operator.1/

It would be extremely difficult to impose such a restriction upon certain classes of truck movement. These include deliveries to residences such as furniture and appliances, construction and maintenance services and deliveries to and from small merchants. The large operation, for example, a supermarket chain, is set up with shipping and receiving personnel who could as easily work nights as days. The small store usually depends upon the owner or manager to supervise receipts of merchandise and thus would have difficulty in accepting night deliveries.

1/ Although statistical data to verify this were unavailable, Louis J. Kibbee, Director of Engineering of the American Trucking Association affirmed this conclusion.

Construction sites present the most severe problem. These generally depend upon a constant flow of material, as storage on the site is extremely limited. A night delivery policy would force many construction operations to go to night shift operations, with resultant added costs, decreased safety and greater disturbance of nearby residences.

It appears that it would be necessary to provide so many exceptions to the night delivery rule that its enforcement would become extremely difficult and its effect minimal. As a result, if some restriction on gasoline powered truck use is found to be necessary, it should be designed so as to encourage the replacement of gasoline powered trucks with diesel trucks by means of positive incentives, coupled with a restriction. Also, a more limited restriction, covering only the 7-9 A.M. and 4-6 P.M. peak hours would perhaps produce adequate results with less disruption of economic activity.

GASOLINE RATIONING

While it is not the function of this report to discourse on the sociology of the American legal system and its relationship to the general public, it must be pointed out that regulation without popular acceptance is almost certain to fail. Americans have been noted for a far greater willingness to enact laws and regulations than for a willingness to obey them. The various attempts at the control of alcoholic beverages and gambling are

graphic examples of this tendency. Another tendency is for a large body of the public to exert every effort to turn laws and regulations to their own advantage and profit in ways largely unanticipated by the framers of such laws and regulations.

Gasoline rationing, as a regional strategy, lends itself to ready evasion and profitable illegal activity. Its effect would be only to penalize the law abiding citizen while leaving the less ethical portion of the population to behave largely unhindered.

If gasoline rationing is imposed on a regional basis, there will be locations immediately outside the region, where gasoline can be purchased without restriction. A typical moderate size automobile can be equipped with a 50 to 75 gallon auxiliary tank mounted in the trunk in a matter of hours. Such a tank would provide vehicles so equipped with an unrefueled range of at least 1000 miles. This would be sufficient for a least three weeks normal driving plus a refueling trip.

Other more subtle forms of evasion are available, including the use of aviation and marine gasoline in automobiles, bootlegging from disguised tank trucks, and even the mixture of gasoline extenders from readily available chemicals, such as methanol and kerosene.

OTHER POSSIBLE SHORT TERM ACTIONS

Propulsion Changes

Several other forms of propulsion available for highway vehicles produce less pollution than the gasoline engine. These include internal combustion engines powered by liquified petroleum gas or natural gas, diesel engines, and storage batteries.

The gaseous fuels require the least change in engine technology. However, problems of storage and handling are severe and maintenance experience with such vehicles has not been satisfactory. The largest user of such vehicles has been the Chicago Transit Authority. It purchased 1500 buses equipped for use with propane fuel between 1950 and 1959, and an additional 150 such buses in 1963. While many of these vehicles remain in service, all buses purchased by the Authority since 1963 have been diesel powered.

The diesel engine is well developed for large highway vehicles, although smaller, automotive size engines are available only from foreign sources. Much improvement in the pollution characterisitics of the diesel engine has been accomplished in recent years by means of improved injector design and intake air flow. Also, the catalytic converter for diesel engine exhaust systems has been thoroughly tested and is in regular use in underground mining and tunnel construction equipment. Perhaps the most impressive example of nearly pollution free internal combustion powered vehicle is the special diesel locomotives used for maintenance of the New York subways.

Battery powered vehicles have been available for many years. While their performance is limited, it is adequate for many applications where high speed and long range are unnecessary.

All of the alternative propulsion systems described above suffer from requiring higher capital expenditures than do gasoline powered vehicles. In addition, all lack the network of publicly available service and maintenance establishments. As a result, it would be difficult to get individual owners of vehicles to convert to these power sources.

It is much more reasonable to expect large fleet operators to convert their vehicles to alternative power sources. These fleets are generally serviced by the owner at a specialized facility. Capital is generally much less of a problem.

The first step would be to encourage governmental bodies to convert their vehicle fleets. Currently transit buses are almost entirely diesel powered, but most service vehicles, school buses and governmentally owned fleet automobiles are gasoline powered.

A next step would be to encourage private owners of large fleets to convert to less polluting power sources. Tax incentives, such as reduced registration fees and reduced motor fuel taxes could be used to encourage such conversions. Taxi operators, utility service vehicles, and large delivery fleets such as bakeries and dairies are likely condidates for such efforts.

Computerized Traffic Signal System

The computerized traffic signal study currently underway in Northern Virginia can be expected to produce some short-term relief in air pollution emissions. A general improvement in traffic flow characteristics will mean less time spent idling and lower overall emission levels. The possibilities for bus priority systems could be particularly beneficial. Nonetheless, the long-term effect of improved traffic flow could well be the encouragement of the use of the private automobile.

Therefore, in terms of air quality, computerized signal systems should be viewed as a short-term benefit, but potentially a long-term disbenefit.

Other Auto Use Disincentives

Some other disincentives to automobile use that could be considered are:

Vehicle weight and engine size taxes or fees

Age related taxes or fees

Restrictions on roadway capacity

Tolls

Weight and engine size taxes or fees would encourage the purchase of smaller automobiles, thus conserving resources and reducing pollution. Such taxes could be in the form of variable registration fees or sales taxes. An increase in the motor fuel tax would have a similar effect, and would apply to existing vehicles as well as new ones.

Age related taxes would be designed to encourage the retirement of older vehicles. These could be in the form of registration fees.

Restrictions on roadway capacity for automobile use could be justified on the basis of alternative uses of the street space, such as additional bus lanes or pedestrian areas.

Tolls do not appear to be a practical alternative, as their effect would be to divert traffic from the toll facility to parallel free routes. There is no isolated segment of this region that could be ringed with toll facilities, as for example, Manhattan Island in the New York region. Tolls on the Potomac River bridges might have some effect in reducing auto use, but such tolls would tend to divide the region into less interdependent sectors, and would work to the disadvantage of the Virginia sector.

Commuter Rail Service

Suggestions have been made to revive commuter rail service from Springfield and Alexandria to Washington. Based on the experience in Maryland, such a line would probably attract only about 300 passengers per day. Patronage could be increased by adding stops at Crystal City and L'Enfant PLaza. However, such stations would require extensive rail facility relocation. In any event, it is impractical to consider rail service for only a four or five year period until Metro is open. New rolling stock would be extremely costly for such a short term operation. An economy service with used rolling stock could be developed, but operating costs would be high, and as pointed out, patronage would be low without expensive station work.

London Transport Executive Plan

In a study performed under contract to the U.S. Department of Transportation's Office of Environment and Urban Systems, the London Transport Executive called for three measures to reduce automotive pollution in Washington (13):

- the development of auto free zones
- improvements in transit marketing
- the development of parking policies.

The potential for parking policies has previously been discussed. Auto-free zones can be effective in reducing pollution at the micro-level, however, careful planning of traffic circulation is mandatory to forestall congestion in adjacent areas. Transit marketing could have a significant impact and should be considered further.

AN ACTION PLAN FOR NORTHERN VIRGINIA - A PROGRAM FOR NVTC

There is an important role to be filled as the planning and implementation agency for transportation control strategies in Northern Virginia. The Northern Virginia Transportation Commission (NVTC), responsible for the transportation interests of its member jurisdictions, is the agency best suited to assume this role. The remainder of this section presents recommendations both of a general and specific nature to assist NVTC in adopting a posture toward the implementation of transportation control strategies in Northern Virginia.

SUMMARY OF RECOMMENDATIONS

The opportunity exists for NVTC to assume a leadership role in the formulation and implementation of transportation policies which can improve the ambient air quality in the National Capital Interstate Region.

NVTC, which will be vitally concerned with the implementation of transportation control strategies, must be a forceful party to their development.

NVTC should do all in its powers to ensure that transportation control strategies are:

- The results of comprehensive study.
- Flexible.
- Subject to periodic review.

More specifically, it is recommended that NVTC initiate the following actions to assume its leadership role in the development of environmentally sound transportation programs:

- Establish a sub-committee of the Commissioners to be responsible for environmental aspects of NVTC programs.
- Establish a staff function in environmental planning either in-house or through the use of a private consultant, to serve the needs of the sub-committee of the Commission. Using this new staff resource, interface with other public agencies and private interest groups for the promotion of clean air objectives in Northern Virginia.
- Investigate funding sources for the planning, design, and operation of transportation improvement programs to improve air quality.
- Sponsor a cost-effectiveness study of alternative control strategies, explicitly identifying costs to the agency and to the general public.
- Establish positions on elements of the proposed control strategy, based on the findings of the cost-effectiveness study.
- Sponsor transit improvement studies of busway facilities.
- Sponsor a study of the parking needs of Metro.

GENERAL RECOMMENDATIONS

The Northern Virginia Transportation Commission should:

- Promote the studied development of transportation control strategies, to ensure the rationality of the implemented plan.
- Insist on the adoption of a flexible plan, to allow for short and long term modifications as dictated by future considerations.
- See that the plan is reviewed periodically to ensure its responsiveness to conditions as they develop.

Study

It is imperative that earnest thought and study be given to the selection of an overall strategy to reduce motor vehicle emissions to an acceptable level. In a viable strategy, the societal benefits must at least equal the costs that are added to the already large transportation costs of the public as a whole. Furthermore, the selected strategy should have the best return for the costs incurred. A hastily concocted plan to reduce emissions might be shown later to be less effective in conserving tax dollars than a plan developed from methodical review of the alternatives. Such a disservice to the public would have understandable repercussions. The control strategy adopted must be the product of a thorough analysis.

From a pragmatic viewpoint, it may be necessary for NVTC to respond to the programs of the State Air Pollution Control Board. However, it is incumbent upon NVTC to ensure that the tax dollars of Northern Virginia's citizens be spent in the most effective manner.

Flexibility

Further, the control strategy must be flexible. The air pollution control authority should have plans available to permit it to raise or lower the control measures, both in short term and long term action. Variations in weather and wind can lead to stagnant air conditions that would require emergency responses. The authority and the ability to respond are needed in a control program. Short term responses are needed for highway construction and road repair. Long term responses are needed to meet trends in road use, in population growth, and in the design of vehicles and their fuels.

Another important justification for the flexibility of the plan is the changing requirements implied by continuing modification and interpretation of the Clean Air Act of 1970. Notable in this regard are the recent relaxations of the new car emission standards and the non-degredation rulings of the Federal courts. Neither of these factors were considered in the development of the proposed implementation plan and both impose serious additional constraints which are not at all reflected in the plan developed to date.

The relaxation of the auto emission standards implies that even more stringent controls will be required if ambient air quality standards are to be attained.

The non-degredation ruling makes it doubtful that existing air pollution hotspots can be dealt with by distributing the emissions over a greater area.

Therefore, the need for flexibility can perhaps best be argued simply by pointing out that the plan which has been discussed throughout this review is already outdated due to recent EPA and Federal court actions.

Review

In addition, the control strategy to be promulgated must be reviewed on a continual basis. The rapid, often unexpected, growth of the suburbs of Northern Virginia is evidence of this need for continual review. A permanent body is needed for the review process. Opportunities to adopt more efficient and less polluting forms of transportation could be lost if a static law were to force Northern Virginia into a straitjacket. Continued review by technical experts is mandatory.

SPECIFIC RECOMMENDATIONS FOR NVTC

There are a number of specific actions which NVTC can take to promote the rational attainment of better air quality in the National Capital Interstate Region.

Establish Sub-Committee

NVTC should establish a sub-committee of the Commissioners charged with the responsibility of ensuring that proper consideration is given to the environmental impacts of NVTC programs. The sub-committee's concern should include not only air quality, but also noise pollution and any other significant environmental impacts of transportation plans.

Establish a Complementary Staff Function

NVTC should establish a supporting staff capability in the area of environmental planning, either in its in-house staff or through the use of a private consultant. This person should be responsible for the following continuing activities:

- Representing NVTC interests in the continuing scenario of control strategy development.
- Interfacing with other public agencies (e.g. WMATA, COG, EPA, Virginia's State Air Pollution Control Board) and private interest groups (e.g. Arlington Coalition on Transportation, Transportation Priorities Alliance, etc.) for the promotion of rational clean air policies in Northern Virginia.

- Interpreting the impact of clean air programs on NVTC's short and long term financial planning.
- Acting as a contract officer to supervise consultant activities supplementing NVTC's planning efforts.
- Keeping abreast of latest developments in EPA requirements, judicial rulings, and regional development characteristics and interpreting their impact on the proposed air quality plan and other environmental conditions.

Specific tasks already awaiting this person include assessments of the impacts of:

- The one-year extension in new car emission standards.
- The non-degredation rulings.
- Industry-imposed gasoline rationing on regional trip-making characteristics.
- The recent EPA rejection of proposed control strategies.

Investigate Funding Sources

NVTC should investigate funding sources for transportation planning and programs designed to abet the air pollution problem. In particular, NVTC should seek support for the staff function previously recommended and for studies called for in the following sections. The willingness of various state agencies, as well as UMTA, EPA and other Federal agencies to participate in the funding of these programs should be fully explored.

A Cost-Effectiveness Study

NVTC should sponsor a study of the cost-effectiveness of alternative control strategies as a guide to the rational use of its resources to yield the highest payoff at the lowest cost. Transportation control strategies proposed in various cities have included a wide range of measures such as:

- Traffic operations improvements
- Staggered work hours
- Improved transit service
- Transit fare reductions
- Parking bans
- Auto-free zones
- Gasoline rationing
- Increased parking rates
- Road-user taxes
- Gasoline taxes
- Car pool incentives
- Retrofit
- Emission control inspection
- Bicycle pathways
- Restrictions on truck use
- Restrictions on taxi use.

While numerous control measures have been advocated on the basis of their ability to reduce vehicular travel, the selection of appropriate measures has heretofore failed to adequately account for the cost effectiveness of vying strategies. Characteristically, measures have been recommended based on large emission reductions with little regard for the cost of achieving those reductions. The issue is well summarized by Fisher and Fisher (14):

> A naive but not uncommmon objective for community policies on automotive and other air pollution would be to eliminate emissions and ensure that our air is "clean". In an absolute sense such an objective is technically impossible, but even more sophisticated objectives such as to reduce emissions by x%, or to prevent any further increase in pollution levels, are logically deficient as no regard is given to the costs of achieving such an objective. The achievement of any objective will involve some costs, if only of opportunities foregone, and it is important that the community and the Governments weigh the benefits of air pollution abatement or control policies against the cost of implementing the policy.

The need for economic considerations in the strategy selection process is critical. Only by comparing costs and effects can rational policy decisions be made.

The study proposed would permit an analysis of the cost-effectiveness of alternatives for reducing air pollutant emissions. It would explicitly identify the cost and effects of each alternative.

The proposed study would start with a set of strategies for reducing mobile source emissions. For each strategy an estimate would be made of the emission reduction and the present cost or benefit of implementing the strategy. The present cost or benefit should include capital and operating costs, benefits derived from savings and accident reductions, and any other factors which can be quantified in economic terms. Costs and benefits occurring over a future time period should all be discounted to present value, using appropriate time periods and discount rates.

It is important in the performance of the study that costs and benefits be disaggregated in terms of incidence group. The perception of costs and benefits is vastly different for a public agency and for the user. A cost to the user is often a revenue to the agency. Conversely, a cost to the agency frequently yields a benefit to the user. The results of this estimation procedure can be displayed graphically as illustrated in the following figure, in which each point represents a particular alternative, from a given point of view (e.g. the agency):

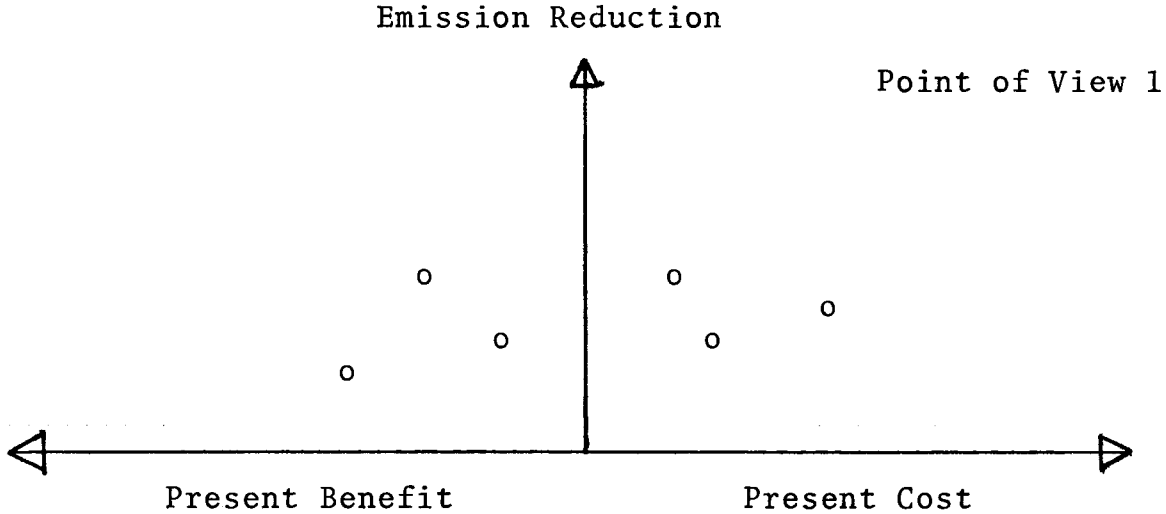

Figure 1. Sample Representation of Cost and Effectiveness

Although a classical cost-effectiveness analysis would require only a cost axis and a measure of effectiveness axis, the evaluation of pollution reduction measures requires a benefit axis because there are alternatives which produce net benefits, aside from their emission reduction potential. Displaying the strategies in this format clarifies the unit costs and makes it straightforward to select the alternatives for implementation in order of decreasing payoffs per unit cost.

It is possible to link the alternatives in vector fashion, in terms of optimal order of implementation, as illustrated:

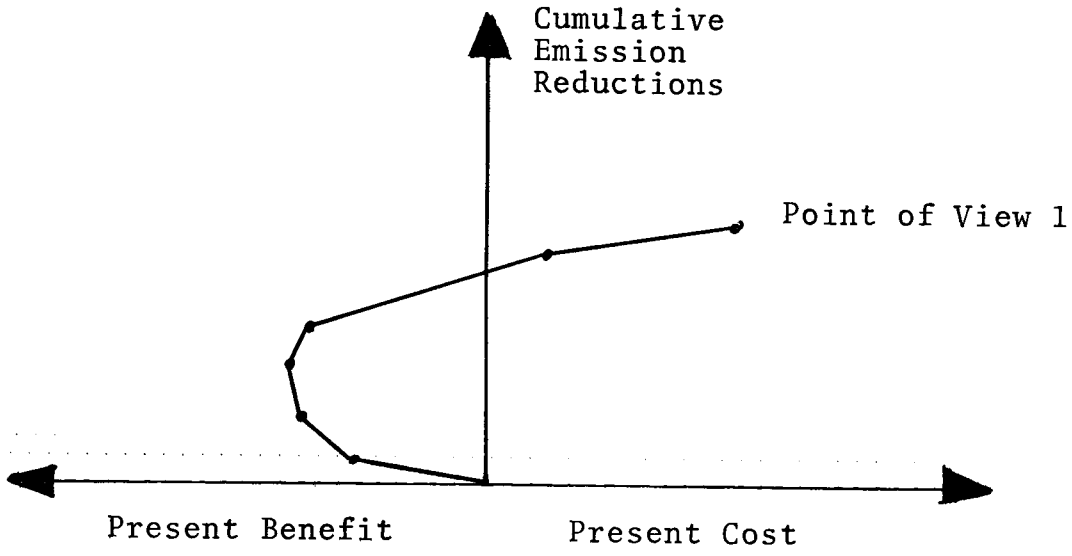

Figure 2: Sample Representation of Cumulative Costs and Effectiveness

Linking the alternatives in this manner indicates the relative desirability (from a cost-effectiveness view) of pursuing a particular strategy. It defines the order in which strategies should be selected to achieve the maximum emission reduction at the least cost.

The methodology should be viewed not as a panacea for decision-makers, but rather as a tool to be used in conjunction with other policy requirements in order to assist the decision-makers in arriving at rational actions. It is recognized that there are significant constraints (e.g. institutional and political feasibility) which are not reflected in the proposed cost-effectiveness approach. Nonetheless the desirability of a cost-effectiveness index in the decision-making process is clear.

It is estimated that the costs and effects of alternatives suitable for use as a decision tool by NVTC could be made from secondary data sources, with a commitment of six (6) man-months. The study should be started as soon as possible, as its results will form a key element of the policies to be adopted by NVTC. Appropriate funding sources would include routine NVTC budgets, the U.S. Environmental Protection Agency, and the Office of the Secretary of Transportation.

Establish NVTC Positions

Based on the findings of the cost-effectiveness study, NVTC should adopt a posture with respect to each element of the proposed transportation control strategies. It should further direct its resources into those strategies which are shown to be most cost-effective.

Study of Busways

While more study and analysis is recommended before a transportation control policy is implemented, certain parts of such a program should be begun at once. Whatever strategy is finally adopted with a particular mix of measures, increased use of the bus is certain to be a part of the program. Hence, detailed studies should begin immediately to design new and improved bus services. As mentioned in the section on mass transit, we recommend the use of several exclusive bus lanes in Northern Virginia. The proposed plan calls for four busways. We feel this is inadequate and would recommend seven or eight busways. It is therefore recommended that NVTC sponsor a two-phase study of busways in Northern Virginia. The first phase would be a feasibility study, examining perhaps a dozen potential locations for busway facilities and recommending seven or eight for detailed planning. Phase two would consist of a detailed design of the facilities recommended in phase one. It is estimated that the phase one effort would require nine (9) man-months, while the phase two effort would require an estimated twenty-four (24) man-months. The likely funding source for these programs would be the UMTA Technical Studies Program.

Parking Needs of Metro

The Metro parking program appears to be very inadequate based on experience in similar areas. Metro is planning to provide 11,000 parking spaces at eight of its fifteen non-core stations in Northern Virginia. These stations are expected to generate some 240,000 users by 1990. Thus there will be parking for only 4.4% of the users. By contrast, the PATCO Lindenwold Line, in Southern New Jersey provides parking for 40% of the users. Experiments with the provision of parking and feeder bus service in the New York Metropolitan area have indicated that parking is a far more effective means of attracting auto users than are feeder bus services, particularly in suburban areas similar to Northern Virginia.

Another problem that could be severe if adequate parking is not provided is the congestion of streets near the Metro stations with parked cars of Metro riders. Experience at several New Jersey suburban rail stations has been that it is almost impossible to prevent such street parking if adequate off-street space is not available. In such situations, a high level of complaints follow any enforcement campaign. Thus it is recommended that an additional review be made of the parking requirements at Metro stations and that planning for expanded parking be undertaken. It is suggested that this planning include the possibility of providing parking areas at additional stations.

A study to assess the parking needs of Metro would require an estimated twelve (12) man-months. The likely funding source is the UMTA Technical Studies Program.

MANPOWER REQUIREMENTS

Program Element	Manpower Commitment
Establish Sub-Committee	Additional Commissioner Time
Complementary Staff Function	20 Hours/Week - Continuous
Investigate Funding Sources	Routine
A Cost-Effectiveness Study	6 Man-Months
Study of Busways	33 Man-Months
Parking Needs Study	12 Man-Months

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