TRANSPORTATION CONTROL MEASURES

An analysis of potential Transportation Control Measures for implementation in the Pennsylvania portion of the DVRPC region

May 1994

Delaware Valley Regional Planning Commission

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The Bourse Building - 8th Floor
111 S. Independence Mall East
Philadelphia, Pennsylvania 19106-2515

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Created in 1965, the Delaware Valley Regional Planning Commission (DVRPC) is an interstate, intercounty and intercity agency which provides continuing, comprehensive and coordinated planning for the orderly growth and development of the Delaware Valley region. The region includes Bucks, Chester, Delaware, and Montgomery counties as well as the City of Philadelphia in Pennsylvania and Burlington, Camden, Gloucester, and Mercer counties in New Jersey. The Commission is an advisory agency which divides its planning and service functions among the Office of the Executive Director, the Office of Public Affairs, and three line Divisions: Transportation Planning, Regional Information Services Center, which includes the Office of Regional Planning, and Finance and Administration. DVRPC's mission for the 1990s is to emphasize technical assistance and services and to conduct high priority studies for member state and local governments, while determining and meeting the needs of the private sector.

The DVRPC logo is adapted from the official seal of the Commission and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River flowing through it. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey. The logo combines these elements to depict the areas served by DVRPC.

DELAWARE VALLEY REGIONAL PLANNING COMMISSION

Publication Abstract

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TRANSPORTATION CONTROL MEASURES *An analysis of potential Transportation Control Measures for implementation in the Pennsylvania portion of the DVRPC region*	**Publication No.** 94012

Geographic Area Covered:

The Pennsylvania portion of the DVRPC region including Bucks, Chester, Delaware, Montgomery, and Philadelphia Counties

Key Words:

Clean Air Act Amendments of 1990, Transportation Control Measures, State Implementation Plan, test scenarios, Travel Demand Management Evaluation Model, Post-Processor for Air Quality, sketch planning techniques, emissions reduction, cost-effectiveness

ABSTRACT

This report presents the results of COMSIS' evaluation of thirty-seven Transportation Control Measures for implementation in the Pennsylvania portion of the DVRPC region. COMSIS used its own Travel Demand Management Evaluation Model, DVRPC's regional travel simulation model, MOBILE5a, Garmen Associates' Post-Processor for Air Quality, and sketch planning techniques to estimate the changes in travel (work travel, total travel, and VMT) and emissions (VOCs, CO, and NO_x) that would result if each measure were implemented. The costs and cost-effectiveness of implementing and operating each measure were also calculated.

For More Information Contact:

Delaware Valley Regional Planning Commission
Regional Information Services Center
The Bourse Building - 8th Floor
111 S. Independence Mall East
Philadelphia Pa. 19106-2515
(215) 592-1800

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INTRODUCTION

The Clean Air Act Amendments of 1990 require severe and above ozone nonattainment areas, such as the Philadelphia Region, to implement Transportation Control Measures (TCMs) to help reduce emissions from highway vehicles. In anticipation of including TCMs in upcoming State Implementation Plan (SIP) revisions, the Pennsylvania Department of Transportation retained COMSIS, a transportation consultant, to assist DVRPC in specifying potential TCMs and analyzing their effects on trip making, travel, and emissions. This report presents the results of COMSIS' analysis.

Thirty-seven potential TCMs, or *test scenarios*, were evaluated. The test scenarios are not actual projects, but rather representative applications of the various broad categories of TCMs. Since this analysis was being performed in preparation for Pennsylvania's SIP revisions, the scenarios were limited to the Pennsylvania portion of the DVRPC region. In addition, the analysis focuses primarily on projects that could provide a substantial portion of their emissions reduction benefits by 1996 — the year by which a 15% reduction in VOCs must be achieved.

COMSIS used its own Travel Demand Management Evaluation Model, DVRPC's regional travel simulation model, MOBILE5a, Garmen Associates' Post-Processor for Air Quality, sketch planning techniques, and various combinations of these methods to estimate the changes in travel (work travel, total travel, and VMT) and emissions (VOCs, CO, and NO_x) that would result in the five-county Pennsylvania region if each measure were implemented. The costs and cost-effectiveness of implementing and operating each measure were also calculated.

RESULTS AND CONCLUSIONS

Table 1 (Page 3) lists all of the scenarios that were tested and ranks them according to their annual emissions reduction. Their corresponding cost-effectiveness ranking is also provided. The analysis clearly reveals that certain types of strategies are more effective than others. Of the 37 strategies tested, the pricing measures (gas tax, VMT tax, regional parking charge, and parking tax in the CBD) show the most emissions reduction potential and are the most cost-effective (in fact, these strategies are revenue-producing). Also exhibiting high emissions reduction potential and cost-effectiveness are the ETRP and related strategies, educational efforts, and low-emission vehicles/fuels. Transit capital improvements, such as rail service extensions and restorations, have the lowest emission reduction potential and the lowest near-term cost-effectiveness. The analysis highlights various types of strategies

that could be classified as moderately effective, including bicycle improvements, advanced signal system improvements, ramp metering, limits on new parking facilities, and removing pre-1980 vehicles. Figure 1 illustrates the range of cost-effectiveness for the different types of strategies.

The ease of implementing the different emission reduction strategies will vary greatly. Strategies that require state initiation or legislative action, or that will spur public opposition, will be the most time-consuming and difficult to implement. Pricing strategies and technological measures, which are the most effective strategies, along with many strategies that require behavioral change, fall into this category. Projects that can be carried out at the regional level, such as transit improvements, bicycle improvements, selected measures to reduce traffic congestion and delay, financial support for ridesharing and other transportation demand management programs, and educational programs, will be much easier to implement.

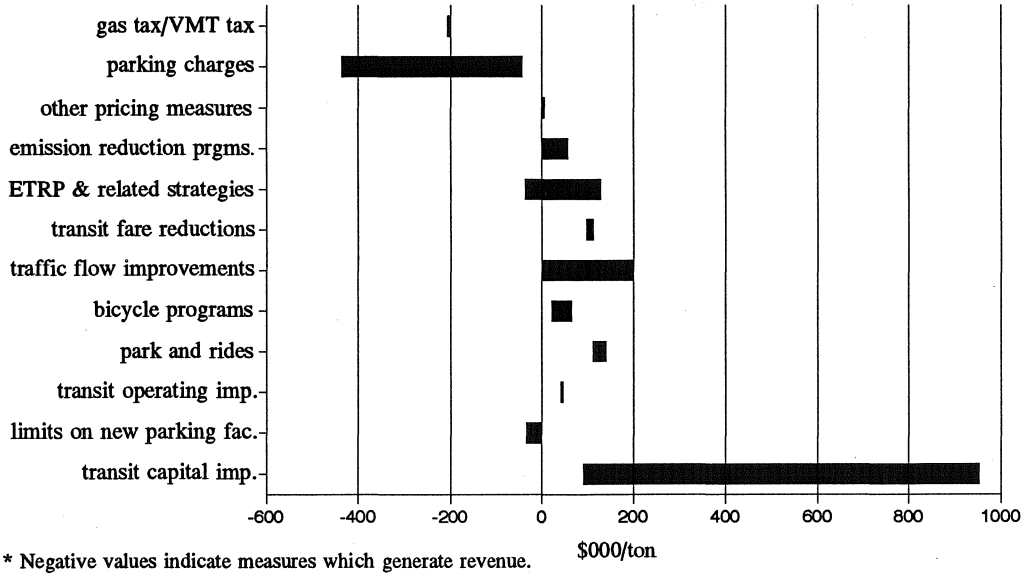
DVRPC's role in project implementation will depend on strategy type. For strategies that are the State's responsibility, DVRPC's role may be limited to adopting a resolution of endorsement or support. For strategies that can be initiated at the regional level, DVRPC will be actively involved in transforming the test scenarios into actual projects, building consensus for the projects, and carrying them through the planning and programming process.

The figures presented in this report are only *estimates*; they should not be considered precise *measurements*. The analytical methods used in the study are not perfect and assumptions must be made frequently throughout the process. The estimates should be used to gauge the relative effectiveness of the different types of strategies and serve as an indicator of the emissions reduction potential for a class of TCMs. In addition, when comparing the effectiveness of the measures, it is important to be familiar with the project definition and scope that is provided in Section 2. The test scenarios differ in scale and are not always directly comparable. Some of the sample applications are applied region-wide and have greater potential for impact than do those which are more localized.

The TCM analysis provides a valuable base of information with which to form policy recommendations that will guide the content of future SIPs, Transportation Improvement Programs, Transportation Plans, and Work Programs. □

Figure 1

Ranges of Cost-Effectiveness



* Negative values indicate measures which generate revenue.

Table 1
Test Scenarios Ranked in Order of Emissions Reduction with Corresponding Cost-Effectiveness Ranking

ID #	Test Scenario	Rank of TCMs Sorted by Total Emissions Reduction	Rank of TCMs Based on Cost-Effectiveness	Change in Annual Total Emissions (tons) (a)
35	$.84 per gallon gas tax	1	2	-3486
36	$.04 per vehicle mile travelled tax	2	3	-3486
31	Removal of 50% of pre-1980 vehicles	3	21	-1863
24	$3 parking surcharge paid by all regional employees	4	1	-1100
17	Implementation of PA ETRP (all APO targets reached)	5	5	-998
32	Reduction in cold starts	6	9	-402
33	California cars	7	13	-341
20	Telecommuting	8	15	-317
25	$3 parking tax in Philadelphia CBD	9	4	-301
11	50% system-wide transit fare reduction	10	27	-289
5	Enforce 55 mph speed limit on PA Turnpike	11	14	-201
30	Bike captures 5% of non-work trips ≤ 5 miles	12	17	-169
18	Comprehensive regional ridesharing program	13	12	-156
21	Compressed work weeks (9/80)	14	7	-119
10	20% system-wide transit fare reduction	15	24	-115
34	Feebate on new car purchase	16	11	-114
4	Ramp metering	17	10	-112
28	Bike captures 5% of auto work trips ≤ 5 miles	18	20	-98
1	Advanced signal system on 4-lane arterials	19	16	-77
27	Expand parking at rail stations	20	28	-75
19	$25 TransitChek	21	31	-65
9	10% system-wide transit fare reduction	22	25	-56
15	Improve City Transit Division service	23	18	-46
12	Improve suburban bus service	24	19	-42

ID #	Test Scenario	Rank of TCMs Sorted by Total Emissions Reduction	Rank of TCMs Based on Cost-Effectiveness	Change in Annual Total Emissions (tons) (a)
23	Limit parking facilities at new suburban employment sites	25	6	-41
3	CIMS on interstate system	26	33	-39
26	New park and ride lots along highways	27	32	-35
2	Advanced signal system in Philadelphia CBD	28	30	-16
8	Improvement to express service on regional rail lines	29	26	-11
16	Philadelphia to Harrisburg rail service improvements	30	34	-10
13	Apply "Transit-First" in Philadelphia CBD	31	29	-9
6	Restoration of service on regional rail lines	32	35	-8
14	Reuse surplus LRVs on bus routes in Philadelphia	33	23	-4
37	Facility pricing (double turnpike tolls during peak periods)	34	8	-2
29	Bike captures 5% of access trips $\leq$ 5 miles for work purposes to 14 rail stations	35	22	-1
7	Extension of Route 66 trackless trolley	36	36	-1
22	Prohibit new parking facilities in Center City	37	37	Negligible Impact

(a) Total Emissions = VOC + NO_x

DELAWARE VALLEY
REGIONAL PLANNING COMMISSION

This report was written by the Delaware Valley Regional Planning Commission under contract to the Pennsylvania Department of Transportation.

May 1994

1 INTRODUCTION

In anticipation of including Transportation Control Measures (TCMs) in Pennsylvania's 15% State Implementation Plan (SIP) revision due on November 15, 1993, the Pennsylvania Department of Transportation retained COMSIS, a transportation consultant, to assist DVRPC in specifying potential TCMs and analyzing their effects on trip making, travel, and emissions. This report presents the results of COMSIS' analysis.

The potential TCMs, or *test scenarios*, that were evaluated were suggested by a series of *white papers* completed by DVRPC in 1992. The white papers examined the broad TCM categories specifically listed in the 1990 Clean Air Act Amendments and considered their applicability to the Delaware Valley region. To evaluate the potential of the measures for reducing emissions, it was necessary to represent each TCM category by one or more test scenarios. The test scenarios enable the desired TCM application to be described in enough detail to make calculating its travel and emissions impacts possible.

The list of scenarios that developed from the white papers was supplemented and refined by COMSIS and the TCM Working Group of the CMAQ Subcommittee of the Regional Transportation Committee to ensure that a comprehensive set of measures was represented. In all, 37 scenarios were identified for testing. Since this analysis was being performed in preparation for Pennsylvania's SIP revision, the scenarios were limited to the Pennsylvania portion of the DVRPC region. In addition, the analysis primarily focused on projects that could provide a substantial portion of their emission reduction benefits by 1996 — the year by which the 15% reduction in VOCs must be achieved. The test scenarios are listed in Table 2.

COMSIS used its own Travel Demand Management (TDM) Evaluation Model, DVRPC's regional travel simulation model, MOBILE 5a, Garmen Associates' Post-Processor for Air Quality (PPAQ), sketch planning techniques, and various combinations of these methods to estimate the changes in travel (work travel, total travel, and VMT) and emissions (VOCs, CO, and NO_x) that would result in the five-county Pennsylvania region if each measure were implemented. The costs and cost-effectiveness of implementing and operating each measure were also calculated.

An important point to keep in mind is that the scenarios that were tested are not actual projects, but rather representative applications of the various categories of TCMs. In addition, the figures presented in this report are only *estimates*; they should not be considered precise *measurements*. The analytical methods used in the study are not perfect and assumptions are made frequently throughout the process. The figures should be used to gauge the relative effectiveness of the different types of strategies and serve as an indicator of the emissions reduction potential for a class of TCMs. Even though it has been since determined that TCMs will not be needed in the 15% SIP, knowing which types of strategies are likely to have significant emissions impacts and are cost-effective will contribute to the development of meaningful and effective projects that will be incorporated into future SIP revisions.

Section 2 of the report presents worksheets for each test scenario. The worksheets include a description of the measure and brief explanations of the travel, emissions, and cost analyses. Section 3 contains the results of the analysis in the form of summary tables and graphs. Policy implications and directions are discussed in Section 4. Detailed descriptions of the COMSIS TDM Model, the sketch planning techniques, and the PPAQ parameters, and a listing of the reports used for background information are found in the appendices.

Table 2
Transportation Control Measures
Scenarios for Testing in 1993

	TRAFFIC FLOW IMPROVEMENTS
1	Advanced signal system improvements on four-lane arterials with the highest peak volumes
2	Advanced signal system improvements — Comprehensive system for Philadelphia CBD
3	Congestion and incident management systems on interstates within Philadelphia and the four suburban counties
4	Ramp metering
5	Enforce adherence to 55 mph speed limit on freeways
	TRANSIT OPERATIONS
6	Restoration of service on regional rail lines
7	Extension of the Route 66 trackless trolley
8	Improvement to express services on regional rail lines
9	System-wide fare reductions of 10% from current levels
10	System-wide fare reductions of 20% from current levels
11	System-wide fare reductions of 50% from current levels
12	Improve suburban bus service
13	Application of "transit first" principles to selected bus and light rail lines in Philadelphia
14	Reuse of surplus light rail vehicles and trackless trolleys on bus routes in Philadelphia
15	Improve City Transit Division service
16	Philadelphia to Harrisburg rail service improvements
	TRANSPORTATION MANAGEMENT PLANS
17	Implementation of the PA Employer Trip Reduction Program (all APO targets reached)
18	Comprehensive regional ridesharing program
19	Availability and promotion of $25 TransitChek

Table 2 (continued)

20	Telecommuting
21	Compressed work weeks (9/80)
	PARKING MANAGEMENT
22	Prohibit new construction of parking facilities in Center City Philadelphia
23	Limit parking facilities at new suburban employment sites
24	$3 parking surcharge paid by all regional employees arriving in private vehicles
25	$3 parking tax in the Philadelphia CBD with the rate based on time of day
26	Construct new park-and-ride lots along highways
27	Expand parking at rail stations
	NON-MOTORIZED PROGRAMS AND FACILITIES
28	Comprehensive bicycle improvements in the region that would capture 5% of auto work trips with a length of 5 miles or less
29	Comprehensive bicycle improvements in the region that would capture 5% of access trips of 5 miles or less for work purposes to 14 selected rail stations
30	Comprehensive bicycle improvements in the region that would capture 5% of non work trips with a length of 5 miles or less
	EMISSIONS REDUCTION PROGRAMS
31	Removal of 50% of pre-1980 vehicles
32	Reduction in cold starts
33	California cars
	PRICING MECHANISMS
34	Feebate on purchase of new car
35	Comprehensive gas tax of $.84 per gallon
36	$.04 per vehicle mile travelled tax
37	Facility pricing (double Turnpike tolls during peak periods)

2 WORKSHEETS

The purpose of the worksheets is to provide brief yet detailed descriptions of each potential TCM along with documentation on how its impacts were analyzed. Each worksheet is divided into three sections — definition, travel and emissions analysis, and cost methodology.

The worksheets evolved over the course of the study. Initially, they were used for discussion purposes in review committee meetings in an effort to more clearly define each test scenario. As part of this on-going process, the worksheets alternated between DVRPC and COMSIS for clarification and refinement. DVRPC mainly contributed to the definition section, while COMSIS was responsible for the emissions analysis and cost sections. In their final form, the worksheets include enough information to understand the intent of each measure and the rationale behind its analysis.

1

ADVANCED SIGNAL SYSTEM IMPROVEMENTS ON FOUR-LANE ARTERIALS WITH THE HIGHEST PEAK VOLUMES

Definition:

The purpose of this TCM is to improve flow on congested arterials through improved signalization. Improved signal systems would be introduced on the 50 most congested miles of 4-lane arterials in the region.

Specific facilities targeted for these treatments are:

Broad St./PA 611/PA 291 from US 1/Roosevelt Blvd. to I-95 (11 miles)

US 1/Roosevelt Blvd. from Broad St./PA 611 to I-276/PA TNPK (15 miles)

US 1/City Line Ave. from I-76 to PA 320 (11 miles)

PA 3/West Chester Pike from I-476 to Cobbs Creek Parkway, and Walnut St./Chestnut St. from Cobbs Creek Parkway to the Schuylkill River (11 miles)

Travel and Emissions Analysis:

This TCM's impact was judged to be purely in the improvement of flow conditions resulting in higher average speeds which equate to lower rates of vehicle emissions. There was assumed to be no substantive impact through these improvements on modal split or trip generation. However, allowance was made for differences in trip length and VMT resulting from route shifting due to improved speeds on affected routes.

Based on conversations with local operations staff, and subsequent discussions between COMSIS and DVRPC staff, it was concluded that the types of improvements defined under this TCM would result in an average increase in speeds of 10% on all affected links as well as a 10% increase in capacities. COMSIS created link update records reflecting these improvements and sent the file to DVRPC for network modification and assignment.

DVRPC ran a network update and traffic assignment using the base 1996 vehicle trips and the modified 1996 no-build network. Results of the assignment were sent to COMSIS for calculation of emissions impacts using PPAQ.

Cost Methodology:

The public cost would consist of both a capital component and an operating/maintenance component. The capital cost assumed four signalized intersections per mile at a cost of $50,000 each. This capital cost would be incurred to upgrade existing traffic signals. The improvements were assumed to have a ten-year life. An 8% discount rate was used to calculate an annual cost. The operating/maintenance cost per traffic signal was assumed to be $1,500.

2

ADVANCED SIGNAL SYSTEM IMPROVEMENTS — COMPREHENSIVE SYSTEM FOR PHILADELPHIA CBD

Definition:

This TCM would attempt to improve traffic flow operations in the Philadelphia CBD through improved signalization and flow channelization. The effects would be to reduce delay and increase speeds, thereby reducing emissions.

The following street system is affected by this plan:

Delaware Ave. to 40th Street
Spring Garden to South Street

Travel and Emissions Analysis:

As with TCM 1, the impact of this TCM was adjudged to be in improved speeds through less queuing and delay. Following discussions with DVRPC, City of Philadelphia, and PennDOT staff, it was decided that these improvements would result in roughly a 6.5% increase in link speeds.

DVRPC first identified locations for improved signal systems installation from the Center City Signal Improvement Project Feasibility Study. COMSIS then used "CBD" area type and "Philadelphia" jurisdiction identifiers to select the affected roadway links. COMSIS created link update records reflecting improvements in speed and capacity as a result of reduction in delays and time required to traverse these links.

The link updates were sent to DVRPC for network update and traffic assignment using the 1996 base vehicle trip table. The revised assignment was then sent to COMSIS for calculation of emissions effects using PPAQ.

Cost Methodology:

This element included both the Stage I and Stage II of the Center City Traffic System. The capital costs were taken from the FY 1994 - 1999 Transportation Improvement Program (TIP). There would be no additional operation/maintenance costs associated with these improvements.

3

CONGESTION AND INCIDENT MANAGEMENT SYSTEMS ON INTERSTATES WITHIN PHILADELPHIA AND THE FOUR SUBURBAN COUNTIES

Definition:

This TCM would aim to reduce the "catastrophic" delay caused by major traffic stoppages, or incidents, caused by accidents or breakdowns. This random type of system failure in an already-congested highway system produces major -- but unpredictable -- delays. An Incident Management system attempts to rapidly identify these incidents and alleviate them through: (a) a high state of readiness which removes obstructions and (b) traveler information which suggests routing alternatives.

In preliminary research, it was determined that PennDOT's Traffic and Incident Management System (TIMS) program is targeting the 115 miles of interstate roads that serve the five-county Philadelphia region for incident management treatment. The systems likely to be in place by 1996 are:

I-476: 357 detectors and 8 CCTV cameras;

I-95: 4 changeable message signs and 12 CCTV cameras;

I-676: 7 CCTV cameras, 3 changeable message signs, 4 detectors, and a Control Center.

(Note: Ramp Meters are considered separately from TIMS in the next TCM.)

Travel and Emissions Analysis:

A methodology was developed to approximate the effect incident management would have on system performance. This methodology consisted of the following assumptions:

- It was reasoned that incidents are responsible for over 50% of delay on freeways. An estimate was then made of the percentage of that delay that might be eliminated through incident management -- again 50%. The effect on system performance was then estimated to be:

Uncongested freeway speed:	60 mph	1.0 min/mile
DVRPC base freeway speed:	33.3 mph	1.8 min/mile
Total delay:		0.8 min/mile

Delay due to incidents (50%):		0.4 min/mile
50% reduction in incident delay:		0.2 min/mile
New delay:		0.6 min/mile
New base freeway speed:	37.5 mph	1.6 min/mile
Net change in speed:	***+4.2 mph***	

- Comparing this estimate with freeway speeds on the DVRPC network, it was concluded that this estimate was of a reasonable order of magnitude, and a net increase in speed of **5%** was agreed to.

- Specific freeway and ramp locations where TIMS would be implemented were identified by DVRPC. Speed and capacity changes were then made by COMSIS and a file of link update records was transmitted to DVRPC for network update and traffic assignment using the base 1996 vehicle trip table. The assignment results were transmitted to COMSIS for calculation of emissions effects using PPAQ.

Cost Methodology:

There are four projects included in this element. Two of the projects are already part of the 1994 - 1996 Transportation Improvement Program and the remaining two projects are contained in the 1992 JHK study. The capital costs of $31,720,000 were obtained from these sources and assumed to have a ten-year useful life for calculation of annual capital costs. An 8% discount rate was used in the annual cost calculation. Annual operations/maintenance costs were assumed to be 10% of total capital costs.

4

RAMP METERING

Definition:

This TCM would attempt to improve flow on major limited access facilities by "metering" access of entering traffic so as to not disrupt the delicate flow balance of traffic levels that are approaching capacity conditions. 17 ramp locations in the region would be metered to pace entry of mixed traffic.

Preliminary research indicated that the following ramp meters identified in PennDOT's TIMS program would be in place by 1996:

I-476 - 16 ramp meters
I-676 - 1 ramp meter

Travel and Emissions Analysis:

This TCM's impact was judged to be purely in the improvement of flow conditions resulting in higher average speeds, which equate to lower rates of vehicle emissions. There was assumed to be no substantive impact through these improvements on modal split or trip generation. However, allowance was made for differences in trip length and VMT resulting from route shifting due to improved speeds on affected routes.

Based on conversations with local operations staff, and subsequent discussions between COMSIS and DVRPC staff, it was concluded that the type of improvements defined under this TCM would result in an average increase in speeds of 6 mph on the freeway links adjoining the ramps that are planned to be metered. Initially, consideration was given to quantifying the effects of HOV bypass of the ramp meters. This was not done due to the fact that ramps are not explicitly coded in the DVRPC network.

COMSIS created link update records reflecting these improvements and sent the file to DVRPC for network modification and assignment. DVRPC ran a network update and traffic assignment using the base 1996 vehicle trips and the modified 1996 no-build network. Results of the assignment were sent to COMSIS for calculation of emissions impacts using PPAQ.

Cost Methodology:

The ramp metering interchanges are included in the larger PennDOT TIMS project. For TCM comparison purposes, each of the 17 ramps to be metered was assumed to cost $50,000. In

addition, a $1 million enhancement and expansion of the present centralized control system would be required. The annual operations and maintenance cost of $1500 per ramp was assumed. Capital costs are amortized over a ten-year period using an 8% discount rate.

5

ENFORCE ADHERENCE TO 55 MPH SPEED LIMIT ON FREEWAYS

Definition:

Emissions are very sensitive to vehicle speed. Vehicles exceeding 55 mph are generating considerably more emissions than those travelling at the speed limit. This TCM would try to increase adherence to the 55 mph limit through increased enforcement, with the objective of attaining 85% adherence.

This measure was restricted in definition to apply only to the Pennsylvania Turnpike, where it appears that speeds regularly exceed 55 mph at all times of day (whereas on other Class 1 facilities, speeds may not exceed 55 during peak periods). Therefore, this measure has been applied to the PA Turnpike only as a "demonstration" project.

Analysis:

For this analysis it was presumed that the current average speeds on the Pennsylvania Turnpike (all segments within the DVRPC region) are 65 mph, and that under increased enforcement, 85% would adhere to 55 mph (remainder at 65 mph), resulting in a new average speed of 56 mph.

No new assignment runs reflecting these altered speeds were made. Instead, these new speeds for the turnpike links were adjusted directly within PPAQ and revised regional emissions calculated directly from the change in speeds.

Cost Methodology:

This measure increases enforcement of the 55 miles per hour speed limit on 192 directional (total one-way) miles of the Pennsylvania Turnpike. It was assumed that one trooper would be required for each ten directional miles, thereby requiring 19.2 troopers. The annual cost for the trooper and the cruiser was estimated to be $100,000. In addition, there would be an annual campaign costing $500,000 to inform the public of the added speed limit enforcement and the higher emissions caused by excessive speeds. There is no revenue assumed in this analysis, since the additional citations are offset by increased cost of adjudication.

6

RESTORATION OF SERVICE ON REGIONAL RAIL LINES

Definition:

SEPTA has an extensive system of rail lines throughout the region. Service has been terminated on some of these lines or segments in the recent past due to low ridership and cost considerations. This TCM attempts to increase regional transit utilization by restoring rail service on several of these prior routes.

The lines targeted for restoration of service by 1996 are:

R3-Elwyn to Wawa
R6-Cynwyd to Ivy Ridge
R8-Fox Chase to Newtown

Travel and Emissions Analysis:

To quantify the travel impacts related to these service adjustments, it was assumed that service levels on the restored portions would be the same as those on the currently active portions.

These changes in service were made by DVRPC in the regional travel network and the ridership effects calculated through the regional mode choice model. DVRPC then performed a new regional assignment, and transmitted the assignment results to COMSIS for emissions estimation with PPAQ.

Cost Methodology:

The restoration of regional rail lines by 1996 assumed that the infrastructure (track, electrical substations, stations/platforms, and parking areas) would require a capital investment of $45 million to permit operations once again. In addition, rail vehicles were assumed to be available, since, in 1991 there was a 24% commuter rail spare ratio. Also, it is assumed that operating and maintenance costs would be slightly higher than the rail system average (10% higher) and that the farebox revenue would be at the system wide average: operating expense per passenger trip = $7.28, and revenue per trip = $3.20. The capital cost was amortized over 20 years with an 8% discount rate.

7

EXTENSION OF THE ROUTE 66 TRACKLESS TROLLEY

Definition:

This TCM would extend the Route 66 trackless trolley from its current terminus at Frankford Avenue and the City line to Franklin Mills Mall.

Travel and Emissions Analysis:

This TCM was evaluated using the same basic procedure as outlined for TCM 6, with primary travel impacts estimated by DVRPC through modification of the transit network and application of the regional mode choice model.

Ridership and mode shifts were estimated by DVRPC using the regional mode choice model, and the results taken through a new regional assignment. Assignment results were then sent to COMSIS for emissions calculation with PPAQ.

Cost Methodology:

This measure extends the Route 66 trackless trolley two miles from its current terminus at Frankford Avenue and the City Line to Franklin Mills Mall. The methodology assumed that the electric power for the trackless trolley requires a capital investment of $12.5 million, which is amortized over 20 years at an 8% discount rate. There would be sufficient surplus vehicles to operate the service extension. Systemwide averages were assumed: Operating cost per passenger = $0.77, revenue per passenger = $0.34 per passenger (or 4.4% average recovery rate).

8

IMPROVEMENTS TO EXPRESS SERVICE ON REGIONAL RAIL LINES

Definition:

This TCM would attempt to increase transit utilization on regional rail lines through the improvement of express service.

This TCM would affect the following lines with the indicated service improvements:

R3 (West Trenton):

5% reduction in peak period run time
25% reduction in peak period headways

R5 (Paoli and Lansdale):

4% reduction in peak period run time
20% reduction in peak period headways

R7 (Trenton):

10% reduction in peak period run time
40% reduction in peak period headways

The assumptions for the R7 and R3 lines were based on numbers provided by the transit consultants working on the I-95 project. They provided a range of peak period run time and headway reductions that could occur if certain physical and operational improvements were made. The ranges were as follows:

R7: 5-10% reduction in average peak period run time
20-40% reduction in average peak period headway

R3: 3-5% reduction in average peak period run time
15-25% reduction in average peak period headway

The high end of the range was chosen by DVRPC for the analysis. Since no numbers were provided for the R5, the average of the ranges given for the R3 were used. More conservative numbers were used on the R5 because current service on this line is already very good. Where routes joined on common links, the lower travel time savings was used.

Travel and Emissions Analysis:

Analysis of travel and emissions impacts occurred as follows:

- DVRPC modified the appropriate transit links in the transit network.
- DVRPC calculated mode choice impacts through the regional mode choice model.
- The revised trip table was assigned to the regional 1996 no-build network.
- Revised assignments were sent to COMSIS for emissions estimation with PPAQ.

Cost Methodology:

The same approach was used as with TCM 6. Additional rail vehicles would be required; the capital cost per passenger = $2.57, based upon the purchase of a $2.5 million self-propelled electric car and a thirty year useful life at an 8% discount rate. Operating revenue is the system-wide average, 44% of operating expense.

9,10,11

SYSTEMWIDE FARE REDUCTIONS

Definition:

Level of fare is an important consideration in the decision to use transit over private vehicle. Reductions in current fare level are likely to increase ridership. This TCM looks at 10%, 20% and 50% reductions in fare compared to current levels on SEPTA.

Travel and Emissions Analysis:

This measure was defined as applying to the entire SEPTA system and all fare instruments. All transit fares were reduced by 10%, 20% and 50%, respectively, for transit path impedance calculation and mode choice calculation.

The regional mode choice model was rerun by DVRPC with these changes. Each pricing scenario was then run through a new assignment, followed by emissions estimation by COMSIS with PPAQ.

Cost Methodology:

This measure included three levels of systemwide fare reductions on all SEPTA fares. It was assumed that the travel methodology will produce a change in total transit passenger trips aggregated for all modes. Therefore, the cost methodology uses systemwide weighted average by passenger trips to calculate both capital and operating costs. The weighted average capital cost per unlinked passenger trip = $0.64, and operating cost = $2.00. The system weighted average calculations are based upon the 1991 Section 15 data for SEPTA.

12

IMPROVE SUBURBAN BUS SERVICE

Definition:

This TCM would improve service on existing bus routes in the suburban counties. These improvements would include hourly off-peak service, half-hour peak service, and transfers of no more than 10 minutes.

Specific bus routes targeted for service improvements are as follows:

91 - Norristown to Eagleville and Graterford
92 - West Chester to King of Prussia
93 - Norristown to Pottstown
94 - Chestnut Hill to Montgomery Mall
95 - Plymouth Meeting Mall to King of Prussia
96 - Norristown to Telford
97 - Penn Square to Spring Mill
99 - Norristown to Royersford
104 - 69th St. Terminal to West Chester
105 - 69th St. Terminal to Ardmore or Paoli
118 - Chester to King of Prussia
120 - 69th St. Terminal to Cheyney University
124 - Philadelphia to King of Prussia and Chesterbrook
125 - Philadelphia to King of Prussia and Valley Forge National Park
127 - Penndel or Oxford Valley Mall to Morrisville
128 - Oxford Valley Mall to Bucks County Office Center
129 - Oxford Valley Mall to Morrell Park
130 - Neshaminy Mall to Oxford Valley Mall

The following assumptions were made as to the level of service improvements on these routes:

30-minute peak period headways
Transfers of no more than 10 minutes
No increase in travel speed (run times).

Travel and Emissions Analysis:

These service adjustments were evaluated using the same general process as with the other transit TCMs:

- DVRPC modified the appropriate transit links in the transit network.
- DVRPC calculated mode choice impacts through the regional mode choice model.
- Revised trip tables were assigned to the regional 1996 no-build network.
- Revised assignments were sent to COMSIS for emissions estimation with PPAQ.

Cost Methodology:

This measure would improve the existing suburban bus routes by adding off-peak and peak service. The capital cost per new passenger trip = $0.19, and the operating cost per passenger trip = $1.15. The revenue per new passenger trip was estimated to be $0.51.

13

APPLICATION OF "TRANSIT-FIRST" PRINCIPLES TO SELECTED BUS AND LIGHT RAIL LINES IN PHILADELPHIA

Definition:

SEPTA has an extensive bus and light-rail system which services the City. Under this TCM, a "transit first" policy would be invoked which would give the vehicle priority when it operates in mixed traffic and are affected by signals and crossings, and thus reduce travel time for users and increase ridership demand for transit.

Transit First principles were applied to the following selected bus and light rail lines in Philadelphia:

Routes 9, 10, 48, 52 and 56

Transit First treatment was defined as consisting of physical as well as operational improvements, resulting in a 10% reduction in travel time on the designated routes.

Travel and Emissions Analysis:

Once the routes and specific service improvements were defined, the estimation of travel and emissions impacts was determined in the same general procedure as used for the other transit TCMs:

- DVRPC modified the appropriate transit links in the transit network.
- DVRPC calculated mode choice impacts through the regional mode choice model.
- Revised trip tables were assigned to the regional 1996 no-build network.
- Revised assignments were sent to COMSIS for emissions estimation with PPAQ.

Cost Methodology:

This measure includes the application of "Transit First" principles to light rail lines in Philadelphia. It is assumed that the capital costs of the "Transit First" principles are included in other TCM measures (TCM 2), except for catenary cost of $880,000 amortized at 8% discount rate over 10 years. The additional capital cost associated with this measure was for additional LRV vehicles; the capital cost per new passenger trip = $0.43. The operating cost per new passenger trip = $1.06, and the associated revenue = $0.47.

14

REUSE OF SURPLUS LIGHT RAIL VEHICLES (LRVs) AND TRACKLESS TROLLEYS ON BUS ROUTES IN PHILADELPHIA

Definition:

SEPTA is re-equipping 5 of its light rail routes with new vehicles. Some of the old vehicles from these routes will then be used to convert 3 bus routes back to light rail. After this conversion, there will still be about 41 surplus LRVs. In addition, SEPTA has about 50 trackless trolleys surplus to the needs of its existing trackless trolley routes. Assuming that all of these surplus vehicles could be put to use on existing bus routes in a relatively short time frame, two types of benefits could be realized: (1) air quality improvements resulting from the switch to electric power, and (2) ridership increases resulting from the change of mode.

Travel and Emissions Analysis:

This TCM was evaluated with Sketch Planning methods because no known national data of such a switch was available.

According to 1991 Section 15 data, both LRVs and trolleys have a greater average passenger count per revenue hour than buses, which could be attributed to the following:

- larger capacity of these vehicles;
- longer headways between these vehicles; and
- these vehicle modes attract more riders.

Since trolleys and buses are assumed to use the same roadways in mixed traffic, there could be a slight loss in ridership if trolleys were substituted for buses. However, this reduction would be offset by the factors given above. Also, transit generated emissions would be reduced.

Assuming LRVs are more desirable than buses, an increase in ridership is possible as long as there are no required bus-to-rail transfers, and the "Transit First" principles are implemented to increase the running speeds of the LRVs.

The impacts were calculated as follows:

Assume a 10-mile route and a speed of 10.3 mph

Assume a bus headway of 10 minutes and an LRV headway of 15 minutes

Each vehicle takes 58.2 minutes (rounded to 60 minutes) per run

6 buses or 4 LRVs will be required to serve:

Passengers per bus, peak direction in 1 hour: 52.2 Total Pas/Hr = 315.11
Passengers per LRV, peak direction in 1 hour: 83.8 Total Pas/Hr = 335.34
Difference: 20.23
or 6.42%

41 LRVs will replace 61.5 buses and carry 10,069,602 Annual Passengers OR 646,468 additional LRV passengers.

The impact of the reduction in emissions was calculated using the delta VMT method:

1,464,500 Annual VMT reduction

5,858 Daily VMT reduction

Cost Methodology:

This measure reuses surplus LRVs and trolleys on bus routes in Philadelphia. Cost methodology is similar to TCM 13, except that there is no additional capital costs for rolling stock, since there are surplus vehicles currently available.

15

IMPROVE CITY TRANSIT DIVISION SERVICE

Definition:

The purpose of this TCM is to attract more people to transit service in the City by providing more frequent service. Specifically, this TCM would reduce all day headways on City Transit Division routes by 10% in order to replicate service levels of five years ago. A 10% reduction in headways was arrived at by comparing numbers from the 1991-92 Pennsylvania Mass Transit Statistical Report with the 1987-88 version.

Travel and Emissions Analysis:

DVRPC edited transit line cards of CTD routes to ultimately reflect a 10% reduction in all day headways. Travel and emissions results were then estimated through the same general process:

- DVRPC modified the appropriate transit links in the transit network.
- DVRPC calculated mode choice impacts through the regional mode choice model.
- Revised trip tables were assigned to the regional 1996 no-build network.
- Revised assignments were sent to COMSIS for emissions estimation with PPAQ.

Cost Methodology:

This measure reduced headways for the entire day on City Transit Division routes in an attempt to attract additional riders. The cost methodology is similar to that used in TCM 12, except that the capital cost for new transit vehicles was calculated using only the increase in transit for work trips, since there are sufficient off-peak surplus vehicle available.

16

PHILADELPHIA TO HARRISBURG RAIL SERVICE IMPROVEMENTS

Definition:

The purpose of this TCM is to increase transit utilization in the Philadelphia to Harrisburg rail corridor by offering more frequent service and increasing travel speeds.

The improvements to existing service to be analyzed were developed in the 1992 Philadelphia - Harrisburg Rail Study prepared for PennDOT by DVRPC. This report recommends a series of track improvements that would reduce travel times by 5 to 6 minutes. In addition, three future service scenarios are developed:

(1) continue existing service,
(2) moderate enhancement, and
(3) high enhancement.

As a TCM, the "moderate enhancement" scenario was used. Under this scenario, service would include 10 round trips on weekdays and 7 round trips on weekends and holidays. The ridership projections and cost estimates in this 1992 report were also to be used as the source for the TCM impact estimates.

The report assumed that commuters living in Chester County and east will use the SEPTA rail service, since it is cheaper than existing AMTRAK service. Therefore, the new weekday trips are all "external" to the DVRPC region, originating in Lancaster County and traveling to downtown Philadelphia. The change in mode of travel is assumed to be from auto (at 1.25 occupancy) to intercity rail.

The estimated increase in ridership resulting from Scenario 2 vs. Scenario 1 (existing conditions) is as follows:

Philadelphia commuter	22,353 ann. pass.
Philadelphia discretionary	67,893 ann. pass.
Total	90,246 ann. pass.
Daily increase (250 days/yr)	360 pass
Round trips	180/day

It was assumed that a negligible number of Philadelphia residents would use the service to reverse

commute to Lancaster; it was further assumed that these Lancaster-to-Philadelphia commuters would reach their final destination by walking or public transit.

Travel and Emissions Analysis:

Impacts were estimated through a sketch planning technique, similar to that used for PennDOT CMAQ project evaluations:

- Assume Lancaster to Phila. trip length of 72 miles.

  Portion of trip actually within DVRPC region = 49 miles

Chester County:	29 miles
Montgomery County:	15 miles
Philadelphia County:	5 miles

- Calculate change in VMT, assuming each transit trip drawn from private vehicle at 1.25 occupancy.

- Use emissions factors with delta VMT to calculate change in emissions by county.

Cost Methodology:

This measure adds rail passenger service from Harrisburg to Philadelphia as depicted in Scenario II from the 1992 DVRPC study. The capital costs are $76.9 million, which is $7.8 million annually. Per new passenger trip, the annual cost computations were: capital cost = $49.83, operating cost = $25.03, revenue = $8.82.

17

IMPLEMENTATION OF PENNSYLVANIA EMPLOYER TRIP REDUCTION PROGRAM

Definition:

Because the Philadelphia region is a Severe Ozone Non-Attainment Area, it will be obliged to implement mandatory ETR programs in its SIP. These programs require that regional employers of 100 or more institute measures that increase Average Vehicle Occupancy by 25% over background levels.

In its preliminary steps to implement the ETR requirement of the Clean Air Act, DVRPC defined a system of 4 AVO zones which correspond to different geographies and travel conditions in the Pennsylvania portion of the region. A different AVO target was developed for each of these four zones. These are described below along with the associated trip reduction requirement that affected employers will have to attain with their programs.

AVO Zone 1: Philadelphia Central Business District

This area is characterized by high density employment and extensive existing transit service and utilization.

Current AVO: 2.85
Target AVO: 3.00
Implied AVO Improvement: 5%
Implied Vehicle Trip Reduction: 5%

AVO Zone 2: Urban Ring

This is the area surrounding the CBD. It is also of relatively high density, includes manufacturing and warehouse activity, and still enjoys good transit service and utilization.

Current AVO: 1.54
Target AVO: 1.75
Implied AVO Improvement: 14%
Implied Vehicle Trip Reduction: 12%

AVO Zone 3: Suburban Ring

This area includes NE and NW Philadelphia, the older built-out suburban municipalities, and inner portions of Chester, Montgomery and Bucks Counties. This consists of moderate density development in stable, built-out neighborhoods, major office parks and areas of generally good transit service.

Current AVO: 1.21
Target AVO: 1.58
Implied AVO Improvement: 31%
Implied Vehicle Trip Reduction: 23.4%

AVO Zone 4: Rural Ring

This is the remaining outer portion of the region, comprised of most of Bucks and Chester Counties and the western half of Montgomery County. This area is characterized as low density development, rapid and scattered growth, and generally limited transit service.

Current AVO: 1.15
Target AVO: 1.50
Implied AVO Improvement: 30%
Implied Vehicle Trip Reduction: 23.3%

Travel and Emissions Analysis:

The impact of the mandatory ETR program on travel and emissions was estimated through the following methodological steps and assumptions:

- It was assumed that all employers of 100 or more would implement program measures necessary **to hit their full trip reduction targets** by 1996. *In reality, state regulations governing implementation of ETR provide for phased attainment of goals;* specifically, by 1996, employers of 1000 are only expected to reach 80% of their goal and employers under 1000 are expected to reach only 50% of their goal (full compliance by November 1997).

- Partial trip tables were developed for each of the four AVO zones, depicting home-based work travel from all regional origins (including New Jersey) to the designated AVO zone.

- Using DVRPC data, it was determined that only 79.4% of regional employees arrive at the work site between 6 to 10 a.m. These are the only trips impacted by ETR.

- Also using DVRPC data, it was determined that the percentage of employers with 100 or more employees was different in each AVO zone:

  AVO Zone 1: 67.2% over 100
  AVO Zone 2: 53.8% over 100
  AVO Zone 3: 45.9% over 100
  AVO Zone 4: 39.7% over 100

- New vehicle trip reduction ceilings were established for each AVO zone using the nominal trip reduction targets calculated above and the two assumptions related to peak period employees

(79.4%) and percentage of employers over 100:

Revised Trip Base = Daily HBW Veh. Tr. x % 6-10 a.m. x % >100

Target Trip Reduction = Rev. Base x Nominal % Trip Red.

Revised Net V.T. = Base - Target Trip Red.

Zone 1: 111,594 x 79.4% x 67.2% = 61,677 base

Target Reduction = 61,677 x 5% = 3084 v.t.
Vehicle Trip Ceiling = 111,594 - 3,084 = 108,510

Zone 2: 324,236 x 79.4% x 53.8% = 138,505 base

Target Reduction = 138,505 x 12% = 16,621 v.t.
Vehicle Trip Ceiling = 324,326 - 16,621 = 307,615

Zone 3: 1,330,532 x 79.4% x 45.9% = 484,907 base

Target Reduction = 484,907 x 23% = 112,983 v.t.
Vehicle Trip Ceiling = 1,330,532 - 112,983 = 1,217,549

Zone 4: 416,973 x 79.4% x 39.7% = 131,437 base

Target Reduction = 131,437 x 23% = 30,624 v.t.
Vehicle Trip Ceiling = 416,973 - 30,624 = 386,348

- The TDM Model was run by COMSIS on each AVO zone situation to identify a TDM program package that, if implemented by employers of 100 +, would achieve the respective trip reduction goal. Efforts were made to make these programs (developed through trial and error) as consistent as possible across situations, and as little dependent on pricing measures as possible. The selected programs are summarized in Table 3.

- Scenarios containing these designated TDM programs were used to develop revised trip tables in the TDM model, separately for each AVO zone. Individual zonal tables were then collapsed into a revised total trip table for the Pennsylvania portion of the region.

- The revised HBW trip tables were merged with total trips and sent to DVRPC for assignment on the 1996 no-build network. The new assignment was then furnished to COMSIS for emissions estimation with PPAQ.

Table 3
Employer Trip Reduction Program Targets and Elements

AVO Zone	Employer Size	Trip Reduction	*Support Programs			Tele-commuting	Transit Subsidy	Vanpool Subsidy	SOV Parking Charge
			Transit	Carpool	Vanpool				
1	100+	5%	L4(1)				$0		
2	100+	12%	L4(1)	L2(0)		Yes	$60		
3	100+	23%	L4(0)	L4(0)	L2(0)	Yes	$60	$60	$60
4	100+	23%	L4(0)	L4(0)	L2(0)	Yes	$60	$60	$60

* The Support Programs columns should be interpreted as follows: The transit support for employers in AVO Zone 1 is currently at Level 1 and will increase to Level 4. The different levels of effort are described in detail below.

CARPOOL SUPPORT LEVELS

The values of 1 to 4 represent the level of effort the employer will put into a carpooling program.

Level 1: Carpool information activities (tied in with areawide matching), and a 1/4 time transportation coordinator.

Level 2: In-house carpool matching services and/or personalized carpool candidate get-togethers (including information activities), and a 1/4 time transportation coordinator.

Level 3: In-house carpool matching and information services, plus preferential (reserved, inside, and/or especially convenient) parking for carpools, a policy of flexible work schedules to accommodate carpools, and a 1/2 time transportation coordinator.

Level 4: In-house carpool matching and information services, plus preferential parking for carpools, flexible schedules, guaranteed ride home, and a full-time transportation coordinator.

VANPOOL SUPPORT LEVELS

The values of 1 to 4 represent the level of effort the employer will put into a vanpool program.

Level 1: Vanpool information activities (tied in with areawide vanpool matching and/or third-party vanpool programs), plus a 1/4 time transportation coordinator.

Level 2: In-house vanpool matching services, and/or personalized vanpool candidate get-togethers, and non-monetary vanpool development, plus 1/4 time transportation coordinator and a policy of flexible work schedules.

Level 3: In-house vanpool matching services, vanpool development and operating assistance including financial assistance such as vanpool purchase loan guarantees, consolidated purchase of insurance, and start-up subsidy (generally at least two forms of such financial assistance), and additional incentives such as van washing and preferential (reserved, inside, and/or especially convenient) parking for vanpools, plus a 1/2 time transportation coordinator.

Level 4: In-house vanpool matching services, vanpool development and operating assistance including major financial assistance such as employer purchase of vans with favorable leaseback (or alternative continuing subsidy to keep vanpool fares low) in addition to start-up subsidy, several additional incentives such as van washing, preferential parking for vanpools and guaranteed ride home, and a full-time transportation coordinator, and/or personalized vanpool candidate get-togethers.

TRANSIT SUPPORT LEVELS

The values of 1 to 4 represent the level of effort the employer will put into a transit program.

Level 1: Transit information center plus 1/4 time transportation coordinator.

Level 2: Transit information center and a policy of work hours flexibility to accommodate transit schedules/delays, plus 1/4 time transportation coordinator.

Level 3: Transit information center and a policy of work hours flexibility, on-site bus pass sales, plus a 1/2 time transportation coordinator.

Level 4: Transit information center and a policy of work hours flexibility, on-site bus pass sales, guaranteed ride home, and a full-time transportation coordinator.

Cost Methodology:

This measure is the full mandatory implementation of the employer trip reduction program. The public cost of administering the program was estimated by a 1992 Ernst & Young Study of Regulation XV to be $2300 per plan. The other portion of the public costs was in the provision of additional transit service. The transit cost methodology for the additional transit service was outlined in the description for TCMs 9, 10, and 11. One of the ETRP components is the administering of transit passes sold at various discounts. The public has a cost to administer this program. This annual cost was assumed to be 10% of the value of the transit pass subsidy ($2,611,239).

The private cost was $105 per employee for all employers with over 100 employees ($79,472,505), plus the transit subsidy based upon the AVO zone subsidy levels ($26,112,394), and the telecommute cost of $350 per employee which telecommutes ($5,354,780). Private revenue of $184,046,340 was calculated by multiplying $3 per day for each single occupant vehicle employee car parked for employees working in firms with over 100 employees.

18

COMPREHENSIVE REGIONAL RIDESHARING PROGRAM

Definition:

This TCM encompasses a full range of institutional aids and support actions to encourage interest in ridesharing. These incentives include improved regional rideshare matching capabilities, guaranteed ride home, and satellite stations at TMAs, large employers and office parks.

An effort was made to define the application of this measure such that its impacts would be in addition to those attributable to ridesharing as a part of TCM 17 (ETRP). Thus, the travel and emissions impacts of TCMs 17 and 18 should be roughly additive.

It is assumed that a publicly-based Regional Rideshare program would be effective in the following manner:

- While employers over 100 under mandatory ETR will implement their own rideshare support programs, it is assumed that the Regional Rideshare program might fairly be credited with *half* of the rideshare mode shift and transit mode shift *associated with "employer support" strategies* under ETRP as captured in the TDM Model.

- All other employees -- those in (1) firms under 100, (2) in AVO zones where employer rideshare or transit "support" was not applied under ETR, or (3) employees in firms over 100 that were not part of the 6-10 a.m. target population -- would be assumed to receive nominal rideshare/transit support.

Travel and Emissions Analysis:

The travel and emissions impacts of this TCM were evaluated using the TDM and PPAQ Models through the following steps:

- Carpool, Vanpool and Transit support were set at Level 2 in the TDM model for all 4 AVO zones. This approximates a reasonable level of information, promotion, and encouragement such as might be derived from a regional program as is proposed by DVRPC.

- To account for impacts due to employer support of ridesharing and transit already applied under ETRP (to avoid double counting of benefits with TCM 17), the TDM model was then run at Level 2 Carpool, Vanpool and Transit support just for the ETR-affected sample, and these vehicle trip reductions (transit trip increases) were then netted out of the simulation above.

- The revised trip tables resulting from the above analysis were merged with the rest of regional

trip table and transmitted to DVRPC for assignment to 1996 no-build network, which was then returned to COMSIS for estimation of emissions using the PPAQ model.

Cost Methodology:

This measure encompasses a full range of actions to encourage interest in ridesharing including improved regional rideshare matching capabilities, guaranteed ride home, satellite stations at TMAs, large employers and office parks. The public costs were provided by DVRPC to administer this program, estimated to be $750,000 annually. The private cost was calculated as $1.00 per employee, or $853,505, which represents only a nominal cost to the private sector and should cover the program outlined above.

19

AVAILABILITY AND PROMOTION OF TRANSITCHEK

Definition:

TransitChek is a mechanism through which employers can subsidize employee's use of transit. The employer purchases check-like instruments from the transit provider which may then be used by the employee for up to a certain dollar value of transit service per month. Thanks to the Federal Energy Bill of 1992, previous caps on employer subsidy of $21 per month were raised to $60, which can be used by employers as an important tax-exempt fringe benefit for employees.

An effort was made to define the application of this measure such that its impacts would be in addition to those attributable to the transit subsidy as a part of TCM 17 (ETRP). Thus, the travel and emissions impacts of TCMs 17 and 19 should be roughly additive.

Travel and Emissions Analysis:

The following assumptions were made in estimating the likely impact of this measure on travel and emissions:

- It was assumed that the average employer transit subsidy under this TCM would be $25 per month (this works out to $1.15 per day, x .58 (1980 to 1993 time deflation factor) = $.67 per day).

- Since AVO zones 2, 3 and 4 all had ETR programs which featured Transit Subsidies of at least $25 (actually $60/mo.) to 79.4% of all employees in employers of 100 +, it was assumed that only the remaining 21% of employees would receive the $25 subsidy amount.

- For employers with fewer than 100 employees in all AVO zones, it was assumed that a $25 monthly transit subsidy would be available to 50% of all such employees.

- In AVO zone 1, where there was no ETRP transit subsidy, it was assumed that 50% of all employees with employers of 100+ would also get the $25 subsidy.

The impacts of the above conditions on travel were calculated using the TDM Model. A revised trip table was produced which was merged with total travel and then transmitted to DVRPC for assignment to the 1996 no-build network. Assignment results were then returned to COMSIS where emissions effects were estimated using the PPAQ model.

Cost Methodology:

This measure promotes the transit subsidy equal to the ETRP program. This TCM is only for all other employees not covered by the ETRP. The public cost of providing additional transit service is similar to TCMs 9, 10, and 11. The administration cost of the TransitChek program was estimated to be 10% of the value of issued TransitCheks. The private cost has two parts: the first was the proportional cost of the $105 per employee in the ETRP, TCM 17, which is 17.2% or $18 per employee for administration, and second the direct employer subsidy, which was calculated at $616 per participating employee.

20

TELECOMMUTING

Definition:

This measure assumes that Pennsylvania employers will make liberal use of telecommuting among their employees, wherein the employee could work at home using modern telecommunications hookup and avoid a physical trip to the central workplace on one or more days per week.

An effort was made to define the application of this measure such that its impacts would be in addition to those attributable to telecommuting as a part of TCM 17 (ETRP). Thus, the travel and emissions impacts of TCMs 17 and 20 should be roughly additive.

Travel and Emissions Analysis:

A two-part analysis was used to estimate the impacts of a regional telecommuting initiative:

(1) Potential for Telecommuting in Regional Employment Base

Regional employment (Pennsylvania sector) was distributed by SIC code. Based on national telecommuting studies and application of judgement, an assessment was made of the potential of each SIC group to support telecommuting. This assessment, which is detailed in Table 4, suggests the percentage of employers in the SIC group who "could" implement telecommute based on the characteristics of their activities and the reasonableness of conducting their functions through employees who are not on-site, even for a portion of a week.

The following is a summary of the degree to which particular SIC groups could support Telecommuting (shows percent of employment situations in the stated group, who *could allow their employees to telecommute*):

100%: Trade Associations (SIC 86), Engineering and Mgt. Consult. Svcs. (87), Misc Services (89); this is 4.9% of regional base.

50%: Government (SIC 90); this is 12% of regional base.

25%: Finance/Investment/Real Estate (SIC 60-67), Business Services (73); this is 13.5% of the regional base.

10%: Health Services (80), Legal Services (81), Educational Services (82); this is 14% of the regional base.

None: All manufacturing, industrial and trade (SICs 01 through 59); Hotels (70); Personnel Services (72); Auto Repair (75); Movies and Amusements (78-79); Social Services (83); and Museums/Gardens (84). This non-eligible group comprises 55.6% of the regional base.

Thus, the effective potential base for telecommuting covers 15.6% of the regional employment base.

(2) Estimate Travel Changes Resulting from Telecommuting

The COMSIS TDM Model was used to translate this eligibility to actual travel changes. Drawing upon a synthesis of national experience as reported in a 1992 study by Daniel Rathbone: *Telecommuting in the United States* (ITE Journal, Dec. 1992), the following relationships were assumed:

If telecommute is offered by an employer, **32%** will actually do so.

Of those who telecommute, the average number of days per week that the employee telecommutes is **1.8 days.**

The TDM model was calibrated to include these rates. To ensure that the regional telecommute program would be independent of telecommute measures included under ETRP (TCM 17), the following additional steps were then taken:

In AVO zone 1, where no telecommuting measures were applied under ETRP, telecommuting was assumed to be offered to all eligible employees (as defined by SIC code above) regardless of size (over or under 100).

In AVO zones 2 through 4, where telecommute was assumed for employers of 100+, telecommuting was assumed to apply to all eligible employees in firms under 100, and to only 21% (100% less 79.4%) of those in firms of 100+.

The TDM model was run on the HBW trip table with the assumptions regarding telecommuting as delineated above. The resulting revised trip table was merged with total regional travel and sent to DVRPC for assignment to the 1996 no-build network. The assignment was then returned to COMSIS for estimation of emissions using the PPAQ model.

Cost Methodology:

There was no public cost of this program, except for the public sector as an employer participating in the telecommute program. It was assumed that there is a $350 private cost per telecommute employee, based upon a Federal Highway Administration study for purchase of computer equipment and accessories.

Table 4
Telecommuting Potential

SIC Code	Description	DVRPC-PA 1990 Employment	Overall Percent	Tele-commute Potential	Tele-commute % Eligible	Potential # of Tele-commuters
01-09	Agriculture	24,671	1.3	None	0.0	0
10-14	Mining	2,014	0.1	None	0.0	0
15-17	Construction	96,123	4.9	None	0.0	0
20-39	Manufacturing	278,800	14.2	None	0.0	0
40-49	Transportation	80,426	4.1	None	0.0	0
50-51	Wholesale Trade	111,695	5.7	None	0.0	0
52-59	Retail Trade	326,771	16.6	None	0.0	0
60-67	FIRE	164,600	8.4	25%	2.1	41,150
70	Hotels/Lodging	12,220	0.6	None	0.0	0
72	Prsnl. Services	18,077	0.9	None	0.0	0
73	Business Services	100,085	5.1	25%	1.3	25,021
75	Auto Repair	14,978	0.8	None	0.0	0
78	Movies	5,388	0.3	None	0.0	0
79	Amusements/Recreation	13,492	0.7	None	0.0	0
80	Health Services	188,071	9.6	10%	1.0	18,807
81	Legal Services	24,451	1.2	10%	0.1	2,445
82	Educ. Services	63,067	3.2	10%	0.3	6,307
83	Social Services	41,299	2.1	None	0.0	0
84	Musms./Gdn.	1,500	0.1	None	0.0	0
86	Mbrs. Trd. A.	33,123	1.7	100%	1.7	33,123
87	Engr. Mgt. Sv.	59,633	3.0	100%	3.0	59,633
89	Misc. Services	3,629	0.2	100%	0.2	3,629
90	*Govt. - All	235,473	12.0	50%	6.0	117,737
	*TOTALS	1,899,584	96.5		15.6	307,851
	*Ttl. Emp. (PA)	1,967,884				16.2% of TOTALS
	Office Ttl. Only	979,084				31.4% of Office Ttl.

*Govt.- All = Excludes Military
*TOTALS = Excludes Railroad Employees and Self-employed Persons
*Ttl. Emp. = Includes Railroad Employees and Self-employed Persons

21

COMPRESSED WORK WEEKS

Definition:

Compressed work weeks may be an effective way of reducing daily vehicle travel and VMT. This measure is defined as relevant employers in the Pennsylvania portion of the DVRPC region offering a shortened work week to all or some of their employees. There are numerous types of compressed work week; this test is limited to a 9/80 arrangement, where the employee works an average 9-hour day for 9 days over an 80-hour (2-week) cycle and receives the 10th day off.

Note: This measure is independent of TCM 17 (ETRP), since Compressed Work Weeks were not considered as a measure in the employer plans. Hence, this measure may be considered additive with TCM 17.

Travel and Emissions Analysis:

A two-part analysis was used to estimate the impacts of a regional 9/80 compressed work week initiative:

(1) Potential for Compressed Work Week in Regional Employment Base

Regional employment (Pennsylvania sector) was distributed by SIC code. Based on national studies and application of judgement, an assessment was made of the potential of each SIC group to support compressed work weeks. This assessment, which is detailed in Table 5, suggests the percentage of employers in the SIC group who "could" implement compressed work weeks based on the characteristics of their work and the likelihood that those functions could be performed effectively if the site were not open 5 days per week.

The following list summarizes the degree to which particular SIC groups could support Compressed Work Weeks (shows percent of employment situations in the stated group who *could allow their employees to have a compressed work week schedule*):

100%: None

50%: Trade Associations (SIC 86); this is 1.7% of regional base.

25%: Finance/Investment/Real Estate (SIC 60-67), Business Services (73); Social Services (83); Engineering and Management Services (87); Miscellaneous Services (89); and Government (SIC 90); this is 24.8% of the regional base.

10%: Personnel Services (72), Health Services (80), Legal Services (81), this is 11.7% of the regional base.

None: All manufacturing, industrial and trade (SICs 01 through 59); Hotels (70); Auto Repair (75); Movies and Amusements (78-79); Educational Services (82); and Museums/Gardens (84). This non-eligible group comprises 61.8% of the regional base.

Thus, the effective potential base for compressed work week covers **9.7%** of the regional employment base.

(2) Estimate Travel Changes Resulting from Compressed Work Weeks

The COMSIS TDM Model was used to translate this eligibility to actual travel changes. Using straight mathematics, a person who participated in a 9/80 work week would travel 10% less over a 2-week period (eliminate 1 day in 10). It was assumed that this day would be randomized by employers, i.e., that any weekday would be equally likely to be the day off (more likely to be a Monday or Friday), such that the effect on regional travel would be a 10% reduction in HBW travel on a given weekday.

Using the TDM Model, the percent eligibility was set at 9.7% and the reduction rates applied to all 1996 HBW trips with destinations in the Pennsylvania portion of the region. Evaluation of this scenario with the TDM model resulted in a revised HBW trip table which was then merged with total travel (complete regional trip table) and transmitted to DVRPC for assignment to the 1996 no-build network. The assignment was then returned to COMSIS for emissions estimation using the PPAQ model.

Cost Methodology:

This measure assumes that the effects of a compressed work week would remove single occupant commuters from the peak periods. There was no significant public capital cost of this program. The public transit operating costs and subsidies will be reduced to reflect the reduction in transit ridership.

Table 5
Compressed Work Week Potential

SIC Code	Description	DVRPC-PA 1990 Employment	Overall Percent	Compressed Work Week Potential	Compressed Work Week % Eligible	Potential # of CWW commuters
01-09	Agriculture	24,671	1.3	None	0.0	0
10-14	Mining	2,014	0.1	None	0.0	0
15-17	Construction	96,123	4.9	None	0.0	0
20-39	Manufacturing	278,800	14.2	None	0.0	0
40-49	Transportation	80,426	4.1	None	0.0	0
50-51	Wholesale Trade	111,695	5.7	None	0.0	0
52-59	Retail Trade	326,771	16.6	None	0.0	0
60-67	FIRE	164,600	8.4	25%	2.1	41,150
70	Hotels/Lodging	12,220	0.6	None	0.0	0
72	Prsnl. Services	18,077	0.9	10%	0.1	1,808
73	Busi. Services	100,085	5.1	25%	1.3	25,021
75	Auto Repair	14,978	0.8	None	0.0	0
78	Movies	5,388	0.3	None	0.0	0
79	Amsmts./Rec.	13,492	0.7	None	0.0	0
80	Health Services	188,071	9.6	10%	1.0	18,807
81	Legal Services	24,451	1.2	10%	0.1	2,445
82	Educ. Services	63,067	3.2	None	0.0	0
83	Social Services	41,299	2.1	25%	0.5	10,325
84	Musms./Gdn.	1,500	0.1	None	0.0	0
86	Mbrs. Trd. A.	33,123	1.7	50%	0.8	16,561
87	Engr. Mgt. Sv.	59,633	3.0	25%	0.8	14,908
89	Misc. Services	3,629	0.2	25%	0.0	907
90	*Govt. - All	235,473	12.0	25%	3.0	58,868
	*TOTALS	1,899,584	96.5		9.7	190,801
	*Ttl. Emp. (PA)	1,967,884				10.0% of TOTALS
	Office Ttl. Only	979,084				19.5% of Office Ttl.

*Govt.- All = Excludes Military
*TOTALS = Excludes Railroad Employees and Self-employed Persons
*Ttl. Emp. = Includes Railroad Employees and Self-employed Persons

22

PROHIBIT NEW CONSTRUCTION OF PARKING FACILITIES IN CENTER CITY

Definition:

This TCM would further constrain parking supply in the Center City by restricting the construction of any new parking downtown between now and 1996. The effect would be to reduce the overall parking ratio, thus limiting the number of vehicles which could park downtown, while also, presumably, raising the cost of parking at the remaining spaces.

Travel and Emissions Analysis:

This measure was evaluated using Sketch Planning techniques. It was assumed that the predominant effect would be in restricting parking supply such that vehicles physically could not park, thus forcing a shift to alternative modes. While such a constraint on space would likely also increase prices, there was no way to estimate what such an increase would be.

To estimate the impact on restricting parking supply relative to demand, the following analysis was performed:

- Change in employment in the Center City was estimated using Planning Area employment data from DVRPC for Planning Area 1:

  Increase in employment, Zone 1:

  1996 Employment Forecast: 288,656
  1990 Employment Actual: 287,887

  New Jobs: 769

  Interpolate jobs, 1994-96: 2/6 (769) = 254

- Calculate Vehicle Trip Demand: 24.9% x 254 = 63 new trips

  Assume that this net increase in vehicle trip demand can be met by existing parking supply. Hence, no impact is assumed from this measure.

23

LIMIT PARKING FACILITIES AT NEW SUBURBAN EMPLOYMENT SITES

Definition:

This TCM would restrict parking at new suburban employment sites to that required to satisfy the APO target under the Employer Trip Reduction Program. In and of itself, such restrictions could ensure that associated sites would meet their AVO targets, assuming spillover possibilities were limited.

Travel and Emissions Analysis:

This measure was evaluated using a sketch planning methodology to estimate the number of vehicle trips that would be eliminated by selective constraints in the supply of new parking. This estimate of trip reduction was then related to the HBW trip table through manual matrix adjustment.

The following steps were followed:

1. First, it was assumed that "suburban" parking would refer to facilities in the two outer AVO zones -- AVO 3 and AVO 4 -- established for the ETRP analysis. Geographically, this corresponds to the following counties and planning districts:

AVO Zone	County	Planning Districts
3	Delaware	13 - 18
	Chester	19
	Montgomery	30-35,37
	Bucks	46,48,50,51
4	Chester	20-29
	Montgomery	36,38-39
	Bucks	40-45,47,49

2. To approximate the increase in demand for new parking that would occur between 1994 and 1996, the increase in employment was estimated from DVRPC employment forecasts:

County	1990 Employment	1996 Employment	Change: 1994-96	Percent Increase
Delaware	230,450	237,680	2,386	1.03
Chester	197,740	206,480	2,884	1.46
Montgm.	457,449	487,508	10,020	2.19
Bucks	245,340	265,564	6,408	2.61

3. This increase in employment was used as a growth factor to estimate the increase in daily home based work trips that would occur between 1994 and 1996.

County	1996 HBW Pers. Trips	1994-6 % Increase	New P-T 1994-96
Delaware	343,474	1.03	3,537
Chester	305,861	1.46	4,466
Montgm.	694,872	2.19	15,218
Bucks	378,200	2.61	9,871

4. The increased parking demand that would be exerted by these additional HBW trips was estimated by calculating the number of vehicle trips that these person trips would generate, using current vehicle trip/person trip ratios for each county (these ratios were determined from model data at a planning district level). Increase in parking demand would be equal to 1/2 of the new daily vehicle trips:

County	Curr. VT/PT Ratio	1994-96 Per. Trips	Projected Veh. Trips	Parking Demand
Delaware	0.84	3,537	2,971	1,486
Chester	0.87	4,466	3,885	1,943
Montgm.	0.86	15,218	13,087	6,544
Bucks	0.88	9,871	8,686	4,343

5. It would then be assumed that this new parking demand would be constrained *not entirely, but to a new parking ratio that would limit parking to rates consistent with the trip reduction requirements of ETR -- namely, if ETR requires a 23.3% reduction in current vehicle trip making in these zones, then parking would need to be constrained to yield a VT/PT ratio which is 23.3% less than the current VT/PT.*

County	Constr VT/PT Ratio	Constr Parking Demand	Uncons. Parking Demand	Unmet Parking Demand	Vehicle Trip Reduction
Delaware	0.64	1,132	1,486	354	708
Chester	0.67	1,496	1,943	447	894
Montgm.	0.66	5,022	6,544	1,522	3,044
Bucks	0.67	3,306	4,343	1,037	2,074
		Total =	3,360	6,720	

6. These trip reductions were then compared to total 1996 HBW vehicle trips for each county. A *percent reduction* was calculated, and this reduction percent was used to reduce daily vehicle trips for each planning district in the respective county in the trip table. This revised trip table was then assigned to the 1996 no-build network by DVRPC, and emissions then estimated by COMSIS using PPAQ.

County	Total HBW Veh Trips	Parking Reduct.	Percent Reduct.
Delaware	288,731	708	0.25%
Chester	265,121	894	0.34%
Montgm.	596,465	3,044	0.51%
Bucks	331,191	2,074	0.63%

Cost Methodology:

This measure would restrict parking at new suburban employment sites to that required under the Employer Trip Reduction Program. In the short term, there would be no costs associated with this measure because the parking supply already exists and the local zoning regulations would have to be amended. In the long term, new construction or major renovation projects could reduce the number of required parking spaces or the development density could be increased. For the purpose of estimating a cost for this TCM, 3360 fewer parking spaces would be needed to accommodate the new suburban employment. The private capital cost savings would be $4,000 per space, amortized over twenty years at a discount rate of 8%.

24

PARKING CHARGE PAID BY ALL EMPLOYEES ARRIVING IN PRIVATE VEHICLES

Definition:

Free or subsidized employee parking at the work site is a major incentive for solo driving; placing a price on the use of that parking has been demonstrated to cause major shifts in employee use of alternative modes and/or work schedules. This TCM would test the impact of a $3 daily surcharge on parking to be paid by all regional employees.

An effort was made to define the application of this measure such that its impacts would be in addition to those attributable to the parking charges as a part of TCM 17 (ETRP). Thus, the travel and emissions impacts of TCMs 17 and 24 should be roughly additive.

Travel and Emissions Analysis:

The travel impacts of this measure were analyzed through the TDM Evaluation Model. A $3 surcharge was placed on all regional employees who commute to a Pennsylvania work site in a private vehicle, whether they drive alone, carpool or vanpool. The charge is levied on a vehicle, so while rideshare units are also charged, the price per person is reduced by the number of occupants. The $3 daily charge was deflated by a cost of living index of 0.58 to $1.74 before testing in the model.

In order to separate the impact of this surcharge from parking pricing measures applied in the ETR program (TCM 17), the following procedures were followed:

- In AVO zones 1 and 2, there was no surcharge applied under TCM 17 (ETRP). Thus the $3 daily charge ($1.74 after deflation) is applied to all private vehicle trips.

- In AVO zones 3 and 4, $3 ($1.74 in the model) is levied upon all private vehicle trips made by employees in firms under 100, since they also experienced no charge under ETRP.

- In AVO zones 3 and 4, 79.4% of all employees in firms of 100+ who travel in private vehicles are already receiving the $3 parking surcharge under ETRP, so they are exempt. However, since the charge is to be levied on <u>all</u> employee parking, it is now applied to the 21% previously unaffected (simulated by $0.37 to 100%). Also, all CP and VP trips by employees in these firms will now be charged $3 per vehicle trip, to be consistent with the definition of the measure (they were not being charged under ETRP).

These assumptions were related to the TDM Model, which was then run on a HBW trip table for

the Pennsylvania portion of the region. The simulation resulted in a revised HBW trip table, which was then merged with total travel to produce a revised regional trip table. This was transmitted to DVRPC for assignment to the 1996 no-build network; the assignment was then returned to COMSIS for estimation of emissions using the PPAQ model.

Cost Methodology:

The $3.00 per day parking surcharge applies to all regional employees arriving in private vehicles. The public costs include both a capital and operating transit cost for the additional riders using the same methodology used in TCMs 9, 10, and 11. The public sector also has an administrative cost of $500,000.

The private sector will collect the surcharge at a cost of $42.00 per space per year. This cost is the proportion of the ETRP cost in TCM 17 associated with the parking surcharge.

25

PARKING TAX IN THE PHILADELPHIA CBD WITH THE RATE BASED ON TIME OF DAY

Definition:

This measure was designed as a $3 parking tax to be levied on all employees parking in the Philadelphia CBD.

Travel and Emissions Analysis:

This analysis was performed through the TDM Model. A $1.74 tax ($3 deflated by 0.58) was assumed to be applied to all parking, public or private, and hence was treated as surcharge levied on all vehicle trips with destinations in Planning Area 1.

Cost Methodology:

The same methodology is used as in TCM 24 except that the surcharge applies only to employee private vehicles arriving in downtown Philadelphia. The administrative cost was assumed to be $250,000.

26

CONSTRUCT NEW PARK AND RIDE LOTS

Definition:

This TCM would construct about 7,500 new park-and-ride spaces in 22 new lots throughout the region available for carpooling or bus commuting. The lots are described below.

Reference Number	Name/ Facility	County	Demand	R/S	Bus	Rail
30	Middletown	Bucks	154	X	X	X
32	Bristol	Bucks	371	X		
33	Bensalem	Bucks	429	X		
35	Bensalem	Bucks	544	X		X
74	Bristol	Bucks	279	X	X	X
56	E. Whiteland	Chester	105	X	X	X
59	Valley	Chester	218	X	X	X
62	Westown, Thornberry	Chester	281	X		
65	Radnor	Delaware	374	X	X	X
66	Marple	Delaware	590	X	X	
67	Nether Providence	Delaware	617	X	X	X
68	Chester/Ridley	Delaware	481	X	X	X
37	Upper Moreland	Montgomery	114	X	X	
41	Montgomery	Montgomery	112	X	X	
42	Upper Dublin	Montgomery	289	X	X	
43	Plymouth	Montgomery	232	X	X	
45	Towamencin	Montgomery	115	X		
53	Limerick	Montgomery	178	X		
54	Collegeville	Montgomery	115	X	X	
55	Upper Providence	Montgomery	118	X	X	
34	Normandy	Philadelphia	662	X	X	
36	N.E. Philadelphia	Philadelphia	1145	X		
			7523			

Travel and Emissions Analysis:

The methodology adapted here differs from a pure empirical approach used in other studies because of some special conditions: (1) Preliminary detailed estimates by DVRPC of lot utilization, showing person trips from each lot to a system of 10 regional destinations; and (2) a new feature in the TDM model that allows on-line review and editing of individual trip table Origin-Destination trip flows/mode split.

The procedure used for evaluation was as follows:

1. Determine the Planning Area (District) identity of each lot location and each of the 10 destinations.

2. Using the **F10** trip table editing function in the TDM Model, access and print out the trip table information for each of the O-D pairs in #1.

3. The task is to modify the modal split in the affected O-D pairs consistent with the "demand" precipitated by the lot. The DVRPC study estimates the breakdown of demand (persons utilizing spaces) for each destination. For example, if a lot has a demand of 200 (implies utilization of 200 spaces by users, which we do not question), the DVRPC table will indicate the demand from the lot to destination *x*, which may be King of Prussia. Suppose this demand is 60 trips. The task is then to look at the trip table for the lot to King of Prussia, and modify the mode split by 60 trips to place those people into the appropriate alternative modes.

   This manipulation will be done by proportioning demand to the trips based on (1) the type of lot — transit, rideshare or mixed use; and (2) the existing mode split.

- If the lot is *transit only*, take the quoted "demand" from the DVRPC tables, double the number because the O-D tables are daily two-way, increase transit person trips by this amount, and reduce private vehicle trips in proportion to the current vehicle occupancy rate. For example, if the figures suggest a "demand" of 60, that would be 120 new transit trips for the given O-D. If the average vehicle occupancy is 1.07 for private vehicle travel (calculated by subtracting transit trips from person trips and then dividing by vehicle trips), then the 120 new transit trips would reduce vehicle trips by 120/1.07 = 112.

- If the lot is *rideshare only*, then demand will come from both drive alone and transit. First calculate transit loss: multiply current transit share (transit trips divided by person trips) times lot demand for that O-D times 2 for daily. Subtract this demand from transit trips in the trip table. Then calculate the reduction in vehicle trips: divide the residual demand (person demand minus transit demand) by 2.5 persons per vehicle, and subtract this amount from the vehicle trip total for that O-D.

- If the lot is *mixed use*, assign the demand proportionately based on current transit and auto use rates. First multiply current transit share times the stated demand times 2 for daily. Add this

to the transit total for the O-D pair. Take the remaining demand (multiplied by 2) and divide by 2.5 persons per vehicle. Subtract this vehicle trip change from the vehicle trip total in the trip table.

4. Make these changes for each affected O-D pair using the **F10** function in the TDM model. Save the revised trip tables under a different name, reflecting all the Park and Ride lots in the regional sample. Then merge these with total trips, run through assignment and proceed to emissions modeling.

Cost Methodology:

This measure would construct 7523 surface park-and-ride spaces in 22 lots. The construction cost used was $4,000 per space, which does not include any land costs. The construction was amortized over a 20-year period with an 8% discount rate. The other portion of the public cost was for the additional transit users using the methodology documented for TCMs 9, 10, and 11. The operating cost per space was assumed to be $0.50 per day. The parking is free, and therefore, there are no private costs.

27

EXPAND PARKING AT RAIL STATIONS

Definition:

This TCM would construct about 6,400 new parking spaces at rail stations throughout the region.

According to SEPTA's parking expansion program, parking will be expanded at the following stations by 1996:

Line	Station	County	# of New Spaces
R3	Yardley	Bucks	120
R3	Woodbourne	Bucks	101
R3	Langhorne	Bucks	50
R3	Neshaminy Falls	Bucks	62
R3	Trevose	Bucks	46
R3	Elwyn	Delaware	122
R3	Media	Delaware	40
R3	Moylan-Rose Valley	Delaware	26
R3	Philmont	Montgomery	76
R3	Bethayres	Montgomery	92
R3	Forest Hills	Philadelphia	60
R5	Link Belt	Bucks	250
R5	Thorndale	Chester	450
R5	Daylesford	Chester	118
R5	Devon	Chester	85
R5	Malvern	Chester	150
R5	Whitford	Chester	150
R5	Colmar	Montgomery	246
R5	Gwynedd/202	Montgomery	400
R5	Ft. Washington	Montgomery	240
R5	Ardmore	Montgomery	250
R7	Croydon	Bucks	69
R7	Cornwells Heights	Bucks	1842
R2	Baldwin/Crum Lynne	Delaware	1000
R2	Marcus Hook	Delaware	100
R6	Norristown Trans. Center	Montgomery	109
BSS	Fern Rock	Philadelphia	112

Travel and Emissions Analysis:

This measure was evaluated through the TDM Model using a technique similar to the procedure outlined for Measure 26:

1. The planning area (district) for each transit station/lot expansion was identified.

2. It was assumed that all persons using these station/park and rides had destinations in downtown Philadelphia (district 1).

3. Using the **F10** function in the TDM model, current modal split was determined between the district containing the P&R lot and the destination (district 1).

4. New transit demand is assumed to equal the number of new spaces (assume all the spaces will be utilized). Take the new transit riders from the current mode split identified in (3) in proportion to current mode split.

5. Adjust trip table elements for all affected O-Ds in the TDM model with **F10** function. Save as revised set of trip tables showing effects of the entire system of park and ride lots.

6. Merge these revised HBW trip tables with all other travel, run assignment and calculate emissions effects with PPAQ.

Cost Methodology:

This measure would construct 6400 additional parking spaces at 27 new lots. The cost methodology is the same as in TCM 26.

28

COMPREHENSIVE BICYCLE IMPROVEMENTS IN THE REGION THAT WOULD CAPTURE 5% OF AUTO WORK TRIPS WITH A LENGTH OF 5 MILES OR LESS

Definition:

This measure would determine the effectiveness of attracting a higher percentage of work trips 5 miles or less to bicycle.

Travel and Emissions Analysis:

This analysis was performed using sketch planning techniques.

1. The current share of work trips made by bicycle was determined from 1990 NPTS data. In urbanized areas with a population of 1 million or more, with rail transit, the percentage of regional HBW trips made by bicycle is 0.27%. This figure concurs with findings of the National Bicycling and Walking Study: *Case Study No. 1: Reasons Why Bicycling and Walking are not Being Used More Extensively as Travel Modes.*

   An analysis of DVRPC trip distributions by trip length indicates that 36% of all HBW person trips are 5 miles or less. If we assume that all bicycle trips are 5 miles or less in length, then the bicycle share of HBW trips $\leq$ 5 miles = 0.27% $\div$ .36, or 0.75%.

2. Since specific bicycle improvement projects could not be assessed, bicycle use rates for work found in metro areas that had reasonably active bike programs, including facilities, were copied from the National Bicycling Study cited above. These areas (Tucson, Palo Alto, Seattle, Phoenix, Minneapolis, and San Diego) had an average bicycle use rate of 2.2%. The regional bicycle work trip goal was set to 2.2%, which equals 5.8% of trips under 5 miles.

3. The task is to increase bicycle trips $\leq$ 5 miles to 5.8%, less the existing rate of 0.75%, which is a net increase of 5%, or 79,185 daily bike trips.

4. All interchanges (O-D pairs) in HBW trip tables with trip lengths of 5 miles or less were selected. The number of trips and modal split was determined. The 79,185 new bicycle trips were pulled from the total person trip population above, in proportion to population.

5. Once the number of person trips for each O-D pair to be converted to bicycle is known, the trips are then further proportioned out of existing modes according to the existing share.

6. This manipulation is done for all affected O-Ds pairs, and the results are used to create new HBW trip tables. These trip tables are merged with total travel, assigned to the highway

network, and run through PPAQ for emissions.

Cost Methodology:

This measure would construct the required bicycle facilities to capture 5% of auto work trips with a length of 5 miles or less. The calculation of the capital cost of additional bicycle facilities was taken from the City of Chicago, CATS Conrail Bikeway Phase I Study, using only the engineering and construction costs. Using a 20-year amortization and an 8% discount rate, the cost per bicycle mile traveled is $0.13. The transit costs were calculated using the same methodology as in TCMs 9, 10, and 11. The private cost would include the cost of providing bicycle lockers at the place of employment. Each bicyclist would have a bike locker available at their work place. The cost of the bicycle lockers was $1,000 apiece (from CATS study), amortized over ten-years at a discount rate of 8%. Commuters will use biking as an alternate mode for only four months of a year.

29

COMPREHENSIVE BICYCLE IMPROVEMENTS IN THE REGION THAT WOULD CAPTURE 5% OF ACCESS TRIPS OF 5 MILES OR LESS FOR WORK PURPOSES TO 14 SELECTED RAIL STATIONS

Definition:

This measure would determine the effectiveness of drawing a higher percentage of persons within 5 miles of a rail station to access that station by bicycle.

Travel and Emissions Analysis:

This analysis was performed using sketch planning techniques.

1. Fourteen rail stations were identified which were felt to be likely candidates for access/utilization improvements directed at the bicycle mode. These stations are listed below, along with their current usage (taken from 1991 SEPTA Rail Passenger Survey):

Station	District	Inbound Boardings	% Work (Peak)	Riders Peak	New Bike Riders
Elwyn	17	329	.903	659	34
Media	17	401			
Langhorne	49	377	.908	342	17
Somerton	12	484	.935	452	23
Jenkintown	32	1082	.915	990	50
Levittown	50	456	.861	393	20
Torresdale	48	672	.945	635	32
Fox Chase	11	1050	.903	948	47
Paoli	19	1185	.908	1076	54
Bryn Mawr	34	916	.826	756	38
Overbrook	4	450	.878	395	20
Ambler	31	661	.875	579	29
East Falls	9	278	.817	617	31
Wyndmore	9	477			

The number of new bike riders shown above is multiplied by 2 to get daily bike trips.

2. The rail survey suggests that the current average bicycle access rate to these stations is about 1%. It is assumed that the share of persons within a 5 miles radius accessing the station by bicycle is increased to 5 percent of all trips. It is further assumed that improved access by bicycle will not affect the total trip mode split (to the ultimate destination) by shifting more

people to rail transit, but will only help to pull current private vehicle users out of short vehicle access trips in the vicinity of station.

3. For each station/district, all adjacent zone pairs with trip lengths of 5 miles or less were arrayed. The number of bicycle trips calculated above were extracted from current vehicle and transit trips in proportion to the person trips for each station area.

4. All of the adjustments were compiled into a single new HBW trip table, merged with total trips, assigned to the network, and run through PPAQ for emissions.

Cost Methodology:

This measure would attract 5% of work destination rail access trips $\leq$ 5 miles onto bicycles. The methodology was the same as in TCM 28, except that the bicycle lockers would be a public cost at rail stations. Again, bicycle trips will be used to access rail stations for only four months of the year.

30

COMPREHENSIVE BICYCLE IMPROVEMENTS IN THE REGION THAT WOULD CAPTURE 5% OF NON-WORK TRIPS WITH A LENGTH OF 5 MILES OR LESS

Definition:

This measure would determine the effectiveness of attracting a higher percentage of non-work trips less than or equal to 5 miles to bicycle.

Travel and Emissions Analysis:

This analysis was performed using sketch planning techniques.

1. The current share of non-work bicycle trips was estimated from the 1990 NPTS data to be 0.89% for areas with a population over 1 million, with rail transit.

2. Set the goal for non-work trips. If the increase due to bicycle improvements for work trips was 1.93% (2.2% - 0.27%) regionally, and 5% for trips under 5 miles, then seek to increase non-work bicycle trips by 1.93%. (1.93% x 13,532,122 non-work person trips = 261,170 new bicycle trips).

3. These 261,170 new bicycle trips were taken entirely from district-to-district interchanges (O-D pairs) where trip lengths are 5 miles or less. The base for this manipulation is 7,741,288 trips. The 261,170 bicycle trips were taken in proportion to O-D person trips first, and then from existing modes within the O-D pair in proportion to the current mode split.

4. New regional non-work trip tables reflecting these adjustments were formulated, merged with other travel (HBW), and run through a new network assignment. The new assignments were processed with PPAQ to estimate emissions.

Cost Methodology:

This measure would attract 5% of the non-work trips with a length of 5 miles or less to bicycle. The methodology is similar to TCMs 28 and 29, except that the bicycle lockers would be privately funded and used four times per day instead of once a day. Also, non-peak transit headways and service are not adjusted to reflect a reduction in ridership since the headways are policy driven and not capacity driven. However, transit revenue is reduced to reflect a drop in ridership.

31

REMOVAL OF PRE-1980 VEHICLES

Definition:

This TCM would attempt to eliminate half of all cars built before 1980 that are still in service. These vehicles produce emissions that are many times those of vehicles manufactured after 1980.

Travel and Emissions Analysis:

Assumptions:

- Only emissions rates will be affected. No changes in travel will result.
- Registered vehicles in the region will remain constant.
- Vehicle age distribution closely parallels the corresponding VMT values.

Procedure:

The input vehicle age distribution data for running MOBILE5a was adjusted to reflect the implementation of this measure. MOBILE5a was run and the emissions effects calculated.

Cost Methodology:

This measure purchases pre-1980 vehicles from private owners. The cost per vehicle purchased was $700, plus the public administration fee of $50 per vehicle. The purchase price was not amortized.

32

REDUCTION IN COLD STARTS

Definition:

This TCM would attempt to eliminate 5% of all vehicle cold starts across the region through a concerted public education program.

Travel and Emissions Analysis:

Assumptions:

- A public education program can be successful in eliminating 5% of cold starts.
- 10% of the total reduction in cold starts will come from people foregoing their normal trip. This results in a 0.5% drop in trips and VMT (=10% * 5%). The other 90% reduction in cold starts will come from changes in trip patterns and scheduling and presumed to have no net impact on trips or VMT. All of this 90% reduction would come from HBO and NHB trips proportionally (70% vs. 30%).
- The program will only affect vehicle trips produced within the Pennsylvania portion of the DVRPC region. Daily vehicle trips produced in Pennsylvania portion are:

  HBW 2,134,050
  HBO 3,765,222
  NHB 2,059,180
  TOT 7,958,452

- The education program only affects personal travel and the resulting change in trips is not large enough to affect average highway speed.
- Average trip lengths by purpose (miles):

  HBW 8.0
  HBO 5.6
  NHB 5.0

- Proportion of trips that are cold starts:

  HBW 90%
  HBO 50%

NHB 40%

Based on the assumptions stated above, the reduction of cold starts and the corresponding VMT was computed manually. The reductions were entered into an analysis spreadsheet and estimated emissions effects were calculated.

Cost Methodology:

This measure is a public information program to reduce cold starts affecting personal travel. It was assumed that the public information program would cost $750,000 annually with most of the cost for producing and distributing audio, video and text materials.

33

CALIFORNIA CARS

Definition:

This TCM would implement the California program requirements (emissions standards and fleet make up).

Travel and Emissions Analysis:

Assumptions:

- Only emissions rates will be affected. No changes in travel will result.

Procedure:

Appropriate changes were made to the MOBILE5a setup and the resulting emissions were calculated.

Cost Methodology:

This measure would most likely be implemented after 1996. The cost to achieve the emissions reduction assumes that the first year of implementation would be 1996 model year cars and that 10% of the registered autos will be purchased in model year 1996 and that 10% of the new cars purchased would be California low emissions vehicles (LEV). The private cost per LEV used was $205 per vehicle.

34

FEEBATE ON PURCHASE OF NEW CAR

Definition:

This TCM encourages consumers to purchase new cars with higher efficiency characteristics. Specifically, it would evaluate the EPA test case of placing a fee on the purchase of vehicles with poor MPG, with a maximum of $1364 on vehicles attaining no more than 21 mpg, and a maximum rebate of $395 on 45 mpg vehicles.

Upon further discussion, the definition of this TCM has been revised to reflect a feebate schedule that induces emissions improvements rather than MPG. Indeed, vehicles with higher fuel economy may well produce higher emissions.

Travel and Emissions Analysis:

The feebate schedule is the same as that used by EPA in their 1991 study:

MPG	Fee/(Rebate)	MPG	Fee/Rebate
45	$(395)	31	$472
43	(286)	29	621
41	(173)	27	781
39	(56)	25	960
37	55	23	1154
35	193	21	1364
33	329		

Source: Meeting Mobility and Air Quality Goals: Strategies that Work (EPA, Office of Policy Analysis, January 1993)

Assume that the fee structure will be linked to emissions instead of MPG. The fee system applied to emissions is estimated to produce an improvement in average MPG for current model year cars from 27 in 1991 to 33 in 2000, an improvement of 22.2% This translates to a 2.2% per year improvement; we assume the same improvement would translate to emissions.

Thus: were this system to be instituted in 1995, then 1995 model year cars would be 2.2% cleaner than they would have been otherwise, and 1996 model year cars would be 4.4% cleaner. To evaluate impact on regional emissions, adjust the emissions factors in MOBILE to reflect these improvements for this portion of the stock.

Cost Methodology:

This measure provides a rebate to the purchase of new cars that are lower in emissions than the regular new car standard. The new cars that produce higher levels of emissions would be charged a fee (tax). The program would be established to pay for itself except for the administration fee. This fee was estimated to be $500,000 annually.

35

COMPREHENSIVE GAS TAX

Definition:

This TCM is defined as a comprehensive regional gas tax of $0.84 per gallon.

Travel and Emissions Analysis:

Evaluation was made with the DVRPC regional mode choice model applied to both work and non-work travel. The cost increase per gallon was translated to a cost per mile through assumption of a 21 mpg per average vehicle (then deflated by 0.58 time inflation factor).

Revised trip tables will be run through network assignment and then PPAQ for emissions estimation.

Cost Methodology:

This measure would increase gasoline taxes by $0.84 per gallon. The number of gallons consumed was calculated assuming a 21 miles per gallon average vehicle fleet rate and proportioned from the VMT tax of 4 cents per mile. An administration cost of $750,000 was assumed for collection of additional tax and auditing the tax collection program.

36

VEHICLE MILES TRAVELLED (VMT) TAX

Definition:

This TCM would impose a 4 cents tax per mile on all Vehicle Miles of Travel (VMT). The effect should be to decrease VMT by encouraging a shift to higher-occupancy modes, reducing the frequency and distance of travel, and possibly even causing a shift to more efficient vehicles.

Travel and Emissions Analysis:

This analysis will be performed in the same manner as the gas tax, through the DVRPC mode choice model, followed by assignment and PPAQ emissions model.

Auto operating cost was increased by 4 cents per mile in the travel skims, and the mode choice model run on such a difference in cost for both work and non-work travel. Revised trip tables were run through assignment and PPAQ.

Cost Methodology:

This measure would impose a four cents per mile tax on all vehicle miles travelled. The administration costs were assumed to be $1,000,000 to collect the vehicle mileage at the time of state inspection and to bill the owner.

37

FACILITY PRICING

Definition:

This TCM would double the current tolls for all vehicles getting both on and off the PA Turnpike (I-276) between the Route 100 and Route 1 interchanges, and the Northeast Extension (PA 9) from its origin to the interchange at Quakertown, during the AM peak period (6:30 to 9:00) and the PM peak period (4:00 to 6:30). (The measure would be complementary to the Cross-County Metro, if and when it is built.)

Travel and Emissions Analysis:

This measure was analyzed by DVRPC by adjusting the toll links in question to have a greater impedance and re-running the assignment and emissions models. The links were identified, and the assignment was re-run without re-running the mode choice/distribution model (thus, no effect on VMT).

Cost Methodology:

This measure would result in increased revenues from higher SOV tolls, which would then be used to cover reduced tolls for HOV users plus increased administrative costs. It is assumed that the toll structure will be adjusted to just cover the costs/subsidy increases, thus the program will operate *revenue neutral.*

3 RESULTS

The analysis clearly reveals that certain types of strategies are more effective than others. Of the 37 strategies tested, the pricing measures ($.84 gas tax, $.04 per VMT tax, $3/day regional parking charge, and $3/day parking tax in the CBD) show the most emissions reduction potential and are the most cost-effective (in fact, these strategies are revenue-producing). Also exhibiting high emissions reduction potential and cost-effectiveness are the ETRP and related strategies, educational efforts, and low-emission vehicles/fuels. Transit capital improvements, such as rail service extensions and restorations, have the lowest emission reduction potential and the lowest near-term cost-effectiveness. The analysis highlights various types of strategies that could be classified as moderately effective, including bicycle improvements, advanced signal system improvements, ramp metering, limits on new parking facilities, and removing pre-1980 vehicles.

When comparing the effectiveness of the measures using the figures presented below, it is important to also be familiar with the project definition and scope provided in the worksheets. The test scenarios vary greatly in scale and are not always directly comparable. Some of the sample applications are applied region-wide and have a greater potential for impact than do those which are more localized.

The results of the analysis are presented in the following summary tables. Keep in mind that the figures are estimates and not precise measurements.

Table 6 provides the travel and emissions impacts for each test scenario for an average summer weekday. Changes in vehicle trips and transit trips for home-based work travel and total travel are given along with changes in vehicle miles of travel. The change in emissions is shown in kilograms for VOC, CO, and NO_x.

Table 7 summarizes costs. Annual public sector and private sector costs and revenues are given, along with total cost-effectiveness in dollars per vehicle miles of travel reduced and dollars per ton of emissions reduced.

Table 8 groups the test scenarios by strategy type and provides their changes in annual VMT and emissions, and their cost-effectiveness. This purpose of this table is to highlight the range of impact and effectiveness within a particular class of strategies.

Table 9 ranks the measures in order of their annual emissions reduction while Table 10 ranks them by total cost-effectiveness.

Table 11 is a matrix categorizing each measure according to its emissions reduction potential and its cost-effectiveness. The emissions reduction levels are listed in the far left column and range from more than 1,000 annual tons reduced to 1 to 10 annual tons reduced. Cost-effectiveness levels are shown across the top row of the table and range from revenue-producing to more than $100,000 per ton. Each TCM that was tested is placed in the appropriate box. The measures with the most

emissions reduction potential and the highest cost-effectiveness fall into the upper left corner of the table, while the ones with the least emissions reduction potential and the lowest cost-effectiveness fall into the lower right corner.

Table 6
Travel and Emissions Impact Summary for an Average Summer Weekday

		CHANGE IN HOME-BASED WORK TRAVEL		CHANGE IN TOTAL TRAVEL		CHANGE IN TOTAL VMT	CHANGE IN EMISSIONS		
		Vehicle Trips % Change	Transit Trips % Change	Vehicle Trips % Change	Transit Trips % Change	Veh-Miles % Change	kg of VOC % Change	kg of CO % Change	kg of NO_x % Change
	1996 Base Condition 5-County PA Region Only	2,066,000 (a)	456,000 (a)	10,092,000 (a)	764,000 (a)	71,701,500 (b,c)	79,500 (b)	510,500 (b)	111,000 (b)
ID #	Test Scenario								
	TRAFFIC FLOW IMPROVEMENTS								
1	Advanced signal systems on 50 miles of the most congested 4-lane arterials	Not Calculated	Not Calculated	Not Calculated	Not Calculated	-70,544 -0.1	-135 -0.2	-545 -0.1	-145 -0.1
2	Advanced signal system improvements - Comprehensive system for Philadelphia CBD	Not Calculated	Not Calculated	Not Calculated	Not Calculated	-7,336 -0.0	-32 -0.0	-227 -0.0	-25 -0.0
3	Congestion and incident management systems on interstates within Philadelphia and the four suburban counties	Not Calculated	Not Calculated	Not Calculated	Not Calculated	+12,472 0.0	-149 -0.2	-638 -0.1	6 0.0
4	Ramp metering	Not Calculated	Not Calculated	Not Calculated	Not Calculated	-43,216 -0.1	-374 -0.5	-3,159 -0.6	-31 -0.0

		CHANGE IN HOME-BASED WORK TRAVEL		CHANGE IN TOTAL TRAVEL		CHANGE IN TOTAL VMT	CHANGE IN EMISSIONS		
		Vehicle Trips % Change	Transit Trips % Change	Vehicle Trips % Change	Transit Trips % Change	Veh-Miles % Change	kg of VOC % Change	kg of CO % Change	kg of NO_x % Change
	1996 Base Condition 5-County PA Region Only	2,066,000 (a)	456,000 (a)	10,092,000 (a)	764,000 (a)	71,701,500 (b,c)	79,500 (b)	510,500 (b)	111,000 (b)
ID #	Test Scenario								
5	Enforce adherence to 55 mph speed limit on PA Turnpike	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	-161 -0.2	-5,230 -1.0	-567 -0.5
	TRANSIT OPERATIONS								
6	Restoration of service on regional rail lines	-1,000 -0.0	1,267 0.3	-1,255 -0.0	1,998 0.3	-10,360 -0.0	-10 -0.0	-61 -0.0	-18 -0.0
7	Extension of Route 66 trackless trolley	-154 -0.0	171 0.0	-278 -0.0	364 0.0	-1,360 -0.0	-2 -0.0	-10 -0.0	-3 -0.0
8	Improvement to express service on regional rail lines	-368 -0.0	466 0.1	-505 -0.0	731 0.1	-14,752 -0.0	-14 -0.0	-87 -0.0	-26 -0.0
9	Systemwide fare reductions of 10%	-4,693 -0.2	5,505 1.2	-9,497 -0.1	13,164 1.7	-73,488 -0.1	-84 -0.1	-506 -0.1	-118 -0.1
10	Systemwide fare reductions of 20%	-8,275 -0.4	9,696 2.1	-16,762 -0.2	23,473 3.1	-144,016 -0.2	-178 -0.2	-977 -0.2	-238 -0.2
11	Systemwide fare reductions of 50%	-19,970 -1.0	23,409 5.1	-42,071 -0.4	58,884 7.7	-362,432 -0.5	-425 -0.5	-2,460 -0.5	-622 -0.6
12	Improve suburban bus service	-5,373 -0.3	6,161 1.4	-7,248 -0.1	9,216 1.2	-54,000 -0.1	-61 -0.1	-393 -0.1	-92 -0.1

		CHANGE IN HOME-BASED WORK TRAVEL		CHANGE IN TOTAL TRAVEL		CHANGE IN TOTAL VMT	CHANGE IN EMISSIONS		
		Vehicle Trips % Change	Transit Trips % Change	Vehicle Trips % Change	Transit Trips % Change	Veh-Miles % Change	kg of VOC % Change	kg of CO % Change	kg of NO_x % Change
	1996 Base Condition 5-County PA Region Only	2,066,000 (a)	456,000 (a)	10,092,000 (a)	764,000 (a)	71,701,500 (b,c)	79,500 (b)	510,500 (b)	111,000 (b)
ID #	Test Scenario								
13	Application of "transit first" principles in Philadelphia	-1,263 -0.1	1,508 0.3	-2,677 -0.0	3,742 0.5	-9,264 -0.0	-18 -0.0	-74 -0.0	-14 -0.0
14	Reuse of surplus LRVs and trackless trolleys on bus routes in Philadelphia	Not Calculated	Not Calculated	-2,192 -0.0	2,586 0.3	-5,858 -0.0	-6 -0.0	-40 -0.0	-9 -0.0
15	Improve City Transit Division service	-4,579 -0.2	5,343 1.2	-7,800 -0.1	10,604 1.4	-52,512 -0.1	-85 -0.1	-372 -0.1	-81 -0.1
16	Philadelphia to Harrisburg rail service improvements	Not Calculated	Not Calculated	-288 -0.0	360 0.0	-14,212 -0.0	-11 -0.0	-80 -0.0	-24 -0.0
	TRANSPORTATION MANAGEMENT PLANS								
17	Implementation of ETRP in Pennsylvania (all APO targets reached)	-161,236 -7.8	55,567 12.2	-161,236 -1.6	55,567 7.3	-1,226,424 -1.7	-1,625 -2.0	-10,415 -2.0	-1,996 -1.8
18	Comprehensive regional ridesharing program (d)	-24,142 -1.2	5,539 1.2	-24,142 -0.2	5,539 0.7	-184,256 -0.3	-272 -0.3	-1,399 -0.3	-295 -0.3

		CHANGE IN HOME-BASED WORK TRAVEL		CHANGE IN TOTAL TRAVEL		CHANGE IN TOTAL VMT	CHANGE IN EMISSIONS		
		Vehicle Trips % Change	Transit Trips % Change	Vehicle Trips % Change	Transit Trips % Change	Veh-Miles % Change	kg of VOC % Change	kg of CO % Change	kg of NO_x % Change
	1996 Base Condition 5-County PA Region Only	2,066,000 (a)	456,000 (a)	10,092,000 (a)	764,000 (a)	71,701,500 (b,c)	79,500 (b)	510,500 (b)	111,000 (b)
ID #	Test Scenario								
19	Availability and promotion of $25 Transitchek (d)	-12,348 -0.6	7,467 1.6	-12,348 -0.1	7,467 1.0	-84,792 -0.1	-108 -0.1	-634 -0.1	-128 -0.1
20	Telecommuting (d)	-48,306 -2.3	-20,289 -4.5	-48,306 -0.5	-20,289 -2.7	-388,368 -0.5	-532 -0.7	-3,005 -0.6	-619 -0.6
21	Compressed work weeks (9/80)	-21,440 -1.0	-4,762 -1.0	-21,440 -0.2	-4,762 -0.6	-162,288 -0.2	-186 -0.2	-1,165 -0.2	-245 -0.2
	PARKING MANAGEMENT								
22	Prohibit new construction of parking facilities in Center City	Negligible Impact	Negligible Impact	Negligible Impact	Negligible Impact	Negligible Impact	Negligible Impact	Negligible Impact	Negligible Impact
23	Limit parking facilities at new suburban employment sites	-6,720 -0.3	None	-6,720 -0.1	None	-47,613 -0.1	-76 -0.1	-398 -0.1	-72 -0.1
24	$3.00 parking surcharge paid by all regional employees arriving in private vehicles	-177,922 -8.6	139,772 30.7	-177,922 -1.8	139,772 18.3	-1,373,592 -1.9	-1,725 -2.2	-10,772 -2.1	-2,266 -2.0

		CHANGE IN HOME-BASED WORK TRAVEL		CHANGE IN TOTAL TRAVEL		CHANGE IN TOTAL VMT	CHANGE IN EMISSIONS		
		Vehicle Trips % Change	Transit Trips % Change	Vehicle Trips % Change	Transit Trips % Change	Veh-Miles % Change	kg of VOC % Change	kg of CO % Change	kg of NO_x % Change
	1996 Base Condition 5-County PA Region Only	2,066,000 (a)	456,000 (a)	10,092,000 (a)	764,000 (a)	71,701,500 (b,c)	79,500 (b)	510,500 (b)	111,000 (b)
ID #	Test Scenario								
25	Institute a $3.00 parking tax in the Phila CBD to be paid by all employees	-45,042 -2.2	48,844 10.7	-45,042 -0.4	48,844 6.4	-392,336 -0.5	-430 -0.5	-2,832 -0.6	-661 -0.6
26	Construct new park and ride lots along highways	None	-1,985 -0.4	None	-1,985 -0.3	-50,616 -0.1	-49 -0.1	-299 -0.1	-78 -0.1
27	Expand parking at rail stations	None	7,352 1.6	None	7,352 1.0	-106,160 -0.1	-101 -0.1	-593 -0.1	-170 -0.2
	NON-MOTORIZED PROGRAMS AND FACILITIES								
28	Comprehensive bicycle improvements in the region that would capture 5% of auto work trips ≤ 5 miles	-61,985 -3.0	-13,469 -3.0	-61,985 -0.6	-13,469 -1.8	-92,584 -0.1	-191 -0.2	-931 -0.2	-163 -0.1

		CHANGE IN HOME-BASED WORK TRAVEL		CHANGE IN TOTAL TRAVEL		CHANGE IN TOTAL VMT	CHANGE IN EMISSIONS		
		Vehicle Trips % Change	Transit Trips % Change	Vehicle Trips % Change	Transit Trips % Change	Veh-Miles % Change	kg of VOC % Change	kg of CO % Change	kg of NO_x % Change
	1996 Base Condition 5-County PA Region Only	2,066,000 (a)	456,000 (a)	10,092,000 (a)	764,000 (a)	71,701,500 (b,c)	79,500 (b)	510,500 (b)	111,000 (b)
ID #	Test Scenario								
29	Comprehensive bicycle improvements in the region that would capture 5% of access trips of ≤ 5 miles for work purposes to 14 selected rail stations	-651 -0.0	-63 -0.0	-651 -0.0	-63 -0.0	-1,320 -0.0	-2 -0.0	-11 -0.0	-2 -0.0
30	Comprehensive bicycle improvements in the region that would capture 5% of non-work trips ≤ 5 miles	None	None	-112,712 -1.1	-7,484 -1.0	-160,336 -0.2	-301 -0.4	-1,588 -0.3	-311 -0.3
	EMISSIONS REDUCTION PROGRAMS								
31	Removal of 50% of pre-1980 vehicles	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	-4,501 -5.7	-31,076 -6.1	-2,261 -2.0
32	Reduction in cold starts	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	-888 -1.1	-6,671 -1.3	-572 -0.5
33	California cars	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	-517 -0.7	-1,524 -0.3	-720 -0.7

		CHANGE IN HOME-BASED WORK TRAVEL		CHANGE IN TOTAL TRAVEL		CHANGE IN TOTAL VMT	CHANGE IN EMISSIONS		
		Vehicle Trips % Change	Transit Trips % Change	Vehicle Trips % Change	Transit Trips % Change	Veh-Miles % Change	kg of VOC % Change	kg of CO % Change	kg of NO_x % Change
	1996 Base Condition 5-County PA Region Only	2,066,000 (a)	456,000 (a)	10,092,000 (a)	764,000 (a)	71,701,500 (b,c)	79,500 (b)	510,500 (b)	111,000 (b)
ID #	Test Scenario								
	PRICING MECHANISMS								
34	Feebate on purchase of new car	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	-257 -0.3	-876 -0.2	-156 -0.1
35	Comprehensive gas tax of $.84 per gallon	-8,841 -0.4	14,206 3.1	-13,699 -0.1	25,739 3.4	-5,236,544 -7.3	-4,740 -6.0	-28,697 -5.6	-7,909 -7.2
36	VMT tax of $.04	-8,841 -0.4	14,206 3.1	-13,699 -0.1	25,739 3.4	-5,236,544 -7.3	-4,740 -6.0	-28,697 -5.6	-7,909 -7.2
37	Double tolls on PA Turnpike during peak periods	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	-6 -0.0	183 0.0	0 0.0
		Notes: (a) = Source is DVRPC's 1996 No-Build Network (b) = Source is PPAQ Air Quality Model (COMSIS Corp./Garmen Associates) (c) = HB ADWT Work VMT is about 25% of Total ADWT VMT for the 1996 Base Condition (d) = Impact of this test scenario is independent of #17-ETRP							

Table 7
Cost Impact Summary

		Annual Public Sector (Govt) Cost and Revenue (a) Annual Private Sector Cost and Revenue (a)						Total Cost Effectiveness (public & private) (d)	
ID #	Test Scenario	Capital Cost	Operating Cost	Revenue	Net Cost	Change in Annual VMT (Veh-miles) (a)	Change in Annual Emissions (tons) (a,b,c)	$/VMT reduced (a)	$/ton reduced (a,b,c)
				TRAFFIC FLOW IMPROVEMENTS					
1	Advanced signal systems on 50 miles of the most congested 4-lane arterials	$1,388,657 $0	$279,540 $0	$0 $0	$1,668,197 $0	-17,636,000	-77	$0.09	$21,620
2	Advanced signal system improvements - Comprehensive system for Philadelphia CBD	$1,964,209 $0	$0 $0	$0 $0	$1,964,209 $0	-1,834,000	-16	$1.07	$125,048
3	Congestion and incident management systems on interstates within Philadelphia and the four suburban counties	$4,727,215 $0	$3,172,000 $0	$0 $0	$7,899,215 $0	+3,118,000	-39	$2.53 (per VMT *added*)	$200,452
4	Ramp metering	$275,705 $0	$25,500 $0	$0 $0	$301,205 $0	-10,804,000	-112	$0.03	$2,699

		Annual Public Sector (Govt) Cost and Revenue (a) Annual Private Sector Cost and Revenue (a)						Total Cost Effectiveness (public & private) (d)	
ID #	Test Scenario	Capital Cost	Operating Cost	Revenue	Net Cost	Change in Annual VMT (Veh-miles) (a)	Change in Annual Emissions (tons) (a,b,c)	$/VMT reduced (a)	$/ton reduced (a,b,c)
5	Enforce adherence to 55 mph speed limit on PA Turnpike	$0 $0	$2,240,000 $0	$0 $0	$2,240,000 $0	Not Applicable	-201	NA	$11,166
	TRANSIT OPERATIONS								
6	Restoration of service on regional rail lines	$4,583,349 $0	$3,636,360 $0	$1,599,998 $0	$6,619,711 $0	-2,590,000	-8	$2.56	$857,915
7	Extension of Route 66 trackless trolley	$1,273,153 $0	$70,070 $0	$30,940 $0	$1,312,283 $0	-340,000	-1	$3.86	$952,402
8	Improvement to express service on regional rail lines	$469,668 $0	$1,330,420 $0	$585,385 $0	$1,214,703 $0	-3,688,000	-11	$0.33	$110,198
9	Systemwide fare reductions of 10%	$2,106,240 $0	$6,582,000 $0	$2,606,472 $0	$6,081,768 $0	-18,372,000	-56	$0.33	$109,255
10	Systemwide fare reductions of 20%	$3,755,680 $0	$11,736,500 $0	$4,131,248 $0	$11,360,932 $0	-36,004,000	-115	$0.32	$99,102
11	Systemwide fare reductions of 50%	$9,421,440 $0	$29,442,000 $0	$6,477,240 $0	$32,386,200 $0	-90,608,000	-289	$0.36	$112,247

		Annual Public Sector (Govt) Cost and Revenue (a) Annual Private Sector Cost and Revenue (a)						Total Cost Effectiveness (public & private) (d)	
ID #	Test Scenario	Capital Cost	Operating Cost	Revenue	Net Cost	Change in Annual VMT (Veh-miles) (a)	Change in Annual Emissions (tons) (a,b,c)	$/VMT reduced (a)	$/ton reduced (a,b,c)
12	Improve suburban bus service	$437,760 $0	$2,649,600 $0	$1,175,040 $0	$1,912,320 $0	-13,500,000	-42	$0.14	$45,356
13	Application of "transit first" principles in Philadelphia	$533,411 $0	$991,630 $0	$439,685 $0	$1,085,356 $0	-2,316,000	-9	$0.47	$123,079
14	Reuse of surplus LRVs and trackless trolleys on bus routes in Philadelphia	$0 $0	$685,290 $0	$303,855 $0	$381,435 $0	-1,464,500	-4	$0.26	$92,277
15	Improve City Transit Division service	$253,793 $0	$3,048,650 $0	$1,352,010 $0	$1,950,433 $0	-13,128,000	-46	$0.15	$42,637
16	Philadelphia to Harrisburg rail service improvements	$4,484,700 $0	$2,252,700 $0	$739,800 $0	$5,943,600 $0	-3,553,000	-10	$1.67	$619,774
	TRANSPORTATION MANAGEMENT PLANS								
17	Implementation of ETRP in Pennsylvania (all APO targets reached)	$8,890,720 $0	$36,119,439 $114,690,255	$12,224,740 $184,046,340	$32,785,419 -$69,356,085	-306,606,000	-998	-$0.12	-$36,649

		Annual Public Sector (Govt) Cost and Revenue (a) Annual Private Sector Cost and Revenue (a)						Total Cost Effectiveness (public & private) (d)	
ID #	Test Scenario	Capital Cost	Operating Cost	Revenue	Net Cost	Change in Annual VMT (Veh-miles) (a)	Change in Annual Emissions (tons) (a,b,c)	$/VMT reduced (a)	$/ton reduced (a,b,c)
18	Comprehensive regional ridesharing program	$0 $0	$750,000 $853,505	$0 $0	$750,000 $853,505	-46,064,000	-156	$0.03	$10,262
19	Availability and promotion of $25 Transitchek	$1,194,720 $0	$4,195,679 $4,621,792	$1,642,740 $0	$3,747,659 $4,621,792	-21,198,000	-65	$0.39	$128,691
20	Telecommuting	$0 $0	-$10,144,500 $10,207,817	-$4,463,580 $0	-$5,680,920 $10,207,817	-97,092,000	-317	$0.05	$14,272
21	Compressed work weeks (9/80)	$0 $0	-$2,381,000 $0	-$1,047,640 $0	-$1,333,360 $0	-40,572,000	-119	-$0.03	-$11,226
	PARKING MANAGEMENT								
22	Prohibit new construction of parking facilities in Center City	Negligible Impact	Negligible Impact	Negligible Impact	Negligible Impact	Negligible Impact	Negligible Impact	Negligible Impact	Negligible Impact
23	Limit parking facilities at new suburban employment sites	$0 -$1,368,894	$0 $0	$0 $0	$0 -$1,368,894	-11,903,213	-41	-$0.12	-$33,728

		Annual Public Sector (Govt) Cost and Revenue (a) Annual Private Sector Cost and Revenue (a)						Total Cost Effectiveness (public & private) (d)	
ID #	Test Scenario	Capital Cost	Operating Cost	Revenue	Net Cost	Change in Annual VMT (Veh-miles) (a)	Change in Annual Emissions (tons) (a,b,c)	$/VMT reduced (a)	$/ton reduced (a,b,c)
24	$3.00 parking surcharge paid by all regional employees arriving in private vehicles	$22,363,520 $0	$70,386,000 $20,275,332	$30,749,840 $561,696,750	$61,999,680 -$541,421,418	-343,398,000	-1,100	-$1.40	-$435,912
25	Institute a $3.00 parking tax in the Phila CBD to be paid by all employees	$7,815,040 $0	$24,672,000 $2,072,868	$10,745,680 $37,015,500	$21,741,360 -$34,942,632	-98,084,000	-301	-$0.13	-$43,909
26	Construct new park and ride lots along highways	$3,390,057 $0	$1,956,375 $0	$447,040 $0	$4,899,392 $0	-12,654,000	-35	$0.39	$139,991
27	Expand parking at rail stations	$4,427,257 $0	$6,487,000 $0	$2,502,280 $0	$8,411,977 $0	-26,540,000	-75	$0.32	$112,640
	NON-MOTORIZED PROGRAMS AND FACILITIES								
28	Comprehensive bicycle improvements in the region that would capture 5% of auto work trips ≤ 5 miles	$2,016,017 $5,265,510	-$4,512,115 $0	-$1,985,331 $0	-$510,768 $5,265,510	-23,146,000	-98	$0.21	$48,740

		Annual Public Sector (Govt) Cost and Revenue (a) Annual Private Sector Cost and Revenue (a)						Total Cost Effectiveness (public & private) (d)	
ID #	Test Scenario	Capital Cost	Operating Cost	Revenue	Net Cost	Change in Annual VMT (Veh-miles) (a)	Change in Annual Emissions (tons) (a,b,c)	$/VMT reduced (a)	$/ton reduced (a,b,c)
29	Comprehensive bicycle improvements in the region that would capture 5% of access trips of ≤ 5 miles for work purposes to 14 selected rail stations	$84,033 $0	-$21,105 $0	-$9,286 $0	$72,214 $0	-330,000	-1	$0.22	$65,513
30	Comprehensive bicycle improvements in the region that would capture 5% of non-work trips ≤ 5 miles	$164,537 $2,393,563	$0 $0	-$1,103,142 $0	$1,267,679 $2,393,563	-40,084,000	-169	$0.09	$21,709
	EMISSIONS REDUCTION PROGRAMS								
31	Removal of 50% of pre-1980 vehicles	$99,750,000 $0	$7,125,000 $0	$0 $0	$106,875,000 $0	Not Applicable	-1,863	Not Applicable	$57,354
32	Reduction in cold starts	$0 $0	$750,000 $0	$0 $0	$750,000 $0	Not Applicable	-402	Not Applicable	$1,864

		Annual Public Sector (Govt) Cost and Revenue (a) Annual Private Sector Cost and Revenue (a)						Total Cost Effectiveness (public & private) (d)	
ID #	Test Scenario	Capital Cost	Operating Cost	Revenue	Net Cost	Change in Annual VMT (Veh-miles) (a)	Change in Annual Emissions (tons) (a,b,c)	$/VMT reduced (a)	$/ton reduced (a,b,c)
33	California cars	$0 $3,714,664	$0 $0	$0 $0	$0 $3,714,664	Not Applicable	-341	Not Applicable	$10,897
	PRICING MECHANISMS								
34	Feebate on purchase of new car	$0 $0	$500,000 $0	$0 $0	$500,000 $0	Not Applicable	-114	Not Applicable	$4,393
35	Comprehensive gas tax of $.84 per gallon	$0 $0	$750,000 $0	$717,010,640 $0	-$716,260,640 $0	-1,309,136,000	-3,486	-$0.55	-$205,484
36	VMT tax of $.04	$0 $0	$1,000,000 $0	$717,010,640 $0	-$716,010,640 $0	-1,309,136,000	-3,486	-$0.55	-$205,412
37	Double tolls on PA Turnpike during peak periods	$0 $0	$250,000 $0	$250,000 $0	$0 $0	Not Applicable	-2	Not Applicable	$0
		Notes: (a) = Annual calculation is based on 250 days per year (b) = Each ton of emissions is the sum of VOC and NO_x (c) = 1kg of emissions daily = (1*250)/907.2 tons annually (0.2756) (d) = A negative value in the Cost-Effectiveness column indicates that the measure will generate revenue							

Table 8
TCM Test Scenarios Grouped by Strategy Type

ID #	Test Scenario	Change in Annual VMT (millions of veh-miles)	Total Cost Effectiveness ($/VMT reduced) (a)	Change in Annual Emissions (tons) (b)	Total Cost Effectiveness ($000/ton reduced) (a)
	Traffic Flow Improvements				
1	Advanced signal system on 4-lane arterials	-17.6	$0.09	-77	$21.6
2	Advanced signal system in Phila CBD	-1.8	$1.07	-16	$125.0
3	CIMS on interstate system	+3.1	$2.53(c)	-39	$200.5
4	Ramp metering	-10.8	$0.03	-112	$2.7
5	Enforce 55 mph speed limit on PA Tpk	NA	NA	-201	$11.2
	Transit Operations				
6	Restoration of service on regional rail lines	-2.6	$2.56	-8	$857.9
7	Extension of Rte 66 trackless trolley	-0.3	$3.86	-1	$952.4
8	Improvement to express service on regional rail lines	-3.7	$0.33	-11	$110.2
9	10% system-wide transit fare reduction	-18.4	$0.33	-56	$109.3
10	20% system-wide transit fare reduction	-36.0	$0.32	-115	$99.1
11	50% system-wide transit fare reduction	-90.6	$0.36	-289	$112.2
12	Improve suburban bus service	-13.5	$0.14	-42	$45.4
13	Apply "Transit-First" in Phila CBD	-2.3	$0.47	-9	$123.1
14	Reuse surplus LRVs on bus routes in Phila	-1.5	$0.26	-4	$92.3
15	Improve City Transit Division service	-13.1	$0.15	-46	$42.6
16	Philadelphia to Harrisburg rail service improvements	-3.6	$1.67	-10	$619.8
	Transportation Management Plans				
17	Implementation of PA ETRP (all APO targets reached)	-306.6	-$0.12	-998	-$36.6
18	Comprehensive regional ridesharing program	-46.1	$0.03	-156	$10.3
19	$25 TransitChek	-21.2	$0.39	-65	$128.7
20	Telecommuting	-97.1	$0.05	-317	$14.3

ID #	Test Scenario	Change in Annual VMT (millions of veh-miles)	Total Cost Effectiveness ($/VMT reduced) (a)	Change in Annual Emissions (tons) (b)	Total Cost Effectiveness ($000/ton reduced) (a)
21	Compressed work weeks (9/80)	-40.6	-$0.03	-119	-$11.2
	Parking Management				
22	Prohibit new parking facilities in Center City	Negligible Impact	Negligible Impact	Negligible Impact	Negligible Impact
23	Limit parking facilities at new suburban employment sites	-11.9	-$0.12	-41	-$33.7
24	$3 parking surcharge paid by all regional employees	-343.4	-$1.40	-1100	-$435.9
25	$3 parking tax in Philadelphia CBD	-98.1	-$0.13	-301	-$43.9
26	New park and ride lots along highways	-12.7	$0.39	-35	$140.0
27	Expand parking at rail stations	-26.5	$0.32	-75	$112.6
	Non-Motorized Programs & Facilities				
28	Bike captures 5% of auto work trips ≤ 5 miles	-23.1	$0.21	-98	$48.7
29	Bike captures 5% of access trips ≤ 5 miles for work purposes to 14 rail stations	-0.3	$0.22	-1	$65.5
30	Bike captures 5% of non-work trips ≤ 5 miles	-40.1	$0.09	-169	$21.7
	Emissions Reduction Programs				
31	Removal of 50% of pre-1980 vehicles	NA	NA	-1863	$57.4
32	Reduction in cold starts	NA	NA	-402	$1.9
33	California cars	NA	NA	-341	$10.9
	Pricing Mechanisms				
34	Feebate on new car purchase	NA	NA	-114	$4.4
35	$.84 per gallon gas tax	-1309.1	-$0.55	-3486	-$205.5
36	$.04 per vehicle mile travelled tax	-1309.1	-$0.55	-3486	-$205.4
37	Facility pricing (double Turnpike tolls during peak periods)	NA	NA	-2	$0.0

(a) = A negative value in the Cost-Effectiveness column indicates that the measure will generate revenue
(b) = Each ton of emissions is the sum of VOC and NO_x
(c) = $2.53 per VMT *added*

Table 9
Test Scenarios Ranked in Order of Emissions Reduction Potential

ID #	Test Scenario	Change in Annual Emissions (tons) (a)	Total Cost Effectiveness ($000/ton reduced) (b)	Change in Annual VMT (millions of veh-miles)	Total Cost Effectiveness ($/VMT reduced) (b)
35	$.84 per gallon gas tax	-3486	-$205.5	-1309.1	-$0.55
36	$.04 per vehicle mile travelled tax	-3486	-$205.4	-1309.1	-$0.55
31	Removal of 50% of pre-1980 vehicles	-1863	$57.4	NA	NA
24	$3 parking surcharge paid by all regional employees	-1100	-$435.9	-343.4	-$1.40
17	Implementation of PA ETRP (all APO targets reached)	-998	-$36.6	-306.6	-$0.12
32	Reduction in cold starts	-402	$1.9	NA	NA
33	California cars	-341	$10.9	NA	NA
20	Telecommuting	-317	$14.3	-97.1	$0.05
25	$3 parking tax in Philadelphia CBD	-301	-$43.9	-98.1	-$0.13
11	50% system-wide transit fare reduction	-289	$112.2	-90.6	$0.36
5	Enforce 55 mph speed limit on PA Tpk	-201	$11.2	NA	NA
30	Bike captures 5% of non-work trips ≤ 5 miles	-169	$21.7	-40.1	$0.09
18	Comprehensive regional ridesharing program	-156	$10.3	-46.1	$0.03
21	Compressed work weeks (9/80)	-119	-$11.2	-40.6	-$0.03
10	20% system-wide transit fare reduction	-115	$99.1	-36.0	$0.32
34	Feebate on new car purchase	-114	$4.4	NA	NA
4	Ramp metering	-112	$2.7	-10.8	$0.03
28	Bike captures 5% of auto work trips ≤ 5 miles	-98	$48.7	-23.1	$0.21
1	Advanced signal system on 4-lane arterials	-77	$21.6	-17.6	$0.09
27	Expand parking at rail stations	-75	$112.6	-26.5	$0.32
19	$25 TransitChek	-65	$128.7	-21.2	$0.39
9	10% system-wide transit fare reduction	-56	$109.3	-18.4	$0.33

ID #	Test Scenario	Change in Annual Emissions (tons) (a)	Total Cost Effectiveness ($000/ton reduced) (b)	Change in Annual VMT (millions of veh-miles)	Total Cost Effectiveness ($/VMT reduced) (b)
15	Improve City Transit Division service	-46	$42.6	-13.1	$0.15
12	Improve suburban bus service	-42	$45.4	-13.5	$0.14
23	Limit parking facilities at new suburban employment sites	-41	-$33.7	-11.9	-$0.12
3	CIMS on interstate system	-39	$200.5	+3.1	$2.53(c)
26	New park and ride lots along highways	-35	$140.0	-12.7	$0.39
2	Advanced signal system in Phila CBD	-16	$125.0	-1.8	$1.07
8	Improvement to express service on regional rail lines	-11	$110.2	-3.7	$0.33
16	Philadelphia to Harrisburg rail service improvements	-10	$619.8	-3.6	$1.67
13	Apply "Transit-First" in Phila CBD	-9	$123.1	-2.3	$0.47
6	Restoration of service on regional rail lines	-8	$857.9	-2.6	$2.56
14	Reuse surplus LRVs on bus routes in Phila	-4	$92.3	-1.5	$0.26
37	Facility pricing (double Turnpike tolls during peak periods)	-2	$0.0	NA	NA
29	Bike captures 5% of access trips $\leq$ 5 for work purposes to 14 rail stations	-1	$65.5	-0.3	$0.22
7	Extension of Rte 66 trackless trolley	-1	$952.4	-0.3	$3.86
22	Prohibit new parking facilities in Center City	Negligible Impact	Negligible Impact	Negligible Impact	Negligible Impact

(a) = Each ton of emissions is the sum of VOC and NO_x
(b) = A negative value in the Cost-Effectiveness column indicates that the measure will generate revenue
(c) = $2.53 per VMT *added*

Table 10
Test Scenarios Ranked in Order of Cost-Effectiveness

ID #	Test Scenario	Total Cost Effectiveness ($000/ton reduced) (a)	Change in Annual Emissions (tons) (b)	Change in Annual VMT (millions of veh-miles)	Total Cost Effectiveness ($/VMT reduced) (a)
24	$3 parking surcharge paid by all regional employees	-$435.9	-1100	-343.4	-$1.40
35	$.84 per gallon gas tax	-$205.5	-3486	-1309.1	-$0.55
36	$.04 per vehicle mile travelled tax	-$205.4	-3486	-1309.1	-$0.55
25	$3 parking tax in Philadelphia CBD	-$43.9	-301	-98.1	-$0.13
17	Implementation of PA ETRP (all APO targets reached)	-$36.6	-998	-306.6	-$0.12
23	Limit parking facilities at new suburban employment sites	-$33.7	-41	-11.9	-$0.12
21	Compressed work weeks (9/80)	-$11.2	-119	-40.6	-$0.03
37	Facility pricing (double Turnpike tolls during peak periods)	$0.0	-2	NA	NA
32	Reduction in cold starts	$1.9	-402	NA	NA
4	Ramp metering	$2.7	-112	-10.8	$0.03
34	Feebate on new car purchase	$4.4	-114	NA	NA
18	Comprehensive regional ridesharing program	$10.3	-156	-46.1	$0.03
33	California cars	$10.9	-341	NA	NA
5	Enforce 55 mph speed limit on PA Tpk	$11.2	-201	NA	NA
20	Telecommuting	$14.3	-317	-97.1	$0.05
1	Advanced signal system on 4-lane arterials	$21.6	-77	-17.6	$0.09
30	Bike captures 5% of non-work trips $\leq$ 5 miles	$21.7	-169	-40.1	$0.09
15	Improve City Transit Division service	$42.6	-46	-13.1	$0.15
12	Improve suburban bus service	$45.4	-42	-13.5	$0.14
28	Bike captures 5% of auto work trips $\leq$ 5 miles	$48.7	-98	-23.1	$0.21
31	Removal of 50% of pre-1980 vehicles	$57.4	-1863	NA	NA

ID #	Test Scenario	Total Cost Effectiveness ($000/ton reduced) (a)	Change in Annual Emissions (tons) (b)	Change in Annual VMT (millions of veh-miles)	Total Cost Effectiveness ($/VMT reduced) (a)
29	Bike captures 5% of rail Access trips ≤ 5 miles for work purposes to 14 rail stations	$65.5	-1	-0.3	$0.22
14	Reuse surplus LRVs on bus routes in Phila	$92.3	-4	-1.5	$0.26
10	20% system-wide transit fare reduction	$99.1	-115	-36.0	$0.32
9	10% system-wide transit fare reduction	$109.3	-56	-18.4	$0.33
8	Improvement to express service on regional rail lines	$110.2	-11	-3.7	$0.33
11	50% system-wide transit fare reduction	$112.2	-289	-90.6	$0.36
27	Expand parking at rail stations	$112.6	-75	-26.5	$0.32
13	Apply "Transit-First" in Phila CBD	$123.1	-9	-2.3	$0.47
2	Advanced signal system in Phila CBD	$125.0	-16	-1.8	$1.07
19	$25 TransitChek	$128.7	-65	-21.2	$0.39
26	New park and ride lots along highways	$140.0	-35	-12.7	$0.39
3	CIMS on interstate system	$200.5	-39	+3.1	$2.53(c)
16	Philadelphia to Harrisburg rail service improvements	$619.8	-10	-3.6	$1.67
6	Restoration of service on regional rail lines	$857.9	-8	-2.6	$2.56
7	Extension of Rte 66 trackless trolley	$952.4	-1	-0.3	$3.86
22	Prohibit new parking facilities in Center City	Negligible Impact	Negligible Impact	Negligible Impact	Negligible Impact

(a) = A negative value in the Cost-Effectiveness column indicates that the measure will generate revenue
(b) = Each ton of emissions is the sum of VOC and NO_x
(c) = $2.53 per VMT *added*

Table 11
TCM Emissions Reduction Potential Versus Cost-Effectiveness

Emissions Reduction	Revenue-Producing TCMs	Cost: $0 to $25,000 per ton	Cost: $26,000 to $100,000 per ton	Cost: > $100,000 per ton
>1,000 annual tons	$3 parking surcharge on all employees $.84 per gallon gas tax $.04 per vehicle mile travelled tax		Removal of pre-1980 vehicles	
301 - 1,000 annual tons	Implementation of ETRP $3 parking tax on all CBD employees	California cars Telecommuting Reduction in cold starts		
101 - 300 annual tons	Compressed work week	Ramp metering Enforce 55 mph limit on Turnpike Comprehensive regional rideshare prgm Feebate on new car purchase Bike captures 5% non-work trips ≤ 5 miles	20% transit fare reduction	50% transit fare reduction
11 - 100 annual tons	Limit parking facilities at new suburban sites	Advanced signal system on 4-lane arterials	Improve suburban bus service Improve City Transit Division service Bike captures 5% auto work trips ≤ 5 miles	Advncd signal system in Phila CBD CIMS on interstates Improvements to RR express service 10% transit fare reduction $25 per month Transitchek New park and ride lots Expand rail station P&R lots
1 - 10 annual tons		Facility pricing (double Turnpike tolls)	Reuse surplus LRVs on bus rts in Phila Bike captures 5% of access trips ≤ 5 miles to rail stations for work purposes	Service restoration on RR lines Extension of Rt 66 trackless trolley "Transit-first" in CBD Improve Phila-Harrisburg rail service

4 POLICY IMPLICATIONS AND DIRECTIONS

The TCM analysis provides a valuable base of information with which to form policy recommendations that will guide the content of future SIPs, Transportation Improvement Programs (TIPs), Transportation Plans, and Work Programs. The results of the analysis raise numerous policy questions for consideration by the DVRPC Board, some of which follow.

Pricing Measures

Should the Board recommend that the states pursue pricing strategies for incorporation into the SIP? Measures such as gas taxes, vehicle miles travelled taxes, and parking charges have the highest emission reduction potential and are the most cost-effective. In fact, pricing strategies usually produce revenue, which can be used to used to subsidize other worthwhile but less cost-effective projects such as transit fare reductions.

On the other hand, pricing strategies will be the most difficult and time consuming strategies to implement. They require state initiation or legislative action and will undoubtedly spur public opposition and political disputes. Even though pricing strategies offer the highest potential benefit, it may be unwise to concentrate on projects where the consensus necessary for implementation cannot be guaranteed.

Transit Capital Measures

Should the Board recommend any transit capital projects for incorporation into the SIP? Although transit measures such as rail service extensions and restorations have lower emission reduction potential and are less cost-effective in the short term than other types of strategies, their effectiveness may significantly increase over a longer time frame since transit capital improvements assure a *permanent* alternative to single occupant vehicles. Whether placed in the SIP or not, transit projects will continue to be actively pursued in the TIP and work program.

Region-Implementable Measures

Should the Board recommend pursuing the strategies that can be implemented through the region's planning and programming process even if they demonstrate only moderate emission reduction potential and cost-effectiveness? These types of measures include bicycle improvements, transit operational improvements, selected measures to reduce traffic congestion and delay, and financial support for ridesharing and other transportation demand management programs.

Since these types of strategies can be carried out at the regional level, implementation can occur more quickly and easily than for projects that require state action.

ETRP and Related Strategies

Should the Board recommend continued support and endorsement of the ETRP and related strategies? The analysis indicates that a full scale effort in which all of the employers meet their trip reductions goals can be successful in reducing emissions and cost-effective.

However, it is doubtful that all employers will reach their targets — in fact, several nation-wide studies estimate that ETRPs will result in relatively small emissions reductions. In addition, some local businesses actively oppose the ETRP, claiming it will produce minimal benefits at a very high cost.

Technical Measures

Should the Board recommend that the states continue to exploit technological means to reduce emissions? Advancing technological measures such as reformulated fuels, reductions in Reid Vapor Pressure (RVP), and California Low-Emission Vehicle Standards can lead to significant emissions reductions.

However, it may be unnecessary to become involved in pursuing these types of strategies, since they are and will continue to be under the purview of the EPA and the Ozone Transport Commission.

Educational Efforts

Should the Board recommend that the states continue to promote behavioral changes through educational programs? Although educational programs in and of themselves will not reduce emissions, they will build a necessary constituency for air quality measures. The fact that recycling is now considered a normal part of everyday life illustrates the potential effectiveness of a large scale educational program.

However, the highly visible, on-going, multi-media campaign necessary for a successful air quality educational program will require considerable financial resources. Since only limited funds are available, projects with more tangible results may take precedence.

DVRPC's role in project implementation must also be examined in the policy making process. For strategies that are the state's responsibility, DVRPC's role may be limited to adopting a resolution of endorsement or support. For strategies that can be initiated at the regional level, DVRPC will be actively involved in transforming the test scenarios into actual projects, building consensus for the projects, and carrying them through the planning and programming process.

The next step in the TCM development process will be to generate formal policy recommendations along with a detailed action plan that will help the region focus its resources. Any future recommendations, plans, or additional analysis precipitated by this report will be documented in the form of report supplements.

APPENDICES

Appendix A: Travel Demand Management Evaluation Model

Overview of Technique

A number of TCMs were evaluated through a special analytic tool called the TDM Evaluation Model. The TDM Model was developed by COMSIS Corporation of Silver Spring, Maryland for the express purpose of quick, quantitative analysis of the travel impacts of Travel Demand Management strategies. This model was developed in the late 1980's by COMSIS, drawing upon its nationwide research in TDM, and is in use by numerous Metropolitan Planning Organizations around the country. A public-domain version of the TDM Model was sponsored by the Federal Highway Administration in 1993, and is now being released through McTrans.

The TDM Model is a self-contained software package that operates on a microcomputer. The user inputs scenario assumptions on a system of worksheet screens. Strategies may be tested individually or in combination, where interactive effects are accounted for. Input data is generally in the form of trip tables, although surveys or other sources may be used.

The model is essentially a "pivot point" technique; this means that it discerns the current condition of the travel environment from the modal split of the background travel data, and then projects the change in modal split due to the tested policies or strategies as departures from this starting point. Thus, it is not necessary to compile detailed information on starting conditions. While this is the model's strength, it is also its limitation — the TDM Model does not operate at the same level of detail as the regional mode choice model (within the 4 step process).

The TDM Model was designed to be (1) a quick, reasonably accurate, and interactive "policy" tool, and (2) a device capable of providing quantitative estimates of TDM strategies, such as employer support measures and alternative work hours, which are not readily handled by existing transportation planning models. It also has special faculties to deal with partial "participation" of the employment base, such as might happen when adoption of TDM is elective or imposed on only a portion of the population, such as employers of 100 or more.

Types of Strategies

A wide range of strategies can be examined in the TDM model. Mainly, the model was developed to address employer-based TDM. However, it can also look at areawide measures, such as transit improvements, HOV lanes, and a range of pricing actions. The following list highlights the measures that can be examined with the TDM Model.

Employer Support Measures:

- Information programs
- Employer transportation coordinators

Flexible work schedules
Rideshare matching
Vanpool formation and support
Transit pass sales
Preferential parking for HOVs
Guaranteed ride home

Alternate Work Schedules:

Flexible work hours
Staggered work hours
Compressed work weeks (4/40 and 9/80)
Telecommuting

Financial Incentives and Disincentives:

Modal subsidies for transit, carpool or vanpool
Parking surcharges

The TDM Model was judged to be the most appropriate tool for evaluating the following TCMs in this study:

17. Employer Trip Reduction Programs
18. Regional Ridesharing Program
19. $25 Transit Check
20. Telecommuting
21. Compressed Work Weeks
24. $3 Regional Parking Surcharge
25. $3 CBD Parking Tax
26. New Park & Ride Lots Along Highways
27. Expanded Park & Ride Lots at Rail Stations

There were characteristics of these measures that made it difficult or impossible to use the regional mode choice model for their evaluation, while the TDM Model was either directly suited to their evaluation, or was the best compromise analytic tool (could be made to work with some creativity in assumptions/input data). The reader should consult the individual measure worksheets in Section 2 to gain insight as to why and how the TDM model was applied in these cases.

Computational Characteristics

The primary computational characteristic of the TDM Model is that it operates as a "pivot point" tool. While it is based largely on elasticity relationships derived from and applied within the context of a logit model, it differs from the DVRPC regional mode choice model in important ways. In the

latter, information must be relayed to the model on performance characteristics (time, cost) of each travel alternative for each origin-destination pair from the trip table under consideration. Subsequently, when policies or strategies are applied to any given mode, it is necessary to access and modify the appropriate "skim" (performance vector) for that mode for each origin-destination where it is changed, and uniquely for the changes that apply in that origin-destination pair. While this is the most accurate way to relate system performance changes, it is a very intensive and tedious process. The pivot point approach, in contrast, simply takes the current modal shares (mode split) for each origin-destination pair and "adjusts" those shares in relation to the particular strategy or strategies which are being applied. It does this through elasticity relationships, using (in most cases) the same coefficients as exist in the regional mode choice model. For reasonable changes in conditions (i.e., travel time or cost) from the current starting point, these estimated changes in share are fairly accurate. Moreover, the TDM model handles the interactive (cross-elasticity) effect; when more than one strategy is applied or more than one mode is being affected, the result is different than the simple sum of the individual measures applied alone. The TDM Model performs this assessment simultaneously through equations where the overall utility is adjusted for each mode for each strategy, just as the regional logit model would do — it simply is doing that calculation from a starting pivot rather than from scratch.

There are two primary types of analytic procedures operating in the TDM Model. Policies/strategies which represent changes in travel time or cost are handled through a logit model type of formulation. The coefficients for this procedure are taken from the regional mode choice model, although national default coefficients are also available in the model. The second type of policy/strategy is estimated using values from empirical look-up tables. In the present TDM Model, this is the procedure used to estimate the effect of non-monetary employer-based support strategies and alternative work schedules. The reason for this is that conventional elasticity relationships for these measures had not yet been developed at the time of the TDM Model. The current values are empirically derived from the extensive research on employer-based TDM programs by COMSIS and others (which has been published in *Evaluation of TDM Measures to Alleviate Traffic Congestion* (COMSIS for the Federal Highway Administration, 1990) and *Implementation of Effective TDM Measures* (COMSIS for the Federal Highway and Federal Transit Administrations, 1993). To account for differences that clearly occur in the level of impact of these types of strategies, the impact values entered in the TDM model vary by type of employer, size of employer, and type of participation as affected by law/regulation (voluntary/mandatory).

Data Requirements

The TDM Model most commonly utilizes the same trip table information as is generated in the conventional 4-step process. It requires information on Person Trips, Vehicle Trips and Transit [Person] Trips for each origin-destination pair. It will perform its mode split computation for every O-D pair for which it has information.

The input trip tables can be in a variety of formats. The TDM Model has been designed to directly exchange information with MINUTP, TRANPLAN and EMME/2, and uses ASCII format as an

ultimate default. It will process trip tables up to 1,100 zones, although its operating complexity/speed suggests that it was designed for much smaller trip table configurations, i.e., ideally under 100.

For the DVRPC analysis, the TDM model evaluations were run using a district-level trip table. In total, 71 districts, or Planning Areas, are used to define the DVRPC region. Of these, districts 1 through 51 constitute the Pennsylvania portion of the region, with the remainder located in New Jersey. When the TDM Model (or any of the analysis tools) were applied, the scheme was to assume targeting of TCMs to trip table destinations in Pennsylvania only, which means that regional travelers located in New Jersey would be affected by TCMs sited in Pennsylvania. From an emissions perspective, only VMT changes occurring on Pennsylvania roadways were included in the emissions calculations.

These trip table inputs were taken from DVRPC's regional model, processed by the TDM Model, and revised trip tables returned to DVRPC for assignment to the highway network. The revised assignments were then returned to COMSIS for estimation of emissions through the PPAQ model.

Model Outputs

For each run of the TDM model, the following output results are generated:

A revised set of trip tables (person, vehicle, transit) for each tested scenario; and

A tabular output report record that relates the change in modal split, and person, vehicle, and transit trips for each scenario. A sample of this tabular summary report is shown below.

Test Scenario

	PERCENT MODE SHARE					PEAK HOUR			% REDUCTION		
	DA	TRN	CP	VP	AVR	PERSON TRIPS	VEHICLE TRIPS	V M T	PERS TRIPS	VEH TRIPS	VMT
0	77.1	2.4	20.6	.0	1.15	7176	6240	24609			
1	69.6	3.7	26.5	.3	1.21	7134	5872	22993	.6	5.9	6.6
2	58.7	5.1	35.0	1.2	1.33	7062	5327	20823	1.6	14.6	15.4
3	48.1	6.4	43.2	2.2	1.45	6993	4810	18762	2.6	22.9	23.8
4	45.8	6.8	44.9	2.6	1.49	6974	4687	18279	2.8	24.9	25.7

Scenario Descriptions

0 Base Conditions
1 Trial 1
2 Trial 2
3 Trial 3
4 Trial 4

Appendix B: Sketch Planning Analysis

Overview of Technique:

The task of evaluating a broad system of Transportation Control Measures was found to be a challenging process, not only to DVRPC but to all agencies involved in TCM analysis for SIP development. The current transportation planning process was not designed for examining many of these innovative measures, and in many cases was not found to be particularly suitable (or at all suitable) for their evaluation. In these instances, it has been necessary to develop alternative means for evaluating these measures; the TDM Model, which is discussed in the previous appendix, has provided one such means. The more general approach to structuring an analysis in the absence of a pre-existing formal technique has been referred to here as "sketch planning".

TCMs which are reasonably handled by the mode choice feature in the conventional 4-step planning process are those involving rather direct changes in travel time or cost. Good examples are most transit service improvements, highway system changes, and pricing actions. If the effect of these measures varies importantly by service/location, or is only being applied to a corridor, subarea or jurisdiction, the conventional mode choice model is the best choice.

Many TCMs do not readily conform to this format, however, because of their unique nature, and hence are not well-handled by the standard 4-step process. Specific TCMs on the DVRPC list which were evaluated in whole or in large part through sketch planning methods are:

1. Advanced Signals on 4-Lane Arterials
2. Advanced Signalization in Philadelphia CBD
3. Incident Management Systems
4. Ramp Metering
14. Reuse of Surplus LRVs and Trackless Trolleys
16. Philadelphia/Harrisburg Rail Service Improvements
20. Telecommuting
21. Compressed Work Weeks
22. Prohibit Construction of New Parking in CBD
23. Limit Supply of Parking at New Suburban Employment Sites
26. New Park & Ride Lots along Highways
27. Expand Parking at Rail Stations
28. Improved Bike Facilities for Work Trips
29. Improved Bike Access for Rail Trips
30. Improved Bike Access for Non-Work Trips

For these measures, case specific procedures and methodologies had to be developed to arrive at a sound, defensible estimate of the probable impact of the measure on travel and emissions. The reader will need to consult the individual measure documentation in Section 2 to properly understand the particular methodology for each of these applications, but in general the techniques developed

consisted of:

(1) judgements as to the key variables (behavior, system or vehicle) that were being affected by the measure, and the manner in which they would be affected,

(2) consultation of applicable research in the field,

(3) construction of utilitarian methodologies employing market segmentation methods, factoring, and application of empirical findings/relationships to fashion a forecast of the travel behavior change, and

(4) translation of the relevant changes in mode split to changes in trips and VMT at a district (71x71) trip table level.

The results of the above methods were then moved on to emissions estimation. This procedure consisted of reassignment of the modified trip tables to the no-build highway network, followed by application of PPAQ to estimate emissions.

Appendix C: Post-Processor for Air Quality

Overview of Technique

To estimate the effects of a TCM alternative on the region's emissions, travel changes were estimated with the DVRPC transportation model, the TDM evaluation model, or supplemental specialized techniques. These methods produced either estimates of traffic volume changes on the highway network, or changes in vehicle miles of travel (VMT) on groups of roadways in specific counties. The Post Processor for Air Quality (PPAQ) and MOBILE5a were then used to calculate the levels of emissions for the region which would result; estimates for alternatives were compared with the base case to produce the net benefit of the alternative.

MOBILE5a is USEPA's program which calculates emissions factors. It has several groups of input variables which describe the vehicle fleet and operating conditions:

- Traffic flow data, such as speeds, cold start fractions, and vehicle types;
- Vehicle fleet data, such as age distributions and inspection/maintenance status;
- Fuel parameters, such as reformulated or oxygenated fuels and refueling controls; and
- Environmental variables, including temperature.

For most of the TCMs which were considered, the vehicle fleet, fuel, and environmental data were held constant. They were specified to reflect 1996 conditions, including Pennsylvania's most current (at the time of analysis) proposals for enhanced inspection/maintenance and fuels. In some cases adjustments to the fleet descriptions or fuel parameters were made to reflect specific conditions of the TCM alternative.

Calculation of Traffic Flow Variables Using PPAQ

For most alternatives, the TCM produced changes in the amount and character of travel. The effects were reduced to changes in VMT, speeds, or the number of cold starting vehicles, using the PPAQ software. PPAQ performs a number of operations which together compile the traffic flow variables needed for emissions analysis. These operations include the following:

Hourly Distribution and Vehicle Type Mix - Each link of the DVRPC model's highway network contains a 24-hour traffic volume. Pattern data provided by PennDOT are used to disaggregate each link's volume to 24 hourly volumes, and to further split those volumes to the eight vehicle types used by MOBILE. These hourly data are then used for calculating speeds, as described below.

VMT Accumulation - VMT data is accumulated from the alternative's network by multiplying individual link distances by the traffic volume on the link. For each alternative, VMT is separately accumulated for four time periods (morning and evening peak periods, midday, and night) and for each facility type and county. Factors were derived from the 1990 condition to adjust the VMT to

reconcile with totals reported to the Highway Performance Monitoring System (HPMS). For freeways and arterials the adjustments are small, since virtually all of those facilities are in both the model and HPMS. Local streets are under-represented in the model, so larger adjustments are needed to account for this lack of coverage. Additional adjustments were also derived from PennDOT data to convert from the typical annual weekday represented by the model, to a July weekday.

These factors were then applied to each TCM alternative's VMT to produce the total amount of travel, as derived from the model network. For some TCMs the VMT change was estimated directly without reassignment of traffic to the network. In those cases, the accumulated VMT totals were adjusted by the calculated change due to the TCM.

Cold / Hot Start Fractions - As a starting point in the base conditions, EPA's recommended default cold and hot-start fractions (20.6 and 27.3 percent respectively) were applied to all VMT. Some TCMs involve actions which will change the number of vehicular cold starts. For those TCMs, the amount of cold-start VMT which changed to hot stabilized, or which was eliminated, was estimated. This differential VMT was input to PPAQ, which calculated modified cold start percentages for each county, facility type, and time period. The new fractions were then input to MOBILE as the TCM's emissions factors were calculated.

Speed Estimation - Physical attributes of each highway segment are contained in the model's network database, and include facility type, area type, and number of lanes. Using this information the zero-volume speed and capacity of the segment are estimated. Truck percentage adjustments are then applied to produce an adjusted hourly capacity.

For facility types which do not have control devices (i.e. freeways and expressways), a modified BPR formula with adjusted coefficients is used to calculate the speeds that will occur on each segment. For other facility types (i.e. arterials and local streets) an intersection approach model is used to simulate the effect of traffic signals on speed. For each type of facility (differentiated by type, number lanes, and area type), key parameters such as average signal spacing, cycle length, green time, additional approach lanes, and progression factors are extracted from a lookup table. Using delay equations from the 1985 Highway Capacity Manual, the effect of traffic volume on traffic signal delay is calculated and added to the link travel time calculated for unsignalized segments. Field travel time inventories were performed on freeways within Philadelphia to support calibration and validation of the speed algorithms.

The result of this process is, for each highway segment, an estimated average travel time and speed for each hour of the day. The average time is multiplied by volume to produce vehicle hours of travel (VHT). VHT is then accumulated for each of four time periods, county, and facility type, consistent with the way VMT is accumulated. Average speed is then calculated by dividing VMT by VHT for each combination.

Emissions Calculation - The procedures described above assemble for each cell an average speed, cold start percentage, and vehicle type mix, which comprise the traffic flow variables input to

MOBILE. It is then used to calculate an emission factor (in grams per vehicle mile) for each of the three criteria pollutants — VOC's, CO, and NO_x. This calculation is done for each combination of county, facility type, and time period. The diurnal and evaporative VOC emission factors calculated by MOBILE are adjusted to account for the time of day modeling. Finally, the emission factors for each cell are multiplied by their respective VMT, and summed to produce the region emission estimate for the TCM alternative.

Model Outputs

For each run of the PPAQ/MOBILE system, a number of outputs are generated:

- VMT for each cell, or combination of county, facility type, and time period; subtotals for each county and facility type; and totals for the region;
- Average Speed for each cell, plus averages for each county and facility type and for the region; and
- Emission quantities of VOC's, CO, and NO_x for each cell, plus subtotals and region totals.

Appendix D: List of Reports Used for Background Information

Chicago Area Transportation Study. "Sample CMAQ Calculations #7: Analysis Summaries for: Rail Station Parking Lots, Bike Lockers, Bike Paths," Compiled by the Bicycle Coalition of the Delaware Valley.

Delaware Valley Regional Planning Commission. Direction 2020 Report Number 5: Journey-to-Work Trends in the Delaware Valley Region, 1970 - 1990. June, 1993.

Delaware Valley Regional Planning Commission. Direction 2020 Report Number 11: Overview of Transportation Control Measures. August, 1993.

Delaware Valley Regional Planning Commission. I-95 Intermodal Mobility Project: Heading for the Twenty-First Century, Report #11, Rail Passenger Survey. Prepared for the Pennsylvania Department of Transportation, January, 1991.

Delaware Valley Regional Planning Commission. Regional Analysis of Parking. August, 1993.

Delaware Valley Regional Planning Commission. Regional Park and Ride Assessment: Highway Related Facilities. January, 1993.

Delaware Valley Regional Planning Commission in Association with R.L. Banks and Associates, Inc., Main Line Management Services, Inc., LTK Engineering Services, and Canby Associates. Philadelphia - Harrisburg Rail Study. Prepared for the Pennsylvania Department of Transportation, January, 1992.

JHK and Associates in Association with Gannett Fleming, Inc. and Michael Baker, Jr. Inc. Traffic and Incident Management System for the Philadelphia Area. Submitted to the Pennsylvania Department of Transportation, District 6, the Pennsylvania Turnpike Commission, and the Federal Highway Administration, September 11, 1992.

Kessler, Jon and William Schroeer. "Meeting Mobility and Air Quality Goals: Strategies that Work," United States Environmental Protection Agency, Office of Policy Analysis, Draft Report, April 20, 1993.

METRA and the Chicago Area Transportation Study. "Sample CMAQ Calculations #1: Commuter Station Auto and Bicycle Parking," Compiled by the Bicycle Coalition of the Delaware Valley.

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Pennsylvania Department of Transportation, Bureau of Public Transportation. Pennsylvania Mass Transit Statistical Report: 1991-92. 1993.

Pennsylvania Department of Transportation, Bureau of Public Transportation. Pennsylvania Mass Transit Statistical Report: 1987-88. 1989.

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Southeastern Pennsylvania Transportation Authority. A New Look at Restoration of Rail Service to Newtown. January, 1991.

United States Department of Commerce, Economics and Statistics Administration, Bureau of the Census. County Business Patterns - New Jersey, 1990. 1992.

United States Department of Commerce, Economics and Statistics Administration, Bureau of the Census. County Business Patterns - Pennsylvania, 1990. 1992.

United States Department of Commerce, Economics and Statistics Administration, Bureau of the Census. Statistical Abstract of the United States - 1990.