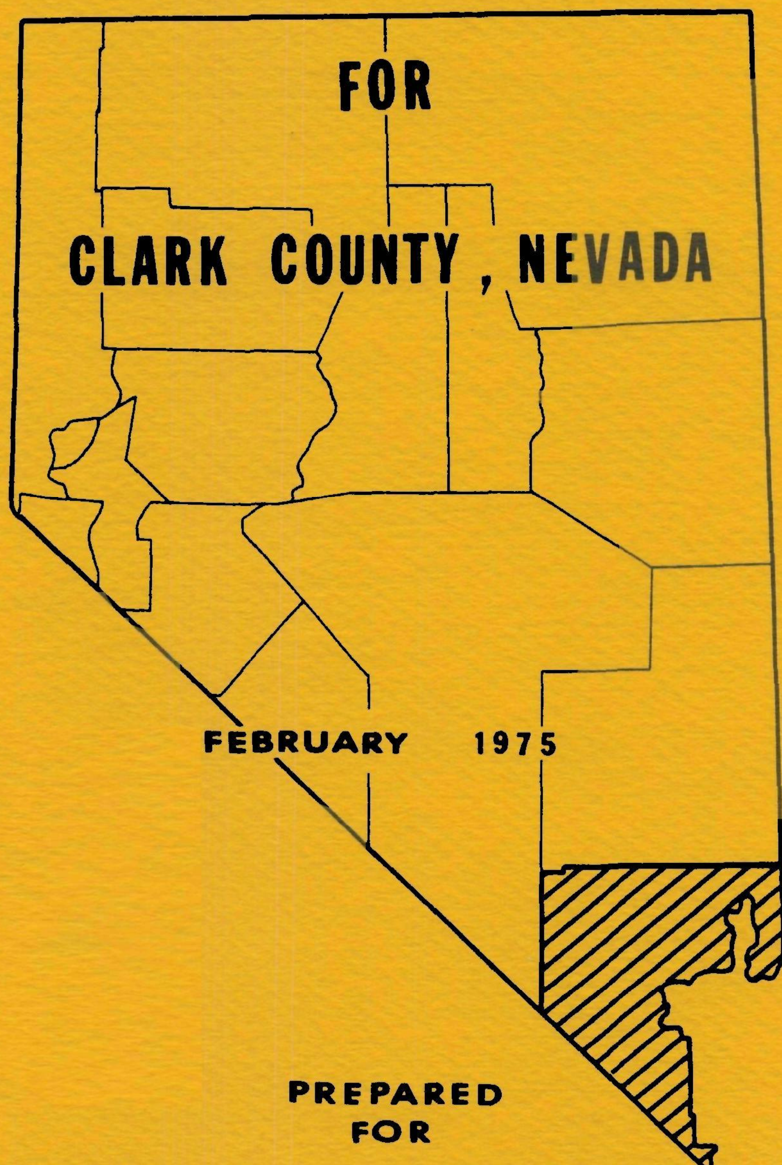
TRANSPORTATION CONTROL PLAN DEVELOPMENT

FOR

CLARK COUNTY, NEVADA

FEBRUARY 1975



PREPARED
FOR

ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NORTH CAROLINA

TRW. TRANSPORTATION & ENVIRONMENTAL OPERATIONS

TRANSPORTATION CONTROL PLAN DEVELOPMENT
FOR CLARK COUNTY, NEVADA

FEBRUARY 1975

Prepared by

TRANSPORTATION AND ENVIRONMENTAL OPERATIONS OF TRW, INC.

One Space Park

Redondo Beach, California

Contract No. 68-02-1385

For the

ENVIRONMENTAL PROTECTION AGENCY

Research Triangle Park, North Carolina

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1.0 FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This report presents the results of an analysis of a range of transportation control strategies aimed at reducing air pollution in the Nevada portion (i.e. Clark County) of the Clark-Mohave-Yuma Interstate Air Quality Control Region (#013). The pollutants under consideration are carbon monoxide and photochemical oxidant, primarily ozone. Since ozone is a secondary pollutant (i.e. it is not emitted directly as a pollutant), its control is dependent upon the elimination of reactive hydrocarbons which, along with nitrogen oxides, leads to its formation. The purpose of the study is threefold:

- To compile a baseline and projected emission inventory for reactive hydrocarbons and carbon monoxide.
- To evaluate the effectiveness of various transportation related control measures in reducing emissions.
- Recommend the implementation of various control strategies required to achieve the national ambient air quality standards for photochemical oxidant and carbon monoxide in Clark County.

The target date for attainment of the standards is 1977.

Stationary sources - Presently, stationary source contributions to the overall problem are much less than mobile sources. However, they do comprise a significant problem. Unless further control of these sources are implemented, it is very unlikely that ambient air quality standards will be met. No analysis was carried out on the reductions possible from additional controls of these sources. The reductions in hydrocarbon emissions from the Texaco and Cal/Nev PL Terminals stated in Chapter 4 have been assumed possible by the Clark County District Health Department.

Mobile sources - There are many categories of mobile source emissions; this report has examined only the most significant categories - in use light and heavy duty vehicles. However, as motor vehicle controls become increasingly stringent, it will be important to investigate measures to control the other sources, such as motorcycles, aircraft and railroads.[1] Left uncontrolled, they will contribute significant quantities of pollution by 1977.

[1] It must be noted that the federal government has pre-empted state and local authorities in the area of controls on aircraft.

1.1 LIMITATIONS OF THE TRANSPORTATION CONTROL STRATEGY ANALYSIS

To be acceptable, an air pollution control strategy must reduce emission levels sufficiently to allow for the attainment and maintenance of national ambient air quality standards. However, such a plan must also consider the economic factors associated with its adoption, as well as the social and political changes necessary to accommodate each specific control measure. The air quality benefits must be balanced against the social and economic costs of implementation. Limitations in the data and analytical methods became obvious during the course of the study and care must be taken in the interpretation and evaluation of the control strategy recommendations. The proposed strategy must be considered as an initial attempt to quantify the relationship between transportation processes and the regional air pollution problem. Further study is needed and warranted before embarking on controls that are likely to significantly disrupt the lifestyles of Clark County residents. Several specific areas which need to be confirmed and validated by future study are listed below.

Emission Factors - The mobile source emission estimates in this study are based upon the best available emission factors. These emission factors are being revised in light of in-use and new vehicle testing programs being conducted by the Environmental Protection Agency. It is highly recommended that these new factors be utilized as they become available to recompute the severity of the mobile source generated emissions in the area.

It should also be noted that stationary source estimates also suffer from inaccuracies in the projection of industrial growth. The change in emission factors for these sources, including the results from the application of yet untested control technologies, is yet another source of error.

Traffic Data Projections - Historically, traffic data projections have not been collected with the intent of using them for estimating motor vehicle emissions. The data was reworked into the format necessary for emission calculations. Potential inaccuracies are introduced by this process.

Analytical Technique - The key calculation in control measure assessment is relating emission levels to expected ambient air quality. The use of proportional rollback for CO and Appendix J (of the Federal Register, Vol. 36, No. 158) for hydrocarbons in this study is at best a rough estimate of emission reductions required. Instead, the use of modeling techniques which can account for the effects of local meteorological and topographical features is highly recommended.

1.2 FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

The following summarize the major findings, conclusions and recommendations that have emerged as a result of this study.

Findings:

- Photochemical oxidant and carbon monoxide concentrations are above the national ambient air quality standards a significant portion of the time.
- The geography and meteorology of the Las Vegas Valley contribute to the severity of the problem and the difficulties of its elimination.
- Presently, stationary source contributions to the air pollution problem are much less than those from mobile sources. However, unless additional controls are applied to stationary sources, it is highly unlikely that ambient air quality standards will be met.
- Ambient air quality standards for carbon monoxide and oxidant will not be met by 1975. It will be extremely difficult to achieve these standards by 1977 without a massive change in the lifestyles of Clark County residents.

Conclusions:

- Additional controls on stationary sources, aircraft and heavy duty gasoline powered vehicles will be necessary to achieve air quality standards.
- As a control measure, gasoline rationing appears to be the most effective means of significantly reducing VMT.
- The use of vehicles cannot be restrained significantly without providing some alternative means of transportation.
- The implementation of evaporative loss control from gasoline stations should be instituted as soon as the appropriate devices become available.

Recommendations (see Chapter 7.0):

It is recommended that Phase I hardware control measures be implemented as rapidly as possible. However, because of time and financial constraints, a detailed analysis as to the social, economic and political ramifications of VMT reduction measures was not made in this report. Therefore, it is also recommended that such a detailed analysis be performed before the VMT reduction measures are implemented. The final decision regarding the implementation of the Phase II control measure should be deferred until (a) an evaluation of additional controls on stationary sources, heavy duty gasoline powered motor vehicles and aircraft can be made, and (b) a careful analysis of the impact of such a Phase II program on the occupants of the region is done.

2.0 INTRODUCTION

The Federal Government has promulgated national ambient air quality standards for particulate matter, sulfur dioxide, carbon monoxide, hydrocarbons, oxides of nitrogen and photochemical oxidants. Each state has been required to prepare and submit a plan which provides for the implementation, maintenance and enforcement of the federal standards within each Air Quality Control Region of the state.

The original Nevada State Implementation Plan (SIP) submittal was approved by EPA since it provided adequate measures to attain ambient air quality standards for carbon monoxide and photochemical oxidants in the Nevada portion of the Clark-Mohave-Yuma Interstate Air Quality Control Region (AQCR 013). In addition to credit taken for emission reductions brought about by the federal motor vehicle emission standards, the SIP specified reductions of emissions achievable through a vehicle testing and inspection program, traffic flow improvements in accordance with provisions of the Las Vegas Valley Transportation Study and control of aircraft emissions as a result of federally promulgated standards.

On June 8, 1973, the EPA promulgated rules and regulations which specified additional requirements related to the development of transportation control programs by the states. The EPA has requested, on the basis of these new requirements, that the previously approved carbon monoxide and hydrocarbon control strategies contained in the SIP be reassessed. Among other things, the newly published rules and regulations contain and refer to revised motor vehicle emission factors and revised estimates of the effectiveness of inspection/maintenance and retrofit programs.

Due to limited resources, the State of Nevada and Clark County air pollution control agencies [1] expressed a willingness to cooperate in a program in which the EPA would provide contractual assistance for developing a comprehensive hydrocarbon and carbon monoxide pollutant emission

[1] In Clark County, the District Health Department (DHD) is the agency which has the responsibility of air pollution control.

data base and for evaluating the feasibility and effectiveness of transportation control measures. TRW has been chosen by EPA to conduct such a study which will:

- Compile a baseline emission inventory and projections for hydrocarbons and carbon monoxide,
- Evaluate the effectiveness of various transportation control related measures in reducing emissions,
- Recommend the implementation of various control strategies required to achieve the national ambient air quality standards for photochemical oxidants and carbon monoxide in Clark County.

2.1 THE CLARK-MOHAVE INTERSTATE AIR QUALITY CONTROL REGION

The portion of this region which lies in Nevada consists entirely of Clark County. The 1970 population of the county was 273,288, the majority of which is concentrated in Las Vegas (125,787), the adjacent community of North Las Vegas (36,216), nearby Henderson (16,395) and Boulder City (5,223). The most important industry is tourism, attracted by legalized gambling, luxurious hotels, lavish shows and a pleasant desert resort climate. Resort recreational activity is also developing along the Colorado River and Lake Mead, which forms the southeastern boundary of the county. The economy of the metropolitan Las Vegas area is diversifying and there is a considerable amount of industrial and commercial activity which does not depend on tourism. Large corporations involved in mineral and chemical processing are well represented in Clark County. The county is also the location of a large coal burning power plant providing power for the southwest.

Clark County is the site of Nellis Air Force Base, which is located in the northeast corner of the Las Vegas Valley. The area is served by McCarran International Airport, one of the busiest airports in the west. Several smaller airfields are also located in the county.

Las Vegas and the nearby communities lie in a large bowl surrounded by mountains, the tallest of which is Charleston Peak (11,910 ft) to the northwest. These topographic features aggrevate atmospheric pollution problems. Atmospheric inversion conditions exist for about 45% of the year. There are periods of sustained stagnation lasting several days, occurring most frequently between November and January. Average maximum and minimum temperatures in Las Vegas range from 32°F in January to 105°F in July.

3.0 BASELINE AIR QUALITY

Like many other areas in the southwest and California, photochemical oxidant is the major air pollution problem in the Las Vegas Region, with carbon monoxide a smaller but significant problem. Table 3-1 shows the National Ambient Air Quality Standards for oxidant and CO along with the actual readings from air quality data in Las Vegas.

Table 3-1 Las Vegas Air Quality Summary

Pollutant	Applicable Federal Primary Standard	2nd Highest Observed Concentration	Year	% Rollback
Oxidant	160 $\mu g/m^3$ (1 hr.max)	410 $\mu g/m^3$ 351 $\mu g/m^3$	1972 1973	70[(1)]
Carbon Monoxide	10 mg/m^3 (max.8 hr avg)	22.4 mg/m^3*	1973	54[(2)]

(1) Based on Figure A-3, Appendix A.
(2) Linear rollback assumed.
* This is actually the highest reading; see Section 3.2 for an explanation

3.1 OXIDANT

Air quality data for oxidant were available for the years 1970 to the present at one site near downtown Las Vegas (625 Shadow Lane). Table 3-2 shows the maximum oxidant values observed during the 1970 to 1973 period. The observed maxima are compared to statistically predicted maxima for 1972 and 1973 (see Appendix A and Figures A-1 and A-2 for details of the statistical model). Agreement of predicted and observed values is closer during 1973 than during 1972. Although the 1972 predicted 2nd highest oxidant concentration is higher than the reported 2nd highest value, the observed value does not appear out of line with historical data in Table 3-2. A 70% rollback is indicated in Table 3-1 based upon the 410 $\mu g/m^3$ level. Federal Standards are interpreted as the level to be exceeded only once per year, and thus the second highest oxidant concentration in Las Vegas is used for rollback calculation in Table 3-1.

Figure 3-1 illustrates the seasonal pattern for oxidant at the District Health Department. Summer concentrations tend to be higher than those in the winter, with May through August being the highest months. 1972 appears to be a high year for oxidant as illustrated by both the yearly average (Fig. 3-1) and the maximum (Table 3-2). The choice of 1972 as a base year for oxidant is thus a conservative one. The seasonal pattern and the diurnal variation of oxidant concentrations (Figure 3-2) illustrate the photochemical nature of this pollutant.

It should be commented that photochemical oxidant tends to be an area-wide problem. Since oxidant is a secondary (formed in the atmosphere) pollutant, some atmospheric dispersion of precursor hydrocarbon has already occurred prior to oxidant formation. Further, emissions (especially from automobiles) tend to diffuse. Thus the existence of only one sampling site for oxidant should not drastically bias the maximum value to be observed in the Las Vegas area.

It has been observed in the Los Angeles and San Diego Air Basins, for instance, that spatial variations in observed oxidant maxima occur over large distances. The uncertainties of the oxidant measurement itself are often as large as these spatial variations. Other pollutants such as CO and particulates, on the other hand, can vary dramatically over short distances as a reflection of emission sources.

Table 3-2 First and Second Highest Observed Oxidant Concentrations

Year	Date	Concentration ($\mu g/m^3$)	Expected Maximum (2nd Highest Current Reading) (See Appendix A)
1970	4/18 10/9	300 300	
1971	7/3 6/21	478 375	
1972	3/18 5/24	415* 410	540
1973	5/10 6/25	438 351	420

*A reported value of 524 $\mu g/m^3$ was apparently incorrect due to analytical errors.

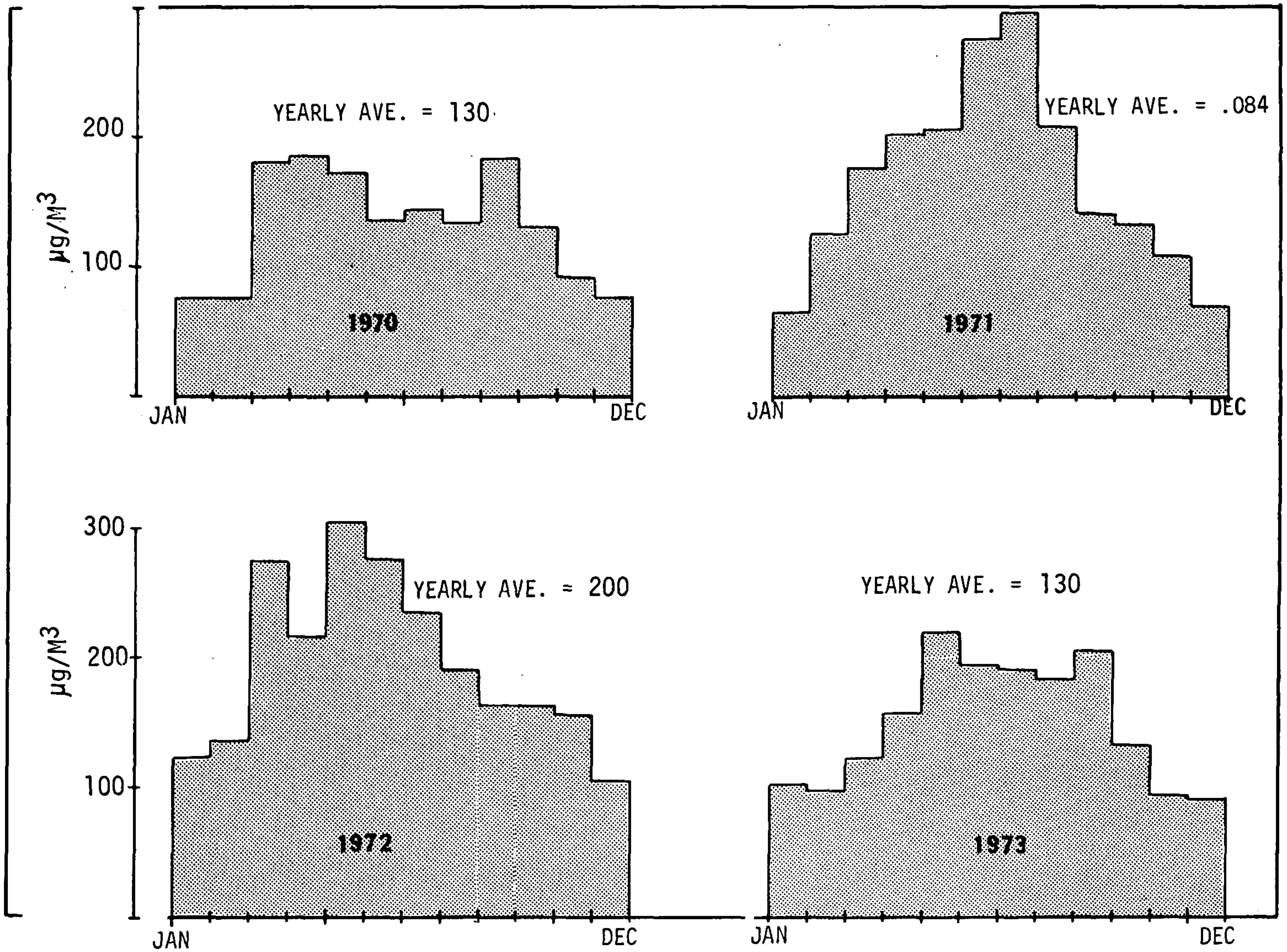

Figure 3-1. Las Vegas Seasonal Pattern for Oxidant in μg/m^3
(Average of Daily Maximum Hourly Averages by Month)

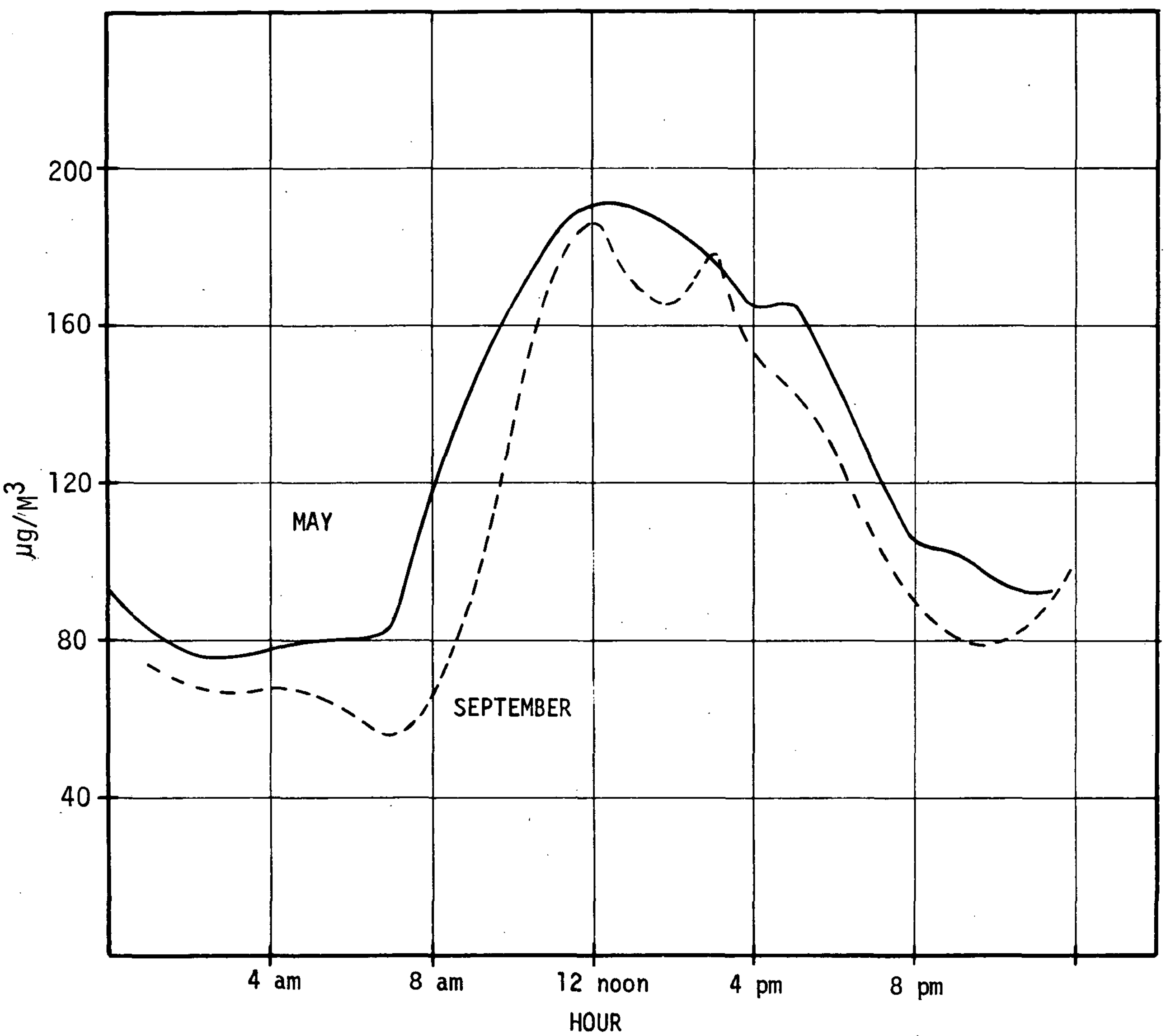

Figure 3·2. Monthly Average of Oxidant Concentrations by Hour of the Day, Las Vegas, 1973

3.2 CARBON MONOXIDE

CO has been continuously monitored at a site in downtown Las Vegas only since November of 1973. Additional monitoring for CO was done at major intersections in the area from October through December of 1973. Lack of 1972 data requires 1973 to be used as the base year. Table 3-3 lists the observed CO maxima since November 1973. The first high CO concentration is used for rollback calculations since an entire year's data was not available.

Table 3-3 First and Second Highest 8 Hour Average Carbon Monoxide Concentrations in Las Vegas-1973

Location	Date	8 Hour Average(mg/m^3)
Downtown (Fire station)	12/7	16.6
	11/29	16.2
Maryland Parkway & Desert Inn Road	12/5	22.4
	12/7	19.0

(The federal primary standard is 10 mg/m^3 for an 8 hour average.)

Table 3-4 shows the general pattern of CO levels over a 9 month period. The winter months tend to be higher than spring and summer months, reflecting probably more periods of stagnant air during winter. (A similar pattern is observed in several California Air Basins). Carbon monoxide, unlike oxidant, is a primary pollutant, and thus reflects localized emissions and is subject to local variations. Not surprisingly then, the highest observed level occurred at a heavily traveled intersection with little wind activity. The CO levels in Table 3-4 are at rooftop level and are somewhat lower than at major intersections.

A statistical approach to CO data similar to that for oxidant was not attempted due to insufficient data. The 22.4 mg/m^3 value is thus used as an 8 hour maximum. It should be commented that the 1 hour federal CO standards of 40 mg/m^3 will also be met by a rollback of the magnitude required to meet the 8 hour standard of 10 mg/m^3.

Table 3-4 Las Vegas Carbon Monoxide Concentrations by Month (Downtown Sampling Site) (mg/m^3)

	1973		1974					
	NOV	DEC	JAN	FEB*	MAR	APRIL*	MAY*	JUNE*
Daily Avg.	4.4	5.4	3.9	2.3	3.5	1.5	0.87	1.9
1 hour maximum	40	25	58	39	16	11	8	12
8 hour maximum	16	17	17	10	12	4	4	7

*Concentrations are not entirely representative since several days during some months are missing data. The numbers do show the trend referred to in the text, however.

In view of the high summer oxidant pattern and high winter carbon monoxide pattern and the dominance of automotive contributions to both oxidant and CO, it would not be appropriate to apply controls on a seasonal basis.

4.0 EMISSION INVENTORY

This section of the report details the sources of information, methods of calculation and assumptions made in compiling baseline and projected (1977 and 1982) emission inventories.

4.1 BASELINE EMISSION INVENTORY

Both the Clark County District Health Department (DHD) and EPA (in the form of the National Emission Data System, or NEDS) have compiled comprehensive area and point source emission inventories for the year 1972. Unfortunately, it was not possible to use these inventories for both carbon monoxide and hydrocarbons. This is because the lack of 1972 air quality data for CO prevented the drawing of any conclusions relating CO air quality and emissions in 1972. To circumvent this difficulty, the following strategy was adopted: (1) because CO air quality data is available for 1973, this year was chosen as the baseline year for CO and 1972 emissions were projected for one year (the method of projection is explained in Section 4.2.1) and (2) however, since significantly higher oxidant readings occured in 1972 as compared to 1973, 1972 was selected as the baseline year for hydrocarbon emissions.

4.1.1 Hydrocarbon Reactivity Factors

The reactivity factors used in this study are based on the latest EPA analysis of smog chamber data (see Table 4-0). They are identical to the factors used in a recent oxidant contingency plan study (4-18), except for diesel marketing and power plants burning coal.

4.1.2 Stationary Sources

The following agencies were contacted to obtain a 1972 inventory of hydrocarbons and carbon monoxide:

Agency	Source Categories
Clark County DHD	• Area sources of industrial processes • Domestic, commercial and industrial space heating • Solid Waste disposal

Agency	Source Categories
EPA (in the form of NEDS)	• Point sources of industrial process • Power plants

One source category not covered by the Clark County DHD and EPA is organic solvent usage. To estimate hydrocarbon emissions from this source category (no CO is emitted), the emission factor of 8 lbs/capita year (4-17) was used. Table 4-1 illustrates 1972 hydrocarbon and carbon monoxide emissions.

As mentioned in Section 4.1, the 1972 emission figures for hydrocarbons suffice . In order to arrive at a projected 1973 figure for carbon monoxide, the following strategy was used:

Source Category	Method
• Area sources of industrial processes • Domestic, commercial and industrial space heating • Solid waste disposal	The Nevada State Implementation Plan assumes an 18% growth rate from 1970 to 1975 for these sources, or a 3.6%/ year growth rate. Thus a 3.6% increase from 1972 to 1973 was assumed.
• Point sources of industrial process • Power plants	In Section 4.2.1, emission projections for these sources are done for the years 1977 and 1982. By linear intepolation between 1972 and 1977, 1973 figures were obtained.

The results of this process are shown in Table 4-2.

It was considered desirable to divide space heating emissions into two categories, domestic and commercial-industrial. Since the only inventory located which made this breakdown is the one in the 1970 SIP, the following procedure was adopted - in 1970, domestic fuel combustion contributed 64% of the total CO fuel combustion emissions and 18% of the total HC fuel combustion emissions, while commercial-industrial fuel combustion contributed the remainder (Table 4-3). These percentages were assumed to hold true in 1972 and all subsequent years. Table 4-4 illustrates this breakdown, as well as being a summary baseline emission inventory for CO and HC.

4.1.3 Mobile Sources

Aircraft

The general approach to calculating aircraft emissions is explained in Appendix C.

Table 4-0 Hydrocarbon Reactivity Factors

Stationary Sources	
Gasoline Marketing	93%
Diesel Marketing	100%
Power Plants - Coal Combustion	0%
Organic Solvents	20%
Other	10%
Motor Vehicles	
Light Duty Vehicle Exhaust	77%
Heavy Duty Vehicle Exhaust	79%
Light and Heavy Duty Vehicle Evaporative	93%
Motorcycles	96% (2-stroke)
	86% (4-stroke)
Diesels	99%
Other Mobile Sources	
Jet Aircraft	90%
Piston Aircraft	77% exhaust
	93% evaporative

Source : Reference 4-8, except for diesel marketing (Reference 4-19) and power plants - coal combustion (Reference 4-20)

Table 4-1. 1972 Stationary Source Emission Inventory for Clark County (tons/year)

Source Category	Total HC	CO
Industrial Processes		
(1) Area	221	-
(2) Point	2804	3008
Power Plants*	631	1066
Domestic, Industrial and Commercial		
Space Heating	345	169
Solid Waste Disposal	14	32
Organic Solvent Usage**	1292	-
Total	5307	4275

*Does not include the Mohave Power Plant whose emissions have a negligable effect on the observed air quality values near Las Vegas.

**Based on 8 lbs/capita-year and a population of 322,915.

Table 4-2. 1973 Stationary Source Emission Projections for Carbon Monoxide in Clark County (tons/year)

Source Category	CO
Industrial Processes	
(1) Area	-
(2) Point	3008
Power Plants	1128
Domestic, Industrial and Commercial	
Space Heating	175
Solid Waste Disposal	33
Total	4334

Table 4-3. Fuel Combustion Emissions in 1970 for Clark County (tons/year)

Source Category	THC	% of Total	CO	% of Total
Residential	43	18	105	64
Commercial-Industrial	196	82	58	36
Total	239	100	163	100

Source: Nevada State Implementation Plan (1970)

Table 4-4. Baseline Stationary Source Emission Inventory

Source Category	Total HC (1972)		Reactive HC (1972)	CO (1973)	
	tons/year	tons/day	tons/day	tons/yr	tons/day
Industrial Processes					
(1) Area	221	0.6	0.06	-	-
(2) Point	2804	7.7	7.0	3008	8.2
Power Plants	631	1.7	0.09	1128	3.1
Space Heating					
(1) Domestic	62	0.2	0.02	112	0.3
(2) Commercial-Indus.	283	0.8	0.08	63	0.2
Solid Waste Disposal	14	0.04	-	33	0.1
Organic Solvent Usage	1292	3.5	0.7	-	-
Total	5307	14.5	8.0	4344	11.9

The Clark County Department of Aviation (4-1) and McCarran International Airport (4-2) were the sources of information for the number of aircraft operations at McCarran in 1972. For the North Las Vegas Air Terminal, 1972 aircraft operations information was obtained from the Federal Aviation Administration (4-3) and the North Las Vegas Air Terminal (4-4). For Nellis Air Force Base, information was obtained from personnel at the base (4-5). (Emissions from approximately 8 small general aviation airfields in Clark County were ignored because the magnitude of their contributions was considered insignificant as compared to McCarran, North Las Vegas, and Nellis.)

The data provided a description of each airport in terms of air carrier, general aviation and military activity and also an identification of aircraft types within these activity classes for the period of January through December of 1972.

In order to compute emissions generated by the various aircraft at these airports, each aircraft type was classified (in the scope of this report) according to the EPA aircraft classification system (see Appendix C). The EPA emission factors were then applied directly to the aircraft activities within each classification.

The baseline year for hydrocarbon emission calculations is 1972, while 1973 is the carbon monoxide baseline year. To obtain 1973 aircraft activity, the 1972 figures were projected for one year, using the commercial, general aviation and military aircraft operations growth factors contained in the State Implementation Plan. The application of this projection technique is discussed in detail in Section 4.2.2.

Total hydrocarbons and carbon monoxide emissions for the respective 1972 and 1973 base years were computed by using the operation activity for each aircraft class at each airport, and emission factors from the revision of EPA document AP-42 (4-6). The procedure for calculation is given by

$$E_{BY} = \frac{\left(A\ \frac{\text{operations}}{\text{year}}\right)\left(\begin{matrix}\text{pollutant emission factor}\\ \text{in lbs/LTO engine}\end{matrix}\right)\left(N\ \text{engines}\right)}{\left(365\ \frac{\text{days}}{\text{year}}\right)\left(2000\ \frac{\text{lbs}}{\text{ton}}\right)\left(2\ \frac{\text{operations}}{\text{LTO cycle}}\right)}$$

Table 4-5 Base Year THC Aircraft Emissions at McCarran International Airport

Aircraft Class	Total Operations in 1972 (Thousands)	Number of Engines	Engine LTO Cycles* (Thousands)	1972 THC Emission (Tons/Day)
1	1.25	3	1.88	.03
1	1.26	4	2.52	.04
2	24.55	4	49.10	2.77
3	21.98	2	21.98	0.11
3	14.99	3	22.49	0.11
3	18.40	4	36.80	0.19
4	5.48	2	5.48	0.02
4	1.56	4	3.12	0.01
5	4.76	1	2.38	0.01
6	0.05	2	0.05	0.00
7	70.58	1	35.29	0.02
7	18.00	2	18.00	0.01
7	1.40	4	2.80	0.002
11	24.21	1	12.11	0.17
12	1.07	2	1.07	0.03
12	0.20	4	0.40	0.01
			Total =	3.53

*LTO Cycles = $\frac{\text{Operations}}{2}$ x Number of Engines

Table 4-6 Base Year Total Hydrocarbon and Carbon Monoxide Emissions at Clark County Airports

Airport	Aircraft Class	THC (Tons/Day) 1972	RHC (Tons/Day) 1972	CO (Tons/Day) 1973
McCarran International Airport	1	0.07	0.06	0.29
	2	2.77	2.49	3.28
	3	0.41	0.37	1.95
	4	0.03	0.02	0.08
	5	0.01	0.01	0.05
	6	-	-	-
	7	0.03	0.02	0.97
	11	0.16	0.14	0.25
	12	0.04	0.03	0.30
Total		3.52	3.14	7.17
North Las Vegas Air Terminal	5	0.01	0.01	0.03
	7	0.04	0.03	1.39
	9	-	-	0.02
Total		0.05	0.04	1.44
Nellis Air Force	1	-	-	-
	9	-	-	-
	10	-	-	-
	11	0.91	0.82	1.39
	12	0.01	0.01	0.08
Total		0.92	0.83	1.47
All Airports Total		4.5	4.0	10.1

where E_{BY} is the base year emission in tons/day for a specified aircraft class, A is the operations activity for the specified aircraft class in operations per year, and N is the number of engines for the specified aircraft class. Table 4-5 shows a sample calculation for McCarran International Airport for the base year 1972 hydrocarbon emissions. From the example it can be seen that all Class 1, 3, 4, 7, and 12 aircraft do not possess the same number of engines (see Appendix C for aircraft classification). Hence, Class 1, 3, 4, 7, and 12 have been segregated by aircraft engine number to account for the total number of "engine LTOs."

Table 4-6 shows the base year hydrocarbon and carbon monoxide emissions for each airport and for each aircraft class at each airport in Clark County.

Railroads

The State Implementation Plan attributed 275 tons/year of carbon monoxide and 382 tons/year of hydrocarbons to railroad emissions in 1970. Using a 3.6% per year growth rate (4-9), the baseline emissions from railroads are shown in Table 4-7.

Table 4-7. Baseline Emissions from Railroads

	tons/year	tons/day
THC (1972) -	410	1.12
RHC (1972) -	406	1.1
CO (1973) -	306	0.84

Motor Vehicles

Baseline emissions for light duty vehicles, heavy duty gasoline and diesel powered vehicles and motorcycles were calculated by the method discussed in Appendix B. The results are shown in Table 4-8.

Table 4-8. Baseline Emissions from Motor Vehicles (tons/day)

	THC (1972)	RHC (1972)	CO (1973)
Light Duty Vehicles	22.0	18.4	110.8
Heavy Duty Vehicles			
Gasoline Powered	6.1	5.1	33.7
Diesel Powered	0.2	0.19	1.4
Motorcycles	0.8	0.74	2.9

Gasoline Marketing

The total number of gallons of gasoline marketed in Clark County in 1972 is shown in Table 4-9. To obtain emissions, it is assumed that all service station storage tanks are equipped with submerged fill pipes, in accordance with Section 20 of the District Health Department (DHD) regulations (4-10). Emissions from gasoline marketing are shown in Table 4-10.

Table 4-9. Gasoline Marketed in Clark County, 1972

	Gallons
Sales by Service Stations	176,091,171
Federal Sales	2,478,351*
Railroads	17,801*
Miscellaneous	87,491*
Total	178,674,814

*These figures are 55% of statewide figures (55% of Nevada's population lives in Clark County).

Source: State of Nevada, Department of Highways, Accounting and Finance Division

Table 4-10. Emissions from Gasoline Marketing Operations, 1972

Point of Emission	THC Emission Factor* ($lbs/10^3$ gallons)	Gallons Throughput	Emissions (tons/day) THC	RHC
Service station tank (submerged fill)	7	178,674,814	1.7	1.6
Filling automobile tank	12	178,674,814	2.9	2.7
Total			4.6	4.3

*Source: Reference 4-11

Table 4-11. Summary Baseline CO and RHC Emission Inventory (tons/day)

	RHC (1972)	CO (1973)
Stationary Sources		
1. Industrial Processes		
a) Area	0.06	-
b) Point	7.0	8.2
2. Power Plants	0.09	3.1
3. Space Heating		
a) Domestic	0.02	0.3
b) Industrial and Commercial	0.08	0.2
4. Solid Waste Disposal	-	0.1
5. Organic Solvent Usage	0.7	-
Total, Stationary Sources	8.0	11.9
Mobile Sources		
1. Light Duty Vehicles	18.4	110.8
2. Heavy Duty Gasoline Powered Vehicles	5.1	33.7
3. Heavy Duty Diesel Powered Vehicles	0.2	1.4
4. Motorcycles		
a) Two stroke	0.48	0.9
b) Four stroke	0.26	2.2
5. Aircraft	4.0	10.1
6. Railroads	1.1	0.84
7. Gasoline Marketing	4.3	-
Total, Mobile Sources	33.8	159.7
Grand Total	41.8	171.8

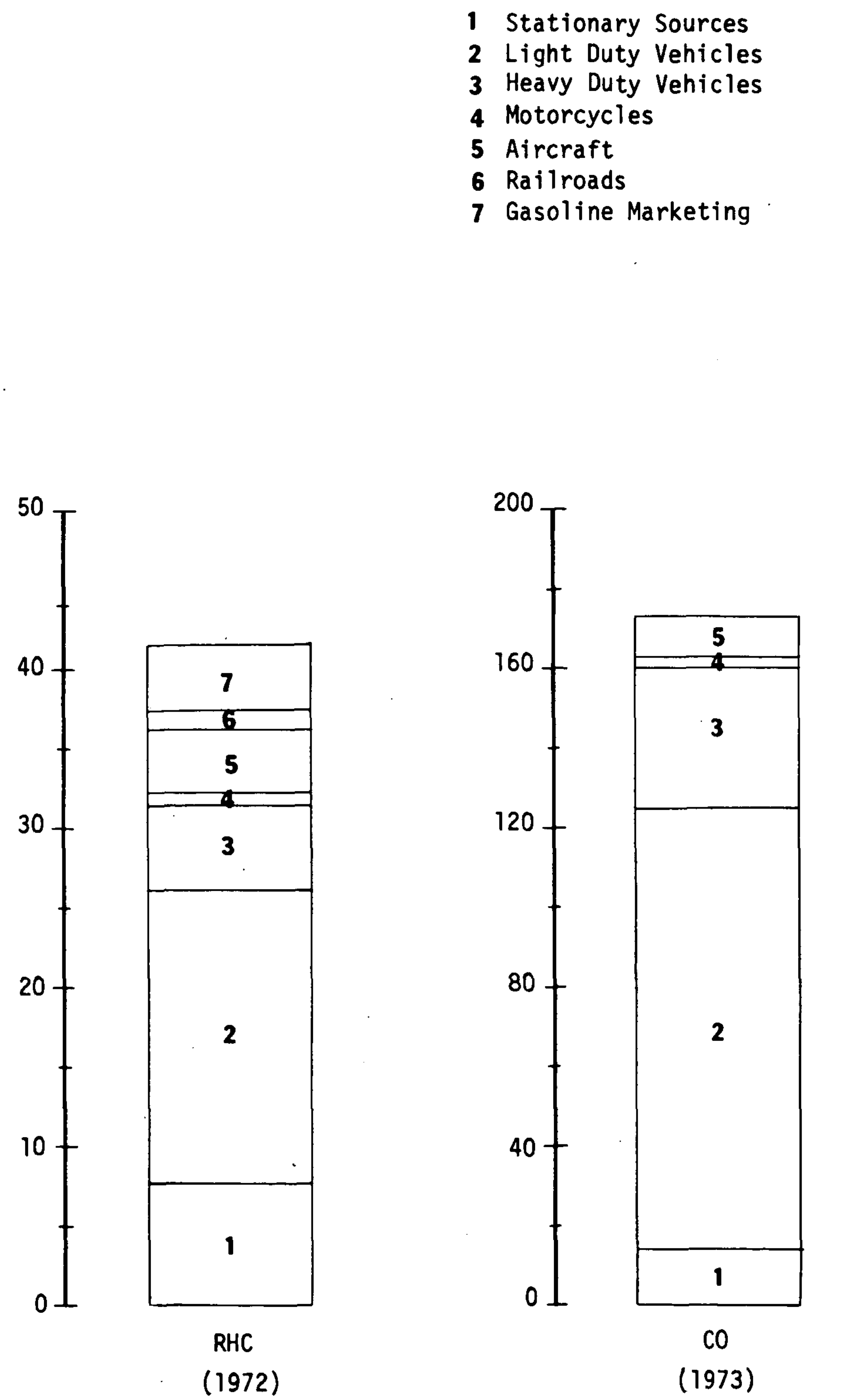

Figure 4-1. Summary Baseline CO and RHC Emission Inventory (tons/day)

4.2 EMISSION PROJECTIONS

The two projection years are 1977 and 1982. It must be recognized that many factors, among which are changes in the economy, availability of energy supplies and the introduction of new technologies in control equipment have not and cannot be accounted for in the scope of this report. The projections made are based on the limited nature of information available.

4.2.1 Stationary Sources

In the source categories of area source industrial processes, domestic, commercial and institutional space heating and solid waste disposal, a 3.6% per year growth rate from 1972 to 1975 and a 4% per year growth rate from 1975 through 1982 was used. These rates were obtained from the State Implementation Plan which assumed an 18% increase in emissions from 1970 to 1975 (or 3.6% per year) and an 8% increase from 1975 to 1977 (or 4% per year). The 4% growth rate was assumed to be accurate through 1982. As for organic solvent usage, the same growth rates were assumed. Table 4-12 shows the emissions from these sources in 1977 and 1982.

As for power plants and point sources of industrial processes, the expert opinion of personnel at the DHD was solicited to determine what growth factors were applicable. These factors and projections are contained in Table 4-13.

4.2.2 Mobile Sources

Aircraft

The equations and data used for projecting aircraft emissions to 1977 and 1982 are shown in Table 4-14. The first data column in the table provides estimates (4-7) of engine life for turbines (15 years) and pistons (20 years). The second column lists the equations derived for estimating future emissions from known base year emissions (E_{BY}), growth rate (G) and emission reductions (R). E_{BY} is expressed in terms of tons/day of pollutant from the indicated aircraft class. G is the fraction increase of base year emissions, except when used in calculating E_{82}, the emissions for 1982, where E_{78} is the synthetic base year;[1] and growth is expressed as a fraction increase in emissions from 1978.

[1] A synthetic base year is used due to proposed emission regulations for engines produced after January 1, 1979.

Table 4-12. Emission Projections for Area Industrial Processes: Residential, Commercial and Industrial Space Heating; Solid Waste Disposal

Source Category	1977 THC tons/day	1977 RHC tons/day	1977 CO tons/day	1982 THC tons/day	1982 RHC tons/day	1982 CO tons/day
Industrial Process						
(1) Area	0.7	0.07	-	0.9	0.09	-
Space Heating						
(1) Residential	0.2	0.02	0.4	0.2	0.02	0.45
(2) Commercial - Industrial	0.9	0.09	0.2	1.1	0.1	0.25
Solid Waste Disposal	.05	0.01	0.1	0.07	0.01	0.13
Organic Solvent Usage	4.2	0.8	-	5.8	1.2	-
Total	5.2	1.0	0.7	6.7	1.4	0.8

Similarly, emission reduction is expressed as a fraction decrease of base year emissions for the indicated projection year. The reduction is based on 1978 emissions for calculating projected 1982 emissions. The derivation of values for G and R will be discussed later.

The equations used for Aircraft Class 1 and Classes 4 through 12 are identical. Emissions in 1977, and 1978 are calculated by simply applying the appropriate growth factor to the base year emissions for each class. Here, 1978 emissions are calculated only for use in projecting 1982 emissions. The expression for E_{82} differs from the preceding equations in the table because of federal aircraft emission regulations which affect all new engines produced after 1 January 1979 (4-8). This expression contains essentially three terms and was derived as follows:

Table 4-13. NEDS Emission Inventory - Total and Reactive Hydrocarbon Emissions (Tons/Year)

Description of Source	UTM Coordinates (KM) Horizontal	Vertical	1972 (Base) THC	RHC	1977 THC	RHC	1982 THC	RHC	Reactivity Factor	Comments
Mohave Generating Station	720.0	3,890.2	224	0	294	0	336	0	0	See CO projections
Mohave Generating Station	720.0	3,890.0	224	0	294	0	336	0	0	See CO projections
Shell Oil Company	666.0	3,995.0	309	278	30.7	27.6	33.9	30.5	0.9	Aircraft Bulk Terminal Loading Station - Growth of 2% per year - 90% evaporative controls by 1977
Flintkote Apex	687.5	4,025.4	9	0.9	9	0.9	9	0.9	0.1	Constant (lime manufacturing)
Flintkote Apex	687.5	4,025.4	9	0	9	0	9	0	0	Constant (natural gas fuel combustion)
Flintkote Apex	687.5	4,025.4	10	0.9	10	1	10	1	0.1	Constant (lime manufacturing)
Flintkote Apex	687.5	4,025.4	10	0	10	0	10	0	0	Constant (natural gas combustion)
Flintkote Blue	645.3	3,991.2	2	0	2	0	2	0	0	Constant (natural gas combustion)
Nevada Power Company	711.6	4,095.5								
Unit #1			42	0	47.3	0	50.4	0	0	See CO projections
Unit #3			0	0	21	0	50.4	0	0	See CO projections
Unit #4			0	0	0	0	43.7	0	0	See CO projections
Unit #2			52	0	58.5	0	62.4	0	0	See CO projections
Nevada Power Company	675.8	3,995.2	51	5.1	51	5.1	51	5.1	0.1	See CO projections
Nevada Power Company	675.8	3,995.2	92	9.2	92	9.2	92	9.2	0.1	See CO projections
Nevada Power Company	675.8	3,995.2	81	8.1	81	8.1	81	8.1	0.1	See CO projections
Nevada Power Company	676.9	3,990.2	89	8.9	89	8.9	89	8.9	0.1	See CO projections
Stauffer Chemical	679.5	3,990.2	62	6.2	62	6.2	62	6.2	0.1	See CO projections
Johns Manville	691.3	4,010.8	1	0.1	1	0.1	1	0.1	0.1	See CO projections
Cal-Nev P/L Terminal	675.7	4,012.9	146	146	161.2	161.2	171.1	171.1	1	Storage loss of diesel fuel, no additional controls, 2% per year growth rate
Cal-Nev P/L Terminal	675.7	4,012.9	624	624	68.8	68.8	72	72	1	Diesel fuel working loss, 2% per year growth rate, 90% control in 1977
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Gasoline storage loss, no controls, 2% per year growth rate
Cal-Nev P/L Terminal	675.7	4,012.9	920	855.6	101.7	94.6	107.9	100.3	.93	Gasoline working loss, 90% control in 1973, 2% per year growth rate
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Storage loss, no controls, 2% per year growth rate
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Same as above
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Same as above
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Same as above
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Same as above
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Same as above
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Same as above
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Same as above
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Same as above

Table 4-13. NEDS Emission Inventory - Total and Reactive Hydrocarbon Emissions (Tons/Year) (Continued)

Description of Source	UTM Coordinates (KM) Horizontal	Vertical	1972 (Base) THC	RHC	1977 THC	RHC	1982 THC	RHC	Reactivity Factor	Comments
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Storage Loss, no controls, 2% per year growth rate
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Same as above
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Same as above
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Same as above
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Same as above
Cal-Nev P/L Terminal	675.7	4,012.9	26	24.2	28.6	26.6	30.4	28.3	.93	Same as above
Texaco, Inc.	675.7	4,012.9	31	31	34.2	34.2	36.3	36.3	1.0	Same as above (diesel fuel)
Texaco, Inc.	675.7	4,012.9	53	53	58.4	58.4	62	62	1.0	Same as above (diesel fuel)
Texaco, Inc.	675.7	4,012.9	21	19.5	26.7	24.8	30.9	28.7	.93	Gasoline storage loss, 5% per year growth rate, no controls
Texaco, Inc.	675.7	4,012.9	115	107	14.7	13.7	17	15.8	.93	90% control by 1973, 5% per year growth rate, gasoline storage
Texaco, Inc.	675.7	4,012.9	21	19.5	26.7	24.8	30.9	28.7	.93	Petroleum products storage, 5% per year growth rate
Texaco, Inc.	675.7	4,012.9	35	32.6	44.6	41.5	51.6	47.9	.93	Same as above
Nevada Rock and Sand	677.7	4,000.9	5	0.5	5	0.5	5	0.5	.1	No growth
Nevada Rock and Sand	677.7	4,000.9	5	0	5	0	5	0	0	No growth (natural gas combustion)

Table 4-13. NEDS Emission Inventory - Carbon Monoxide Emissions (Tons/Year) (Continued)

Description of Source	UTM Coordinates (KM) Horizontal	Vertical	1972 (base)	1973	1977	1982	Comments
Mohave Generating Station	720.0	3,890.2	747	794	980	1120.5	Presently at 60% generating capacity, projected 90% generating capacity by 1980 and holding at 90% through 1982. Fuel is bituminous coal.
Mohave Generating Station	720.0	3,890.0	747	794	980	1120.5	Same as above
Flintkote Blue	645.3	3,991.2	4	4	4	4	Constant through 1982, no growth and no controls
Nevada Power Company	711.6	4,059.5					
Unit #1			140	143.5	157.5	168	Presently at 75% generating capacity, projected 90% generating capacity by 1980 and holding constant at 90% through 1982. Fuel is bituminous coal.
Unit #3			0	0	84	168	To be installed. Will be at 30% generating capacity in 1976 and 90% capacity by 1980 and holding constant thereafter
Unit #4			0	0	0	145.6	To be installed, will be at 30% generating capacity by 1978 and 90% capacity by 1983.
Unit #2	711.6	4,059.5	175	186	229.5	262.5	Same as Unit #1
Nevada Power Company	675.8	3,995.2	1	1	1	1	At 75% capacity, no growth expected, turbine units to be added but these units have negligible CO and HC emissions. Fuel is residual oil.
Nevada Power Company	675.8	3,995.2	1	1	1	1	At capacity, no growth. Fuel is residual oil.
Nevada Power Company	675.8	3,995.2	1	1	1	1	At capacity, no growth. Fuel is natural gas.
Nevada Power Company	676.9	3,990.2	1	1	1	1	At capacity, no growth. Fuel is residual oil. Turbine units to be added, but these units have negligible HC and CO emissions.
Stauffer Chemical	679.5	3,990.2	1	1	1	1	No growth anticipated. (Nat'l gas comb)
Johns Manville	691.3	4,010.8	3	3	3	3	No growth anticipated.
Titanium Metals	680.4	3,990.3	3000	3000	3000	3000	No growth, no controls.

	1.		2.		3.
1982 Emissions =	1978 emissions	+	emissions increase due to growth in operations	-	emissions reduction due to engine replacement

Term 1: 1978 Emissions = E_{78}, as previously calculated

Term 2: Emissions increase due to growth in operations = G X (1-R) XE_{78}

(Note: Since this growth occurs after the proposed emission regulations come into effect, the growth must be modified by the application of an appropriately reduced emission rate, ergo the (1-R) factor.)

Term 3: Emissions reduction due to engine replacement = $R \times \left(\frac{1982-1978}{L}\right) \times E_{78}$

$$= R \times \left(\frac{4}{L} \right) \times E_{78}$$

where L is the life of the engine. The fraction 4/L represents the fraction of the aircraft engines of a particular class in 1978 which will be replaced with new engines by 1982. This fraction effects a proportionate reduction in emissions, since the replacement engines must comply with the 1 January 1979 emission standards.

Thus, the emissions equation for 1982 reduces to the following:

$$E_{82} = E_{78} \left(1 + G\,(1-R) - R \left(\frac{4}{L} \right) \right)$$

Classes 2 and 3 are special cases as one may observe from Table 4-14, because of burner can retrofit programs which effectively reduce hydrocarbon and carbon monoxide emissions. These programs affect emissions in 1977 and the respective emission equations must show this.

For Class 2, the retrofit program is assumed (4-7) to be planned for the three-year period from 1975 through 1977. It is estimated to have the following effect on emission factors (4-7):

	THC	CO
Pre-retrofit	41 lb/engine/LTO	47.4 lb/engine/LTO
Post-retrofit	25 lb/engine/LTO	43.0 lb/engine/LTO

The equations used for estimating 1977 and 1978 emissions were derived as follows, taking the projection year 1977 for the purpose of illustration.

	1.		2.		3.
1977 emissions =	base year emissions	+	emissions increase due to growth in operations	-	emissions reduction due to portion of retrofit program complete by mid-1977

Term 1: Base year emissions = E_{BY}

Term 2: Emissions increase due to growth in operations = $G \times E_{BY}$

Term 3: Emissions reduction due to portion of retrofit program complete by mid-1977 =

$$R \times (1+G) \times E_{BY}$$

Where:

R is the appropriate reduction factor for 1977 (discussed later in this text).

Thus,

$$E_{77} = E_{BY} + (G \times E_{BY}) - R \times (1+G) \times E_{BY}$$

$$= E_{BY}\ (1+G)\ \ (1-R)$$

Emissions for 1978 are calculated similarly.

For Class 3 aircraft, similar logic leads to identical equations, this time because the retrofit program (as described previously in this text) was at a near state of completion in the base year, 1972. Thus the effective reduction in emissions from the base year to 1977 or 1978 depends on the base year selected.

Emission reductions are shown in Table 4-14 for each base year, each projected year, each pollutant, and each aircraft class. Emission reductions effective in 1977 and 1978 result from the burner can retrofit programs involving Class 2 and Class 3 aircraft, described earlier in the text. All Class 2 aircraft had the same (pre-retrofit) emission factor, regardless whether the base year was 1972 or 1973. However, the future emission factor depends on the projected year, since the retrofit program is planned for 1975 through 1977. Thus, since the pre-retrofit total hydrocarbon emission factor for Class 2 aircraft was 41 lb/engine/LTO and the post-retrofit emission factor will be 25 lb/engine/LTO, the average emission factor in 1977 will be:

$$41 \text{ lb/engine/LTO} - 5/6 \times (41 - 25) \text{ lb/engine/LTO}$$

and the reduction factor R will be:

$$5/6 \times \frac{(41 - 25)}{41} = 0.33 \quad \text{(in other words 33\%).}$$

Reductions for 1978 were calculated similarly and appear in Table 4-14.

For Class 3 aircraft, the reduction depends on the base year, since the burner can retrofit program was carried out through 1972. The emission factors for Class 3 aircraft are shown in Table 4-15 for four possible base years. Thus, since the post-retrofit total hydrocarbon emission factor is (as was indicated earlier) 3.5 lb/engine/LTO, and the 1970 emission factor was 4.7 lb/engine/LTO, the reduction R for 1977, and 1978 (i.e., any year after the retrofit program was completed but before new standards come into effect) is:

$$\frac{4.7 \text{ lb/engine/LTO} - 3.5 \text{ lb/engine/LTO}}{4.7 \text{ lb/engine/LTO}} = 0.26$$

Emission reductions for all classes of aircraft between 1978 and 1982 are a result of the proposed federal emission standards, to be effective on new turbine and piston aircraft engines starting 1 January 1979. The emissions from each new engine (i.e., each engine manufactured on or after 1 January 1979(will be lower than the emissions from its older (i.e., pre-1979) counterpart by the estimated (4-7) reduction values shown in Table 4-14.

Table 4-14. Data for Computation of Projected Civil Aircraft Emissions

Aircraft Class	Engine Life, L (Yr)	Emission Equations E (Tons/Yr)	Emission Reductions, R (Fraction of B.Y. Emissions) HC B.Y.: 1972	HC 1973	HC 1978	CO 1972	CO 1973	CO 1978
1. Jumbo Jet	15	$E_{77} = E_{BY}\ (1+G)$	0	0	-	0	0	-
		$E_{78} = E_{BY}\ (1+G)$	0	0	-	0	0	-
		$E_{82} = E_{78}\ (1+G\ \ (1-R) - R\ (\frac{4}{L})\ )$	-	-	0.70	-	-	0.60
2. Long Range Jet	15	$E_{77} = E_{BY}\ (1+G)\ (1-R)$	0.33	0.33	-	0.077	0.077	-
		$E_{78} = E_{BY}\ (1+G)\ (1-R)$	0.39	0.39	-	0.093	0.093	-
		$E_{82} = E_{78}\ (1+G\ \ (1-R) - R\ (\frac{4}{L})\ )$	-	-	0.70	-	-	0.60
3. Medium Range Jet	15	$E_{77} = E_{BY}\ (1+G)\ (1-R)$	0.05	0.00	-	0.03	0.00	-
		$E_{78} = E_{BY}\ (1+G)\ (1-R)$	0.05	0.00	-	0.03	0.00	-
		$E_{82} = E_{78}\ (1+G)\ (1-R) - R\ (\frac{4}{L})\ )$	-	-	0.70	-	-	0.60
4. Air Carrier Turboprop	15	(See Class 1)	(See Class 1)			(See Class 1)		
5. Business Jet	15	(See Class 1)	(See Class 1)			(See Class 1)		
6. General Aviation Turboprop	15	(See Class 1)	(See Class 1)			(See Class 1)		
7. General Aviation	20	(See Class 1)	0	0	-	0	0	-
			0	0	-	0	0	-
			-	-	0.50	-	-	0.50
8. Piston Transport	20	(See Class 1)	-	-	-	-	-	-
			-	-	-	-	-	-
			-	-	-	-	-	-
9. Helicopter[a]	15	(See Class 1)	(See Class 1)			(See Class 1)		
10. Military Transport	15	(See Class 1)	(See Class 1)			(See Class 1)		
11. Military Jet	15	(See Class 1)	(See Class 1)			(See Class 1)		
12. Military Piston	20	(See Class 1)	(See Class 7)			(See Class 7)		

[a]It is assumed that all have turbine engines.

Table 4-15. Emission Factors for Class 3 Aircraft

Pollutant	(Units in lb/engine/LTO) 1969	1970	1971	1972	1973
THC	4.9	4.7	4.2	3.7	3.5
CO	20.0	19.5	18.5	17.5	17.0

Table 4-16 shows the listed general aviation, air carriers and military operations activities for each airport and for each aircraft class at these airports. Also shown are the activity growth factors from the designated base years (1972 for HC, 1973 for CO) for each aircraft class in 1977, 1978 and 1982. The growth factors, which were derived from the State Implementation Plan are indicative of a 3% (air carrier), 3% (general aviation) and -1% (military) yearly growth for each respective aircraft category. The growth factor for 1982 was computed on the basis of growth from projected 1978 activity. The 1978 base was used to accommodate the format for emissions projections dictated by the equations in Table 4-14.

Because of more recent information received from EPA, emissions from Nellis AFB were increased by 40% over the projected values predicted by the SIP. This is due to the Air Force's demonstration project known as the Continental Operations Range. Table 4-17 shows the projected hydrocarbon and carbon monoxide emissions for each aircraft class and airport. This table was generated by computations according to the equations specified in Table 4-14 and using the growth factors G (see Table 4-16). An example of such a computation is illustrated below.

Consider the projected hydrocarbon emissions at McCarran International Airport for Class 2 aircraft in 1977. According to Table 4-14, the expected emissions in 1977 will be:

$$E_{77} = E_{BY} \ (1+G) \quad (1-R)$$

where

E_{BY} = Class 2 aircraft emissions in the base year (1977)
= 2.77 tons/day (from Table 4-5)

G = growth in fraction increase of base year
= 0.15 (from Table 4-16).

R = expected emission reductions in fraction of base year emissions
= 0.33 (from Table 4-14)

Substituting,

$$E_{77} = 2.77\ (1 + 0.15)\ (1 - 0.33)$$
$$= 2.1 \text{ tons/day}$$

In 1982,

$$E_{82} = E_{78}\ [1 + G\ (1-R) - \frac{4R}{L}]$$

where

L = engine life time
= 15 years (from Table 4-14)

G = growth factor in fraction increase of 1978 emissions
= 0.12 (Table 4-16)

R = emission reduction in fraction of 1978 emissions
= 0.70 (from Table 4-14)

Thus,

$$E_{78} = E_{BY}\ (1+G)\ (1-R)$$
$$= 2.77\ (1 + 0.18)\ (1 - 0.39)$$
$$= 1.99 \text{ tons/day}$$

and

$$E_{82} = 1.99\ [1 + 0.12\ (1 - 0.7) - \frac{4\ (0.7)}{15}]$$
$$= 1.69 \text{ tons/day}$$

Railroads

A growth rate of 3.6% per year from 1972 through 1975 and a 4% per year growth rate from 1975 through 1982 was assumed. The State Implementation Plan assumed an 18% growth rate from 1970 to 1975 (or 3.6% per year) and an 8% growth rate from 1975 through 1977 (or 4% per year) for railroads. The 4% per year growth rate was assumed to hold true through 1982. Table 4-18 shows the projected emissions.

Table 4-16 Aircraft Operations Activity for Civilian and Military Aircraft in Clark County [a]

Airport	Aircraft Class	Number of Engines	Total Operations in Base Year (Thousands) 1972	Total Operations in Base Year (Thousands) 1973	Operations per Year (Thousands) 1977	Growth Factor from Base Year 1972	Growth Factor from Base Year 1973	Operations per Year (Thousands) 1978	Growth Factor from Base Year 1972	Growth Factor from Base Year 1973	Operations per Year (Thousands) 1982	Growth Factor from Base Year 1978
McCarran International Airport	1	3	1.25	1.29	1.44	0.15	0.12	1.48	0.18	0.15	1.63	0.12
	1	4	1.26	1.30	1.45	0.15	0.12	1.49	0.18	0.15	1.64	0.12
	2	4	24.55	25.29	28.23	0.15	0.12	28.99	0.18	0.15	31.92	0.12
	3	2	21.98	22.64	25.28	0.15	0.12	25.94	0.18	0.15	28.57	0.12
	3	3	14.99	15.44	17.24	0.15	0.12	17.69	0.18	0.15	19.49	0.12
	3	4	18.40	18.95	21.16	0.15	0.12	21.71	0.18	0.15	23.92	0.12
	4	2	5.48	5.64	6.3	0.15	0.12	6.47	0.18	0.15	7.12	0.12
	4	4	1.56	1.61	1.79	0.15	0.12	1.84	0.18	0.15	2.03	0.12
	5	1	4.76	4.90	5.51	0.15	0.12	5.68	0.18	0.15	6.39	0.12
	6	2	0.05	0.05	0.06	0.15	0.12	0.06	0.18	0.15	0.07	0.12
	7	1	70.58	72.69	81.82	0.15	0.12	84.27	0.18	0.15	94.85	0.12
	7	2	18.00	18.54	20.87	0.15	0.12	21.49	0.18	0.15	24.19	0.12
	7	4	1.10	1.44	1.62	0.15	0.12	1.67	0.18	0.15	1.88	0.12
	11	1	24.21	23.97	23.02	-0.05	-0.04	22.79	-0.06	-0.05	21.90	-0.04
	12	2	1.07	1.06	1.02	-0.05	-0.04	1.01	-0.06	-0.05	.97	-0.04
	12	4	.20	.20	.19	-0.05	-0.04	.19	-0.06	-0.05	.18	-0.04
N. Las Vegas Air Terminal	5	1	2.60	2.68	3.02	0.15	0.12	3.11	0.18	0.15	3.50	0.12
	7	1	139.35	143.53	161.55	0.15	0.12	166.39	0.18	0.15	187.28	0.12
	7	2	7.38	7.60	8.55	0.15	0.12	8.81	0.18	0.15	9.91	0.12
	9	1	4.34	4.47	5.03	0.15	0.12	5.19	0.18	0.15	5.84	0.12
Nellis Air Force Base	1	4	0.024	0.024	0.022	-0.05	-0.04	0.022	-0.06	-0.05	0.02	-0.04
	9	1	0.72	0.72	0.68	-0.05	-0.04	0.68	-0.06	-0.05	0.66	-0.04
	10	4	0.10	0.102	0.10	-0.05	-0.04	0.10	-0.06	-0.05	0.10	-0.04
	11	1	26.40	26.14	25.10	-0.05	-0.04	24.84	-0.06	-0.05	23.88	-0.04
	11	2	54.04	53.50	26.40	-0.05	-0.04	50.86	-0.06	-0.05	48.88	-0.04
	12	4	0.20	0.20	0.19	-0.05	-0.04	0.19	-0.06	-0.05	0.18	-0.04

[a] Figures do not include aircraft operations due to the Air Force's Continental Operations Range project

Table 4-17 Base Year and Projected Total and Reactive Hydrocarbon and Carbon Monoxide Emissions at Clark County Airports [a]

Airport	Aircraft Class	THC (Tons/Day) 1972	THC (Tons/Day) 1977	THC (Tons/Day) 1982	CO (Tons/Day) 1973	CO (Tons/Day) 1977	CO (Tons/Day) 1982	RHC (Tons/Day) 1972	RHC (Tons/Day) 1977	RHC (Tons/Day) 1982
McCarran International Airport	1	0.07	0.08	0.07	0.29	0.32	0.29	0.06	0.07	0.06
	2	2.77	1.99	1.69	3.28	3.39	3.12	2.49	1.79	1.52
	3	0.41	0.45	0.39	1.95	2.18	1.99	0.37	0.41	0.35
	4	0.03	0.04	0.03	0.08	0.09	0.08	0.02	0.03	0.02
	5	0.01	0.01	0.01	0.05	0.06	0.06	0.01	0.01	0.01
	6	-	-	-	-	-	-	-	-	-
	7	0.03	0.04	0.03	0.97	1.09	0.99	0.02	0.03	0.02
	11	0.16	0.22	0.17	0.25	0.33	0.28	0.14	0.20	0.15
	12	0.04	0.06	0.04	0.30	0.4	0.32	0.03	0.06	0.04
TOTAL		3.52	2.89	2.43	7.17	7.86	7.13	3.14	2.6	2.17
N. Las Vegas Air Terminal	5	0.01	0.01	0.01	0.03	0.03	0.03	0.01	0.01	0.01
	7	0.04	0.05	0.05	1.39	1.56	1.55	0.03	0.04	0.04
	9	-	-	-	0.02	0.02	0.02	-	-	-
TOTAL		0.05	0.06	0.06	1.44	1.61	1.6	0.04	0.05	0.05
Nellis Air Force Base	1	-	-	-	-	-	-	-	-	-
	9	-	-	-	-	-	-	-	-	-
	10	-	-	-	-	-	-	-	-	-
	11	0.91	1.22	0.97	1.39	1.88	1.58	0.82	1.09	0.87
	12	0.01	0.01	0.01	0.08	0.11	0.08	0.01	0.01	0.01
TOTAL		0.92	1.23	0.98	1.47	1.99	1.66	0.83	1.10	0.88
ALL AIRPORTS TOTAL		4.5	4.2	3.5	10.1	11.5	10.4	4.0	3.8	3.1

[a] Figures account for the Air Force's Continental Operations Range project

Motor Vehicles

Projected emissions from light duty vehicles, heavy duty gasoline and diesel powered vehicles and motorcycles were calculated by the method indicated in Appendix B. Table 4-19 illustrates the results.

Gasoline Marketing

The rate of growth in gasoline marketing from 1972 to 1977 and 1982 was assumed equal to the growth rate in VMT between these years (see Appendix B). Table 4-20 shows the projected number of gallons of gasoline marketed in 1977 and 1982, as well as emissions.

Table 4-18. Projected Emissions from Railroads

	1977 (Tons/Day)	1982 (Tons/Day)
THC	1.4	1.6
RHC	1.38	1.58
CO	0.9	1.2

Table 4-19. Projected Emissions from Motor Vehicles (Tons/Day)

	1977		1982	
	RHC	CO	RHC	CO
Light Duty Vehicles	9.2	70.9	3.8	24.8
Heavy Duty Vehicles				
Gasoline Powered	5.4	36.0	5.8	43.6
Diesel Powered	0.26	1.6	0.33	2.0
Motorcycles	0.96	4.1	1.2	5.2

Table 4-20. Projected Emissions from Gasoline Marketing

Year	Gallons of Gasoline Marketed	THC Emission Factor* ($lbs/10^3$ gallons)	Emissions (Tons/Day) THC	RHC
1977	244,784,495	19**	6.4	5.9
1982	305,533,932	19**	7.9	7.4

*Source: Reference 4-11

**Combined service station tanks and automobile tanks emissions.

4.3 TRANSPORTATION DATA

4.3.1 Travel Characteristics

The Las Vegas Valley Transportation Study (LVVTS) of 1970 derived information gathered by interviews concerning the travel characteristics of residents and visitors in the Las Vegas region.[1] Based on pre 1970 data, this study indicated that:

- The average resident trip length was 9.52 minutes or alternatively 3.77 miles.
- The average vehicular speed was 24 mph.
- The average occupancy was 2.10 persons/trip.

Tables 4-22 and 4-23 summarize the number of trips by mode and type. The projections in Table 4-23 were made assuming 1) government trips will reduce because governments will regionalize, 2) commercial home delivery trips will lessen because of the shoppers' increased mobility, 3) the citywide economy will continue to improve, 4) the birth rate will decline. An interesting fact brought out by the LVVTS was that hotel-motel trips accounted for 2.86 vehicle trips/occupied room/24 hour period, or a total of 44,390 trips, which exceeds both external and taxi trips combined.

[1] The projections of travel characteristics contained in the LVVTS were based on a set of population projections which have since been revised downwards by the Regional Planning Council. The new projections are: 421,300 in 1980, 563,000 in 1990 and 700,000 in 2000.

Table 4-21. Summary of Projected Emissions for Clark County (tons/day)

	1977		1982	
	RHC	CO	RHC	CO
Stationary Sources				
1. Industrial Processes				
a) Area	0.07	-	0.09	-
b) Point	2.7	8.2	2.9	8.2
2. Power Plants *	0.085	3.99	0.085	5.1
3. Space Heating				
a) Domestic	0.02	0.4	0.02	0.45
b) Industrial and Commercial	0.04	0.2	0.1	0.25
4. Solid Waste Disposal	0.01	0.1	0.01	0.13
5. Organic Solvent Usage	0.8	-	1.2	-
Total, Stationary Sources	3.75	12.9	4.3	14.1
Mobile Sources				
1. Light Duty Vehicles	9.2	70.9	3.8	24.8
2. Heavy Duty Gasoline Powered Vehicles	5.4	36.0	5.8	43.6
3. Heavy Duty Diesel Powered Vehicles	0.26	1.6	0.33	2.0
4. Motorcycles				
a) Two stroke	0.66	1.15	0.84	1.45
b) Four stroke	0.30	2.99	0.37	3.77
5. Aircraft	3.8	11.5	3.1	10.4
6. Railroads	1.38	0.9	1.58	1.2
7. Gasoline Marketing	5.9	-	7.4	-
Total, Mobile Sources	26.9	125	23.2	87.2
Grand Total	30.65	137.9	27.5	101.3

* Does not include the Mohave Power Plant

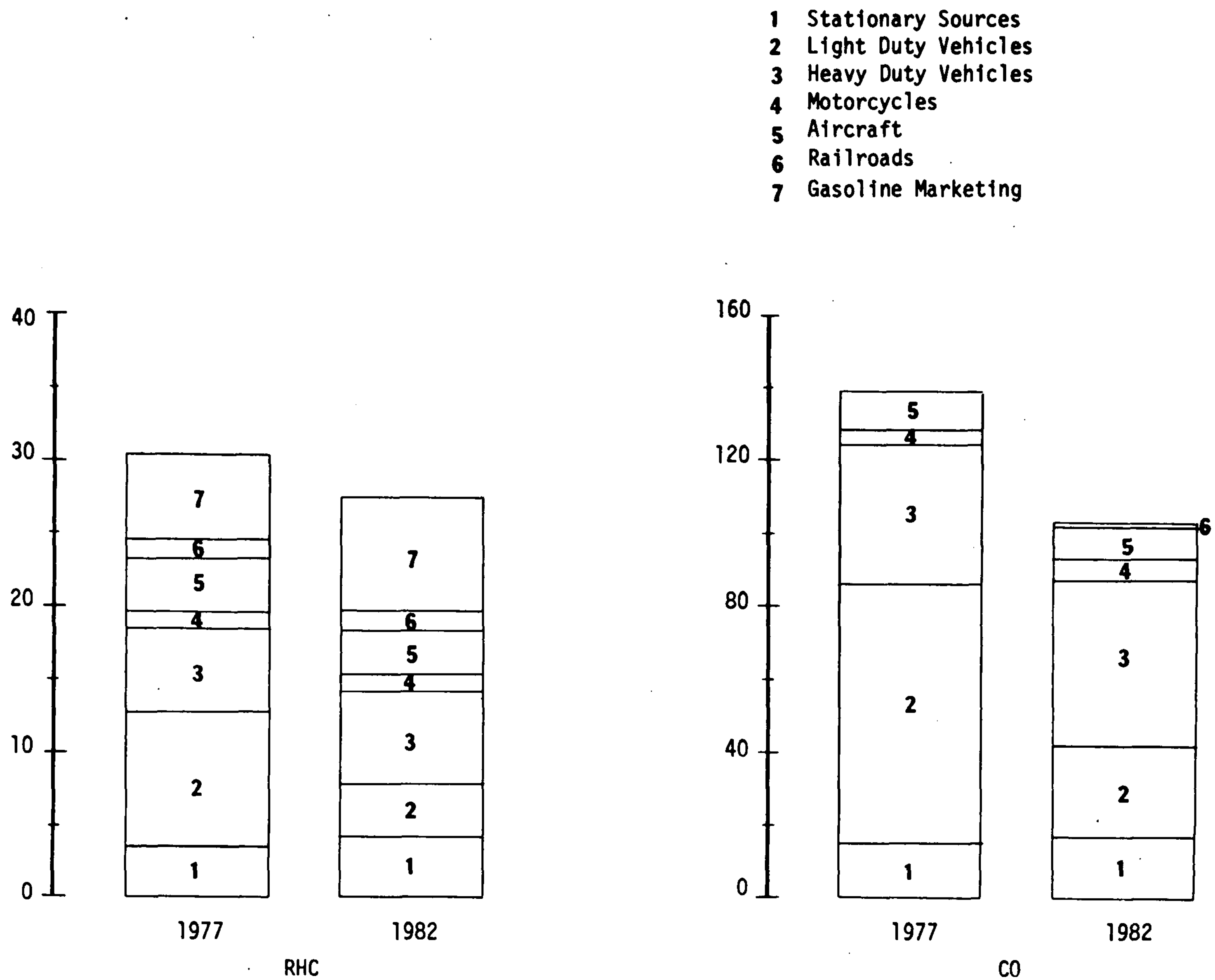

Figure 4-2. Summary of Projected Emissions for Clark County (tons/day)

A study conducted by the City of North Las Vegas (4-12) in 1974 indicated that 80% of the residents in that city drove to work in automobiles, while 15% were automobile riders and only 5% used other modes (walking, bicycle, bus, motorcycle). These figures were considered representative of the entire Las Vegas area (4-13):

4.3.2 Taxi Cab Service

There are presently 11 cab companies operating in the Las Vegas area, with a total of 283 vehicles (4-14). The average trip length is approximately 3 miles and the annual average number of trips is 4 million. The Nevada Taxi Authority regulates the number of cabs, rate structures, safety standards and colors.

4.3.3 Public Transit Service

Only one company, the Las Vegas Transit System, Inc., provides intracity service in Las Vegas. The size of the bus fleet is 25, with 21 operating during peak periods. The company provides 9 routes which are basically circular in nature and the fleet travels approximately 3300 miles per day (4-15). The fare structure is

Adult cash fare	$ .50
Adult token fare (6 tokens)	2.40
Adult commuter card fare (20 rides).	6.70
Children under 13 years of age . . .	.15
Children under 6 years of age with paying adult passenger	free
Transfers	free

In 1965, less than 1.3% of all resident person trips were made via public transit (4-22). In 1972, the average weekday passenger trips totaled 8,000 and average peak hour passenger trips totaled 1,000 (4-21).

The company switched to an east-west routing of lines in September of 1974. This expansion was estimated to provide transit to approximately 75,000 more residents (4-15). However, in January of 1975, the Las Vegas Transit System Inc. petitioned to switch from this east -west routing to a modified radial system because the anticipated increase in ridership did not occur.

4.3.4 Parking Facilities

The LVVTS placed the total number of parking spaces in the central business district of Las Vegas at 10,516 in 1965 (Table 4-24). Off street parking included both public (4,822 spaces) and private (3,434 spaces) facilities, while on street parking consisted of 1,137 metered and 1,113 unmetered spaces. In 1973, metered on street sites totaled 1,169 spaces and unmetered sites, 1,709 (4-16). The LVVTS predicted a deficit of parking spaces as follows:

Year	Population	Number of Spaces Needed
1980	563,000	18,500
1990	700,000	21,100
2000	1,000,000	30,200

Table 4-22. Trip Mode Distribution in the Las Vegas Valley, 1965

Type of Trip	Vehicle Trips	Person Trips	Persons/ Vehicles	Persons Bus
Resident (Work-Home-Based)	105,926	140,882	1.33	2,060
Resident (Socio-Recreation-Home-Based)	78,074	222,511	2.85	516
Resident (Shopping-Home-Based)	94,708	194,151	2.05	651
Resident (Other-Home-Based)	96,701	277,532	2.87	12,834
Resident (Non-Home-Based)	78,933	156,287	1.98	504
Motel Patron	44,390	112,307	2.53	17,233*
Taxi	12,940	25,104	1.94	
Commercial Pickup	47,676	54,351	1.14	
External Cars	22,955	62.897	2.74	
Government Cars	7,332	8,652	1.18	
External Trucks	2,215	3,566	1.61	
Government Trucks	1,129	2,111	1.87	
Commercial Trucks	14,391	16,981	1.18	
Total	607,370	1,277,310		16,565** 33,798***

*Special busses - Motel, Airport Limousine, Tours, etc.
**Total Public Transit
***Total All Bus Passengers

Source: Las Vegas Valley Transportation Study

Table 4-23. Projected Trip Mode Distribution in the Las Vegas Valley

Type of Trip	1965	1970	1980	1990	2000
Resident (Work-Home-Based)	105,926	151,620	260,159	323,219	459.784
Resident (Socio-Recreation-Home-Based)	78,074	109,382	204,497	285,503	376,856
Resident (Shopping-Home-Based)	94,708	137,406	245,768	307,271	441,241
Resident (Other-Home-Based)	96,701	134,619	245,363	306,420	440,261
Resident (Non-Home-Based)	78,933	106,577	191,158	240,525	345,085
Motel	44,390	53,283	95,446	120,878	195,058
Taxi	12,940	20,504	36,827	50,486	72,418
Commercial Pickup	47,676	46,683	82,672	102,697	147,540
External Cars	22,955	25,415	45,676	58,387	83,168
Government Cars	7,332	9,817	17,421	18,699	29,794
External Trucks	2,215	2,506	4,399	5,913	8,359
Government Trucks	1,129	1,607	2,929	2,830	3,254
Commercial Trucks	14,391	20,409	36,828	55,931	79,883
Total Vehicle Trips	607,370	819,828	1,409,143	1,878,759	2,602,702
Population	232,100	315,638	563,000	697,475	996,008

Table 4-24 Parking Space Inventory of Las Vegas Central Business District 1965 Survey (Zones 601, 603, 604, 605, 607, 609, 611, 614)

Type of Parking	Number of Spaces	Percent of Total
Curb		
12 Minute Metered	19	0.2
24 Minute Metered	9	-
30 Minute Metered	14	0.1
1 Hour Metered	944	9.0
2 Hour Metered	156	1.5
Total Metered	1137	10.8
12 Minute	1	-
1 Hour	328	3.1
2 Hour	80	0.8
Unlimited	704	6.7
Total Unmetered	1113	10.6
Total Curb	2250	21.4
Off Street		
Public		
Municipal	1053	10.0
Commercial	3779	35.9
Private		
Patron	2589	24.6
Tenant	85	0.9
Employee	760	7.2
Covered Parking	1244	(not included in Grand Total)
Total Off Street	8266	78.6
Grand Total Parking Spaces	10,516	100.0

Source: Las Vegas Valley Transportation Study

REFERENCES

4-1 Clark County Department of Aviation, McCarran International Airport, 1972.

4-2 Private communication with various personnel at the McCarran International Airport Control Tower, August 1974.

4-3 Federal Aviation Administration Airport Record Form #5010-1 (7-70).

4-4 Private communication with the North Las Vegas Airport Manager's Office, August 1974.

4-5 Private communication with the office of the 57th Civil Engineering Squadron at Nellis Air Force Base, August 1974.

4-6 "Aircraft" - Revision to AP-42, Environmental Protection Agency, 1973.

4-7 Private communication with Mr. Robert Sampson, EPA, Ann Arbor, Michigan, May 1973.

4-8 Federal Register, EPA, December 1972.

4-9 Nevada State Implementation Plan, 1970.

4-10 Richard Ida, Clark County DHD, private communication, August 1974.

4-11 "Compilation of Air Pollutant Emission Factors," EPA, Office of Air and Water Programs, April 1973.

4-12 City of North Las Vegas, Labor Supply Profile, Community Analysis and Evaluation Program, February 1974.

4-13 Franklin J. Bills, City of North Las Vegas, Community Analysis and Evaluation Program Director, private communication, February 1974.

4-14 Manual Cortez, Director, Nevada Taxi Authority, private communication, February 1974.

4-15 Gary Ballinger, Las Vegas Transit System, Inc., private communication, April 1974.

4-16 Robert Kenneston, Traffic Control Supervisor, City of Las Vegas, private communication, February 1974.

4-17 Guide for Compiling a Comprehensive Emission Inventory, EPA, Publication No. APTD 1135, March 1973.

4-18 "Episode Contingency Plan Development for the Metropolitan Los Angeles Air Quality Control Region," TRW, Inc., December 1973.

4-19 B. Demitriades, EPA, Research Triangle Park, North Carolina, private communication, October 1974.

4-20 M. Goldberg, EPA, Region IX, private communication, October 1974.

4-21 W. Flaxa, Nevada Department of Highways Las Vegas, private communication, February 1974.

4-22 The Las Vegas Valley Transportation Study.

5.0 THE NEVADA STATE IMPLEMENTATION PLAN

The Nevada State Implementation Plan (SIP) detailed the control strategies which the state felt necessary in Clark County to meet the National Ambient Air Quality Standards for oxidants and carbon monoxide. The strategies enumerated in the SIP can be summarized as follows:

- A reduction in light and heavy duty vehicle and aircraft emissions due to increasingly stringent federal emission standards.
- A reduction in LDV emissions as the result of a mandatory inspection-maintenance program to be started in 1974 and a catalytic muffler and crankcase ventilation retrofit program for all LDV of model years 1966 through 1974.
- A reduction in vehicle emissions because of improved traffic flow resulting from a road building program discussed in the Las Vegas Valley Transportation Study.

Tables 5-1 and 5-2 illustrate the reductions in emissions obtained in 1975 and 1977 by applying these control measures. Table 5-3 contains the growth factors used in the SIP to project emissions from the base year of 1970.

5.1 SIP CONTROL STRATEGIES

This section briefly summarizes the expected emission reductions specified in the SIP by instituting various control strategies.

Gasoline Driven Light Duty Vehicles

Despite increased automobile usage and automobile population projections, future federal emission standards will result in the following reductions in HC and CO emissions, as calculated by using Appendix I, Figure 2 of the August 14, 1971 Federal Register:

CO :	27%	from 1970 to 1975
	46%	from 1970 to 1977
HC :	38%	from 1970 to 1975
	57%	from 1970 to 1977

Diesel Driven Heavy Duty Vehicles

Beginning with the 1973 model year, federal emission standards were expected to reduce HC and CO, despite a 1% per year growth rate in HDV population and an estimated lifetime of 10 years for diesel vehicles. Resulting reductions were calculated to be:

CO :	16%	from 1970 to 1975
	18%	from 1970 to 1977
HC :	2%	from 1970 to 1975
	3%	from 1970 to 1977

Aircraft

For piston driven general aviation and turbine powered commercial aircraft, federal emission standards were estimated to have a dramatic effect in emissions by the year 1977:

Piston driven general aviation	- CO :	11% increase from 1970 to 1975
		46% decrease from 1970 to 1977
	HC :	12% increase from 1970 to 1975
		45% decrease from 1970 to 1977
Turbine powered commercial	- CO :	79% decrease from 1970 to 1975
		79% decrease from 1970 to 1977
	HC :	79% decrease from 1970 to 1975
		79% decrease from 1970 to 1975
		79% decrease from 1970 to 1977

As for military aircraft, which operate primarily out of Nellis Air Force Base, a switch to Turbine A fuel and anticipated decreases in defense funding were expected to reduce HC emissions by 22% from 1970 to 1975 and 27% from 1970 to 1977.

Traffic Flow Control

Improved traffic flow resulting from an ongoing road building program was expected to reduce CO by 20% and HC by 16% in 1973 from 1970 vehicle related emissions levels. These reductions were obtained as the result of an analysis of average speeds and VMT on different links of the building program.

Mandatory Inspection Maintenance Program

A mandatory inspection-maintenance program for all gasoline driven LDV is to be instituted by 1974 and enforced by 1975 to require such vehicles to submit to an annual check of emission control devices and a test of engine performance. Certifications of compliance by official state designated garages, service stations or new car dealerships will be required on a varying date base for each car registered or usually garaged in Clark County. It was anticipated that such a program would result in the following emission reductions after the application of federal motor vehicle emission standards.

CO :	20% in 1975
	20% in 1977
HC :	30% in 1975
	30% in 1977

Catalytic Muffler and Crankcase Ventilation Retrofit Program

This control measure would entail the mandatory retrofit of all 1966 through 1974 model year LDV starting in 1975 and ending by 1977. A minimum of 53% reduction in CO emissions was expected.

Point and Area Source Regulations

Clark County emission control regulations require the elimination of hydrocarbon losses from large gasoline and oil storage areas through the application of pressurized-sealed systems, use of floating roof tanks and/or installation of vapor recovery systems. These measures were expected to reduce HC emissions by 99%.

Application of regulations controlling service station operating methods and gasoline storage tanks was expected to reduce HC emissions from gasoline marketing sources by 90%.

5.2 COMPARISON OF EMISSION INVENTORIES

Table 5-4 compares the emission inventories (for carbon monoxide and total hydrocarbons) which were (a) presented in the SIP and (b) developed in the course of this study. A more detailed breakdown of emissions by source category was not possible due to the format employed in the SIP. As can be noted, there are significant differences in the two inventories. Because the SIP did not detail its method of emission estimation, it is not possible, in the scope of this report, to examine the specific causes of the differences. However, the following factors may have played a role in

Table 5-1 SIP Specified Reductions of CO in Clark County (tons/yr)

Emission Source	Existing 1970 Emissions	Emissions After the Application of Control Measure #: (see below)									
		1 & 2		1,2 & 3		1,2,3 & 4		1,2 & 5		1,2,3 & 5	
		1975	1977	1975	1977	1975	1977	1975	1977	1975	1977
Motor Vehicle											
Gasoline	135,953	99,667	73,864	79,734	59,091	60,272	36,426	78,342	65,000	62,990	52,000
Diesel	10,775	8,997	8,782	8,997	8,782	8,997	8,782	7,100	7,710	7,100	7,710
Aircraft											
Piston	808	900	435	900	435	900	435	900	435	900	435
Turbine	307	64	66	64	66	64	66	64	66	64	66
All Others	12,170	12,859	12,995	12,859	12,995	12,859	12,995	12,859	12,995	12,859	12,995
Total	160,013	122,487	96,142	102,554	81,369	83,092	58,704	100,323	85,306	83,523	73,006

(1) Federal motor vehicle emission limitations

(2) Federal aircraft emission limitations

(3) Inspection-testing certification program

(4) Retrofit program

(5) Las Vegas study - 21% reduction through traffic flow control in 1973

Emissions required to achieve NAAQS = 78, 886 tons/year

Table 5-2 SIP Specified Reductions of HC in Clark County (tons/year)

Emission Source	1970 Emissions	1970 with Application of County Regulations[a]	Emissions After the Application of Control Measure # (see below)							
			1		2		3		4	
			1975[b]	1977[c]	1975[b]	1977[c]	1975	1977	1975	1977
Fuel Storage	15,819	225	248	257	248	257	248	257	248	257
Diesel Vehicles	2,155	2,155	2,114	2,101	1,780	1,770	2,114	2,101	2,114	2,101
Gasoline Vehicles	23,331	23,331	14,395	10,149	12,100	8,590	11,515	8,729	9,080	4,680
Military Aircraft	2,033	2,033	1,584	1,491	1,584	1,491	1,584	1,491	1,584	1,491
Commercial Aircraft	390	390	82	83	82	83	82	83	82	83
General Aviation	33	33	37	18	37	18	37	18	37	18
Gasoline Marketing	1,619	162	115	123	115	123	115	123	115	123
Other	1,954	1,954	2,308	2,466	2,308	2,466	2,308	2,466	2,308	2,466
Total	47,334	30,283	20,883	16,688	18,254	14,798	18,003	15,268	15,568	11,219

(1) After Federal motor vehicle and aircraft limitations
(2) Measure #1 plus Las Vegas Study, which assumes a 16% motor vehicle emission reduction through traffic flow improvements in 1973
(3) Measure #1 plus Automobile Inspection Program
(4) Measure #1 plus Automobile Retrofit Program
a = Elimination of HC emissions from large gasoline and oil storage facilities and a reduction of 90% in emissions from gasoline service stations
b = Includes estimated growth to 1975
c = Includes estimated growth to 1977

Emissions required to achieve NAAQS = 17,561 tons/year

Table 5-3. SIP Growth Factors

Source	1975	1977
Automobiles	1.1	1.14
Diesel Vehicles	1.05	1.07
Commercial Aircraft	1.15	1.21
Military Aircraft	0.95	0.93
General Aviation	1.10	1.14
Fuel Storage	1.18	1.26
Gasoline Marketing	1.18	1.26
Other	1.18	1.26

Table 5-4 Comparison of Emission Inventories [a]
(tons/year)

Source Category	SIP		TRW	
	Total HC	CO	Total HC	CO
Motor Vehicles	25,486	146,728	10,621.5 [c]	54,312 [c]
Aircraft	2,456	1,115	1,642.5	3,686.5
Gasoline Marketing	1,619	-	1,679	-
All Others	17,773	12,170	5,717 [b]	4,650 [b]
Total	47,334	160,013	19,660	62,648.5

[a] Baseyear for the SIP is 1970; baseyear for TRW is 1972 for total HC and 1973 for CO.

[b] Does not include the Mohave Power Plant

[c] Includes motorcycles

the resulting variations:

- The methodology for calculating motor vehicle emissions has been greatly modified in the past five years. Factors such as local vehicle age distributions and a wider range of speed correction factors are accounted for in the present method, whereas they were not when the SIP was written.

- Both motor vehicle and aircraft emission factors have been revised substantially. For example, the EPA approved carbon monoxide emission factor for LDV is approximately three times greater in 1970 as compared to 1974.

- Controls may have been applied to various stationary sources.

6.0 ADDITIONAL CONTROL STRATEGIES

6.1 INTRODUCTION

The purpose of this section is to examine control strategies other than those proposed in the SIP and to reevaluate the emission reduction effectiveness of several strategies enumerated in the SIP, in light of more current research. The strategies may be divided into two general categories, hardware measures such as light duty vehicle retrofit devices and VMT reduction measures, such as carpools. All costs are in terms of 1972 dollars.

6.2 HARDWARE STRATEGIES

The measures under consideration are

- LDV retrofit devices
- Mandatory inspection-maintenance (I/M) programs for LDV
- Gasoline vapor recovery systems at service stations

6.2.1 LDV Retrofit Devices

Retrofit is defined as an application of any device or system that may be added on to a motor vehicle, and/or any modification or adjustment beyond that of regular maintenance which could be made to reduce vehicular emissions. There are three primary emission sources in motor vehicles which can be potentially controlled by various retrofit procedures. For vehicles without emission controls, crankcase venting typically contributes about 20% of the total hydrocarbon emissions from the vehicle. Another 20% of the total hydrocarbon emission typically results from evaporative losses from the carburetor and fuel tank system. Exhaust emissions typically account for the remaining 60% of the hydrocarbon emissions, and 100% of the carbon monoxide emissions.

Crankcase emission systems have been installed in automobiles for some time, therefore crankcase emission retrofit devices will not be considered. Evaporative emission control systems are more recent on new cars; however there are no available retrofit systems for this emission category. For this reason, retrofit devices to control evaporative emissions will not be considered either.

Catalytic muffler retrofit - Because catalytic mufflers require the equipped vehicle to use a non leaded gasoline, not all light duty vehicles of model years 1966 through 1974 can be retrofitted. Unfortunately, no figures for Clark County on the number of model year 1966 through 1974 LDV capable of performing adequately on non leaded gasoline could be located. The decision was reached to assume that figures valid for the State of California would also be valid for Nevada (Table 6-1). The effectiveness of catalytic mufflers in reducing HC and CO emissions is shown in Table 6-2, while the cost figures are illustrated in Table 6-3.

Table 6-1. Percentage of Vehicles Able to Use Non-Leaded Gasoline

Model Year	Percentage of Model Year
1966-1970	20
1971-1974	75

Source: Reference 6-3

Table 6-2. Effectiveness of Oxidizing Catalytic Converter Mufflers

	Percentage Reduction	
Vehicle Type	HC	CO
Controlled (1968 model year and later)	50	50
Precontrolled (pre 1968 model year)	68	63

Source: Reference 6-2

Table 6-3. Cost of Oxidizing Catalytic Converter Mufflers

Cost of catalytic muffler	$150*
Cost of replacing catalyst	$ 15 - $20**
Average lifetime	50,000 miles**

*Source: Reference 6-3
**Source: Reference 6-1

Exhaust gas recirculation (EGR), Vacuum Spark Advance Disconnect (VSAD) and Lean Idle Fuel Adjustment (LIAF) - The EGR is a system which introduces exhaust gas from the exhaust pipe through a EGR valve and back into the intake manifold. A speed control allows for approximately 15% of the exhaust gas to be recirculated to the intake manifold whenever the vehicle speed exceeds 26 MPH and shuts off recirculation whenever the speed drops below approximately 12 MPH. A deceleration switch is also provided to stop recirculation whenever the accelerator pedal is released. The VSAD device disconnects the vacuum spark advance except when a thermostat switch senses when the car is tending to overheat. In that case, the advance is reconnected until the engine cools down. The LIAF requires tuning for a low idle engine rpm with a high air to fuel ratio, normally 14 to 1. The EGR and VSAD retrofit are applicable to most domestic cars after the 1955 model year while LIAF can be applied to all domestic cars not equipped with exhaust control devices. Expected emission reductions and costs are shown in Table 6-4.

Table 6-4. Effectiveness of EGR, VSAD and LIAF

Retrofit Option	Percent Reduction* HC	CO	Installed Cost**
Precontrolled Vehicles (pre 1968 model year)			

(Continued on next page)

Retrofit Option	Percent Reduction* HC	CO	Installed Cost**
LIAF plus VSAD	25	9	$45
EGR plus VSAD	12	31	$35

*Source: Reference 6-2

**Source: Reference 6-1

Gaseous Fuel Conversion - This is a special case of vehicle retrofit. Within the near future, only three types of gaseous fuels can be seriously considered as alternatives to gasoline for powering motor vehicles: liquified petroleum gas (LPG), compressed natural gas (CNG) and liquified natural gas (LNG). These fuels are inherently clean burning and produce fewer hydrocarbons than gasoline, owing to their lower molecular weight and carbon content. Modification to gaseous fuels requires the installation of a special carburetor, special tank (pressure tanks for LPG and CNG , cryogenic tanks for LNG), pressure regulating devices, shutoff valves and fuel lines. This is generally regarded as a simple conversion, although more sophisticated modifications like exhaust gas recirculation and catalytic converters can also be added for further reductions. For simple conversion the cost of modifying an in-use vehicle to CNG or LPG ranges from $350 to $500, while conversion to LNG may cost from $800 to $1000.

6.2.2 Mandatory Inspection-Maintenance Programs

There are basically three categories of I/M programs:

- Emission Inspection Approach - each vehicle is subjected to an emissions test and the results are compared with a set of in-use vehicle emission standards. Vehicles with emissions in excess of the standards are considered to have failed, and are required to have maintenance performed. An emissions retest may be required after the maintenance to ensure that the failed vehicle has been brought into compliance with the emission standards.

- Engine Parameter Inspection Approach - each vehicle is subjected to a sequence of diagnostic tests which seek to evaluate the mechanical condition of various emission related vehicle systems and determine if malfunctions or maladjustments are present. Vehicles showing measurements outside accepted tolerance ranges are considered to have failed, and are required to have corrective maintenance performed. This approach bypasses the question of each vehicle's emission levels, although in some cases emission measurements may be made to evaluate the state of certain vehicle systems.

- Mandatory Maintenance Approach - each vehicle, independent of its emission levels or mechanical condition, is required to have specific maintenance operations performed at required intervals. Thus, the inspection phase is simply eliminated; and the appropriate maintenance is explicitly specified for each type of vehicle and identical for all vehicles of that type, rather than being whatever maintenance is necessary to achieve compliance with an emissions standard or to ensure that specific vehicle pass diagnostic checks.

The expected reduction in emissions and costs of each approach are shown in Tables 6-5, 6-6, and 6-7.

Table 6-5. Emission Inspection I/M Program

Loaded emission test*					
Percent initial failure rate	10	20	30	40	50
Emission reductions (percent)					
HC	8	11	13	14	15
CO	4	7	9	11	12
Idle mode test*					
Percent initial failure rate	10	20	30	40	50
Emission reduction (percent)					
HC	6	8	10	11	11
CO	3	6	8	9	10
Anticipated inspection cost/vehicle**: $1.25					
Average repair cost/serviced vehicle**:$28.50					

*Source: Reference 6-2
**Source: Reference 6-1

Table 6-6. Engine Parameter I/M Approach

Vehicle Type	Failure Rate (percent)	Percent Reduction HC	Percent Reduction CO
Pre-controlled	95	10	6
1966-1970 controlled	95	14	7
1971 NO_x controlled	95	2	7

Anticipated inspection cost/vehicle: $ 7.50
Average repair cost/serviced vehicle:$22.00

Source: Reference 6-1

Table 6-7. Mandatory Maintenance I/M Approach

Vehicle Type	Percent Reduction HC	Percent Reduction CO
Pre 1966 model year	15	11

Anticipated inspection cost/vehicle: None
Average repair cost/serviced vehicle: $55.00

Source: Reference 6-1.

6.2.3 Evaporative Emission Control - Service Station Modification

One approach to controlling evaporative losses from the filling of underground storage tanks is to use some type of vapor recovery or mechanical trap system.

The Standard Oil Company of California has been experimenting with a mechanical trap (vapor return) system to be used during the filling of service station underground storage tanks (6-4). In such a system, vapors displaced from the underground tanks are returned to the delivery truck during the filling operation. Cost estimates for retrofitting service stations with such a system varied from $900 to $2000 per station, with a most probable figure of $1300 per station (6-5). The system as tested consists of a "T" connection to the underground vapor line, valves, and a three inch diameter line (to be carried on the delivery truck). The cost is almost entirely due to labor costs incurred in excavation to gain access to the underground line, T-connector fitting, tank purging and the subsequent repair of the ground surface. In terms of efficiency, the tests revealed that an approximately 94% vapor recovery is entirely feasible.

Recently the American Petroleum Institute sponsored a study of methods available for evaporative emission control between the service station and the automobile. Of the techniques which are primarily service station oriented, "Controlled methods would avoid about 71% of vapor emission immediately upon completion of the service station conversion. The vapor emission avoided would progressively increase over a period of about 10 years to about 94% to 98% depending on the particular method considered" (6-6). The variation in the percentage effectiveness over time is dependent upon the development of a safe vapor tight filling nozzle and a matching standardized automotive fill pipe.

Although many alternatives are available, only three of the most promising techniques are discussed.[1] The descriptions, and cost estimates for these methods are presented:

<u>Case 3</u> - <u>Vapor Displacement to Underground Storage with No Recovery of Excess Vapors</u>

> This control scheme is based on displacing vapor from the vehicle fuel tank to the storage tank from which the fuel was pumped. This is accomplished by making a tight seal at the interface between the fill nozzle and the fuel nozzle and the fuel tank fill pipe. The fill nozzle is designed such that there is a space around the nozzle through which the displaced vapors can be directed to a vapor return line. This line directs the vapors displaced from the vehicle fuel tank back to the underground storage tank from which the fuel is pumped. The volume of the vapors displaced equals the volume of the fuel pumped from the storage tank. The vehicle fuel tank vapor in the underground storage tank is displaced back to the fuel supply truck at each delivery... . Any excess vapors generated at the service station due to temperature conditions is vented to the atmosphere (6-6).

[1] Only Cases 3, 4 and 5 of Reference 6-6 are discussed

Case 4 - Vapor Displacement to Underground Storage with Recovery of Excess Vapors by Refrigeration

This control scheme is based on displacing vehicle fuel tank vapors during refueling back to the storage tank from which the fuel was pumped. This is accomplished by making a tight seal at the interface between the fill nozzle and the fuel tank fill pipe. The fill nozzle is designed such that there is a space around the nozzle through which the displaced vapors can be directed to a vapor return line. This line directs the vapors displaced from the vehicle fuel tank back to the underground storage tank from which the fuel was pumped. The volume of the vapor displaced equals the volume of the fuel pumped into the vehicle fuel tank. The vapor in the underground storage tanks is displaced back to the fuel supply truck at each delivery... . any excess vapors generated at the service station due to temperature conditions are vented to a two-stage vapor compression system with intermediate cooling and final condensation by refrigeration. Condensed vapors consisting of propane and heavier hydrocarbons are returned to the underground storage tanks. The refrigeration unit is of 1.0 ton capacity at -10°F, and it is started and stopped on suction pressure sensing in a vapor holder.(6-6)

Case 5 - Vapor Displacement to Underground Storage with Recovery of Excess Vapors by Activated Carbon Adsorption

This control scheme is based on displacing vehicle fuel tank vapors during refueling back to the storage tank from which the fuel was pumped. This is accomplished by making a tight seal at the interface between the fill nozzle and the fuel tank fill pipe. The fill nozzle is designed such that there is space in the nozzle through which the displaced vapors can be directed to a vapor return line. This line directs the vapors displaced from the vehicle fuel tank back to the underground storage tank from which the fuel was pumped. The volume of the vapors displaced equals the volume of the fuel pumped into the vehicle fuel tank... . Any excess vapors generated at the service station due to temperature conditions are vented to an activated carbon adsorption unit. All of the hydrocarbons are adsorbed in this unit. The activated carbon unit consists of four transportable canisters containing 25 pounds of activated carbon each. These canisters are regenerated about four times per month during the summer and considerably less during the rest of the year. The canisters are regenerated at the fuel supply terminal and their contained vapors are covered in the terminal vapor recovery system. The canisters are hauled to and from the supply terminal on trucks fitted specifically for this purpose (6-6).

A study was recently conducted in San Diego, California, to evaluate the effectiveness, safety and reliability of various vapor recovery systems (6-11). Preliminary results of the study indicate that the overall efficiency of "Case 3" systems ranges from 70% to 88%, while the "Case 4" system has a potential efficiency of at least 90%. One of the major causes of the relatively lower efficiencies of the "Case 3" method resulted from hydrocarbon losses between the automobile gas tank filler neck and the gasoline pump nozzle, despite a rubber seal between the two. The phrase "a potential efficiency of at least 90%" was used for "Case 4" methods of recovery because this figure was a calculated (i.e. on paper) and not a measured one, since many of the tested units were prototypes which malfunctioned during the testing period. There was insufficient information gathered by the study to draw any conclusions concerning the safety and reliability of either system, but it was felt that safety and reliability questions could be resolved with further testing and evaluation.

The costs (6-6) for each case were estimated as follows:

Case 3 - Vapor Displacement to Underground Storage with No Recovery of Excess Vapors

Capital Installed Cost to Service Station

The capital costs show breakout for new and revamp stations.

Capital Installed Cost Per Station

	Material	Labor*
Piping and fittings (screwed)	$ 418	$1,438
(6) tight fill nozzles at $40 each. ($12 of this cost is for the tight seal vapor return feature). (6) combination fill and vapor return hoses at $15 each. ($6 of this cost is for the vapor return hose).	330	78
	$ 748	$1,516
Contingency at 20% material, 10% labor	150	151
	$ 898	$1,667
Concrete removal and repair and tank purging	---	2,500
	$ 898	$4,167

New station cost - $898 + $1,667 = $2,565

Revamp station cost = $898 + $4,167 = $5,065

*Labor costs at $16/hour.

Operating Costs to Service Station

Incremental additional replacement cost of the tight seal vapor return portion of the fill nozzles and the vapor return portion of the hoses at $30/year.

Case 4 - Vapor Displacement to Underground Storage with Recovery of Excess Vapors by Refrigeration

Capital Installed Cost to Service Station

The capital costs show breakout for new and revamp stations.

Capital Installed Cost Per Station

	Material	Labor*
Piping and fittings (screwed)	$ 883	$1,896
(6) tight fill nozzles at $40 each. ($12 of this cost is for the tight seal vapor return feature). (6) combination fill and vapor return hoses at $15 each. ($6 of this cost is for the vapor return hose).	330	78
Condensation-refrigeration package unit	5,000	500
	$6,213	$2,474
Contingency at 20% material, 10% labor	1,243	247
	$7,456	$2,721
Concrete removal, repair, and tank purging	---	2,500
	$7,456	$5,221

New station cost = $7,456 + 2,721 = $10,177

Revamp station cost = $7,456 + $5,221 = $12,677

*Labor costs at $16/hour.

Operating Costs to Service Station

Incremental additional replacement cost of the tight seal vapor return portion of the fill nozzles and the vapor return portion of the hoses at $30/year.

*Cooling water at 3 gpm at $0.20/M gallons, say $28/year.
Power Supply for 3 HP motor at $0.03/KWH, say $63/year.
Maintenance and inspection cost, use 6%/year installed;
equipment cost = $-0,159 x 0.03/year = $609/year.

*Water is used only when equipment is in operation.

Case 5 - Vapor Displacement to Underground Storage with Recovery of Excess Vapors by Activated Carbon Adsorption

Capital Installed Cost to Service Station

The capital costs show breakdown for new and revamp station.

Capital Installed Cost Per Station

	Material	Labor
Piping and fittings (screwed)	$ 638	$2,096
(6) tight fill nozzles at $40 each. ($12 of this cost is for the tight seal vapor return feature). (6) combination fill and vapor return hoses at $15 each. ($6 of this cost is for the vapor return hose).	330	78
(8) carbon canisters at $80 each	640	32
Regeneration facilities**	25	12
	$ 1,633	$2,218
Contingency at 20% material, 10% labor	327	222
	$ 1,960	$2,440
Concrete removal, repair, and tank purging	---	2,500
	$ 1,960	$4,940

New station cost = $1,960 + $2,440 = $4,400

Revamp station cost = $1,960 + $4,940 = $6,900

*Labor costs at $16/hour.
**Regeneration facilities for 167 stations.

Operating Costs to Service Station/Regeneration Terminal

Incremental additional replacement cost of the tight seal vapor return portion of the fill nozzles and the vapor return portion of the hoses at $30/year. Power supply for 5 HP vacuum pump motor at $0.03/KWH, say $1/year.

Table 6-8 compares, for hardware controls, the percent reduction in hydrocarbons and carbon monoxide emissions assumed possible in the SIP and those assumed possible in this report.

Table 6-8. Comparison of Control Effectiveness

Control Measure	Hydrocarbon SIP	Hydrocarbon TRW Report	Carbon Monoxide SIP	Carbon Monoxide TRW Report
Mandatory Inspection - Maintenance	20%	6 - 11%[a]	25 - 30%	3 - 10%[a]
LIAF plus VSAD[b]	N/A	25%	N/A	9%
Catalytic Muffler				
Pre 1968 model years	N/A	68%	53%	63%
1968 and later model years	N/A	50%	53%	50%

[a]Emission inspection approach using an idle mode test.

[b]For pre 1968 model year vehicles.

N/A - not available

6.3 VMT REDUCTION STRATEGIES

In order to evaluate the effectiveness of various VMT reduction strategies, it was originally hoped that some sort of public opinion survey could be conducted to solicit public response to the situation and an evaluation of transportation alternatives. Upon further evaluation, this portion of the study was deleted for several reasons: 1) it was decided that it would not be cost effective to conduct the Market Facts air pollution survey used in numerous other cities, e.g., Phoenix, Los Angeles, San Francisco, 2) a recent survey conducted locally by Franklin Bills in North Las Vegas (6-7) provided some of the desired information, and 3) contrary to TRW's original hopes, the Transportation Committee of the Citizens' Advisory Council decided not to offer voluntary services to conduct a brief telephone survey of local residents' attitudes, and time and financial constraints prohibited TRW from conducting such an extensive survey.

The means to solicit local community input into the evaluation of transporation control alternatives was the Delphi technique - a structured and controlled questionnnaire with feedback - of Las Vegas planners. A good general description of Delphi is given by Dalkey: (6-12)

> "In general, the Delphi procedures have three features: 1) anonymity 2) controlled feedback, and 3) statistical group response. Anonymity effected by the use of questionnaires ... is a way of reducing the effect of dominant individuals. Controlled feedback - conducting the exercise in a sequence of rounds between which a summary of the results of the previous round are communicated to the participants - is a device for reducing noise. Use of statistical definition of the group response is a way of reducing group pressure for conformity; at the end of the exercise there may still be a significant spread of individual opinions. Probably more important, the statistical group response is a device to assure that the opinion of every member of the group is represented in the final response."

It should be emphasized that the results of the questionnaire were intended only to serve as an indicator of local thinking on potential control measures to be implemented. One point which needs to be raised concerning the limitation of interpreting the results is that while every attempt was made to seek "balanced" representation within the group, it is virtually impossible to avoid individual view points that the group was "stacked" with planners, or government officials, or some other group.

Despite all the difficulties, sufficient consensus was reached by the group on a number of issues that it was generally felt the exercise was very useful. Fourteen individuals, each representing different area groups, were invited to participate in the half day session of questions and answers. Eleven actually showed for what proved to be an extremely valuable session. The individuals and organizations represented who participated and the results of the Delphi Panel are presented in Appendix D.

Organizationally, the structure of the survey was aimed at addressing three issues with regard to VMT reduction strategies:

- Overall attractiveness - from a shopping list of measures, the participants were asked to select the measures viewed to be "most attractive" in terms of implementability, effectiveness, minimum socio-economic impact and public acceptance. This phase of the exercise was completed first, since it was felt regardless of how effective a particular measure might be, if it were not implementable and acceptable, it would never receive serious planning consideration.

- Implementation obstacles - once it was determined which control measures were viewed as the most attractive, an assessment of the most critical implementation obstacles was solicited. The respondents were asked to consider the relative importance of six potential implementation obstacles - lack of funding, existing governmental structure, lack of enabling legislation, inadequate state-of-the-art technology, public acceptance and a lack of precedences or a hesitancy to be innovative.

- Effectiveness - a number of specific and general objectives were cited and the respondents were asked to assess (by rank ordering) the relative effectiveness of the control measures for achieving the various objectives. Since the objectives dealt with the need for auto travel and growth issues, inferences can be drawn regarding the air qualtiy implications of these measures.

Table 6-9 presents a summary of the chronological sequencing of issues addressed by the questionnaire. In addition to the actual survey form, a supplemental set of miscellaneous "fact sheets" were provided to each participant. The intent of the handout was merely to provide backup information to the respondents to assist them in their decisions.

Table 6-9 Organization of Delphi Survey

Round Number	Attractiveness	Effectiveness	Comments
Round One	First Iteration		Preliminary screening of most attractive measures.
Additional Round One	Second Iteration		Final selection of most attractive measures.
Round Two	Third Iteration		Ranking of overall attractiveness for measures identified as most attractive.
Round Three	Final Iteration	First Iteration	Final ranking of overall attractiveness of measures and first estimate of effectiveness.
Round Four		Second Iteration	Reconsideration of effectiveness ratings based on feeback of group results (means and distribution). Reasons requested for extreme views.
Round Five		Final Iteration	Based on feedback and reasons for extreme answers, a final consideration of effectiveness. Also, a request for confidence rating of individual responses.

As a result of the Delphi Panel, the measures shown in Table 6-10 were chosen for further consideration.

Table 6-10 Summary of Delphi Panel Control Measures

Control	# of Persons Participating	% VMT Reduction
Supplemental jitney service, mini-bus for heavily traveled routes and/or tourist traffic	$\bar{x}$ = 8051 s = 6343	$\bar{x}$ = 4.86 s = 3.76
Expansion of present transit service-more buses, more frequent service	$\bar{x}$ = 6793 s = 3930	$\bar{x}$ = 5.23 s = 3.72
Subsidized lower mass transit fares (10 - 25¢ fare)	$\bar{x}$ = 6351 s = 7355	$\bar{x}$ = 4.97 s = 5.62

Control	# of Persons Participating	% VMT Reduction
Park and ride facilities along with	$\bar{x}$ = 1700 s = 1290	$\bar{x}$ = 1.67 s = 1.33
Auto-free zones	$\bar{x}$ = 5971 s = 5944	$\bar{x}$ = 2.76 s = 2.24
Employee carpool incentives	$\bar{x}$ = 2793 s = 2664	$\bar{x}$ = 2.25 s = 1.40

One measure not considered by the members of the Delphi Panel but which would be extremely effective in reducing VMT is the limitation of gasoline consumed. Gasoline rationing was implemented during World War II as a conservation measure. Many who were involved in the program viewed it as a necessary evil and although the rationing system had its shortcomings, it was effective in conserving gasoline and significantly reducing VMT. As seen in Figure 6-1, it was also a very effective measure in increasing transit patronage. Gas rationing during the war, although a severe measure, appears to be the only measure implemented during the last 50 years which has been able to effect reduced auto use and induce increased transit ridership. However, such a program would have serious implications for the present life style of Clark County residents and requires, before it can be seriously advocated a more detailed evaluation than can be performed within the scope of this report.

As a control strategy, rationing does have some features which make it attractive:

- Interim control strategy - of the measures considered, it has a high adaptability for use as a seasonal control strategy.
- <u>Not</u> irreversible - properly designed and administered, rationing could be very flexible; unlike strategies such as retrofit devices, this control can be easily and quickly lifted.
- Mid course corrections possible - the degree of control necessary can be changed easily to adjust for changing conditions and circumstances.

- Not technology dependent - does not rely on non-existent or unproven technology.

- Induces other programs effectively, e.g., car pooling and public transit.

- Conservation oriented - aimed at prevention rather than cure.

- Precedent and experience available - the program has been instituted before; hopefully the pitfalls of the World War II experience can be anticipated and minimized.

Despite the features of a gas rationing program as a control strategy, there are at least an equal number of real obstacles and problems which can be anticipated should any attempts be made to implement and enforce such a program. It is these issues which must be adequately addressed and studied before a gasoline rationing program can be recommended. Among the difficulties to be encountered are:

- Administrative problems - the World War II program appears to have encountered significant administrative problems.

- Institutional constraints - it is unlikely many institutions will support a massive rationing program.

- Enforcement problems - black markets, bootlegging and counterfeiting of coupons were all widespread practices during the War; these problems would probably pose even more of a problem today.

- Micro-economic implications - any massive rationing program will significantly affect the economy of the region affected; these effects are difficult to assess accurately but would be major.

- Lack of alternative modes of travel - it has yet to be determined how much additional travel can be handled either by the present transit system or by a projected increase in levels of transit service.

- Public acceptibility - it is doubtful much public support could be mustered for a gasoline rationing program.

- Legal status - it is unclear if the legal authority to implement such a program exists.

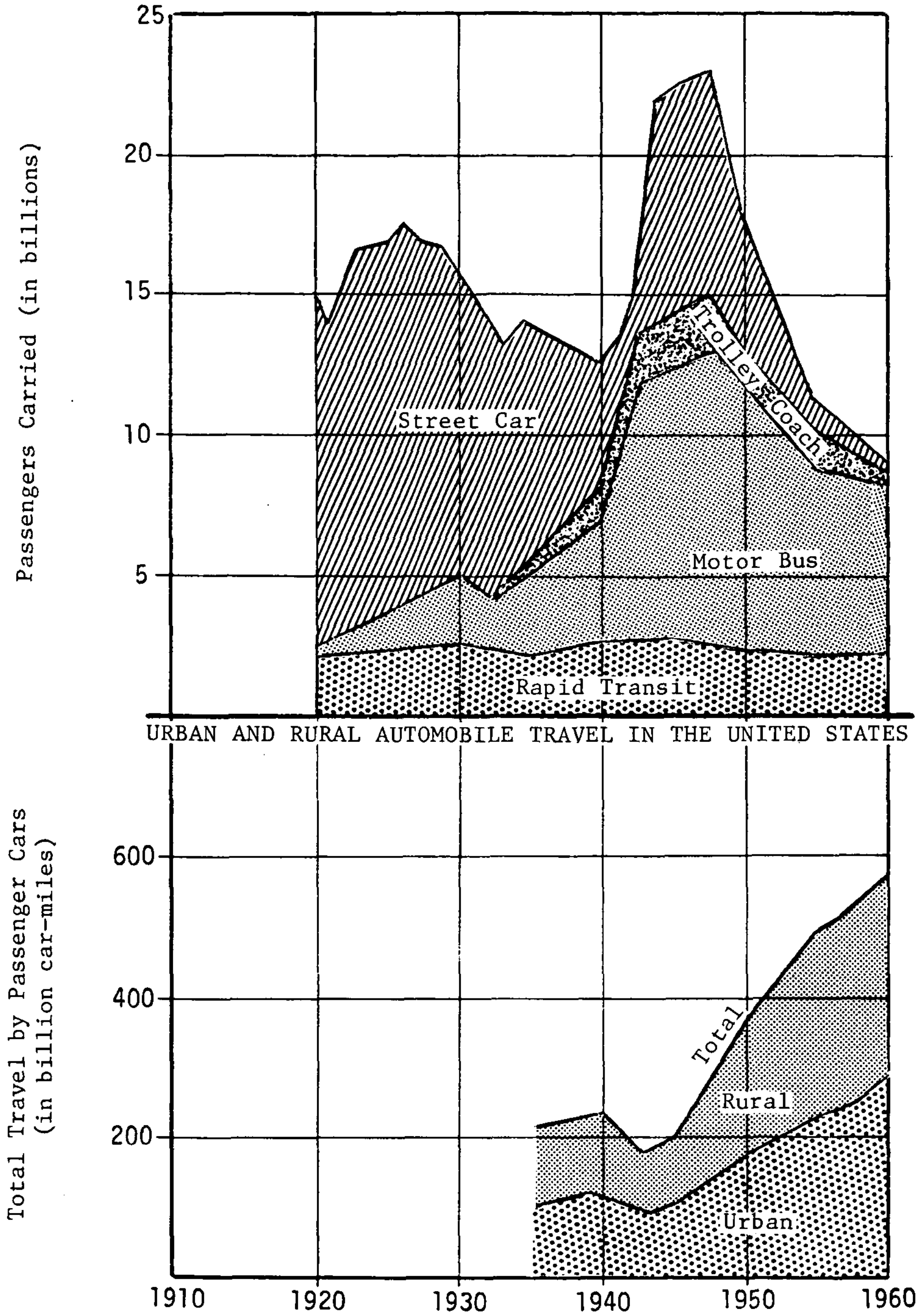

Figure 6-1 Trends in Public Transit Patronage in the United States

Source: Haase, R.H., Are We Willing to Pay for Congestion-Free Transportation?, Rand Corporation, P-2813, Jan. 1964

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7.0 PROPOSED CONTROL PLAN

The relationship between air pollutant emissions and ambient air quality is still not well understood, despite major efforts to develop both sophisticated analytical and statistical models (7-1, 7-2, 7-3). The inaccuracies in the ability to predict air quality result from many factors, among which are:

- Uncertainties in the emission inventories,
- Limited air quality data,
- The representativeness of test cycles to actual driving patterns,
- The uncertainties of the real effectiveness of various control strategies.

The control strategy recommendations presented are based upon proportional rollback for CO and Appendix J (of the Federal Register, Vol. 36, No. 158) for HC. The validity of these techniques as applied to the Las Vegas situation is questionable and consequently does not serve as an adequate basis on which to implement severe control measures.

Full implementation of the control measures outlined should allow attainment of the air quality standards by 1977 and maintenance through 1982. Implementation of Phase I measures can be justified on the basis of air quality improvements at reasonable costs. The impact of implementing Phase II control measures is staggering. This study has neither the time nor data base to fully evaluate the social, political and economic ramifications of such a measure. Hence, it cannot be recommended at this time although it would, in all likelihood, result in the desired goal.

The control measures outlined are not new and have been proposed elsewhere; no "magic" solution was found and only incremental improvements can be expected from each strategy.

As discussed in Section 3.0, the air quality data for Clark County indicates that a 70% reduction of 1972 reactive hydrocarbon emissions and a 54% reduction of 1973 carbon monoxide emissions are needed in order to achieve the National Ambient Air Quality Standards. Table 7-1 provides a summary of baseline, 1977 and 1982 emissions of reactive hydrocarbons and carbon monoxide, as well as indicating the reductions necessary to achieve the air quality standards.

Table 7-1. Summary of Emissions in Clark County (tons/day)

	1972	1973	1977		1982	
	RHC	CO	RHC	CO	RHC	CO
Stationary Sources	8.0	11.9	3.75	12.9	4.3	14.1
Mobile Sources	33.8	159.7	26.9	125	23.2	87.2
Total	41.8	171.8	30.65	137.9	27.5	101.3

Permissible emissions: RHC = 12.5 tons/day
CO = 79.0 tons/day

Percentage reduction of 1977 RHC emissions required to achieve standards = 59%
Percentage reduction of 1982 RHC emissions required to achieve standards = 77%
Percentage reduction of 1977 CO emissions required to achieve standards = 55%
Percentage reduction of 1982 CO emissions required to achieve standards = 22%

7.1 PHASE I MEASURES

7.1.1 Hardware Measures

This section details the hardware measures recommended to reduce emissions. Included are measures required by the SIP which are reevaluated as to their potential for decreasing emissions. Table 7-2 shows the percent emission reductions used in formulating the proposed control plan. It is important to note, however, that the actual (i.e. tons/day) emission reductions reported in this section for vehicle oriented controls are given on a stacked basis.

Table 7-2. Effectiveness of Control Measures

Measure	Percent Reduction of CO Emissions	Percent Reduction of RHC Emissions
Mandatory Inspection/Maintenance	10*	11*
Pre-1968 Model Year Retrofit (LIAF plus VSAD)	9	25
Oxidizing Catalytic Muffler Retrofit		
Pre-1968 Model Years	68	63
1968 and Later Model Years	50	50
Gasoline Evaporative Loss Controls		
"Case 3" method	-	80
"Case 4 or 5" method	-	90

*Assumes a 50% initial failure rate of vehicles tested.

Mandatory Inspection/Maintenance

In an attempt to derive the full benefit for both new and used car emission controls, it is recommended that a mandatory annual inspection/maintenance program be established utilizing an idle emissions test. Such a program can be instituted through official state designated garages, service stations or new car dealerships. Reductions in emissions expected from such a program are:

	1977 (tons/day)	1982 (tons/day)
RHC	0.66	0.31
CO	7.2	2.5

Pre-1968 Retrofit Devices

A lean idle air-fuel adjustment plus a vacuum spark advance disconnect system (LIAF plus VSAD) is recommended for light duty 1955 through 1965 model year vehicles. Implementation of this measure along with mandatory inspection/maintenance, should reduce emissions by the following quantities:

	1977 (tons/day)	1982 (tons/day)
RHC	0.86	0.41
CO	7.8	2.6

Oxidizing Catalytic Converter Muffler Retrofit

It is recommended that light duty vehicle exhaust emissions be controlled by means of catalytic muffler retrofits on 1966 through 1974 model year vehicles. Data indicates that large emission reductions are possible with these mufflers. Because vehicles equipped with such devices are required to use non-leaded gasoline, the question arises as to the availability of this grade of gasoline. However, conversations with knowledgeable personnel at several oil companies have indicated that there should be no problems in supplying adequate quantities of lead free gasoline (7-4). Based on the number of retrofittable vehicles and the expected emission reductions discussed in Section 6.2.1, the decrease in emissions which can be expected (in conjunction with mandatory I/M and pre-1968 retrofit devices) if the program is to be completed by 1977 are:

	1977 (tons/day)	1982 (tons/day)
RHC	2.36	0.81
CO	24.4	7.4

Gasoline Evaporative Loss Controls

It is recommended that controls be required to either prevent or capture gasoline vapor emissions resulting from normal gasoline handling and transfer operations. Control systems for certain transfer operations are presently available and should be installed as quickly as possible. The need for control of these vapor losses becomes increasingly evident as motor vehicle exhaust hydrocarbon emissions are more stringently controlled, and as the percentage of hydrocarbon evaporative emissions from normal gasoline handling and transfer operations increases significantly.

Since controls have already been implemented at bulk terminals (see Section 4.2.1) and for transfer of gasoline from tank trucks into service station storage tanks (see Section 4.1.3), it is recommended that the following controls be implemented for the transfer of gasoline from service station storage tanks to vehicle tanks:

- A vapor balance recovery system ("Case 3" in Section 6.2.3) should be installed at all gasoline service stations by 1977.
- Installation of secondary vapor recovery systems ("Case 4" or "Case 5" in Section 6.2.3) at all gasoline service stations by 1980.

The reasoning behind this two stage approach is to assure that the safety and reliability of the secondary systems is verified before they are required but in the meantime to provide for a gasoline vapor recovery system which is less efficient but fairly safe and reliable. The 1980 deadline was selected to insure adequate lead time for testing, production and installation of secondary systems. The reductions in emissions expected by instituting this measure are:

	1977 (tons/day)	1982 (tons/day)
RHC	4.7	6.7

7.1.2 VMT Reduction Measures

On the basis of the Delphi Panel results (Section 6.3), the following measures were selected because of their potential in decreasing VMT:

Measure	% Reduction in VMT
A) Supplemental jitney service, etc.	4.86
B) Expansion of present transit service	5.23
C) Subsidized lower mass transit fares	4.97
D) Auto free zones	2.76

However, because of the lack of confidence displayed by the Delphi Panel as to the percent reduction in VMT achievable (see Appendix D), it was decided, upon consultation with EPA, to use the following figures which were adopted from a previous study done for the Los Angeles region (7-5):

Measure	% Reduction in VMT
A) Supplemental jitney service, etc.*	2.1*
B) Expansion of present transit service	3.0
C) Subsidized lower mass transit fares	2.0
D) Auto free zones	0.6

*The % reduction in VMT for this measure was not available from Reference 7-5. Upon consultation with the EPA project officer, the % reduction for supplemental jitney service was determined as follows:

$$\left(\frac{\text{\% reduction in VMT for Measures B + C + D for Los Angeles}}{\text{\% reduction in VMT for Measures B + C + D from Delphi Panel}}\right) \times$$

$$\left[4.86\% \left(\begin{array}{c}\text{which is the \% reduction in VMT due to jitney}\\ \text{service as specified by the Delphi Panel}\end{array}\right)\right] = \frac{5.6}{12.96} \times 4.86\%$$

$$= 2.1\%$$

By instituting these strategies in addition to the automobile hardware measures, the expected emission reductions are:

	1977 (tons/day)	1982 (tons/day)
RHC	2.9	1.0
CO	27.9	8.7

Figure 7-1 illustrates the impacts of Phase I controls.

7.2 PHASE II MEASURES

The total reduction in emissions achieved by Phase I measures are summarized below:

	1977 (tons/day)		1982 (tons/day)	
Measure	RHC	CO	RHC	CO
A) Mandatory Inspection/ Maintenance	0.66	7.2	0.31	2.5
B) Pre 1968 Retrofit plus Measure A	0.86	7.8	0.41	2.6
C) Oxidizing Catalytic Muffler plus Measures A and B	2.36	24.4	0.81	7.4

Measure (Continued)	1977 (tons/day) RHC	1977 (tons/day) CO	1982 (tons/day) RHC	1982 (tons/day) CO
D) VMT reduction measures plus Measures A,B, and C	2.90	27.9	1.0	8.7
E) Gasoline Evaporative Loss Controls	4.7	-	6.7	-
Total	7.6	27.9	7.7	8.7

The emissions remaining after institution of Phase I measures are:

	1977 (tons/day)	1982 (tons/day)
RHC	23.1	19.8
CO	110.4	92.6

In order to attain the national standards for oxidant and carbon monoxide by 1977 and to maintain the standards through 1982, the following additional reductions are required (see Figure 7-1 and Table 7-3):

	1977 (tons/day)	1982 (tons/day)
RHC	10.6	7.3
CO	30.5	12.7

For both 1977 and 1982, the limiting pollutant (i.e., the one requiring the most reduction) is RHC. The percentage reductions required are:

$$1977: \frac{10.6 \text{ tons/day}}{23.1 \text{ tons/day}} = 46\%$$

$$1982: \frac{23 \text{ tons/day}}{19.8 \text{ tons/day}} = 37\%$$

These reductions can be achieved through the implementation of a massive program to significantly reduce the vehicle miles traveled within the Las Vegas Valley, hence eliminating major sources of hydrocarbon and carbon monoxide emissions. This can probably be done most effectively by rationing the gasoline supply. Rationing can be accomplished either by limiting the supply to the actual consumers from the gasoline service station or from the refinery to the service station. Gasoline rationing is not a recommended method of achieving VMT reduction because of the inherent social and economic impacts. These adverse impacts have not been fully evaluated.

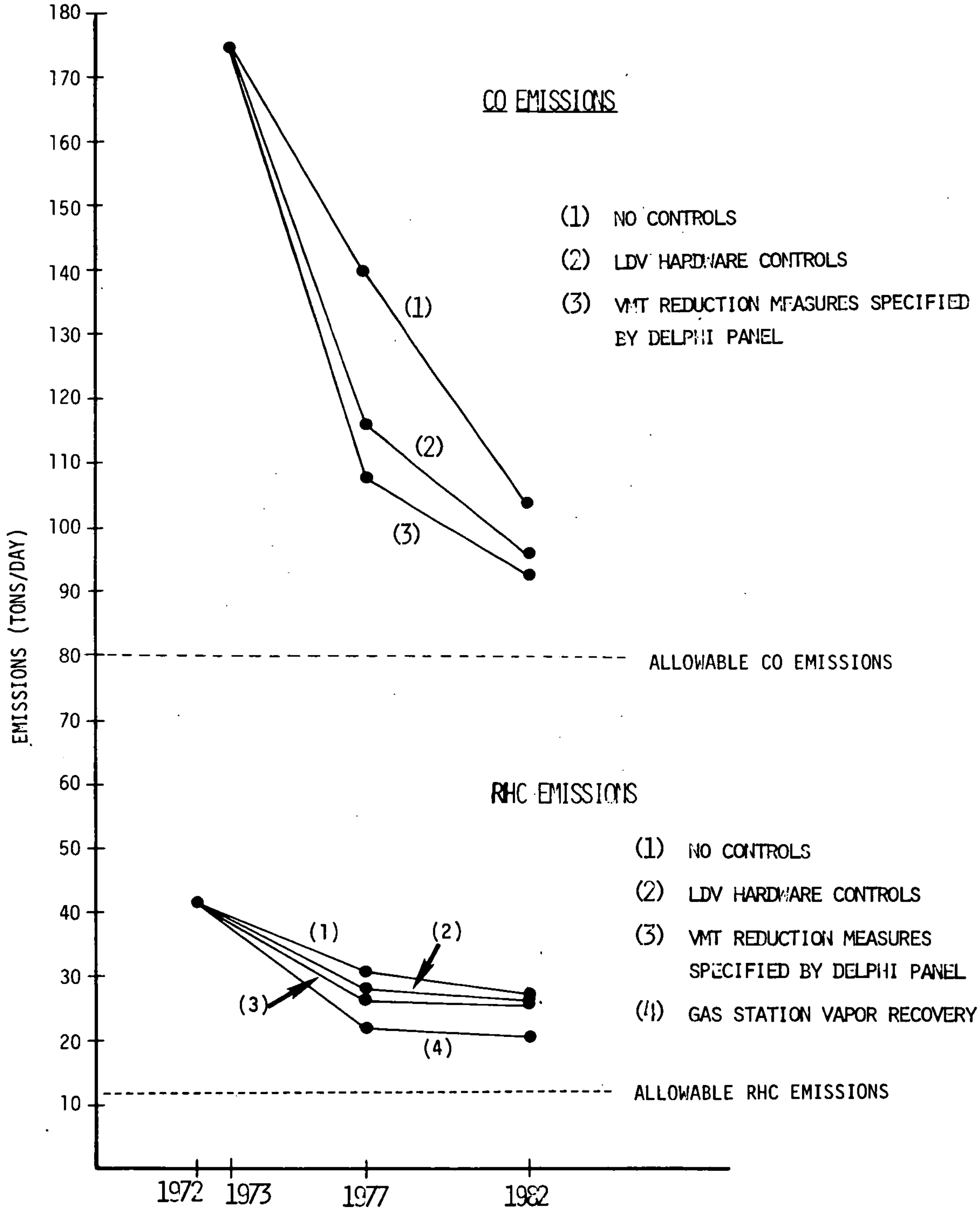

Figure 7-1 Effect of Phase I Control Strategies on CO and RHC Emissions

Table 7-3. Summary of Emissions After the Application of Phase I Measures (tons/day)

Source Category	1977 RHC No Controls	1977 RHC After Phase I	1977 CO No Controls	1977 CO After Phase I	1982 RHC No Controls	1982 RHC After Phase I	1982 CO No Controls	1982 CO After Phase I
Stationary	3.75	3.75	12.9	12.9	4.3	4.3	14.1	14.1
Mobile								
1) Light Duty Vehicles	9.2	6.3	70.9	43.0	3.8	2.8	24.8	16.1
2) Heavy Duty Gasoline Powered Vehicles	5.4	5.4	36.0	36.0	5.8	5.8	43.6	43.6
3) Heavy Duty Diesel Powered Vehicles	0.26	0.26	1.6	1.6	0.33	0.33	2.0	2.0
4) Motorcycles	0.96	0.96	4.54	4.54	1.21	1.21	5.22	5.22
5) Aircraft	3.8	3.8	11.5	11.5	3.1	3.1	10.4	10.4
6) Railroads	1.38	1.38	0.9	0.9	1.58	1.58	1.2	1.2
7) Gasoline Marketing	5.9	1.2	-	-	7.4	0.7	-	-
Total, Mobile	26.9	19.3	125.0	97.5	23.2	15.5	87.2	78.5
Grand Total	30.65	23.1	137.9	110.4	27.5	19.8	101.3	92.6

Allowable Emissions: RHC = 12.5 tons/day
CO = 79.9 tons/day

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8.0 SOCIAL AND ECONOMIC IMPACTS

8.1 SOCIAL IMPACTS

Social impacts are non-monetary costs attributable to the imposition of a set of constraints. These impacts are generally measured by the loss of time, opportunity, and/or inconvenience. The magnitude of the impacts is primarily a function of age, race, and income level. Measures which are intended to influence, control or restrict the ownership and use of motor vehicles will, in general, result in social impacts. In a similar and related manner, measures which affect personal mobility, mode choice decisions, and regional access also induce social costs. To date, because of the very nature of social impacts, it has been difficult to quantitatively evaluate them. For example, only a limited amount of research has been devoted to estimating foregone or lost opportunity costs with respect to not making a trip.

This section presents an overview of the types of social impacts which are likely to result from the implementation of the transportation control measures being contemplated.

8.1.1 Improved Transit Services

Improving transit services is implicitly or explicitly the goal of every transit authority in operation today. In many cases, however, public transit systems have found it necessary to lower the level of transit service due to financial difficulties. When and where this has occurred, a major portion of the problem can generally be traced to the dependence on the private auto for satisfying the largest share of the trip making needs of the region. The importance of the private automobile to the American way of life cannot be overemphasized. Its emergence as the dominant, and in many cases, sole source of urban travel has had a major impact on the role of public transit in our cities.

It should be noted that the Las Vegas Valley Transportation Study Policy Committee is preparing a short range mass transit plan and development program (funded by UMTA) for the Regional Planning Council. Scheduled to be released in February of 1975, this plan should, if adopted by the Regional Planning Council, provide for increased transit service in the Las Vegas Valley.

Impact of Lowered Fares

Among the most crucial aspects of transit service is the fare structure. As a VMT reduction measure, increasing transit ridership through a lowered fare incentive has some practical limitations. For example, while fare free transit is certainly a topic of interest, it raises serious questions regarding financing the transit operations.

Viewed in terms of the organizational paradigm, financing requirements are the key input for implementation of this measure. The principle performance output is increased transit usage. As a consequential impact, it is hoped that auto use and overall VMT will be reduced and air quality improved.

Experience has shown that fare changes impact other aspects of transit operations in addition to changes in ridership levels. These changes can be considered concomitant outputs of the program. For example, significant increases in transit ridership lower existing levels of service. To accommodate the new passengers, longer and more frequent stops are required, increasing overall travel times. To achieve the equivalent level of service experienced before a fare reduction, generally requires additional buses and more frequent scheduling of service (i.e. reduced headways). Both measures increase the transit system's operating costs.

Another probable concomitant impact of lowered fares is latent trip demand, especially from certain underprivileged population segments. In this regard, it is important to remember that increased transit patronage results from more than a simple private auto to transit shift or even previously unmet travel demand. Shifts from all other modes are likely to occur -- carpooling, walking, bicycling. In Los Angeles, for example, implementation of a Mini-bus Project (with a subsidized 10 cent fare) to reduce private auto use in the congested CBD has not been overly successful. Even though ridership levels on the buses have been acceptable, it has been found "most of the daytime passengers who have taken advantage of the service have been diverted from the pedestrian mode rather than the automobile mode." (8-1)

In addition to the direct performance output of lowered fares, i.e. increased transit usage, a host of concomitant and consequential impacts are also likely. In an analysis of the impacts resulting from a fare increase and service reduction on San Francisco's Muni, Lee (8-2) identified several important impact areas. These included impacts on:

- The Transportation System - In reducing service, the majority of mode shifts are from transit to automobiles. The increased auto usage aggrevates congestion for both public and private transportation. Furthermore, reduced service lowers the quality of BART's feeder network, which impacts BART's attractiveness.

- The City Fisc - Increased traffic volumes mean more traffic control, accidents and emergency services, etc. Such increases force the City budget to support services to auto users even more than is presently done.

- Jobs - Service reductions impact the jobs of some dependent on its present level of service, as well as those who actually work for Muni itself.

- Efficiency - It is argued that a more balanced transportation system offers improved transportation efficiency; if so, service reductions and fare reductions aggrevate an already unbalanced system.

- Equity - Reduction in Muni services has an unfavorable equity impact, since those impacted the most are likely to be low income captive riders.

By inference, it is assumed that lowering fares and improving transit service will, in most cases, result directionally in impacts opposite of those cited by Lee.

In summary, an obvious result of lowered fares is to expand the opportunities for transit services to a broader population segment. This is especially true for special groups such as the young, poor, and elderly. For users of transit, lowered fares increases their real income. Thus, the socio-economic impacts of this measure can be viewed as largely positive. In that lowered fares increases transit use and reduces auto use, thereby leading to an overall transportation system which is more balanced and less automobile dependent, the impact is also favorable.

Impact of Improved "Levels of Service

Improvements in the levels of transit service can be accomplished in a number of ways, including increasing the breadth of service, frequency of service, and travel speeds. To be effective as a VMT reduction measure, the improvement in transit service must be sufficient to induce a large number of auto drivers to shift their mode of travel.

The overall low levels of transit ridership experienced today testify to the perceived advantage most auto riders place on their mode of travel. In addition, the fact that operating and out-of-pocket expenses for auto trips generally exceed transit fares indicate the willingness of individuals to pay for the high levels of service offered by private autos.

It has been concluded in studies that, to be effective as a VMT reduction measure, transit service must significantly decrease the travel time advantage now experienced by private autos to make it more competitive as an alternative mode. In a manner analogous to lowering fares, the service levels offered are intimately related to the financial viability of the transit system. Thus, an important direct input for this control measure is careful planning and most probably, additional funding should deficits be incurred.

8.1.2 Auto Free Zones

The auto free zone has been used, in the past, as a means to revitalize central business districts. With the growing concern with the urban environment, the auto free zone also appears to offer an opportunity to reduce auto emissions and undesirable noise levels in congested areas. Over one hundred cities in Europe and Japan and about twenty-four cities in the United States have implemented auto free zones with varying degrees of success. The most evident and immediate effect is to enhance the esthetic quality of the area affected. In some long term applications, special walkways, landscaping, and other pedestrian-oriented structures have been provided in an effort to attract pedestrian traffic.

As a transportation control measure, auto free zones offer the most relief to regions with severe carbon monoxide problems. By essentially eliminating all vehicular emissions from the plagued areas, no local accumulation of carbon monoxide is possible. However, depending on parking and transit availability in the peripheral areas of the auto free zone, higher emissions in these areas are possible. The spatial and/or temporal redistribution of carbon monoxide emissions should in almost all cases, significantly reduce the nature of the problem.

It is much less certain what the impact of auto free zones is on urban areas experiencing photochemical oxidant problems. Again, it is largely a function of the types and quality of accessibility made available to the area's users. Redistributing the overall emissions once experienced in the region to all the peripheral areas would not significantly affect oxidant concentrations. A real potential output of such a program would be a change in time, location, or level of oxidant experienced. The lack of empirical data precludes any definitive statements with regard to technical effectiveness.

The success of auto free zones is a function of many factors including local attitude and objectives, geography and climate, topology of streets, the availability of public transportation and the existing levels of air quality.

Impacts of the auto free zones will be felt by the commercial interests within and surrounding the area and property owners in the area. In fact, these groups have often shown the greatest resistance prior to actual implementation of pedestrial malls. Other impacts are felt by travelers who must maneuver around the closed-off area, cannot find parking spaces, or encounter increased congestion in the areas around the mall.

Implementing auto free zones on a scale large enough to deal with the problems of the urban environment requires the following inputs:(8-3)

- Traffic Circulation Design - Displaced traffic must be accommodated on surrounding streets; changes in traffic signalized may be required.

- Provision of Adequate Parking Facilities - Especially if public transportation modes are inadequate; new spaces must be allocated so as to provide adequate capacity, minimize walking distances, minimize congestion, and provide adequate accessibility.

- Provision of Public Transit Access - To the area and, if applicable, within the area.

- Provision for Truck and Freight Distribution.

- Provision for Police and Fire Protection and Utilities.

It is apparent from the input requirements of this type of control measure that careful detailed planning on an area by area basis is critical to the overall success of the program. Numerous specific regional characteristics must be carefully evaluated and weighed prior to implementation to ensure the desired air pollution reductions. A careful design of auto free zones with the above principles in mind will serve to reduce the social cost of inconveniences and enhance the proclivity for pedestrianism rather than auto travel.

Because of its dependence upon the tourist industry, Las Vegas presents a situation different from many other cities. Heavy concentrations of vehicular traffic can be found along the famed Strip and to a lesser degree, the CBD. The visitor depends on the automobile to journey from one night spot to another and casinos and hotels are oriented towards providing parking for their customers. In contrast to other metropolitan centers, many establishments operate almost on a 24 hour basis. The impact of instituting an auto-free zone along the Strip would be staggering. Lacking an adequate and convenient substitute for the personal automobile, hotels and casinos would experience a drop in patronage, the end effect of which may be the loss of jobs by local residents. As for the CBD, there would be a lesser problem for the visitor (because the major attractions are fairly close together). But difficulties would arise with the residents, as there is presently inadequate transit service to service the home to work trip. In addition, there would remain problems with peripheral parking on the edge of the auto free zone.

Impact on Retail Sales

The effectiveness of auto free zones in increasing retail sales volumes is partially a function of the willingness of pedestrians to walk. This in turn is a function of the attractiveness of the area, the kinds and mix of shops, and the amenities available for workers, e.g., benches, tables, restaurants.

Studies have found that "people generally refuse to walk more than 800 feet between parked car and destination and that the average nonstop trip distance ranges from 400 to 600 feet per person."(8-4) However, if the area is attractive, shoppers will walk much greater distances, e.g., shoppers on Fifth Avenue in New York City or the Champs Elyees may walk a mile.

Data for evaluating the potential of the mall concept for stimulating economic growth is not readily available for those malls that were planned into a town's creation (as in Germany) or temporary implementations. Temporary demonstration projects do not give valid grounds for evaluation because certain potential effects of the auto free zone are sensitive to the permanency of the project. However, data for existing, small scale permanent applications are available.

Some measures for assessing the impact on commercial activity are:

- gross change in retail sales
- value of new construction added
- changes in vacancy rates
- changes in tax base (dollars of assessed evaluations)

A summary of the impacts on retail sales in several United States auto free zones is shown in Table 8-1.(8-6)

Similarly, in Europe and Japan, a positive effect on retail sales was experienced with the implementation of auto free zones. In Vienna shop owners reported a 25 percent to 50 percent increase in business in the first week after the traffic ban went into effect. In Norwick all but two shops

Table 8-1. Summary of Costs and Impacts on Retail Sales in U. S. Auto Free Zones

Location	Area (Blocks)	Project Cost ($Thousands)	Percent Business Increase
Atchison, Kansas	5.5	330	25
Fulton Mall - Fresno, Calif.	6	1,600	20
Burdick Mall - Kalamazoo, Mich.	3	114	15
Lincoln Road Mall - Miami Beach, Fla.	8	600	-
Nicollet Mill - Minneapolis, Minn.	8	3,875	up to 14
Pomona Mall - Pomona, Calif.	5	586	16
Westminister Mall - Providence, R.I.	4	530	up to 35

Source: Barton-Aschman (1972)

in the exclusion area did more business, some experiencing an increase in sales of 10 percent or more. In Essen the increase in trade has been reported to be between 15 percent and 35 percent depending on the type of shop; in Rouen, between 10 percent and 15 percent. In Tokyo, of 574 shops surveyed, 21 percent showed an increase in sales, 60 percent no change, and 19 percent a decrease; 74 percent of the merchants interviewed pronounced themselves in favor of the scheme. The popularity of vehicle exclusion among shopkeepers has been graphically demonstrated in the City of Florence: "Some shopkeepers on the first traffic street on the south of the zone went on strike to press demands that the car ban be expanded to include their street."(8-5)

Summary

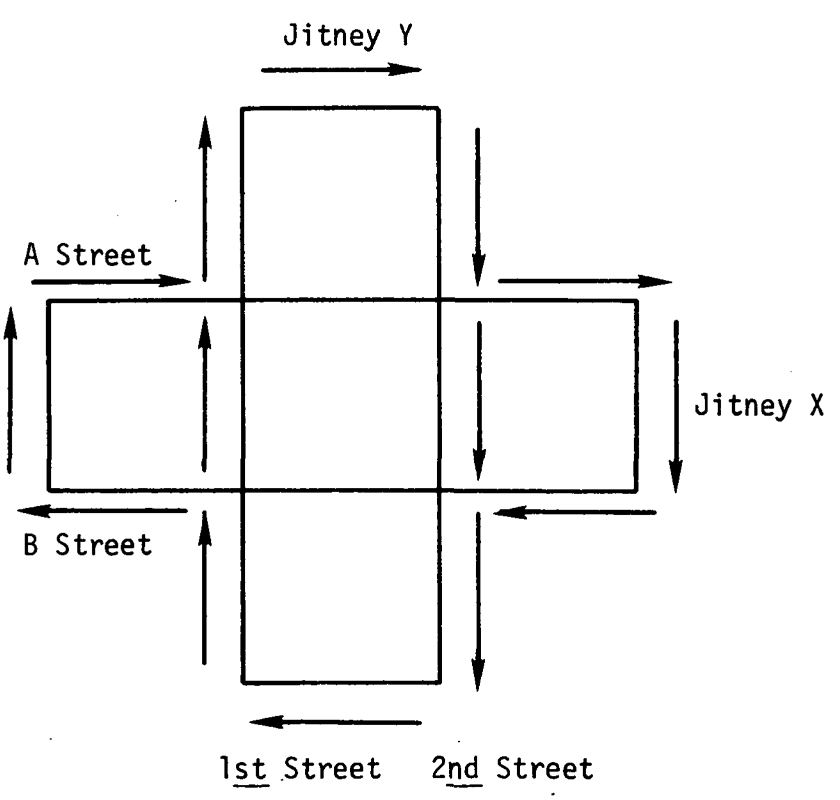
The auto free zone can serve as a focal point of civic pride to the citizens of a city, by providing an attractive entertaining setting for social interaction. It can serve as a public forum for community activities. In Europe, the auto free zone has been used as a tool to rehabilitate or save areas of historic interest. This enhances the city's cultural assets for the enjoyment of residents and tourists alike.

Auto free zones in the U.S. and Europe have generally "enhanced the drawing power of commercial and retail establishments."(8-6) They have become magnets for people and became new centers for relaxation and entertainment as well as for shopping. Preliminary indications are that land values may increase in and surrounding a successful auto free zone and land area related to recreation (and tourism) may expand. With competent traffic design, a mall will result in minimal traffic disruption around the area.

Although the cost of implementing auto free zones can be substantial, these costs are frequently offset by increased business activity within the zone. Once instituted, most of the socio-economic impacts of this control measure are favorable.

8.1.3 Jitney Service

Jitney service has not received overwhelming support in this country in the past, although as fuel prices rise and availability decreases, such transportation modes may be expected to be revitalized. Basically, a jitney service is described as a situation where vehicles run along prescribed routes at frequent intervals. A sample route structure is shown in the figure below:



Jitney X runs a continuous looping path in the east-west direction along streets A and B. Jitney Y runs a similarly continuous looping path in the north-south direction along 1st and 2nd Streets. If the metropolitan area is covered by routes of this type, one may have access to any part of the area by taking any combination of X and Y oriented jitneys. In the special case of Las Vegas, the institution of jitney service would be ideal along the Strip, especially during the peak periods between shows at the various hotels. In addition, the effectiveness of the service would be enhanced if it were instituted in conjunction with designating Las Vegas Blvd. as auto free zone. Jitney vehicles may be of any type from ordinary passenger cars to vans or mini-buses.

The jitney service concept is a key element of the short range transportation plan being developed for Los Angeles by the Southern California Association of Governments, with service being initiated along several routes earlier this year.

The jitney service may be considered to result in no significant social or economic cost since it will be self-supporting. If anything, the institutionalization of jitney service in Las Vegas may be considered a form of transit improvement which will benefit those residents who do not have access to a private automobile.

8.1.4 Hardware Measures

Because auto-oriented controls tend to place the burden of the control cost on the individual owner, the issue of fairness is raised, since such measures are highly regressive and tend to discriminate against lower income groups. Regulations which require expensive retrofit devices and inspection/maintenance checks impose heavy burdens on those least able to absorb the high capital, testing and repair costs.

Equitably internalizing the costs of air pollution control has been the subject of numerous research efforts. A number of methods have been prepared for financing control costs. As the dates approach for implementing many of the controls, it will be necessary to experiment with novel financing schemes. The literature is abundant in approaches which attempt to equitably allocate costs among polluters. What is missing are documented case studies of novel approaches which have actually been attempted. Illustrative of recent proposals for reducing air pollution while remaining sensitive to lower income groups are the following examples (8-7):

- Uniform-Payment-Per-Vehicle-Mile-Driver - simply stated, this scheme takes the total annualized regional costs and divides by the annual...vehicle miles driven...
- Uniform-Payment-Per-Vehicle - in this case, the total annualized regional costs is divided by the number of light duty vehicles in the basin. Each vehicle owner then pays an identical amount per vehicle. Payment could be made by a uniform increase in vehicle registration fees.
- Income-Proportional - payment of the control strategy is made on a scale that is directly proportional to income. For this scheme, everyone in the region - not just those owning vehicles - is responsible for financing the additional controls.

8.1.5 Summary

The social impacts associated with implementing the proposed transportation control measures will be significant. Many impacts identified will be of a positive nature, e.g., improved mobility and accessibility for deprived population groups, more efficient energy utilization. Other impacts, however, are likely to have negative social impacts, e.g., placing additional burdens or regressive measures on smaller population segments.

Critical to minimizing the social impacts will be the time schedules used for implementation of the various controls. Schedules which allow for personal adjustments to the imposed constraints will probably result in orderly transition.

8.2 Economic Impacts

The economic impacts of the recommended transportation control plan are summarized in Table 8-2. Costs are reported in 1972 dollars[1] and have not been annualized due to the current uncertainty in future interest rates and the generally unstable nature of national and international economic situation.

Expenses connected with vehicle oriented controls are to be absorbed by the individual automobile owners, unless one of the more novel approaches suggested in Section 8.1.4 is adopted. Since the number and type of inspection/maintenance has yet to be determined, no cost figures are available. The expenditures necessary for service station vapor recovery systems will be passed on to the consumer, but the actual price increase per gallon should be small. The impact of auto-free zones along the Strip and in the CBD are extremely difficult to assess and cannot be extrapolated from the experiences of other cities (Section 8.1.2) due to the unique character of Las Vegas. Jitney service should be self supporting and may turn out to be a potential source of revenue, if the service is provided by the private sector. It is suggested that the costs of transit service improvements and fare subsidies be financed through gasoline tax revenues, since such a scheme is geared towards having those that generate the pollution (i.e. private automobile owners) "pay as you go." It should be noted that the recipients of the dollar outlays are the local users of the transit system.

[1] The reference documents used did not specify a base year for the costs but since they were prepared in 1972, it is assumed 1972 dollars were used.

Table 8-2. Economic Cost of Recommended Control Strategy

Control Measure	# of Units	Cost per Unit	Total Cost Initial	Total Cost Annual
Gasoline Marketing[a]				
(1) Phase I (balance system)				
(a) Revamp old stations	970	$5,100	$4,947,000	$ 29,100
(b) New stations	N/A	2,600	N/A	N/A
(2) Phase II (secondary system)				
(a) Revamp old stations	970	$12,200	$11,834,000	$ 620,800
(b) New stations	N/A	9,700	N/A	N/A
Inspection/Maintenance (all LDV)[b]	171,600	$ 30	N/A	$5,148,000
LIAF plus VSAD (pre-1968 LDV)[c]	79,119	$ 45	$3,560,355	0
Catalytic Muffler[d]				
(1) 1966-1970 model year LDV	14,213	$ 150	$2,131,950	0
(2) 1971-1974 model year LDV	35,725	$ 150	$5,358,750	0
Jitney	N/A	N/A	N/A	N/A
Transit Fare Subsidy	N/A	N/A	N/A	N/A
Auto Free Zones	N/A	N/A	N/A	N/A
Increased Transit	N/A	N/A	N/A	N/A

[a]The number of units given is the number of service stations in Clark County in 1973 (from Richard Ida, Clark County DHD). No information is available concerning the number of new stations planned in the future.

[b]The number of units given is the number of LDV registered in Clark County as of June, 1973 (from R. L. Polk and Company). The initial cost of setting up inspection stations is not known since the number and type of station has yet to be determined. The cost per unit is for vehicles that fail the inspection.

[c]The number of units given is the number of pre 1968 model year LDV registered in Clark County as of June 1973 (from R. L. Polk and Company).

[d]The number of units given is the number of 1968-1971 model year LDV registered in Clark County as of June 1973 (from R. L. Polk and Company) and which are capable of using unleaded gasoline.

N/A = not available

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9.0 PROBLEM AREAS AND IMPLEMENTATION RESPONSIBILITY

9.1 PROBLEM AREAS

One problem area lies in the fact that the only major public transportation in the Las Vegas Valley is the Las Vegas Transit System, Inc. (LVTS) which is owned by the Tanner-Grey Company of Las Angeles. The LVTS has been operating at a deficit or at best, a breakeven point, for many years. In order to increase transit service (even beyond the expansion presently planned for the LVTS) and to subsidize fares, public monies would have to be funneled to this privately owned corporation. At best, the general public has shown an extreme reluctance to subsidize private enterprise. The alternatives are for local authorities to purchase the transit system or to permit the present operation to flounder and gradually become bankrupt, thus leaving the area without any means of public transportation.

Another area of potential difficulty lies in the institution of the inspection-maintenance program. In 1974 the used car dealers in Nevada filed a court suit challenging the constitutionality of the statutes authorizing I/M on the grounds that they are the only sellers of used vehicles required to provide certificates of compliance. (In all other cases, the purchasers of used vehicles are required to provide certification that the vehicles are equipped with required control devices). The court dismissed the suit but the used car dealers have filed a motion for a new trial. As of the end of November 1974, no action has yet been taken on the motion.

9.2 IDENTIFICATION OF IMPLEMENTATION RESPONSIBILITY

Table 9-1 gives the agency responsible for the implementation of each of the control measures recommended in this study. Vehicle oriented controls should require no additional enabling legislation, as they are authorized under Section 445.630 of the Nevada Revised Statues (NRS). As for gasoline marketing vapor recovery systems, Article 9.1 of the Nevada Air Quality regulation should be adequate (9-1). Except for the transit fare subsidy, transportation system controls do not involve the requirement for major enabling legislation, only the appropriate division of local city and county governments to implement or modify regulations and to impose, where necessary, procedural constraints and encouragements. The transit fare subsidy, however, would necessitate the passage of state legislation to permit the expenditure of gasoline tax revenues.

As for manpower requirements, the commitments specified in the SIP for the Clark County District Health Department should be sufficient, since all vehicle oriented hardware control measures (except for catalytic muffler retrofit) recommended in this study were also contained in the SIP. (These manpower commitments have yet to be realized due to funding difficulties). The installation of gasoline vapor recovery units, however, may necessitate more inspectors to ensure compliance. Transportation control measures should not require substantial additional fulltime manpower commitments from local and state officials. Rather, they can be dealt with through cooperation between existing personnel at the responsible agencies through a low level of effort but on a long term basis. Additional funding (which has yet to be provided) will be required to evaluate the impact of VMT reduction measures.

Table 9-1 Implementation Responsibility

Measure	Responsible Agency	Implementing Agency
Gasoline Marketing Vapor Recovery	State Government	County Government
Inspection/Maintenance	State Government	County Government
LIAF plus VSAD	State Government	County Government
Catalytic Muffler Retrofit	State Government	County Government
Jitney	State Taxi Authority County/City Government	County/City Gov't
Transit Fare Subsidy	State Government	N/A
Auto Free Zones	County/City Government	County/City Gov't
Increased Transit Service	Las Vegas Transit System, Inc. State/County/City Government	Las Vegas Transit System, Inc.

N/A = not available

REFERENCES

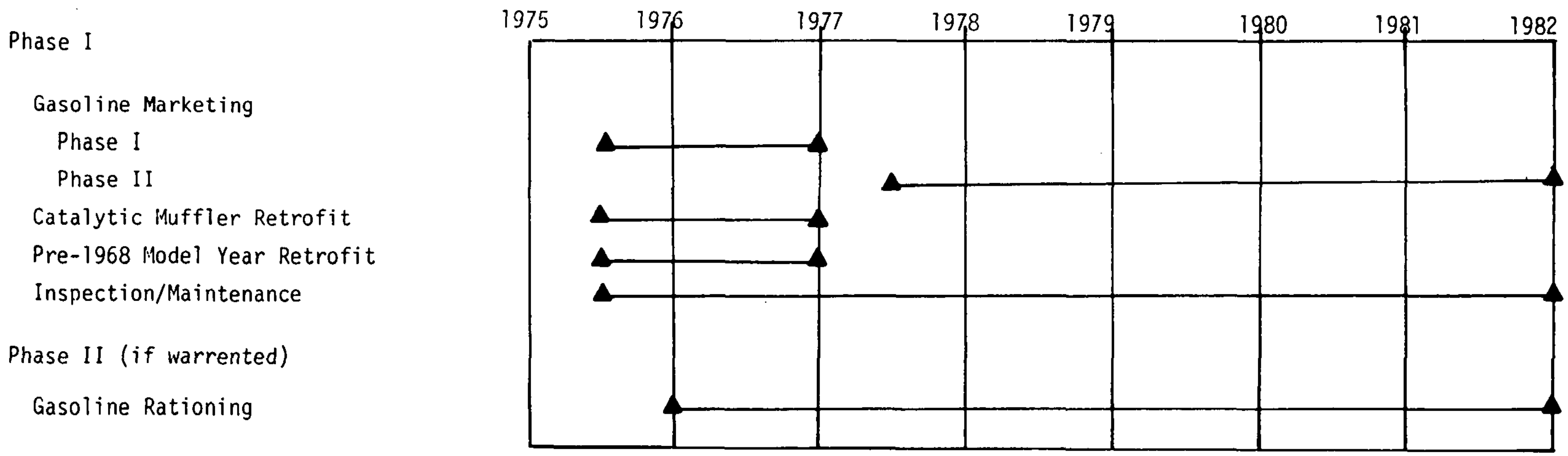
9-1. M. Feiertag, Deputy Attorney General, State of Nevada, private communication, November 1974.

10.0 STRATEGY IMPLEMENTATION

The proposed time schedule for implementation of the control strategy is given in Table 10-1. As the table indicates, all gasoline marketing facilities should have a Phase I balance system installed by 1977. The starting date for Phase II secondary systems is tentative, pending evaluation of the safety and reliability of such systems (see Section 6.2.3). Schedules for retrofit and inspection/maintenance programs are the same as those proposed in the original SIP. No time table is given for jitney service, auto free zones and increased transit service because of planning requirements (such as permits for jitneys and choice of auto free zones). Likewise, no schedule is shown for a transit fare subsidy because of the necessity of legislative approval (passage of legislation permitting the use of gasoline tax revenues for fare subsidies).

Phase I measures are not projected to decrease emissions enough to meet the 1977 target date. It will be necessary, in 1976, to reevaluate the data to determine whether Phase II and/or other measures will be required to attain the national standards.

Table 10-1 Implementation Time Schedule [1]



[1] This time table assumes the acceptance of the measures by the responsible agencies. The dates shown are those needed if 1977 and 1982 are the target dates for implementation of the measures.

APPENDIX A

A-1 A LOG-NORMAL MODEL FOR AIR POLLUTANT DATA[1]

Many air pollutants can be described as log-normally distributed over a year's period. A plot of frequency of occurrence vs. concentration often shows a distribution weighted at the high end. When the log of concentration is used in such a plot, the distribution approximates a normal or Guassian curve. Two parameters are needed to define such a distribution; M_g, the geometric mean, and S_g, the geometric standard deviation. These are defined as follows:

$$M_g = \left[\sum_{c_i=1}^{\overset{N}{\Pi}} c_i \right]^{1/N} = \exp \left[\frac{1}{N} \left(\sum_{c_i=1}^{N} \ln c_i \right) \right] \qquad (1)$$

$$S_g = \exp \left[\frac{1}{N} \sum (\ln c_i - \ln M_g)^2 \right]^{1/2} \qquad (2)$$

where c_i is the concentration of the individual measurements.

Air pollutant data can be handled in a graphical fashion using the log-normal assumption. Plots of observed pollutant values vs. cummulative frequency are made on log-probability paper (see Figures A-1 and A-2). The equation for the best fit line drawn through the points is:

$$\ln c_i = \ln M_g + z \ln S_g \qquad (3)$$

or

$$c_i = M_g S_g^{z_i} \qquad (4)$$

where z is the number of standard deviations that c_i occurs from the geometric mean. One standard deviation would occur at 84% (or 16%). M_g is then estimated from c_i at 50%. It follows that:

$$\ln c_{84\%} = \ln M_g + (1) \ln S_g \quad (5)$$

or

$$S_g = c_{84\%}/c_{50\%} \quad (6)$$

The maximum expected value* is calculated as follows. In N measurements are made per year, a z value for (1-1/N) in percent is taken from a normal error table. Then:

$$C_{max} = M_g \, S_g \, z^{(1-1/N)\%} \quad (7)$$

Alternatively, C_{max} may be read from the log-probability graph at (1-1/N)%.

The log-normal model may also be used to estimate the number or percent of days which a pollutant is expected to exceed a standard. The percent may be read directly from a log-normal plot or calculated from equation (4) using c_i as the concentration to be exceeded. M_g and S_g are known so that a z value can be calculated, followed by obtaining the percent from a normal error table.

A.2 RELATIONSHIP OF LOG-NORMAL DATA TO AIR QUALITY STANDARDS

A log-normal model[2] of air pollutant data may be related to ambient air standards with a few simplifying assumptions. First, it is assumed that emissions are approximately constant during the year so that variations in air pollutant levels are primarily due to meteorology. Further, anthropogenic contributions to air pollution are predominant. Finally, the nature of the particular pollutant does not change as emissions are reduced (i.e. composition changes due to slower reaction kinetics, or the relative contribution of dust to total particulate matter). It follows that emission reduction will be accompanied by a proportional reduction in the geometric (and arithmetic) mean and that the geometric deviation will be essentially unchanged. On the other hand, a change in meteorology could change both the geometric mean and standard deviation. If S_g remains unchanged as emissions are reduced, equation 4 can be applied to the "lower" geometric mean to estimate the percent of the time which a given standard might be exceeded.

*This value is interpreted as that to be exceeded once per year.

An alternative to the above "linear rollback" approach for oxidant has been established by the Environmental Protection Agency.[3] Figure A-3 shows a curve derived from a correlation of early morning non-methane hydrocarbon concentrations with maximum daily oxidant values for several U. S. cities. The "worst case" is assured for the percent reduction required in order to meet the 0.08 ppm 1 hour federal oxidant standard. The 85% rollback calculation in Table 2.1 is taken from this curve. The rollback for carbon monoxide in Table 2.1 is assumed to be linear.

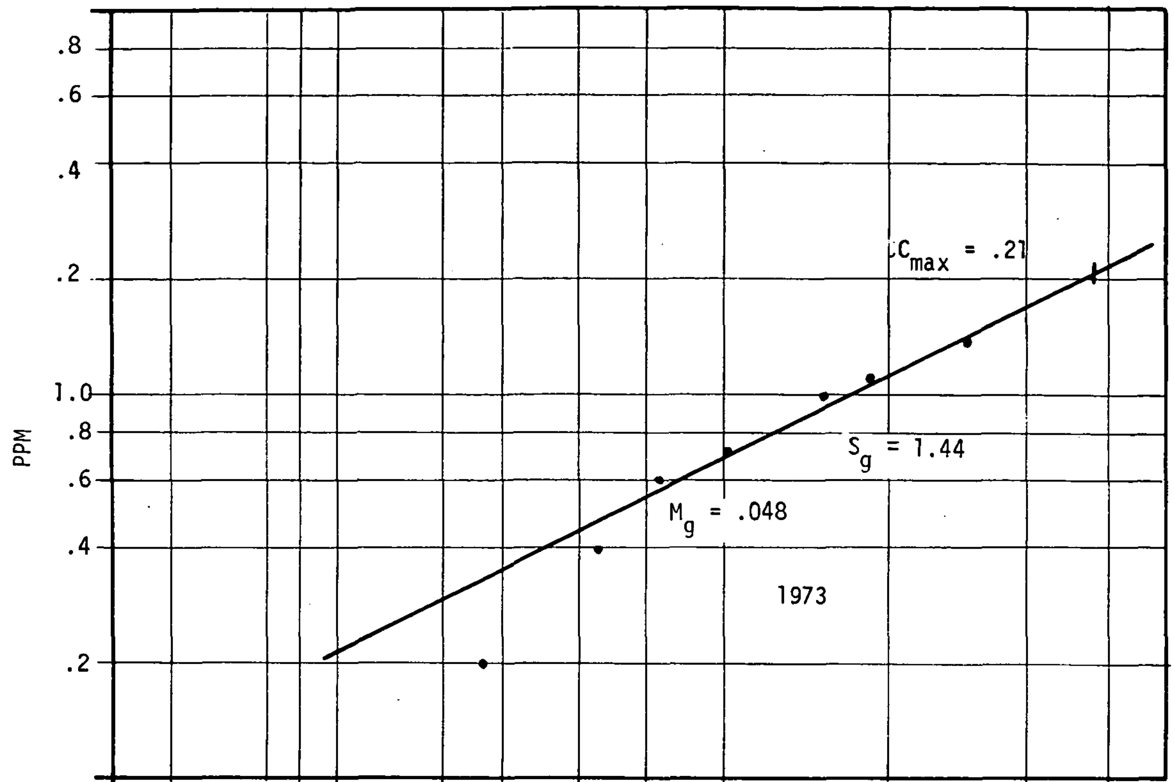


Figure A-1.

CUMULATIVE FREQUENCY (%)

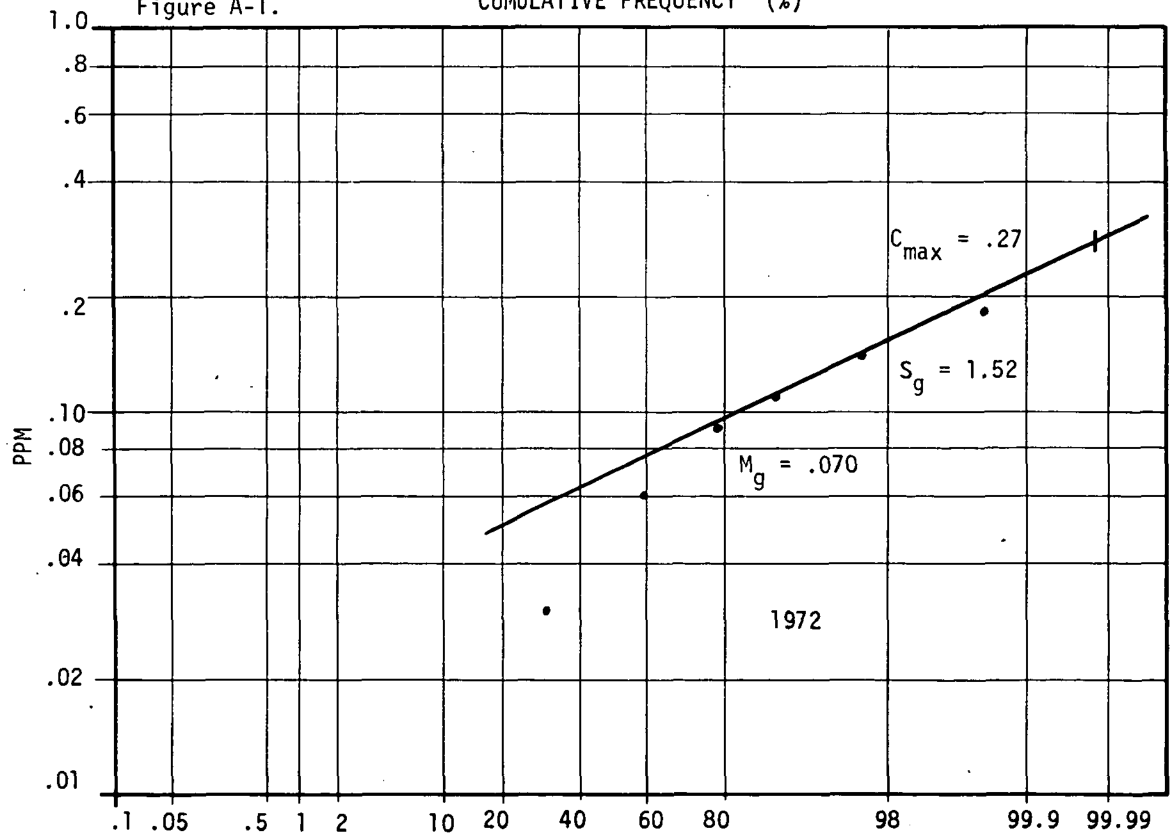


Figure A-2. Las Vegas Cumulative Frequency Distribution for Oxidant

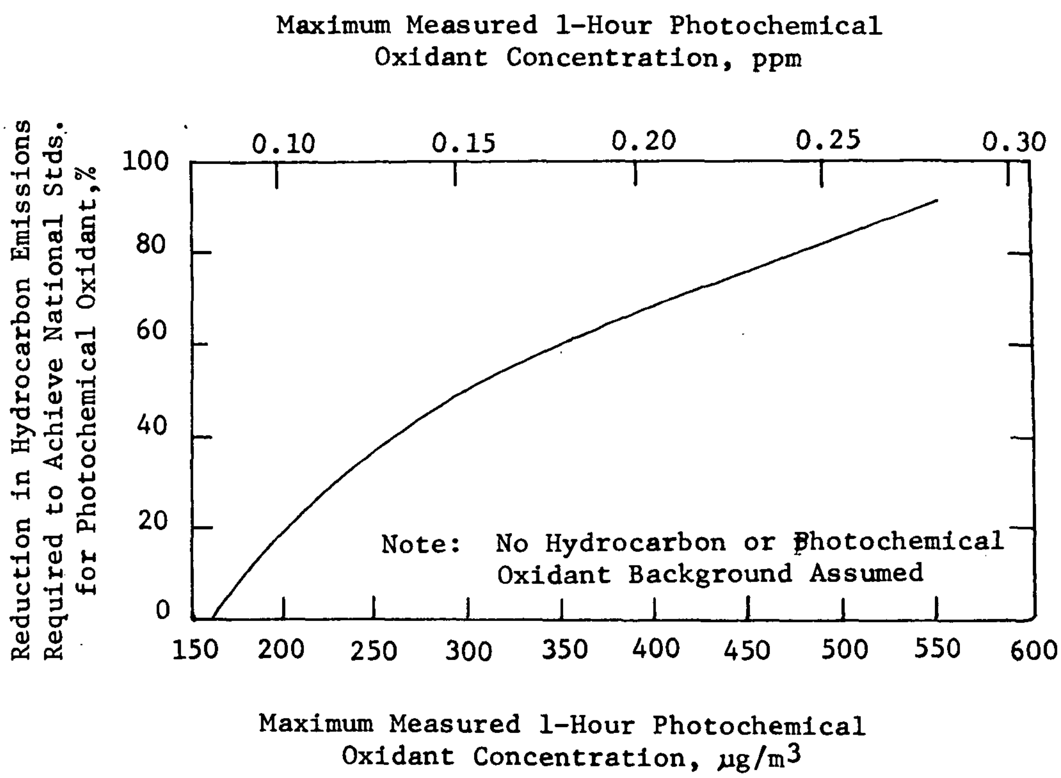


Figure A-3. Appendix J of Federal Register (Vol.36, No. 158)

REFERENCES

1. Larsen, R.I., "A Mathematical Model for Relating Air Quality Measurements to Air Quality Standards, U. S. Environmental Protection Agency, Pub #AP-89, November 1971.

2. Larsen, R.I. et al, "A Method for Calculating Precursor Reduction Needed to Achieve an Oxidant Air Quality Standard, U. S. EPA APTD Series, August 1972.

3. Federal Register, Volume 36, No. 158, August 14, 1971.

APPENDIX B

VEHICLE EMISSIONS ESTIMATES

B.1 INTRODUCTION

Data concerning both present (1970) and projected (1980) vehicle miles traveled were provided by the State of Nevada Division of Highways. This data was generated through the use of origin-destination surveys and the standard series of UMTA (Urban Mass Transportation Association) traffic models. Unfortunately, due to difficulties experienced by the Division of Highways, both the 1970 and the 1980 daily trip demands were allocated to the projected 1980 highway network. Although total 1970 daily VMT should not be significantly affected, distribution problems will occur (it is likely that in many of the fringe areas around the metropolitan area, VMT will appear where no streets presently exist).

The trip purposes accounted for in this modeling process are listed below:

1. home to work trips
2. home to recreation trips
3. home to shopping trips
4. home to miscellaneous trips
5. resident non-home based trips
6. taxi trips
7. motel based auto trips
8. commercial pick-up trips
9. external auto trips
10. government auto trips
11. external large trucks
12. government large trucks
13. commercial large trucks

The last five trip purposes are for external or "through" trips.

The modeling process consists of dividing the metropolitan area into traffic analysis zones and then allocating the trip demand information for the various purposes on a zone to zone basis, resulting in a trip table. The trips are then allocated to the coded highway network. Average speeds resulting on the network are varied in order to accommodate the trip demand, and hence the speeds reported are fictitious.

The VMT reported represents a combined VMT including light duty vehicles, heavy duty vehicles, diesel trucks, and motorcycles. These components were separated out using the following percentage breakdown:

Vehicle Type	% VMT
Light duty vehicles	87.0
Heavy duty vehicles	9.0
Diesels	1.5
Motorcycles	2.5

The VMT data for 1970 and 1980 were handled in two different ways. First, for the purposes of emission inventory development, the total daily VMT for each of those years was taken and used as reference points for estimating both the baseyear VMT and the projected 1977 and 1982 VMT. Second, the Air Pollution Control Division of the Clark County Department of Health requested that a gridded inventory be developed. A separate software package developed by TRW was used to allocate the VMT as well as the other components of the inventory onto a one kilometer UTM (Universal Transverse Mercator) grid covering the Las Vegas Metropolitan area. In both cases, the standard EPA sanctioned method of vehicle emissions computations was used. No information was readily available to estimate the fractions of the total VMT attributable to local (i.e. resident) and tourist traffic. To calculate vehicle emissions, it was assumed that all VMT was due to local traffic and thus applicable Nevada emission factors were used.

It must be recognized that the projected (1980) vehicle miles traveled does not account for the effect of possible energy shortages in the future and this may tend to overestimate VMT. Also unaccounted for are changes in the national and international economic situation which might influence the sale of newer (and less polluting) automobiles.

B.2 ESTIMATION METHOD

Emissions from motor vehicles were investigated by considering separately the contribution from: light duty vehicles, heavy duty gasoline powered vehicles, heavy duty diesel powered vehicles and motorcycles. Emissions were estimated by determining the annual mileage by model year of the region's vehicle population, the overall mileage traveled by vehicles in the region and then applying appropriate emission factors which are attributable to the various vehicle age classifications.

The calculation of light and heavy duty gasoline powered vehicle exhaust emission factors for carbon monoxide and hydrocarbons can be expressed mathematically as:

$$e_{np} \doteq \sum_{i=n-12}^{n+1} (c_{ip})(d_{ipn})(m_{in})(S_{ip})$$

where:

e_{np} = emission factor in grams per vehicle mile for calendar year n and pollutant p

c_{ip} = the 1975 federal test procedure emission rate for pollutant p (grams/mile) for the ith model year at low mileage (available from Reference B-2),

d_{ipn} = the controlled vehicle pollutant p emission deterioration factor for the ith model year at calendar year n (available from Reference B-2),

m_{in} = the weighted annual travel of the ith model year during calendar year n. (The determination of this variable involves the use of the vehicle model year distribution),

S_{ip} = the weighted speed adjustment factor for exhaust emission for pollutant p for the ith model year vehicle.

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

$$f_n = \sum_{i=n-12}^{n+1} (h_i)(m_{in})$$

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

h_i = the combined evaporative and crankcase emissions rate for the ith model year (available from Reference B-2),

m_{in} = the weighted annual travel of the ith model year during calendar year n.

- A light duty vehicle is defined as any motor vehicle either designated primarily for transportation of property and rated at 6,000 lbs gross vehicle weight or less or designated primarily for transportation of persons and having a capacity of 12 persons or less. A heavy duty vehicle is any vehicle which exceeds the above specifications.

- The deterioration factor is the ratio of the pollutant p exhaust emission factor at x miles to the pollutant p exhaust emission factor at 4000 miles.

- The weighted annual mileage factor is determined by the following formula:

$$m_{in} = \frac{(V_i)(D_i)}{\sum_{i=n-12}^{n} (V_i)(D_i)}$$

where,

V_i = fraction of total vehicles in use with age i (in years) (determined from vehicle registration data for Clark County),

D_i = average miles driven by a vehicle of age i (available from Reference B-2).

To calculate the emissions from light and heavy duty vehicles for a given year, the VMT for that year is multiplied times the emission factor for the appropriate pollutant.

Additional controls to reduce vehicle emissions below the baseline emission profile are investigated by adjusting the appropriate mathematical functions which reflect the type of proposed control. For example, the effect of a catalytic muffler retrofit on used light duty vehicles is determined by adjusting the emission and deterioration factors for those models to be retrofitted, and by carrying out the series of summations in the computer model.

The following sections describe the requirements for manipulation of regional data preparatory to input to the computer model. Emissions are calculated separately for light duty vehicles, heavy duty gasoline powered vehicles, heavy duty diesel vehicles and motorcycles.

B.3 LIGHT DUTY VEHICLES

Emissions from light duty vehicles were computed according to the methodology discussed above. This necessitated the determination of 1) weighted annual travel by model year, 2) average vehicle speed in the region, 3) emission factors by model year, 4) deterioration rates for emission factors by model year, and 5) total VMT.

Weighted Annual Travel

To determine the weighted annual travel of various model year vehicles in Clark County, the following vehicle distributions were utilized:

1) Passenger car model year distribution

2) Annual mileage distribution by vehicle model year.

The passenger car model year distribution was obtained from data supplied by R. L. Polk and Company (Tables B-1 and B-2). This data lists registered passenger cars by model year as of July 1, 1972 and July 1, 1973 and does not include pickups or light trucks. It is assumed that this distribution reflects very closely the true distribution by model year of passenger cars traveling in Clark County, although it is recognized that trips by cars registered outside the county may have some influence.

The annual mileage of various model year vehicles are not available for Clark County, so national figures were used instead (Table B-3).

The weighted annual travel of the different model year light duty vehicles was calculated by multiplying the vehicle model year distribution by the model year annual vehicle mileage.

Table B-1. Vehicle Model Year Distribution for Clark County, 1972

	Model Year								
	1972	1971	1970	1969	1968	1967	1966	1965	≤1964
Percentage	8.1	8.9	9.2	10	9.1	7.9	8.6	8.5	9.7

Total number of registered vehicles: 151,875.

Source: R. L. Polk and Company.

Table B-2. Vehicle Model Year Distribution for Clark County, 1973

	Model Year									
	1973	1972	1971	1970	1969	1968	1967	1966	1965	≤1964
Percentage	9.1	10.4	8.3	8.6	9.2	8.3	7.3	7.9	7.7	23.2

Total number of registered vehicles: 171,600

Source: R. L. Polk and Company

Table B-3. National Average Annual Mileage Driven, by Vehicle Age

Vehicle Age	Average Annual Miles Driven
1	7,850*
2	15,900
3	14,000
4	13,100
5	12,200
6	11,300
7	10,300
8	9,400
9	8,500
10	7,600
11	6,700

*Adjusted to reflect the fact that Polk data is for July 1st of 1972 and 1973.

Source: Reference B-2.

Average Vehicle Speed

The average vehicle speed was obtained from the Nevada Department of Highways.

Emission and Deterioration Factors

These factors were obtained from Reference B-2.

VMT

From the Nevada Department of Highways computerized model of traffic flow in Clark County, 1970 and projected 1980 VMT figures for individual surface streets and freeways were made available to TRW (Table B-4). Unfortunately, the model does not cover the entire county (see Figure B-1 for the extent of the model's road network coverage).* In order to account for the "uncovered" portions of the county, the following procedure was used: Traffic count data for 1972 and 1973 were obtained from the Department of Highways for all the major freeways leading into Las Vegas (Table B-5). By multiplying the number of vehicles times the length (in miles) of these freeways outside the model network, VMT figures were obtained (Table B-6). This procedure, however,

- Assumes that vehicles are not likely to turn off these major highways from the time they enter Clark County until they reach the point when they are accounted for by the model.
- Assumes that VMT on roads other than these highways is negligible and presumes that all vehicular traffic on these highways is non county resident generated (this is based on the fact that the Department of Highway's model covers 90% of Clark County's population).
- Assumes that motorcycle traffic on these major highways is negligible.

VMT figures for 1972, 1973 and 1977 within the Department of Highway's model were obtained by extrapolation from 1980 (Table B-4).

To obtain 1977 and 1982 VMT for the "uncovered" portion of the county, the following procedure was used: In 1972, the ratio

$$\frac{\text{VMT in the "uncovered" portion of the county}}{\text{VMT in the Department of Highway's model}} = 0.13$$

It was assumed that this ratio would be the same in 1977 and 1982. Thus, in 1977 and 1982, the VMT in the "uncovered" portion of the county would be 557,966 and 703,684, respectively. Table B-7 illustrates the total VMT for the county in 1972, 1973, 1977 and 1982.

Light duty vehicle VMT for 1972, 1973, 1977 and 1982 is obtained by subtracting the VMT due to heavy duty gasoline and diesel powered vehicles and motorcycles (see Sections B.4 and B.5) and is presented in Table B -8.

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*Nevada Department of Highways, UTM grid coordinates: 641,400 m.E to 688,000 m.E; 3,976,300 m.N to 4,023,000 m.N. TRW UTM grid coordinates: 650,000 m.E to 700,000 m.E; 3,980,000 m.N to 4,020,000 m.N.

— Nevada Department of Highways Grid (approximate)
--- TRW Grid (approximate)

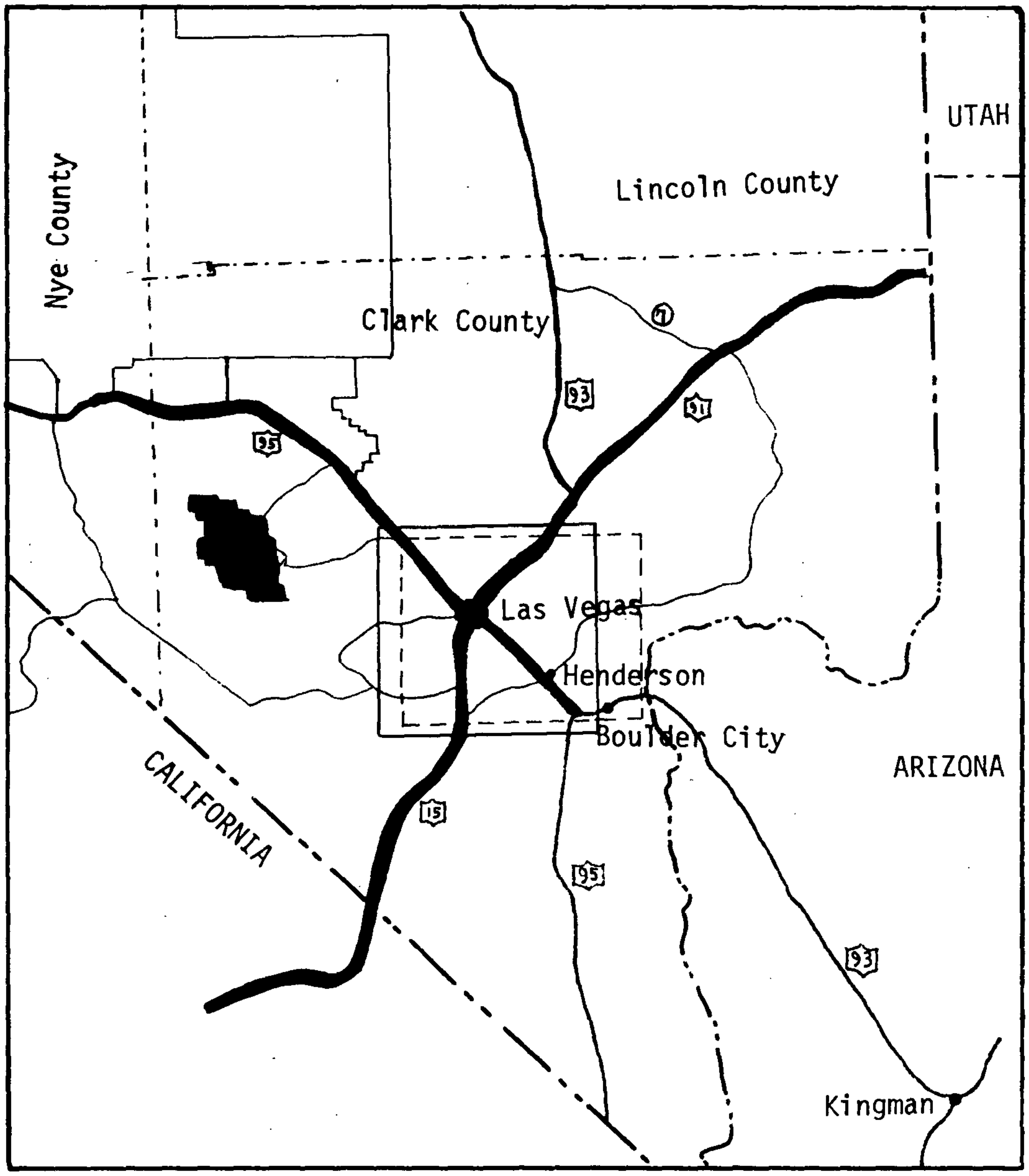

Figure B-1

Table B-4. Daily VMT (Millions) from Nevada Department of Highway Model

	1970	1972*	1973*	1977*	1980	1982**
VMT	2.72	3.17	3.39	4.29	4.96	5.41

* = linear interpolation
** = extrapolation

Table B-5. Traffic on the Major Highways in Clark County

Highway	Average Daily Traffic - Both Directions 1972	1973
Interstate 15 North (Salt Lake City)	4800	4749
U.S. 95 North (Reno - Tonopah)	1150	2425
U.S. 95 South (Searchlight)	600	760
U.S. 95 South (Kingman)	3440	3760
Interstate 15 South (Los Angeles)	10,140	10,840

Table B-6. VMT on the Major Highways in Clark County, Outside Department of Highway's Model Coverage

Highway	Average Daily Traffic 1972	1973	Length (Miles) of Highway Outside Department of Highway's Model	Daily VMT 1972	1973
Interstate 15 North	4800	4749	65	312,000	308,685
U.S. 95 North	1150	2425	20	23,000	48,500
U.S. 95 South (Searchlight)	600	760	47	28,200	35,720
U.S. 95 South (Kingman)	3440	3760	3	10,320	11,280
Interstate 15 South	10140	10840	5	50,700	54,200
Total				424,220	458,385

Table B-7. Total Daily VMT (Millions) for Clark County

	1972	1973	1977	1980	1982
VMT	3.58	3.83	4.84	5.6	6.11

Table B-8. Daily VMT (Millions) for LDV in Clark County

	1972	1973	1977	1982
VMT	3.2	3.38	4.34	5.47

B.4 HEAVY DUTY VEHICLES

Information concerning the total number of heavy duty vehicles (HDV) registered in Clark County is presented in Tables B-9 and B-10. From this data, it is necessary to obtain the number and model year distribution of heavy duty diesel and gasoline powered vehicles. The procedure by which this was accomplished is as follows:

- In the years 1965 through 1972, 40% of all the trucks sold in the nation were heavy duty, of which 14% were diesel powered (B-1).
- On the basis of this sales data, it is assumed that 40% of all the trucks registered in Clark County are heavy duty and 5.6% (14% of 40%) of all the trucks registered are diesel powered.
- As for the model year distributions, it is assumed that the figures in Tables B-9 and B-10 are also applicable for heavy duty vehicles.

Table B-11 shows the number of heavy duty diesel and gasoline powered vehicles in Clark County in 1972 and 1973 as calculated from the above assumptions.

Table B-9. Model Year Distribution of Trucks Registered in Clark County, 1972

	1972	1971	1970	1969	1968	1967	1966	1965	≤1964
Percent	9.3	7.4	9.1	9.0	6.8	5.5	5.9	5.9	41.1

Total number of registered trucks: 35,649 (as of July 1, 1972).

Source: R. L. Polk and Company.

Table B-10. Model Year Distribution of Trucks Registered in Clark County, 1973

	1973	1972	1971	1970	1969	1968	1967	1966	1965	≤1964
Percent	9.1	11.7	7.6	8	7.9	6	5	5.2	5.1	29.4

Total number of registered trucks: 42,585 (as of July 1, 1973).

Source: R. L. Polk and Company.

Table B-11. Number of Heavy Duty Vehicles Registered in Clark County in 1972 and 1973

	1972	1973
Gasoline Powered	12,263	14,649
Diesel Powered	1,999	2,385

B.4.1 Heavy Duty Gasoline Powered Vehicle Emissions

Heavy duty gasoline powered vehicle emissions are calculated by using the same procedure as that for light duty vehicles.

Emission and Deterioration Factors

Emission factors are given in Tables B-12 and B-13. The deterioration factor for all model years is equal to 1 (B-2).

Table B-12. Heavy Duty Gasoline Powered Vehicles Exhaust Emissions Factors

Model Year	HC (grams/mile)	CO (grams/mile)
Pre 1970	140	17
1970 - 1973	140	16
Post 1973	130	13

Source: Reference B-2.

Table B-13. Heavy Duty Gasoline Powered Vehicles Evaporative and Crankcase Hydrocarbon Emission Factors

Model Year	HC (grams/mile)
Pre 1968	8.2
1968 and later	3.0

Source: Reference B-2.

VMT

The daily VMT in 1972 and 1973 by heavy duty gasoline powered vehicles are shown in Tables B-14 and B-15.

Table B-14. VMT for Heavy Duty Gasoline Powered Vehicles, 1972

Model Year	Vehicle Model Distribution*	(B) Total Vehicles	(C) VMT per Vehicle**	B x C Yearly VMT	Daily VMT
1972	.093	1140	7500	8,550,000	23,425
≤1971	.907	11,123	10,000	111,230,000	304,740
Total		12,263		119,780,000	328,165

*Source: Table B-8.

**Source: Reference B-1.

Table B-15. VMT for Heavy Duty Gasoline Powered Vehicles, 1973

Model Year	Vehicle Model Distribution*	Total Vehicles	VMT per Vehicle**	Yearly VMT	Daily VMT
1973	.091	1333	7500	9,997,500	27,390
≤1972	.909	13,316	10,000	133,160,000	364,822
Total		14,649		143,157,500	392,212

*Source: Table B-9.

**Source: Reference B-1

To calculate VMT for 1977 and 1982, the following procedure was used: In 1972, the ratio

$$\frac{\text{VMT by heavy duty gasoline powered trucks in Clark County}}{\text{total VMT in Clark County}} = 0.09.$$

This ratio is assumed to remain constant in 1977 and 1982. Since total VMT in Clark County in 1977 and 1982 was calculated in Section B.3, heavy duty gasoline powered vehicle VMT for these years can be calculated and are shown in Table B-16.

Table B-16. Daily VMT for Heavy Duty Gasoline Powered Vehicles in Clark County

	1972	1973	1977	1982
VMT	328,165	392,212	436,501	550,498

Average Speeds

Average speed figures were obtained from the Department of Highways.

B.4.2 Heavy Duty Diesel Powered Vehicles

Emissions resulting from the operation of heavy duty diesel powered vehicles are calculated in a similar manner as gasoline powered heavy duty vehicles.

Emission factors are available from Reference B-2 and are presented in Table B-17. The effect of deterioration on exhaust emissions from diesel vehicles is considered negligible.

VMT in 1972 and 1973 is calculated as shown in Table B-18 and B-19.

Table B-17. Heavy Duty Diesel Powered Vehicle Exhaust Emission Factors

HC: 3.4 grams/mile

CO: 20.4 grams/mile

Source: Reference B-2.

Table B-18. VMT for Heavy Duty Diesel Powered Vehicles, 1972

Model Year	Vehicle Model Distribution*	Total Vehicles	VMT per Vehicle**	Yearly VMT	Daily VMT
1972	.093	186	7500	1,395,000	3822
≤1971	.907	1813	10,000	18,130,000	49,671
Total		1999		19,525,000	53,493

Source: Table B-4.

Source: Reference B-1.

Table B-19. VMT for Heavy Duty Diesel Powered Vehicles, 1973

Model Year	Vehicle Model Distribution*	Total Vehicles	VMT per Vehicle**	Yearly VMT	Daily VMT
1973	.091	217	7500	1,627,500	4459
≤1972	.909	2,168	10,000	21,680,000	59,397
Total		2885		23,307,500	63,856

*Source: Table B-18.

**Source: Reference B-1.

As for VMT in 1977 and 1982, the procedure outlined for heavy duty gasoline powered trucks was used (Table B-20).

Average speed figures were available from the Department of Highways.

Table B-20. Daily VMT for Heavy Duty Diesel Powered Trucks in Clark County

	1972	1973	1977	1982
VMT	53,443	63,856	72,865	91,138

B.5. MOTORCYCLES

Motorcycle emissions are calculated by multiplying an emission factor (grams/mile) times the VMT attributed to motorcycles in the year of interest. Exhaust, crankcase and evaporative emission factors were obtained from Reference B-2 and combined together, since it was known that the rigor of maintaining separate computations for each category would have a minor effect on the outcome of hydrocarbon emissions, and have no effect on CO (crankcase and evaporative losses represent hydrocarbon emissions only). This is true in the case of hydrocarbon emissions because the crankcase and evaporative emissions are relatively small in comparison to exhaust emissions. Since exhaust emissions from motorcycles are uncontrolled, and no controls are scheduled, the effect of deterioration on exhaust emissions was considered negligible.

VMT figures for 1972 and 1973 were obtained as follows:

- The miles driven per year was estimated to be the same for all models at 4,000.(B-3)
- Two stroke motorcycles were assumed to constitute 1/3 of the total registered motorcycles, while 4 stroke motorcycles constitute 2/3.(Total number of registered motorcycles was obtained from the Department of Motor Vehicles.)
- VMT was calculated by multiplying the number of registered motorcycles times 4000 miles per year.

VMT for 1977 and 1982 was calculated by the same method used for heavy duty vehicles.

Table B-21 illustrates the emissions from motorcycles in 1972, and 1973; Table B-22 shows emissions for 1977 and 1982.

Table B-21. Motorcycle Emissions in Clark County, 1972 and 1973

Year	Motorcycle Type	Motorcycle Population	Miles per Year	Total Miles	Emissions Factor (gm/mi) HC	CO	THC	Emissions (tons/day) RHC	CO
1972	Two stroke	2672	4000	10,688,000	16.36	27	0.5	0.48	0.9
	Four stroke	5404	4000	21,616,000	3.86	33	0.3	0.26	2.2
1973	Two stroke	2635	4000	10,540,000	16.36	27	0.49	0.47	0.88
	Four stroke	5271	4000	21,084,000	3.86	33	0.29	0.25	2.1

Table B-22. Motorcycle Emissions in Clark County, 1977 and 1982

Year	Motorcycle Type	Daily VMT	Emissions (tons/day) THC	RHC	CO
1977	Two stroke	38,800	0.69	0.66	1.15
	Four stroke	82,450	0.35	0.30	2.99
1982	Two stroke	48,933	0.88	0.84	1.45
	Four stroke	103,983	0.44	0.38	3.77

REFERENCES

B-1 1973 Motor Truck Facts. Motor Vehicle Manufacturer's Association.

B-2 Compilation of Air Pollutant Emission Factors. EPA, April 1973.

APPENDIX C

AIRCRAFT EMISSIONS

General Approach

The basic equation used for calculating aircraft emissions of total hydrocarbon and carbon monoxide for a specific aircraft class is as follows:

Emissions of a specific pollutant =

emission factor for the aircraft class	x	number of engines on aircraft in the class	x	number of LTO cycles performed by the aircraft class

Emission factors are documented by the EPA (C-2) in terms of pounds of pollutant emitted per engine per Landing Takeoff (LTO) cycle and are presented in Table C-1. If types of aircraft within a class have different numbers of engines, an average number for the class may be used, or the LTO for the class may be segregated according to engine number.

The number of LTO cycles performed by each type of aircraft within a region must be known or estimated for the base year associated with that region. The aircraft classes designated by EPA are shown in Table C-2.

One special case of base year emission calculations differs from EPA emission factor documentation. This special case involves Aircraft Class 3 only, and results from the fact that aircraft in this class (primarily Boeing 727's, 737's, and Douglas DC-9's) underwent a burner-can retrofit program from 1970 to 1972. Although the object of this program was to reduce the exhaust smoke from these aircraft, additional effects were the reduction of hydrocarbon and carbon monoxide emissions. The emission factors before and after the program were as follows (C-1):

	THC	CO
Pre-retrofit	4.9 lb/engine/LTO	20.0 lb/engine/LTO
Post-retrofit	3.5 lb/engine/LTO	17.0 lb/engine/LTO

Table C-1. Emission Factors per Landing-Takeoff Cycle for Aircraft (Lbs/Engine and Kg/Engine)

Aircraft Class	Total Hydrocarbons		Carbon Monoxide	
	Lb	Kg	Lb	Kg
1	12.2	5.5	46.8	21.2
2	41.2	18.7	47.4	21.5
3	4.9[a]	2.2[a]	20.0[a]	9.0[a]
4	2.9	1.3	6.6	3.0
5	3.6	1.6	15.8	7.17
6	1.1	.5	3.1	1.4
7	0.40	.18	12.2	5.5
8	40.7	18.5	304.0	138.0
9	.52	.24	5.7	2.6
10	2.7	1.2	5.7	2.6
11	9.93	4.5	15.1	6.85
12	20.4	9.3	152.0	69.0

[a]This value describes emissions prior to burner can retrofit.

Source: "Aircraft" - Revision to AP-42, Environmental Protection Agency, 1973.

Table C-2. EPA Aircraft Classification

Aircraft Class Number	Aircraft Class Name	Example Aircraft and Number of Events	Engines Most Commonly Used
1	Jumbo Jet	Boeing 747 (4) Lockheed L-1011 (3) McDonald Douglas DC-10 (3)	Pratt & Witney JT-9D
2	Long Range Jet	Boeing 707 (4) McDonald Douglas DC-8 (4)	Pratt & Witney JT-3D
3	Medium Range Jet	Boeing 737, 727 McDonald Douglas DC-9 (2)	Pratt & Witney JT-8D
4	Air Carrier Turboprop	Convair 580 (2) Electra L-188 (4) Fairchild Hiller FH-227 (2)	Allison 501-D13
5	Business Jet	Lockheed Jetstar (2)	General Electric CJ610 Pratt & Witney JT-12A
6	General Aviation Turboprop	------------------	Pratt & Witney PT-6A
7	General Aviation Piston	Cessna 210 (1) Piper 32-300 (1)	Teledyne-Continental Ø-200 Lycoming Ø-320
8	Piston Transport	Douglas DC-6 (4) CONV 440 (2)	Pratt & Witney R-2800
9	Helicopter	Sikorsky S-61 (2) Vertol 107 (2)	General Electric CT-58
10	Military Transport	Lockhead (C-130) (4)	Alliston T56A7 (T-PROP)
11	Military Jet	--------------	General Electric J-79 Continental J-69
12	Military Piston	--------------	Curtiss-Wright R-1820

Source: "Aircraft" - Revision to AP-42, Environmental Protection Agency, 1973.

It was assumed, for simplicity, that the program proceeded at a constant rate through the three year period. Thus, in mid-year 1970, for example, the program was 1/6 complete, and the average emission factors for this base year were:

THC: 4.9 lb/engine/LTO - 1/6 x (4.9 - 3.5) lb/engine/LTO = 4.7 lb/engine/LTO

CO: 20.0 - 1/6 x (20.0 - 17.0) = 19.5

The emission factors for the base years 1969-1973 are given in Table C-3 for Class 3 aircraft. In this report the base years of concern are 1972 and 1973.

Table C-3. Emission Factors for Class 3 Aircraft

Pollutant	(Units: lb/engine/LTO)				
	1969	1970	1971	1972	1973
THC	4.9	4.7	4.2	3.7	3.5
CO	20.0	19.5	18.5	17.5	17.0

REFERENCES

C-1. Private communication with Mr. Robert Sampson, EPA, Ann Arbor, Michigan, May 1973.

C-2. "Aircraft" - Revision to AP-42, EPA, 1973.

APPENDIX D

Results of Delphi Panel of Las Vegas Planners

Introduction - As noted in Section 6.3, a Delphi panel was conducted to solicit local inputs into evaluating transportation control alternatives. The session was conducted in the Board Room at the Clark County - District Health Department on Thursday, March 28, 1974. The responses solicited were twofold in nature: an assessment of which control alternatives were the most "attractive" in terms of being realistically viable options for Las Vegas and secondly, an estimate of the relative effectiveness of the control measures selected, given they were adopted and implemented in the region.

The individuals and organizations represented who showed up for the session are listed below.

Participants of the Las Vegas Delphi Panel

Participant	Affiliation
Bruce Arkell	State Planning, Governor's Office
Gary Ballinger	Las Vegas Transit
Franklin Bills	Community Analysis and Evaluation, City of North Las Vegas
William Flaxa	Nevada Department of Highways
Bob Gordon	City Planning, City of Henderson
Thomas Graham	Community Development, City of Las Vegas
Dr. R. Guild Gray	Burrows, Smith and Company
Robert Hanzel	Regional Planning Council
Robert Kenneston	Traffic Control, City of Las Vegas
Mary Kozlowski	Citizens Advisory Committee
Dr. Bernie Malamud	University of Nevada

The form of the actual Delphi questionnaire is attached. In addition to the questionnaire, each panel member was also given a "sample" questionnaire, filled out so as to illustrate to each respondent the format of the answers to be submitted; a "Supplement to Las Vegas Delphi Panel Miscellaneous Fact Sheets" was also given to each panel member, presenting factual summaries of relevant demographic and transportation data. The actual inquiries were conducted in six rounds, between each of which the results of the previous round were manually tabulated and fed back to the panel prior to initiating the next round. The design of the survey was to solicit "programmed" responses. Conceptually, the six rounds of interrogation were organized as follows:

Organization of Delphi Survey

Round Number	Attractiveness	Effectiveness	Comments
Round One	First Iteration		Preliminary screening of most attractive measures
Additional Round One	Second Iteration		Final selection of most attractive measures
Round Two	Third Iteration		Ranking of overall attractiveness for measures identified as most attractive
Round Three	Final Iteration	First Iteration	Final ranking of overall attractiveness of measures and first estimate of effectiveness
Round Four		Second Iteration	Reconsideration of effectiveness ratings based on feedback of group results (means and distribution). Reasons requested for extreme views.
Round Five		Final Iteration	Based on feedback and reasons for extreme answers, a final consideration of effectiveness. Also, a request for confidence rating of individual responses.

Round One - In selecting six "best" measures from a list of eighteen, the respondants' results were as follows:

Control Measure	Votes
C - Supplemental jitneys, ...	9
A - Expansion of present service	8
L - Employee carpool incentives	6
P - Auto-free zones	6
B - Subsidized lower fares	5
D - Demand-response buses	5
O - Park-n-ride facilities	4
I - Additional registration fees	3
J - Exclusive bus/carpool lanes	3
K - Computerized/matching carpooling	3
R - Work schedule changes	3

The remaining seven measures received less than three votes and were eliminated from further consideration. The above eleven measures were carried from this preliminary screening to the next round for a final selection of the six "best" measures.

Additional Round One - Each panel member was asked to reconsider his selection of best measures after being presented the Round One results and asked to delete from consideration the seven measures receiving less than three votes. The results of this round are presented.

Control Measure	Votes
C - Supplemental Jitney, ...	10
A - Expansion of present service	9
P - Auto free zones	9
B - Subsidized lower fares	7
O - Park-n-ride facilities	7
L- Employee carpool incentives	6

It is interesting to note that the six top vote-getters were among the top seven named in the previous round. In fact, the next most frequently named measure in this round was "D - Demand-response buses" (5 votes). This would suggest relatively strong agreement among the group on the top six measures. Given this final selection of "best" measures, all other measures were eliminated from further consideration.

Round Two - Having selected six "best" measures, the group was asked to rank each measure on a relative scale (1-6) on a number of criteria. The results of this are presented below. The last column, intended to be a composite ranking of "overall attractiveness" was in reasonable agreement with the vote tallies for "best" measure. If anything, it should be considered a reevaluation of the round one selections. Unchanged in this assessment were the relative ranking of the first, second and last control measures.

ROUND TWO

RANKING OF "MOST ATTRACTIVE" CONTROL MEASURES

Instructions: (1) Rank the alternatives from 1 (Best) to 6 (Worst)

(2) Please base judgments on the greater Las Vegas metropolitan region, and not just the area where you live and work.

	GROUP RESULTS FOR ROUND ONE CONTROL MEASURE	POTENTIAL EFFECTIVENESS*	TECHNICAL FEASIBILITY	POLITICAL-INSTITUTIONAL FEASIBILITY (INCLUDES ECONOMIC FEASIBILITY)	MINIMUM SOCIO-ECONOMIC IMPACT (i.e.PUBLIC ACCEPTANCE/SOCIAL COST)	OVERALL "ATTRACTIVENESS" RANKING**
1. C	Supplemental jitneys, ...	2.64	3.45	3.36	2.45	2.36
2. A	Expansion of present service	2.82	3.73	2.82	2.50	2.36
3. P	Auto-free zones	3.36	4.00	4.27	4.09	4.27
4. B	Subsidized lower fares	3.27	2.82	4.18	3.55	3.09
5. O	Park-n-ride facilities	4.54	3.82	3.45	4.55	4.18
6. L	Employee carpcol incentives	4.36	3.18	2.73	3.00	4.73

*Effectiveness should be judged from the viewpoint of reducing air pollution primarily and not alleviating transportation problems.

**Record these results in first column of ROUND THREE (next page) under "My Round Two Answers." Do so in your order of preference from 1 (Best) to 6 (Worst).

Round Three - This round attempted to solicit a final attractiveness ranking and a preliminary estimate of control measure effectiveness. Effectiveness was requested in terms of the "# of persons participating", or those poeple who would change their life style and participate in the program, if implemented, and secondly, in terms of "% VMT reduction", or an estimate of the overall percentage of vehicle miles travelled which would be reduced by the program. These results are presented below. It is interesting to note that the ranking of attractiveness was the same with the exception of measures "O" and "P". Again, this would indicate good agreement of the group on the overall attractiveness ranking of the six measures.

ROUND THREE

RANKING OF OVERALL "ATTRACTIVENESS" AND "EFFECTIVENESS"

	MY ROUND TWO ANSWERS (OVERALL "ATTRACTIVENESS")		GROUP RESULTS FOR ROUND TWO		OVERALL "ATTRACTIVENESS" RANKING	EFFECTIVENESS*	
	MY RANKING	CONTROL MEASURE	GROUP RANKING	CONTROL MEASURE		# PERSONS PARTICIPATING	%VMT REDUCTION
(BEST)	1.		1.	C	1. 1.55	$\bar{X}$ = 8318 S = 7315	4.7 4.1
	2.		2.	A	2. 2.00	$\bar{X}$ = 6818 S = 3868	5.1 3.7
	3.		3.	B	3. 2.82	$\bar{X}$ = 6591 S = 7569	4.2 4.5
	4.		4.	O	4. 4.00	$\bar{X}$ = 2409 S = 2691	1.8 2.2
	5.		5.	P	5. 3.91	$\bar{X}$ = 6700 S = 6605	3.4 3.0
(WORST)	6.		6.	L	6. 4.81	$\bar{X}$ = 4410 S = 8538	2.9 4.4

*Record these results in first 2 columns of ROUND FOUR (next page) under "My Round Three Answers"

Round Four - After the means and distributions of Round Three were tabulated, they were graphically displayed for the respondents to reconsider in developing their Round Four answers. Also, the respondents were asked to supply reasons for their answer if they persisted in an extreme view. These reasons were fed back for the group to consider prior to Round Five.

The most noticable difference in the Round Four answers was the reduction of noise or distribution of responses received. In every category, the responses were closer to the means than the previous round, as indicated by the smaller standard deviations, S. Also, of interest, is the fact that there were no large deviations in the original means estimated. This would suggest that most individuals felt reasonably comfortable wiht their initial estimates and received reinforcement for their answers from group results. These results are given below.

ROUND FOUR

CONTROL MEASURE "EFFECTIVENESS" RATING

MY ROUND THREE ANSWERS (EFFECTIVENESS)			GROUP RESULTS FOR ROUND TWO	EFFECTIVENESS*	
# PERSONS	% VMT		CONTROL MEASURE	# PERSONS PARTICIPATING	% VMT REDUCTION
		1.	C	X̄ = 7045 S = 5037	4.1 2.8
		2.	A	X̄ = 6591 S = 2548	4.6 3.2
		3.	B	X̄ = 6636 S = 7218	4.1 4.1
		4.	O	X̄ = 1954 S = 1150	1.6 1.1
		5.	D	X̄ = 6300 S = 6147	2.9 2.2
		6.	L	X̄ = 2455 S = 1331	2.1 1.2

*Record these results in first 2 columns of ROUND FIVE (next page) under "My Round Four Answers".

Round Five - In this final round, the group was asked to reconsider in light of reasons for extreme answers, which were supplied by various individuals and the results of Round Four. Also, each participant was asked to give a confidence rating of his (or her) answer for each control measure. This was intended to provide a weighted answer, which might in part, account for varying amounts of expertise in the different areas of interrogation. It was also thought that weighting might reduce the scatter in the distribution of answers received, i.e., the standard deviation S.

While the unweighted Round Five answers did result in a further reduction in the standard deviation, S, of answers received, the weighted results of Round Five (gotten by weighting each answer by the confidence ratings received) appear to be inconclusive. In most cases, in fact, the scatter seems to be greater than noticed with the unweighted answers received. The following tables summarize the results of the effectiveness estimates for Round Five (weighted and unweighted). For comparison with previous rounds, the results of Rounds 3 and 4 are similarly given.

ESTIMATES OF EFFECTIVENESS - # PERSONS PARTICIPATING

Control Measure	Round 3 $\bar{X}$	Round 3 S	Round 4 $\bar{X}$	Round 4 S	Round 5 $\bar{X}$	Round 5 S	Round 5* $\bar{X}$	Round 5* S
C	8318	7315	7045	5037	7727	4630	8051	6430
A	6818	3868	6591	2548	6500	2480	6793	3930
B	6591	7569	6636	7218	6727	7160	6351	7355
O	2409	2691	1954	1150	1770	1110	1700	1290
P	6700	6605	6300	6147	6600	6150	5971	5944
L	4410	8538	2455	1331	2545	1290	2793	2664

ESTIMATES OF EFFECTIVENESS - % VMT REDUCTION

% Red	Round 3 $\bar{X}$	Round 3 S	Round 4 $\bar{X}$	Round 4 S	Round 5 $\bar{X}$	Round 5 S	Round 5* $\bar{X}$	Round 5* S
C	4.7	4.09	4.41	2.75	4.63	2.64	4.86	3.76
A	5.1	3.67	4.6	3.21	4.93	2.83	5.23	3.72
B	4.2	4.46	4.1	4.12	4.47	3.92	4.97	5.62
O	1.8	2.17	1.6	1.12	1.59	1.08	1.67	1.33
P	3.4	3.00	2.9	2.24	2.86	1.93	2.76	2.24
L	2.9	4.37	2.05	1.22	2.18	1.16	2.25	1.40

LAS VEGAS DELPHI PANEL
ON
TRANSPORTATION CONTROL ALTERNATIVES
FOR
REDUCING AIR POLLUTION

MARCH 28, 1974

CONDUCTED BY

TRW TRANSPORTATION & ENVIRONMENTAL OPERATIONS

FOR

ENVIRONMENTAL PROTECTION AGENCY
REGION IX - SAN FRANCISCO, CALIF.

ROUND ONE

PRELIMINARY SCREENING OF POTENTIAL CONTROL MEASURES

Instructions: Choose the six (6) "best" measures in terms of effectiveness, implementability, socio-economic impacts, and public acceptance. Indicate in the margin with an "X".

Improved Mass Transit

_______ A. Expansion of present service -- more buses, more frequent service.

_______ B. Subsidized lowered fares (10-25¢ fare).

_______ C. Supplemental jitneys, mini-buses for heavily traveled routes and/or tourist traffic.

_______ D. Demand-response buses (e.g. Dial-A-Ride, computerized dispatch services).

Parking Controls

_______ E. Elimination of off-street parking.

_______ F. Institute parking surcharge.

_______ G. Close parking lots during peak commute periods.

Economic Disincentives on Auto Usage (Money for Transit)

_______ H. Raise gasoline prices to $1 - 1.50/gallon.

_______ I. Additional registration fee ($100/car/year)

Carpooling Strategies

_______ J. Provide exclusive bus/carpool lanes on freeways during peak commute periods.

_______ K. Provide computerized/matching carpooling programs.

_______ L. Provide employee incentives for carpooling, e.g., best parking spots, time-off.

Limitations on Gasoline Consumption (Rationing)

_______ M. Coupons assigned to registered drivers (for use or resale as proposed by the Federal Energy Office).

_______ N. Reduction in supply at gas station level and no controls on consumer, i.e., first come, first-served.

Other Control Programs

_______ O. Park-n-ride facilities along with bus terminals.

_______ P. Auto-free zones or malls (e.g. Downtown; along the Strip).

_______ Q. Instituting four (4) day work week (e.g. 10 hours per day)

_______ R. Work schedule changes (e.g. staggered work hours).

ADDITIONAL

ROUND ONE

PRELIMINARY SCREENING OF POTENTIAL CONTROL MEASURES

Instructions: Choose the six (6) "best" measures in terms of effectiveness, implementability, socio-economic impacts, and public acceptance. Indicate in the margin with an "X".

Improved Mass Transit

_______ A. Expansion of present service -- more buses, more frequent service.

_______ B. Subsidized lowered fares (10-25¢ fare).

_______ C. Supplemental jitneys, mini-buses for heavily traveled routes and/or tourist traffic.

_______ D. Demand-response buses (e.g. Dial-A-Ride, computerized dispatch services).

Parking Controls

_______ E. Elimination of off-street parking.

_______ F. Institute parking surcharge.

_______ G. Close parking lots during peak commute periods.

Economic Disincentives on Auto Usage (Money for Transit)

_______ H. Raise gasoline prices to $1 - 1.50/gallon.

_______ I. Additional registration fee ($100/car/year)

Carpooling Strategies

_______ J. Provide exclusive bus/carpool lanes on freeways during peak commute periods.

_______ K. Provide computerized/matching carpooling programs.

_______ L. Provide employee incentives for carpooling, e.g., best parking spots, time-off.

Limitations on Gasoline Consumption (Rationing)

_______ M. Coupons assigned to registered drivers (for use or resale as proposed by the Federal Energy Office).

_______ N. Reduction in supply at gas station level and no controls on consumer, i.e., first come, first-served.

Other Control Programs

_______ O. Park-n-ride facilities along with bus terminals.

_______ P. Auto-free zones or malls (e.g. Downtown; along the Strip).

_______ Q. Instituting four (4) day work week (e.g. 10 hours per day)

_______ R. Work schedule changes (e.g. staggered work hours).

ROUND TWO

RANKING OF "MOST ATTRACTIVE" CONTROL MEASURES

Instructions: (1) Rank the alternatives from 1 (Best) to 6 (Worst)

(2) Please base judgments on the greater Las Vegas metropolitan region, and not just the area where you live and work.

	GROUP RESULTS FOR ROUND ONE CONTROL MEASURE	POTENTIAL EFFECTIVENESS*	TECHNICAL FEASIBILITY	POLITICAL-INSTITUTIONAL FEASIBILITY (INCLUDES ECONOMIC FEASIBILITY)	MINIMUM SOCIO-ECONOMIC IMPACT (i.e.PUBLIC ACCEPTANCE/SOCIAL COST)	OVERALL "ATTRACTIVENESS RANKING**
1.	______	______	______	______	______	______
2.	______	______	______	______	______	______
3.	______	______	______	______	______	______
4.	______	______	______	______	______	______
5.	______	______	______	______	______	______
6.	______	______	______	______	______	______

*Effectiveness should be judged from the viewpoint of reducing air pollution primarily and not alleviating transportation problems.

**Record these results in first column of ROUND THREE (next page) under "My Round Two Answers." Do so in your order of preference from 1 (Best) to 6 (Worst).

ROUND THREE

RANKING OF OVERALL "ATTRACTIVENESS" AND "EFFECTIVENESS"

MY ROUND TWO ANSWERS (OVERALL "ATTRACTIVENESS")			GROUP RESULTS FOR ROUND TWO			EFFECTIVENESS*	
	MY RANKING	CONTROL MEASURE	GROUP RANKING	CONTROL MEASURE	OVERALL "ATTRACTIVENESS" RANKING	# PERSONS PARTICIPATING	%VMT REDUCTION
(BEST)	1.	______	1.	______	1. ______	______	______
	2.	______	2.	______	2. ______	______	______
	3.	______	3.	______	3. ______	______	______
	4.	______	4.	______	4. ______	______	______
	5.	______	5.	______	5. ______	______	______
(WORST)	6.	______	6.	______	6. ______	______	______

*Record these results in first 2 columns of ROUND FOUR (next page) under "My Round Three Answers"

ROUND FOUR

CONTROL MEASURE "EFFECTIVENESS" RATING

MY ROUND THREE ANSWERS (EFFECTIVENESS)			GROUP RESULTS FOR ROUND TWO	EFFECTIVENESS*	
# PERSONS	% VMT		CONTROL MEASURE	# PERSONS PARTICIPATING	% VMT REDUCTION
______	______	1.	______	______	______
______	______	2.	______	______	______
______	______	3.	______	______	______
______	______	4.	______	______	______
______	______	5.	______	______	______
______	______	6.	______	______	______

*Record these results in first 2 columns of ROUND FIVE (next page) under "My Round Four Answers".

ROUND FIVE

CONTROL MEASURE "EFFECTIVENESS" RATING

MY ROUND FOUR ANSWERS (EFFECTIVENESS)			GROUP RESULTS FOR ROUND TWO		EFFECTIVENESS	
# PERSONS	% VMT		CONTROL MEASURE	CONFIDENCE RATING*(1-5)	# PERSONS PARTICIPATING	% VMT REDUCTION
________	________	1.	________	________	________	________
________	________	2.	________	________	________	________
________	________	3.	________	________	________	________
________	________	4.	________	________	________	________
________	________	5.	________	________	________	________
________	________	6.	________	________	________	________

*Instructions for Confidence Rating (1-5) - Rate yourself on your overall confidence in the accuracy of your answers (based on either technical training, knowledge of the field, or experience in field of interest).

Scale
1 - Little confidence in my answer
5 - Strong confidence in my answer

SUPPLEMENT TO

LAS VEGAS DELPHI PANEL

MISCELLANEOUS "FACT SHEETS"

March 28, 1974

CONDUCTED BY

TRW TRANSPORTATION & ENVIRONMENTAL OPERATIONS

FOR

ENVIRONMENTAL PROTECTION AGENCY
REGION IX - SAN FRANCISCO, CALIF.

PART I

Selected Statistics for Las Vegas

Miscellaneous Statistics

- In 1970, 1 car per 1.8 persons in the Las Vegas Valley. The figure is up from the 1965 figure of 1 car per 2.2 persons.
- Parking - In 1970, 10,516 available parking spaces for both on and off-street parking; 1,137 street meters; 1,113 curb-side unmetered spaces.
- In 1973, metered streetside spaces increased to 1,169; unmetered curb spaces rose to 1,709. 21.4% of total available parking in "on-street". Total off-street parking totals 45.9% of the total parking facilities. 8,266 off-street spaces in downtown commercial area.
- Public Transit - 1965, less than 1.3% of all resident person trips made via public transit. In 1972, the average weekday passenger trips totaled 8,000; the average peak hour passenger trip, 1,000.
- Existing Traffic Facilities - 25 miles of freeway, 95.1 miles of minor arterials, 266 miles of collector streets, 550 miles of local streets comprised Las Vegas in 1970.
- Traffic Volume - 1965 VMT = 2,293,000. 1970 VMT = 9.9 VMT/person/day. Estimated 1976 VMT = 2,833,510.
- Taxis produced 2.1% of total trips in study area; government trips accounted for 8,461 trips per day representing 1.4% of all vehicle trips.

LAS VEGAS VALLEY URBAN TRANSPORTATION STUDY

TYPE OF TRIP	VEHICLE TRIPS (Thousands)	PERSON TRIPS (Thousands)	PERSONS/ VEHICLE	PERSONS BUS
Resident (Work-Home-Based)	106	141	1.3	2.0
Resident (Socio-Recreation-Home-Based)	78	223	2.9	.5
Resident (Shopping-Home-Based)	95	194	2.1	.7
Resident (Other-Home-Based)	97	278	2.9	13.0
Resident (Nonhome-Based)	79	156	2.0	.5
Motel Patron	44	112	2.5	17.0*
Taxi	13	25	1.9	
Other	95	148	2.0	
TOTAL VEHICLES	607	1277	2.1	17**
				34***

*Special Busses - Motel, Airport Limousine, Tours, etc.
**Total Public Transits
***Total All Bus Passengers

Source: State of Nevada, Department of Highways, "Las Vegas Valley Transportation Study," 1970

LAS VEGAS VALLEY URBAN TRANSPORTATION STUDY

PROJECTION VALUES
VEHICLE TRIPS AND DEMOGRAPHY

	1970	%	1980	%
Resident (Work-Home-Based)	152	18	260	18
Resident (Socio-Recreation-Home-Based)	109	13	204	14
Resident (Shopping-Home-Based)	137	17	246	17
Resident (Other-Home-Based)	135	16	245	17
Resident (Nonhome-Based)	107	13	191	13
Motel	53	7	95	6
Taxi	21	3	37	3
Other	105	13	191	12
TOTAL VEHICLE TRIPS	819	100%	1468	100%
Population	316		563	
Occupied Dwelling Units	96		170	
Employed Persons	118		201	
Pleasure Vehicles	150		278	
Licensed Drivers	176		315	

Source: State of Nevada, Department of Highways, "Las Vegas Valley Transportation Study," 1970.

PARKING STUDY - LAS VEGAS CENTRAL BUSINESS DISTRICT
BASED ON ANNUAL AVERAGE DAILY TRAFFIC

DESCRIPTION	TOTAL
*Total Parking Hours Available in 1965	164
Parking Utilized	44
Surplus	121
Total Parking Hours Utilized in 1970	59
Surplus	105
Total Parking Hours Utilized in 1980	76
Surplus	88

*Total parking hours available have been reduced by 35% to account for turnover time and late night time when parking is not used.

Source: State of Nevada, Department of Highways, "Las Vegas Valley Transportation Study," 1970.

NORTH LAS VEGAS EMPLOYED PERSONS
JOURNEY TO WORK
TRAFFIC DISTRIBUTION BY MODE

City Total

Total Employees Sampled	465	
Total Auto Drivers	372	
% Auto Drivers	80.00	(80%)
Total Auto Passengers	68	
% Auto Passengers	14.62	(15%)
Total Other	25	
% Other	5.38	(5%)
Total %	100.00	(100%)

North Las Vegas
Motor Vehicles Available Per Household

Total Households In Sample	None	%	1 Motor Vehicle	%	2 Motor Vehicles	%	3 or More Motor Vehicles	%
400	34	8.5	161	40	156	39	49	12

Source: Community Analysis and Evaluation Program, City of North Las Vegas, "Labor Supply Profile," February, 1974.

TEN YEAR GROWTH

Southern Nevada Activity Report - Las Vegas Area and Clark County
Statistical Table Showing Economic Trend for 1963 - 1972

BRANCH OF ACTIVITY	1972	1967	% Change	1963	% Change
AIR TRAVEL - McCARRAN INT'L AIRPORT					
Passengers Off and On	$ 4,606,644	$ 2,848,348	+ 61.7	$ 1,444,720	+218.8
EMPLOYMENT TREND					
Total Employment	133,700	97,900	+ 36.5	83,750	+ 59.6
Unemployment	9,300	6,400	+ 45.3	5,558	+ 67.3
Total Labor Force	143,000	104,300	+ 37.1	89,308	+ 60.1
Unemployed Percent of Labor		6.1			
LAS VEGAS CONVENTIONS					
Total Attendance	290,794	155,240	+ 87.3	78,872	+268.6
Total Conventions	385	251	+ 53.3	132	+191.6
GAMBLING - Gross Winnings	476,126,720	209,545,715	+127.0	141,013,081	+238.0
GASOLINE SERVICE STATIONS					
Gasoline Consumption (Gals.)	175,434,320	110,405,441	+ 58.9	92,911,889	+ 88.8
POPULATION	310,000	265,000	+ 16.9	225,000	+ 37.7
SCHOOL ENROLLMENT	75,425	62,775	+ 20.5	50,021	+ 50.7

Source: Bank of Nevada, "Composite Growth Tabulations 1963 - 1972".

PART II

Results of Studies in Other Regions

Selected Results from the "Fourteen Cities Study"

Estimated Automobile VMT Reductions from Traffic Control Measures

	Core (%)	Region (%)
Baltimore	3.0	-
Boston	2.9	1.3
Pittsburgh	3.8	.3
Seattle	1.9	-
Spokane	5.0	-
Los Angeles	0.6	1.3

Source: GCA Corp. and TRW, Inc., "Transportation Controls to Reduce Motor Vehicle Emissions in Major Metropolitan Areas," December, 1972.

Note: With the inclusion of VMT reductions from improved transit, total regional VMT reductions ranged from 0.4 percent in Pittsburgh to 6.0 percent in Baltimore.

Table 7.11. Summary of Impacts for Various Control Strategies in Los Angeles

Strategy Description	Approximate % VMT Reduction
Much Improved Public Transit	$\simeq$ 3
Improved Transit and Tax on Auto Use	$\simeq$ 4
Auto Free Zone (e.g., L.A. C.B.D.)	$\simeq$ 0.6
Increased Parking Costs	Negligible
Four Day Work Week	$\simeq$ 0.6
Exclusive Bus and Carpool Lane	$\simeq$ 2.5
Exclusive Bus and Carpool Land with 3¢/mile tax	$\simeq$ 3.2
Increased Commuter Carpools to Achieve an Average Automobile Occupancy of 1.5 on Freeways	$\simeq$ 4.4

Source: TRW, Inc., "Transportation Control Strategy Development for the Metropolitan Los Angeles Region," January, 1973.

Summary of Impacts for VMT Reduction Strategies in San Francisco, California	
Strategy Description	Approximate Percent VMT Reduction
1. Intercept autos entering San Francisco	
• 50 cent added toll	
- commute traffic only	0.2
- 24 hour basis	0.5
• $2 added toll	
- commute traffic only	0.6
- 24 hour basis	1.4
• $10 added toll	
- commute traffic only	3.0
- 24 hour basis	6.8
• Physical constraints (bus and carpool lanes)	
- half lanes reserved	3.0
• Reduce transit fares	
- commute traffic only	2.0
- 24 hour basis	4.5
• Parking reductions	
- 50 percent CBD reduction	4.0
2. Suburban employer parking restrictions/ subscription bus and carpooling	
• 50 percent reduction in auto use, firms 1000+ employees	2.5
• 75 percent reduction in auto use, firms 1000+ employees	3.8
3. Moratoriums on development	
• Outside transit service area	0.4
• Major generators outside established centers	0.7
4. Traffic disincentives/transit preferential treatment	
• Excluding entrance to San Francisco	0.2
5. Free transit fare	
• Local Service	0.2
• Intercity, excluding entering San Francisco	2.0
6. Improved local transit	0.7
7. Gas taxing/pricing	
• 20 percent price increase	8-12
8. Gas rationing	
• 80 percent current level	13-17
Maximum attainable without gas pricing or rationing	≈ 15

Source: TRW, Inc., "Air Quality Implementation Plan Development for Critical California Regions: San Francisco Bay Intrastate AQCR," July, 1973.

APPENDIX E

This appendix presents the emissions of carbon monoxide (1973 base year) and total hydrocarbons (1972 base year) on a gridded basis for Clark County. The portion of Clark County covered by the grids (each grid is one kilometer by one kilometer in size) is as follows:[1]

- UTM coordinates 650,000 meters E. to 700,000 meters E.
- UTM coordinates 3,980,000 meters N. to 4,020,000 meters N.

The TRW grid does not include all of Clark County but does include the Las Vegas Valley, where the majority of sources are located. Consequently the total emissions of CO and THC presented in this appendix differ from those in Chapter 4.0.

Emissions from the following sources are included in the gridded network presented in this Appendix:

- All point sources listed in Table 4-13 and whose UTM coordinates lie within the boundaries of the TRW network (Thus the TRW network does not include emissions from, for example, the Mohave Power Plant).
- The North Las Vegas Air Terminal, McCarran International Airport and Nellis Air Force Base.
- Industrial area sources; domestic, commercial and industrial space heating; solid waste disposal and organic solvent usage - as specified in Table 4-11. Emissions from these sources are distributed to each grid in proportion to the 1970 population residing within each grid.
- Gasoline marketing emissions - distributed to each grid in proportion to the 1972 VMT in a given grid.
- Motor vehicle emissions in the area jointly covered by the Nevada Department of Highways grid (see Appendix B, Section B.3) and the TRW network.

[1] See Figures E-1 and E-2

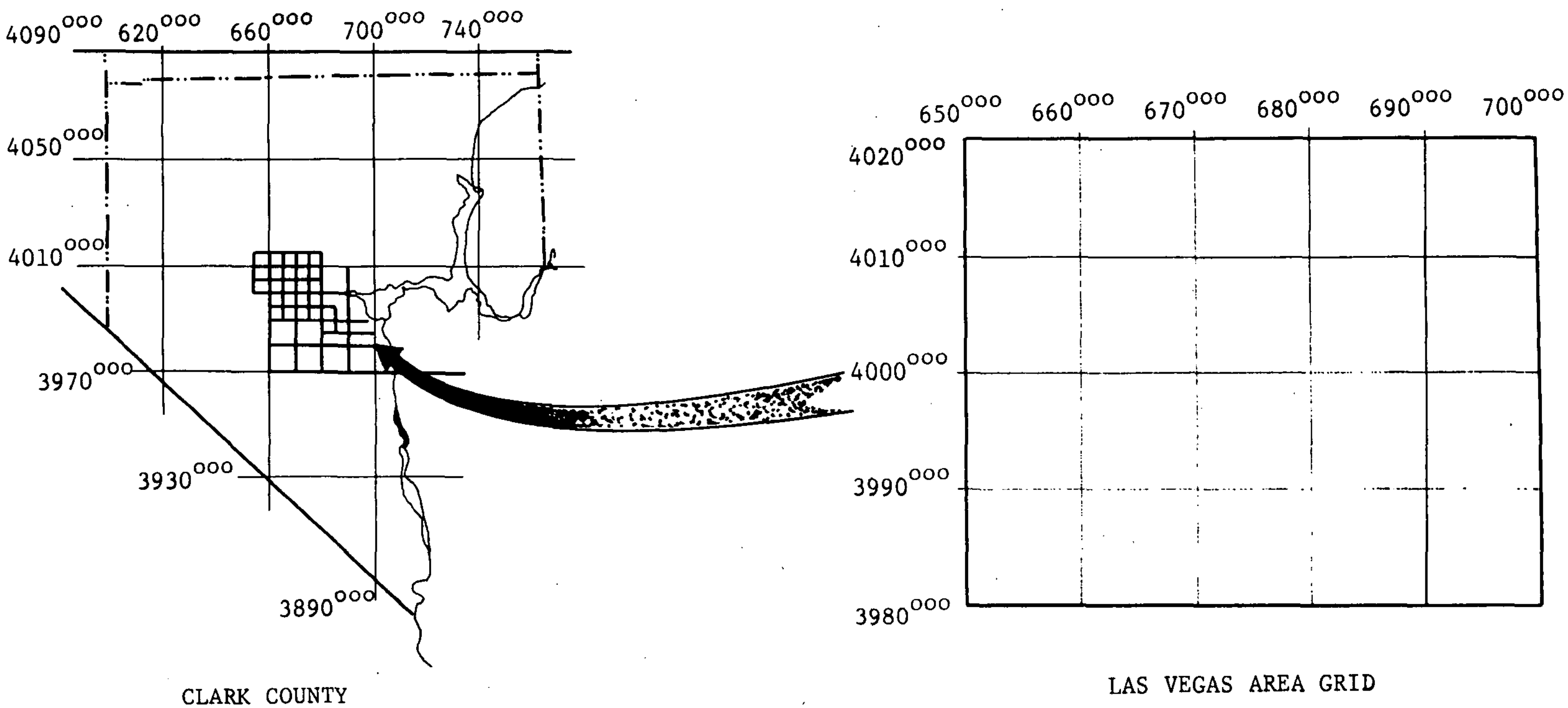

Figure E-1 Las Vegas Metropolitan Area Grid

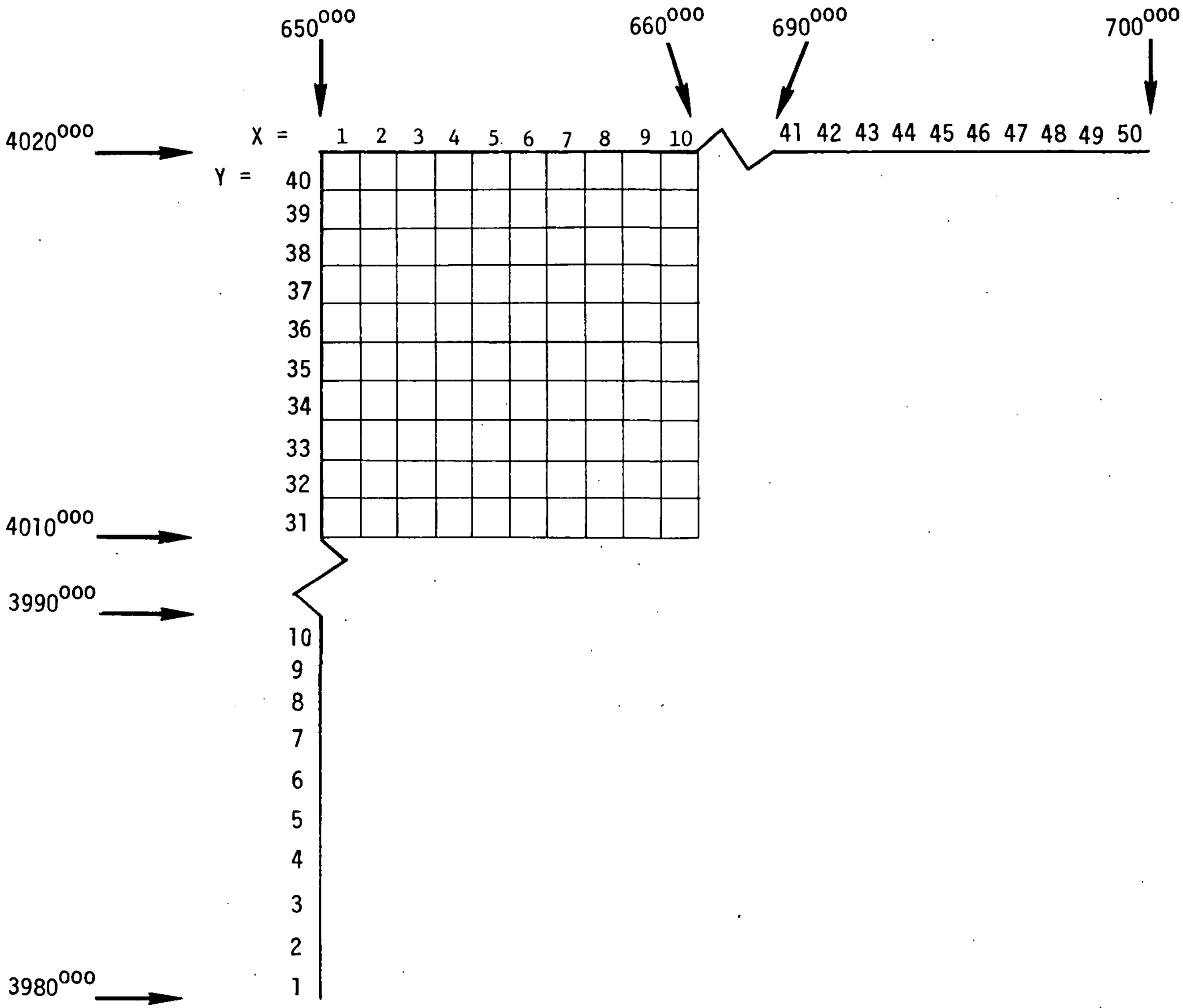

Figure E-2 TRW Grid

Y \ X	1	2	3	4	5	6	7	8	9	10
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0093	.0187	.0236	.0109
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0001	.0015	.0056
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0042	.0081	.0140	.0110
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0000	.0002	.0025	.0004
12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0000	.0034	.0003
13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0000	.0003	.0069	.0010
14	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0086	.0005
15	0.0000	0.0000	0.0000	0.0000	.0002	.0001	.0006	.0013	.0150	.0036
16	0.0000	0.0000	0.0000	0.0000	.0003	0.0000	0.0000	0.0000	.0155	.0017
17	0.0000	0.0000	0.0000	0.0000	.0008	.0001	.0005	.0013	.0172	.0043
18	0.0000	0.0000	0.0000	0.0000	.0013	.0003	.0003	.0002	.0204	.0078
19	0.0000	0.0000	0.0000	0.0000	.0014	.0022	.0021	.0110	.0478	.0470
20	0.0000	0.0000	0.0000	0.0000	.0012	.0038	.0050	.0066	.0672	.1607
21	0.0000	0.0000	0.0000	0.0000	.0004	.0010	0.0000	0.0000	.0676	.0410
22	0.0000	0.0000	0.0000	0.0000	.0011	.0042	.0009	.0070	.1528	.1648
23	0.0000	0.0000	0.0000	0.0000	.0012	.0087	.0100	.0116	.1903	.2173
24	0.0000	0.0000	0.0000	0.0000	.0004	.0074	0.0000	.0632	.2867	.2950
25	0.0000	0.0000	0.0000	0.0000	.0009	.0083	.0119	.0453	.2050	.2792
26	0.0000	0.0000	0.0000	0.0000	.0008	.0045	0.0000	.0356	.2046	.2318
27	0.0000	0.0000	0.0000	0.0000	0.0000	.0012	.0012	.0281	.1519	.0855
28	0.0000	0.0000	0.0000	0.0000	.0001	.0001	0.0000	.0537	.1185	.0645
29	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0760	.1020	.0173
30	0.0000	0.0000	0.0000	0.0000	.0001	.0002	0.0000	.0834	.1077	.0568
31	0.0000	0.0000	0.0000	0.0000	0.0000	.0005	.0002	.0988	.0839	.0461
32	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0006	.0942	.0739	.0862
33	0.0000	0.0000	0.0000	0.0000	.0001	.0102	.0072	.1355	.0909	.1491
34	0.0000	0.0000	0.0000	0.0000	.0018	.0012	.0118	.1755	.0702	.1324
35	0.0000	0.0000	0.0000	0.0000	.0028	.0167	.0589	.1327	.1036	.0504
36	0.0000	0.0000	0.0000	0.0000	0.0000	.0337	.0826	.1573	.0013	.0526
37	0.0000	0.0000	0.0000	0.0000	0.0000	.1258	.1057	.0414	.0176	.0532
38	0.0000	0.0000	0.0000	0.0000	.1139	.0655	.0817	.0005	.0081	.0548
39	0.0000	0.0000	0.0000	.0583	.0674	.0874	0.0000	.0004	0.0000	.0069
40	0.0000	0.0000	.0235	.0661	.1109	.0015	.0003	0.0000	.0001	.0056

Figure E-3 Carbon Monoxide Emissions (tons/day) for Clark County Total Emissions = 140.8 tons/day

X	11	12	13	14	15	16	17	18	19	20
Y 1	0.0000	.0001	0.0000	.0924	.1120	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	.0648	.1332	.0026	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	.0130	.1828	.0065	.0039	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	.0001	.2251	.0086	.0065	.0039	0.0000	0.0000
5	0.0000	0.0000	0.0000	.0001	.1780	.0073	.0109	.0052	.0058	0.0000
6	0.0000	0.0000	0.0000	.0001	.1632	0.0000	.0073	.0124	.0032	.0086
7	0.0000	0.0000	0.0000	.0000	.2200	.0118	.0088	.0039	.0140	.0026
8	0.0000	0.0000	0.0000	.0001	.1956	0.0000	.0044	.0055	.0030	.0315
9	.0099	.0076	0.0000	.0015	.2053	.0210	.0210	.0099	.0070	.0072
10	.0011	.0056	.0184	.0346	.1914	.0019	0.0000	0.0000	0.0000	.0130
11	.0079	.0120	.0043	.0985	.1871	.0196	.0192	.0098	.0075	.0185
12	0.0000	.0007	.0150	.1174	.1537	.0117	.0112	.0134	.0037	.0181
13	0.0000	.0004	.0026	.1475	.1293	.0015	0.0000	.0048	0.0000	.0187
14	.0004	.0038	.0052	.1715	.1374	.4000	.4048	.4007	.3903	.0907
15	.0039	.0052	.0084	.1395	.1781	2.4725	2.4710	.1283	.0322	.0467
16	.0009	.0019	.0008	.1711	.2851	.4816	.5051	.2564	.1098	.1632
17	.0053	.0062	.0090	.3343	.6351	.3464	.3322	.4192	.0743	.1052
18	.0021	.0065	.0034	.2919	.5260	.1611	.3235	.2749	.0681	.1185
19	.0524	.0843	.0790	.7306	1.0221	.5426	.6817	.4616	.2724	.2537
20	.0940	.2145	.1569	.7230	.8973	.8080	.7745	.5906	.4322	.3376
21	.0244	.0939	.1487	.3325	.8336	.9436	.5584	.4933	.2223	.1509
22	.2158	.4503	.5212	.7512	1.3567	1.6458	1.3419	1.1190	.6213	.5897
23	.1192	.2101	.1554	.1112	.5623	1.2032	1.2166	.7296	.2529	.6668
24	.4220	.7524	.6903	.8008	1.2156	1.8052	2.0648	1.6804	1.2671	1.3272
25	.2220	.5494	.3011	.3832	.5506	1.2207	1.3697	1.7350	.7596	1.0779
26	.2735	.6236	.3653	.4653	.6233	.9728	1.4237	1.4423	.8023	.7840
27	.0445	.3035	.1865	.1972	.4195	.6309	.8556	1.4090	.5085	.6706
28	.1541	.3974	.2950	.3851	.1646	.2750	.4826	.9264	.7025	.8392
29	.1116	1.0413	.6794	.1453	.1072	.2167	.1971	.5451	.5226	.7711
30	.1251	.2852	.1813	.0152	.0295	.0861	.0703	.1776	.3397	.3320
31	.0693	.1898	.0046	.0021	.0205	.0454	.0299	.0160	.1790	.3613
32	.1878	.0145	.0120	.0160	.0250	.0266	.0226	.0189	.1487	.1691
33	.0660	.0155	.0217	.0244	.0202	.0168	.0307	.0123	.0375	.1780
34	.0303	.0370	.0385	.0294	.0371	.0367	.0559	.0260	.0317	.0744
35	.0115	.0041	.0159	.0097	.0098	0.0000	0.0000	0.0000	.0217	.0004
36	.0005	.0044	0.0000	.0070	.0020	0.0000	0.0000	0.0000	.0025	0.0000
37	.0021	.0019	.0022	0.0000	.0083	0.0000	0.0000	0.0000	0.0000	0.0000
38	.0072	0.0000	.0022	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
39	.0042	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
40	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N

Figure E-3 (Continued)

X / Y	21	22	23	24	25	26	27	28	29	30
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	.0151	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	.0066	.0151	.0017	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	.0308	.0042	.0061	.0093	.0080	.0094	.0061	0.0000	0.0000	0.0000
10	.0040	.0129	.0071	.0011	0.0000	0.0000	.0042	.0105	.0105	.0105
11	.0031	.0015	.0012	.0244	.0119	.0139	.0237	.0124	.0025	.0027
12	.0026	.0009	.0007	.0140	0.0000	.0002	.0003	0.0000	.0099	.0124
13	.0015	.0064	.0036	.0128	0.0000	.0516	.0603	.0611	.0738	.4120
14	.0618	.0641	.0552	.0567	.0167	.0100	0.0000	0.0000	.3188	.1364
15	.0111	.0310	.0190	.0128	.0213	.0689	.0493	.3736	.1789	.3256
16	.1040	.1135	.0751	.0980	.0140	.0226	.3148	.1878	.2889	.0002
17	.0456	.1038	.0395	.0739	.0711	.2563	.1611	.3850	.0628	.0456
18	.0133	.1168	.0344	.1056	.3809	.2265	.3585	.0343	.0007	.0001
19	.2363	.2910	.1904	.3935	.4760	.3034	.0469	0.0000	0.0000	0.0000
20	.2686	.3249	.3120	.3809	.6007	.0909	.0178	.0028	.0028	.0005
21	.2860	.4127	.3956	.3868	.3009	.0229	.0084	0.0000	0.0000	0.0000
22	.5535	.5110	.2941	.1050	.2126	.0120	.0015	0.0000	0.0000	0.0000
23	.5126	.4033	.3124	.0712	.2299	.0377	.0072	0.0000	0.0000	0.0000
24	.5657	.4763	.1243	.0272	.1891	.0182	.0074	0.0000	0.0000	0.0000
25	.3363	.2033	.2804	.1217	.2189	.0299	.0262	0.0000	0.0000	0.0000
26	.1480	.3523	.2139	.1096	.2480	.0149	.0032	0.0000	0.0000	0.0000
27	.1430	.1273	.1853	.0826	.2299	.0243	.0122	0.0000	0.0000	0.0000
28	.3028	.2792	.1940	.1253	.2740	.1129	.1066	.0166	.0173	.0163
29	.3671	.3106	.1848	.0823	.1905	.0377	.0141	0.0000	0.0000	0.0000
30	.1190	.2864	.0993	.0337	.1586	.0611	.0595	.0071	.0074	.0070
31	.1562	.1390	.2135	.0474	.1080	.1493	.0320	0.0000	0.0000	0.0000
32	.2105	.2094	.1227	.1044	.1765	.2960	.2960	.1184	0.0000	0.0000
33	.1477	.1935	.2332	.1723	.2244	.1085	.3700	.1480	.0444	0.0000
34	.2022	.1448	.2046	.1747	.2305	.0065	.0273	.0371	0.0000	0.0000
35	.0155	.0467	.1064	.0655	.0576	.0929	.0052	.0188	.0188	0.0000
36	.0045	.0147	.0574	.0155	.0651	.0388	.0092	.0092	.0053	.0068
37	.0042	0.0000	.0084	.0311	.0124	.0273	.0679	.0158	.0127	0.0000
38	.0021	0.0000	0.0000	0.0000	.0186	.0311	0.0000	.0558	.0565	.0282
39	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0373	.0249	0.0000	.0332
40	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0125	.0311	.0312

Figure E-3 (Continued)

X / Y	31	32	33	34	35	36	37	38	39	40
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0971	.0182	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0910	.1365	.0010	0.0000
6	0.0000	.0006	.0009	.0011	.0096	.0198	.1557	.0652	.0063	0.0000
7	0.0000	.0055	.0027	0.0000	.0128	.1023	.0538	.0269	0.0000	0.0000
8	0.0000	.0192	.0450	.0135	.1090	.0210	.0436	0.0000	0.0000	0.0000
9	0.0000	.0505	.0496	.2514	.0150	.0274	0.0000	0.0000	0.0000	0.0000
10	.0656	.1778	.3979	.0433	.0321	0.0000	0.0000	0.0000	0.0000	0.0000
11	8.2607	.4813	.2891	.0815	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	.4994	.2427	.2400	.0690	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	.1678	.2406	.1200	.0425	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	.2712	.0015	.0135	.0436	.0439	0.0000	0.0000	0.0000	0.0000	0.0000
15	0.0000	0.0000	0.0000	.0247	0.0000	.0425	.0053	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000	.0111	.0204	.0092	0.0000	0.0000	0.0000	0.0000
17	.0419	.0349	.0271	.0062	0.0000	.0076	.0022	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
26	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
27	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28	.0045	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
29	.0108	.0018	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
30	.0072	.0008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
31	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
32	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
33	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
34	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
35	.0015	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
36	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
37	.0080	.0023	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
38	.0013	.0046	.0040	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
39	.0706	.0374	.0059	.0030	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
40	0.0000	.0344	.0713	.0421	.0003	0.0000	0.0000	0.0000	0.0000	0.0000

Figure E-3 (Continued)

X / Y	41	42	43	44	45	46	47	48	49	50
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
26	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
27	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
29	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
30	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
31	0.0000	.0082	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
32	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
33	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
34	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
35	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
36	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
37	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
38	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
39	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0083	.0022	0.0000	0.0000
40	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Figure E-3 (Continued)

X / Y	1	2	3	4	5	6	7	8	9	10
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0029	.0055	.0069	.0032
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0000	.0004	.0016
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0007	.0014	.0026	.0019
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0000	.0001	.0006	.0001
12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0000	.0009	.0001
13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0000	.0000	.0015	.0002
14	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0018	.0002
15	0.0000	0.0000	0.0000	0.0000	.0000	.0000	.0002	.0004	.0033	.0006
16	0.0000	0.0000	0.0000	0.0000	.0001	0.0000	0.0000	0.0000	.0033	.0028
17	0.0000	0.0000	0.0000	0.0000	.0002	.0000	.0001	.0002	.0037	.0013
18	0.0000	0.0000	0.0000	0.0000	.0003	.0001	.0001	.0001	.0043	.0018
19	0.0000	0.0000	0.0000	0.0000	.0002	.0004	.0004	.0019	.0089	.0089
20	0.0000	0.0000	0.0000	0.0000	.0002	.0007	.0009	.0013	.0125	.0286
21	0.0000	0.0000	0.0000	0.0000	.0001	.0002	0.0000	0.0000	.0124	.0085
22	0.0000	0.0000	0.0000	0.0000	.0002	.0009	.0003	.0013	.0363	.0424
23	0.0000	0.0000	0.0000	0.0000	.0002	.0017	.0021	.0049	.0415	.0521
24	0.0000	0.0000	0.0000	0.0000	.0001	.0019	0.0000	.0182	.0745	.0767
25	0.0000	0.0000	0.0000	0.0000	.0002	.0015	.0022	.0116	.0556	.0782
26	0.0000	0.0000	0.0000	0.0000	.0025	.0009	0.0000	.0229	.0714	.0950
27	0.0000	0.0000	0.0000	0.0000	0.0000	.0002	.0002	.0068	.0436	.0458
28	0.0000	0.0000	0.0000	0.0000	.0000	.0000	0.0000	.0123	.0265	.0285
29	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0174	.0365	.0080
30	0.0000	0.0000	0.0000	0.0000	.0000	.0000	0.0000	.0165	.0241	.0379
31	0.0000	0.0000	0.0000	0.0000	0.0000	.0001	.0000	.0220	.0207	.0176
32	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0001	.0208	.0180	.0245
33	0.0000	0.0000	0.0000	0.0000	.0000	.0029	.0021	.0287	.0293	.0329
34	0.0000	0.0000	0.0000	0.0000	.0005	.0003	.0020	.0468	.0159	.0258
35	0.0000	0.0000	0.0000	0.0000	.0005	.0029	.0169	.0335	.0202	.0118
36	0.0000	0.0000	0.0000	0.0000	0.0000	.0095	.0242	.0388	.0050	.0144
37	0.0000	0.0000	0.0000	0.0000	0.0000	.0369	.0205	.0118	.0055	.0143
38	0.0000	0.0000	0.0000	0.0000	.0334	.0112	.0164	.0025	.0061	.0142
39	0.0000	0.0000	0.0000	.0201	.0171	.0150	0.0000	.0025	0.0000	.0012
40	0.0000	0.0000	.0069	.0194	.0192	.0004	.0001	0.0000	.0000	.0010

N

Figure E-4 Total Hydrocarbon Emissions (tons/day); Total Emissions = 46.8 tons/day

Y \ X	11	12	13	14	15	16	17	18	19	20
1	0.0000	.0000	0.0000	.0191	.0329	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	.0111	.0390	.0008	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	.0022	.0435	.0019	.0011	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	.0000	.0567	.0015	.0019	.0011	0.0000	0.0000
5	0.0000	0.0000	0.0000	.0000	.0427	.0014	.0019	.0015	.0017	0.0000
6	0.0000	0.0000	0.0000	.0000	.0402	0.0000	.0014	.0022	.0009	.0025
7	0.0000	0.0000	0.0000	.0000	.0528	.0020	.0015	.0007	.0024	.0008
8	0.0000	0.0000	0.0000	.0000	.0457	0.0000	.0008	.0009	.0005	.0055
9	.0029	.0022	0.0000	.0004	.0513	.0062	.0062	.0029	.0021	.0021
10	.0002	.0017	.0054	.0102	.0453	.0147	0.0000	0.0000	0.0000	.0025
11	.0014	.0021	.0010	.0287	.0450	.0057	.0033	.0017	.0013	.0034
12	0.0000	.0001	.0026	.0262	.0365	.0057	.0033	.0039	.0011	.0041
13	0.0000	.0001	.0006	.0362	.0283	.0123	0.0000	.0014	0.0000	.0045
14	.0001	.0011	.0037	.0408	.0341	.1874	.1911	.1875	.1854	.0240
15	.0030	.0009	.0014	.0354	.0460	1.2373	1.2250	.0392	.0094	.0109
16	.0003	.0003	.0002	.0414	.0705	.2070	1.0598	.0684	.0367	.0360
17	.0016	.0018	.0026	.0891	.1630	.1016	.0975	.1061	.0202	.0370
18	.0005	.0019	.0009	.0777	.1255	.0322	.0780	.0960	.0198	.0538
19	.0099	.0154	.0148	.1750	.2375	.1614	.1893	.1271	.0865	.0683
20	.0176	.0484	.0395	.1750	.2196	.2343	.2082	.1649	.1021	.1016
21	.0077	.0313	.0563	.0585	.2193	.2835	.1496	.1649	.0718	.0386
22	.0555	.1096	.1360	.1733	.3519	.4348	.3645	.3317	.1764	.1581
23	.0450	.0543	.0762	.0691	.1073	.3038	.3507	.1987	.1223	.2116
24	.1205	.2009	.1894	.2231	.3140	.4495	.5762	.4437	.3791	.3748
25	.0639	.1575	.0875	.1008	.1219	.2814	.3274	.4743	.2221	.2610
26	.1028	.1860	.1085	.1469	.1738	.2766	.3791	.4040	.2283	.2277
27	.0366	.0918	.0700	.0632	.0900	.1660	.1958	.3555	.1861	.2145
28	.0583	.1141	.0845	.0964	.0583	.0757	.1544	.2474	.2238	.2476
29	.0440	.0755	.0750	.0393	.0354	.0628	.0808	.1372	.1592	.2277
30	.0455	.0572	.0321	.0036	.0095	.0310	.0421	.0345	.1307	.0777
31	.0225	.0325	.0008	.0029	.0162	.0078	.0219	.0219	.0374	.1716
32	.0466	.0072	.0141	.0051	.0043	.0046	.0062	.0032	.0255	.0390
33	.0246	.0045	.0056	.0057	.0079	.0049	.0083	.0059	.0086	.0334
34	.0100	.0111	.0090	.0050	.0087	.0063	.0119	.0045	.0058	.0127
35	.0140	.0031	.0027	.0017	.0017	0.0000	0.0000	0.0000	.0061	.0025
36	.0025	.0008	0.0000	.0012	.0003	0.0000	0.0000	0.0000	.0004	0.0000
37	.0053	.0027	.0004	0.0000	.0014	0.0000	0.0000	0.0000	0.0000	0.0000
38	.0036	0.0000	.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
39	.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
40	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Figure E-4 (Continued)

X / Y	21	22	23	24	25	26	27	28	29	30
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	.0044	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	.0017	.0044	.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	.0053	.0007	.0018	.0027	.0024	.0028	.0018	0.0000	0.0000	0.0000
10	.0007	.0022	.0012	.0003	0.0000	0.0000	.0012	.0031	.0031	.0031
11	.0005	.0003	.0002	.0043	.0020	.0024	.2498	.0021	.0004	.1699
12	.0008	.0003	.0002	.0025	0.0000	.0001	.0000	0.0000	.0017	.0021
13	.0004	.0019	.0009	.0046	0.0000	.0152	.0177	.0179	.0217	.1209
14	.0179	.0181	.0147	.0166	.0049	.0020	0.0000	0.0000	.0935	.0363
15	.0147	.0073	.0037	.0107	.0040	.0121	.0084	.1035	.0436	.0677
16	.0215	.0239	.0158	.0198	.0033	.6169	.0924	.0551	.0495	.0001
17	.0113	.0232	.0103	.0155	.0209	.0752	.0473	.0659	.0228	.0078
18	.0027	.0284	.0207	.0249	.1078	.0659	.0652	.0060	.0002	.0000
19	.0677	.0763	.0671	.1234	.1530	.0544	.0320	0.0000	0.0000	0.0000
20	.0638	.0811	.0747	.1175	.1400	.0206	.0056	.0005	.0005	.0001
21	.0727	.1124	.1169	.0829	.0815	.0065	.0024	.0274	0.0000	0.0000
22	.1688	.1505	.0948	.0310	.0502	.0033	.0003	0.0000	0.0000	0.0000
23	.1332	.0953	.0890	.0274	.0523	.0091	.0013	0.0000	0.0000	0.0000
24	.1131	.1316	.0417	.0099	.0693	.0077	.0022	0.0000	0.0000	0.0000
25	.0946	.0593	.0765	.0337	.0528	.0055	.0048	0.0000	0.0000	0.0000
26	.0530	.0755	.0852	.0475	.0647	.0041	.0030	0.0000	0.0000	0.0000
27	.0614	.0588	.0603	.0452	.0678	.0084	.0023	0.0000	0.0000	0.0000
28	.1221	.0916	.0508	.0611	.0715	.0364	.0310	.0049	.0051	.0048
29	.1486	.0914	.0405	.0288	.0547	.0213	.0034	0.0000	0.0000	0.0000
30	.0657	.0855	.0474	.0207	.0473	.0249	.0246	.0012	.0013	.0012
31	.0435	.0414	.0709	.0136	.0413	.0926	.0134	0.0000	0.0000	0.0000
32	.0618	.0415	.0261	.0414	.0461	.1800	.1800	.0720	0.0000	0.0000
33	.0468	.0586	.0532	.0406	.1085	6.5524	.2250	.0900	.0270	0.0000
34	.0348	.0317	.0492	.0399	.0567	.0134	.0080	.0202	0.0000	0.0000
35	.0028	.0080	.0266	.0205	.0219	.0160	.0009	.0055	.0055	0.0000
36	.0009	.0025	.0098	.0026	.0181	.0108	.0016	.0016	.0016	.0020
37	.0007	0.0000	.0014	.0053	.0021	.0074	.0199	.0042	.0022	0.0000
38	.0004	0.0000	0.0000	0.0000	.0032	.0053	0.0000	.0164	.0165	.0078
39	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0064	.0043	0.0000	.0097
40	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0021	.0053	.0053

N

Figure E-4 (Continued)

Y \ X	31	32	33	34	35	36	37	38	39	40
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0285	.0053	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0267	.0401	.0002	0.0000
6	0.0000	.0002	.0003	.0003	.0002	.0058	.0457	.0112	.0011	0.0000
7	0.0000	.0016	.0008	0.0000	.0038	.0300	.0092	.0046	0.0000	0.0000
8	0.0000	.0037	.0097	.0037	.0318	.0036	.0075	0.0000	0.0000	0.0000
9	0.0000	.0125	.0129	.0738	.0026	.0047	0.0000	0.0000	0.0000	0.0000
10	.0193	.0528	.1169	.0090	.0055	0.0000	0.0000	0.0000	0.0000	0.0000
11	.0143	.1476	.0982	.0170	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	.1497	.0858	.0684	.0182	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	.0419	.0652	.0326	.0235	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	.0464	.0123	.0263	.0349	.0129	0.0000	0.0000	0.0000	0.0000	0.0000
15	0.0000	0.0000	0.0000	.0066	0.0000	.0125	.0016	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000	.0019	.0035	.0016	0.0000	0.0000	0.0000	0.0000
17	.0072	.0060	.0046	.0011	0.0000	.0013	.0004	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
26	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
27	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28	.0013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
29	.0032	.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
30	.0012	.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
31	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
32	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
33	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
34	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
35	.0123	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
36	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
37	.0023	.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
38	.0002	.0013	.0012	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
39	.0204	.0107	.0017	.0009	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
40	0.0000	.0100	.0205	.0123	.0001	0.0000	0.0000	0.0000	0.0000	0.0000

Figure E-4 (Continued)

N

X	41	42	43	44	45	46	47	48	49	50
Y 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
26	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
27	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
29	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
30	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
31	0.0000	.0027	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
32	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
33	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
34	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
35	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
36	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
37	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
38	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
39	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0026	.0006	0.0000	0.0000
40	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Figure E-4 (Continued)

N