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TRAFFIC VOLUME ESTIMATES AND GROWTH TRENDS

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16. Abstract

The objective of this study was to develop a procedure to forecast highway traffic volumes through the use of growth factors representative of Kentucky highways and reflecting effects of important socioeconomic and demographic variables. A two-stage modeling process was used. In the first, linear regression models were used to relate average daily travel on Kentucky roadways to personal income, price of fuel, and total miles of streets and highways. In the second, cross-tabulation models were used to relate growth in volume at a specific site--expressed relative to the statewide ADT--to highway functional classification, rural/urban location, county population growth, SMSA/non-SMSA designation, and volume level. The growth model yields estimates not only of the most likely rate of growth at a particular site but also of the range experienced at similar sites statewide.

In collecting historical volume data for model calibration, a file was developed representing approximately 15,000 sites on the state highway system at which counts had been taken during the 1963-86 base period. On average, there were about 5.8 counts for each of these sites. Data in the file is instantly accessible by microcomputer users through dBASE software. A piecewise linear regression routine is used to provide estimates for past years during which counts were not taken.

The historical volume database has been designed for continuous updating as new counts are made. Similarly, the forecasting models have been designed for convenient recalibration at annual intervals.

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EXECUTIVE SUMMARY

The initial objective of this study was to develop a procedure to forecast traffic volumes through the use of growth factors representative of Kentucky highways and reflecting effects of important socioeconomic and demographic variables. The forecasting procedure developed in response to this objective requires the use of two different models. One model is used for forecasting average travel (AADT) on all Kentucky highways, and the second is for project-level forecasts of volume ratio and its future growth. Volume ratio is the ratio between the site-specific volume and the statewide average.

Actually, two methods are provided for generating estimates of future statewide AADT. One involves a simple linear extrapolation of the volume trend: the other is a more detailed procedure incorporating effects of both economic conditions and highway mileage. Input variables necessary for making forecasts using the second method include statewide Kentucky personal income, the price of gasoline, and the total miles of roads and streets in Kentucky.

Forecasts of site-specific volumes are made by developing a base-year volume ratio either from actual data at the site or from a volume-ratio model. Four explanatory variables are required if the volume-ratio model is used: 1) development density in terms of rural/urbanized/small urban categorization, 2) functional classification of facility, 3) rate of past county population growth, and 4) location of county relative to SMSA boundaries.

The growth-factor model produces estimates of growth (annual compounded percentage) in volume ratio as a function of local conditions. These conditions, representative of the site during the base year, include the following: 1) development density in terms of rural/urban categorization, 2) functional classification, 3) past county population growth, and 4) volume level. In general, the procedure for forecasting future travel at a site involves estimating the rate of change in growth at the site as compared to the

statewide average. It is more fully described as follows:

- o Estimate the base-year (current) average volume on all Kentucky roads;
- o Estimate the base-year volume at the project site;
- o Calculate the base-year volume ratio at the site, that is, the ratio of volume at the site to the statewide average volume;
- o Calculate the future-year volume ratio at the site by applying the forecasted growth to the base-year volume ratio;
- o Forecast the future-year average volume on all Kentucky roads; and
- o Calculate the future-year volume at the site.

Creation of a computer-readable volume data base was essential to the primary tasks of model development and calibration. Early in this process, however, the study was expanded to include the task of converting this data base to a form readily accessible to microcomputer users. Operating within a dBASE III Plus environment, users now have almost immediate access to historical volume data on the entire state-maintained road and street system. Provision also has been made to estimate volumes for those earlier years during which actual counts were not taken at the site of interest.

Volume is indisputably the most fundamental characteristic of highway traffic flow. Volume estimates--both past and future--are in constant use by engineers and planners:

- o They are necessary to estimate motor-vehicle tax revenues, determine future highway needs, and develop equitable formulas for highway cost allocation;
- o They dictate the design of new highways including, for example, the number and types of lanes, geometric design details, and pavement thicknesses;
- o They drive many impact assessments including those relating to air and noise pollution, energy conservation, and economics; and

- They serve an indispensable role in monitoring highway performance including pavement wear, highway congestion, and accident experience.

The data bases and models developed as a part of this study extend the analysis and design tools available to engineers and planners in the following ways:

- Historical traffic volumes are immediately accessible for the entire state-maintained system and estimates are automatically available for years during which actual counts were not taken;
- As new data become available, it may be easily entered into the historical file, thereby assuring the file is constantly updated;
- The data base on which growth estimates are based has been tremendously expanded;
- Forecasting procedures are considerably simpler than those that use the more complex trip generation-distribution models;
- Most likely effects of fundamental socioeconomic variables can be reflected in the volume forecasts;
- As a first approximation, the forecasting models reflect the effects of local conditions on traffic volume and its growth;
- Estimates are available not only of the "most likely" values but also of extremes that may reasonably be expected;
- Growth estimates may be made for urban as well as rural facilities; and
- The models may be "automatically" recalibrated at annual intervals, thus always providing the traffic estimator with the most current information available.

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INTRODUCTION

The collection of traffic volume, classification, and weight data has been a significant portion of highway planning activities for many years. Traffic volume estimates and growth trends serve many useful purposes for various functions within a highway agency. In the engineering phases, it is beneficial to know the anticipated volumes for geometric design. The distribution of vehicle types, along with their weights, is essential for pavement designs. For planning purposes, volume estimates and trends are used for the location and design of highway systems. The distribution of traffic by vehicle types and the associated fuel consumption permit estimates of fuel tax revenues. Highway cost allocation studies are based on volume and classification statistics by highway type.

The general approach to traffic volume forecasting has traditionally depended upon whether the forecast was required for a rural or urban facility. Forecasts within urban areas usually follow the trip generation-distribution modeling procedure and very detailed forecast data are produced. In most cases, large amounts of data must be collected for input into computer-based traffic simulation models. These types of models are most useful when area-wide forecasts are desired for an urban location.

Trip generation-distribution models are burdensome for rural applications because of the significant amount of detailed data that is required. For this reason, other types of forecasting models are used for rural areas, models that generally require only site-specific or project-level data and that relate projections to statewide trends. When only project-level or site-specific forecasts are needed, future trends may be represented by models representative of highway characteristics, road-user characteristics, and socioeconomic variables.

Published research related to traffic growth trend projections has been relatively limited. In one early study, rates of changes of traffic volumes on selected Ohio roads were analyzed with 1936 as the base year. Growth trends were analyzed by geographic area, and a close correlation was found between traffic growth and economic welfare (1). Another study of roads in Illinois projected traffic growth rates over 20 years, ranging from a high of 210 percent for interstates to a low of 50 percent for roads carrying local rural traffic (2). Factors identified in the study that were responsible for increasing vehicle miles of travel included population, persons per vehicle, and gallons of gasoline consumed or vehicle miles travelled per vehicle. In addition, growth patterns were found to be related to proximity to an urban area, geographic location, and type of pavement.

An attempt was made by Hartgen to project travel and energy use for the State of New York for the period 1975-1995 (3). The projection was developed from a forecast of gasoline price and supply, improvements in average car efficiency, and population. It was estimated that travel would continue to grow slowly and rise 40-50 percent over 1975 levels by the year 1995.

A study in 1983 by Neveu resulted in models to forecast future-year AADT as a function of base-year AADT, modified by various demographic factors (4). It was found that the type of service the road provides (interurban, interregional, rural to urban, urban to rural) was the only factor that had a significant effect on traffic growth rates.

A recent study by Fricker and Saha resulted in two different types of models, aggregate and disaggregate, to forecast traffic volumes at rural locations on Indiana's state highway network (5). Independent variables used in both models were population, households, vehicle registrations, employment, and fuel price. A problem noted in this study that is common to development of other models of this type is the lack of information pertaining to future estimates of independent variables. Aggregate models represented four categories of rural highways and resulted in reasonably accurate estimates of future volumes. Disaggregate models were calibrated for specific traffic counting stations and the accuracy of prediction was very good as reflected by the correlation coefficients.

Annual tabulations of vehicle miles traveled in each state are compiled by the U. S. Department of Transportation in the publication titled "Highway Statistics" (6). Data are provided for vehicle miles traveled by highway categories and vehicle types. In recent years, travel growth in Kentucky has generally paralleled that in other states: Kentucky's growth was relatively more rapid in the 1970's but slowed somewhat in the 1980's (Figure 1). A comparison of vehicle miles traveled in 1980 and 1985 shows a 16.9-percent increase in travel nationwide as compared to a 13.0-percent increase in Kentucky. The growth in annual average daily traffic volume (AADT) on the typical highway generally mirrors the growth in vehicle miles of travel. However, the AADT on Kentucky roads has increased more rapidly than that in other states (Figure 2) largely because relatively more miles had been added to the road and street inventories in other states (Figure 3). Data detailing the trends in vehicle miles traveled, highway miles, and average annual daily traffic for Kentucky and for the United States as a whole are presented in Table 1.

A study completed in 1975 titled "Kentucky's Future Transportation Needs" focused on economic indicators and population projections as a means of estimating the demand for transportation facilities (7). The relationship between overall inflation and the rate of increase in transportation costs was noted with particular attention given to the "energy crises" of 1973-1974. Based on analysis of economic conditions and future population expectations, it was estimated that highway travel in Kentucky would increase at the rate of slightly over one percent per year even though annual growth rates during the previous 10 years had averaged 4.5 percent.

Forecasts of future traffic volumes for streets and highways within the state are needed by various offices of the Kentucky Transportation Cabinet as well as various local highway and planning organizations. Although many forecasting methodologies exist, these techniques are often complicated and not directly applicable to local conditions in Kentucky. They are often very time and data intensive, and they may be unresponsive to the needs of the user. Where use of those techniques is not practical, forecasts are often made by factoring counts of existing traffic volumes. These factors will generally be an estimated annual percentage increase.

Traffic volume estimates are an integral part of the planning, design, and operational functions. Each of these functions should benefit from the development of more reliable and more timely forecasts. Planning staffs should be able to make forecasts with confidence by relying on a representative data base and a procedure that is statistically acceptable. This could enhance assessments of future highway needs and improve responsiveness to requests for design traffic volumes. A flexible procedure would allow subjective input and permit designers to readily adjust traffic projections to amended design years. Improved reliability of traffic forecasts should contribute greatly to efficiency of design, lessening the probability of under- or over-designed facilities.

The objective of this study was to develop a procedure for estimating traffic volumes through the use of growth factors representative of Kentucky roads. The original proposal was to develop the growth factors so the changes in traffic volumes could be characterized by type of area, functional class of the highway, and volume group. It was also intended to investigate and, if possible, develop relationships between socioeconomic indicators and traffic volumes. The forecasting models were intended to represent project-level or site-specific needs in both rural and urban areas.

PREPARATION OF DATA

After preliminary consideration of model development, it was necessary to determine the types of data that were available for inclusion in prediction models. Several sources of data were initially considered. It was apparent that some form of traffic volume data would be the primary dependent variable. The independent variables would have to include several types of data characterizing the areas of the state and the classes of highways.

Possible sources of traffic volume data included the several files of volume data maintained by the Department of Highways' Division of Planning. Included were the Traffic Volume Summary (TVS) file, the permanent count station file, the Statewide Mileage Tape file (SMT), and the Highway Performance Monitoring System (HPMS) file. Each of the files has some advantages either in terms of accessibility or comprehensiveness of the data. The Traffic Volume Summary file was selected as the primary source of volume data because it was the most comprehensive file both in the context of statewide coverage and in terms of historical representation. To this file was added data from both the permanent count station file and toll road records. Altogether data were included for approximately 15,000 stations for the period 1963-1986. Annual counts included 3,000 to 5,000 stations, which resulted in an average number of about 5.8 years of data for each station included in the file. The distribution of the number of counts per station is as follows:

Extent of Data (Years)	Percentage of Stations	Extent of Data (Years)	Percentage of Stations
1	2.01	13	0.88
2	8.04	14	0.37
3	11.49	15	0.35
4	18.08	16	0.19
5	17.14	17	0.19
6	10.35	18	0.13
7	7.60	19	0.06
8	6.59	20	0.04
9	6.00	21	0.04
10	4.71	22	0.15
11	3.58	23	0.05
12	1.98		

In the early stages of analysis, the range of possible explanatory variables was large and insufficient analyses had been performed to select those with most potential for explaining traffic growth. In an attempt to be comprehensive, 26 candidate variables were selected and extracted from the Statewide Mileage Tape for further consideration (Table 2).

Several socioeconomic variables, such as population, personal income, automobile ownership, and fuel availability and price, affect travel and were considered as part of the overall study. Previous work by Pigman and Vaziri used two of these variables, disposable income and fuel price, to predict statewide travel in terms of vehicle miles traveled (8). Personal income data were obtained from the U.S. Department of Commerce, Bureau of Economic Analysis (9). Fuel price for gasoline in Kentucky was obtained from the Department of Highways' Division of Planning (10).

Other sources of data eventually used in the modeling process were Bureau of Census reports containing information that identified counties within Standard Metropolitan Statistical Areas (SMSA) and tabulated the applicable populations for counties during the period of analysis (11).

DEVELOPMENT OF HISTORICAL VOLUME FILE

After selecting the Traffic Volume Summary file as the primary source of volume data, the task of creating a file in a form suitable for modeling was begun. Preliminary work had been initiated by the Department of Highways' Division of Planning to produce a computerized file of volume data; however, only the most recent year of data was included in this file. As a result, it was determined that the file would be used only to obtain station characteristics and to compare the most recent year with comparable data from the paper file. All volume data on the paper file were transferred to a computer file and merged with the file containing station characteristics. At the beginning of the study, data were available for the period of 1963 through 1984. As data became available, the years 1985 and 1986 were added to the file. There were approximately 25,000 stations for which some counts were available. However, only a single count had been made at many of those stations and a large number were special counts for roads not on the state-maintained system. Only those stations on the state-maintained system were transferred into the computer file, primarily because descriptive characteristics were not available for other stations. Descriptive characteristics of interest in the original Traffic Volume file included the following: 1) county, 2) city, 3) route, 4) milepoint, 5) verbal description of the segment limits where the station was located, 6) station number, 7) type of station, 8) year of count, and 9) most recent traffic volume in the form of ADT. To insure that reasonably accurate data were being entered into the historical file, several editing procedures were implemented (APPENDIX A).

The process of converting 24 years of historical volume data from paper file to computer file was significant, and other progress on development of forecasting models was delayed until completion of this task. The compilation of volume data resulted in the Traffic Volume Summary file, which included data for the period of 1963 through 1986, containing 15,073 stations distributed among the counties as shown in Table 3.

ACCESSING AND USING THE TRAFFIC VOLUME SUMMARY FILE

Because of the apparent benefit of having historical volumes in computerized form, many potential uses were realized and a procedure to prepare the data file in a user-friendly form became an unplanned supplementary task of the research study. The result was a microcomputer file readily accessible with dBASE software. The historical file replaced the current-year volume file initially prepared by the Division of Planning and the result was a new file named, as before, the Traffic Volume Summary file. Procedures for accessing and using the Traffic Volume Summary file are presented in APPENDIX B.

Volume data for the typical counting station were not continuous over the entire 24-year period. As an aid to users needing volume estimates for years in which counts were unavailable, interpolations and/or extrapolations are made based on a weighted, least-squares calibration of the following linear growth curve:

$$ADT = a + b(Year) \quad (1)$$

in which ADT = average daily traffic, Year = date of calendar year, and a and b = calibration constants. Actually, an independent calibration is made for each estimate, and actual counts are weighted by the inverse of the absolute value of the interval (in years) between the date of the estimate and the date of the count. This piecewise linear procedure was selected after it was shown to yield consistently better estimates than either the more normal general linear model or an exponential model. To minimize the extent of erroneous estimation, estimates are not made unless at least four years of volume data are available, and extrapolations and interpolations are limited to years no further removed from an actual count than six years. Within the limits of available data, the traffic estimator may restrict the time interval on which the least-squares estimates are to be based to periods of greatest apparent accuracy.

UPDATING THE TRAFFIC VOLUME SUMMARY FILE

Realizing that a historical volume file would continue to be useful only if new data were continuously added to the file, plans were made to develop a procedure to update the Traffic Volume Summary file. Traffic counts continue to be made by the Department of Highways on a relatively large scale. These volume counts are presently being reviewed and compiled by the Division of Planning. Plans to automate the procedure of processing traffic count data have been made by the Division of Planning so the file may be periodically transferred to the Transportation Research Program for updating the forecasting models. (It should be noted that the file presently compiled by the Division of Planning does not include automatic traffic recorder volume data collected at permanent stations and volume data collected on the toll roads. Both of these types of volume data will have to be manually added to the Traffic Volume Summary file).

Procedures for updating the Historical Volume file (later renamed the Counts file) and the County file, which are used to prepare the Traffic Volume Summary file, are included as APPENDIX C. Also included in APPENDIX C is a file list that identifies all the program files necessary for the updating procedure.

DEVELOPMENT OF VOLUME FORECASTING MODEL

The primary purpose of this research effort was to develop a model for forecasting future traffic volumes (ADT) on Kentucky roads and streets. To be used for project-level analyses in either urban or rural locations, the model was to focus on rate of traffic growth and to incorporate the effects of socioeconomic and demographic variables. Neither time nor resources permitted exploration of the wide variety of models that had been used by others to forecast traffic volumes. A cross-tabulation model was initially selected for evaluation because of prior success with such a model in forecasting equivalent axleloads for pavement design (12, 13) and because many of the potential explanatory variables were categorical in nature. Although a limited examination of regression models was included in subsequent investigations and one regression model is incorporated as a component of the recommended forecasting algorithm, the original decision to use a cross-tabulation model proved to be a sound one.

The purpose of this section is to further explain development and calibration of the volume forecasting model.

CONCEPTUAL DEVELOPMENT OF MODEL

Numerous socioeconomic and demographic attributes--such as population, disposable income, automobile ownership, and fuel availability and price--affect travel generally and, in turn, at specific locations. To properly account for both general and specific effects, a two-stage modeling process was used. In the first stage, influences of statewide economic conditions on the overall growth in travel on Kentucky roads and streets are quantified. In the second stage, local effects--aggregated in this case to the county level--are used to explain how traffic growth on a particular facility is likely to deviate from the statewide trend.

Models applicable to the first stage had been evaluated in an earlier investigation (8), and the following regression model had been judged to be the most useful:

Vehicle Registrations = a + b (Personal Income) (2)

and

Vehicle Miles = c (Vehicle Registrations) + d (Fuel Price) (3)

in which all variables except fuel price represented statewide aggregations. To compute the average annual daily volumes (AADT) on Kentucky roads and streets, the following extension is necessary:

$$\text{Average Annual Daily Traffic} = \text{AADT} = \frac{\text{Vehicle Miles}}{365 \times \text{Miles of Highway}}. \tag{4}$$

To assure that the above model represents current conditions as accurately as possible, annual recalibration using only the most recent 20 years of data is envisioned. Forecasts of future AADT using this model require exogenous estimates of future personal income, fuel price, and miles of roads and streets in Kentucky.

Site-specific analysis occurs in the second stage of the process. Two models are necessary. The first enables estimates of current or base-year volume in the event the project involves new construction or in the event reliable current traffic counts are otherwise unavailable. The second describes how the volume is expected to grow in future years. In each case, the interest is with the relative levels of the site and statewide volumes. The measure of site volume selected for analysis was, therefore, the ratio of the site ADT to the statewide AADT, herein termed the volume ratio. The model for estimating the base-year volume ratio is termed the volume-ratio model and that for estimating growth rate, the growth-factor model.

Unlike the statewide AADT forecast for which an acceptable model had been developed in other earlier work, no models were available for estimating base-year volume ratio and its rate of growth. The early decision to examine cross-tabulation models focused attention on selection of the most relevant among the many possible explanatory variables and specification, where necessary in the case of continuous variables, of the levels or categories of interest.

Selection of candidate explanatory variables was driven in large part by two considerations: the necessity for keeping the models current by annual recalibration and expansiveness of the volume data base to be used in the calibration--volume data were available at approximately 15,000 sites. Potential explanatory variables thus had to be available largely from secondary sources and had to be formatted for direct computer input. The Statewide Mileage Tape proved to be the most useful source for much of the site-specific data including such information as highway classification, rural-urban location, number of lanes, etc. (Table 2). Suitable socioeconomic data were not available at site-specific locations. As a reasonable alternative, a primary data base consisting mainly of population data aggregated to the county level was created.

The statewide AADT model was built in such a way that forecasts of future levels of the explanatory variables must precede the future traffic volume estimation. The project-level volume-ratio model clearly did not demand such treatment: the base-year condition that the model was to estimate needed only to reflect the current--and perhaps past--levels of the explanatory variables. The growth-factor models could have been developed to reflect either current or future levels of the explanatory variables. Since there were no persuasive arguments favoring the use of future levels and since the use of current levels was considerably easier, the decision to use current or base-year levels of the explanatory variables for forecasts with the growth-factor model was an easy one.

In typical cross-tabulation models, sites grouped in the same cell are considered to be identical; the average entry for the group of sites is used to represent the most likely estimate for any particular site. Because it was necessary to exclude many explanatory variables with potentially strong links to traffic volume and its growth--such as proximity of the project to major activity centers and to rapidly developing land--and because of the highly variable nature of traffic volume even among sites that appear to be identical, it was deemed desirable to furnish estimates not only of most likely average measures but also of the extremes encountered among sites located in the same cell. Ultimately, three different estimates were tabulated: the 75th percentile representing a reasonable maximum limit, the 50th percentile representing the most likely estimate, and the 25th percentile representing a reasonable minimum limit. The forecaster is charged with the task of exercising professional judgment in selecting the most reasonable estimate for the project site based upon factors, qualitative or quantitative, not encompassed by the model's explanatory variables.

SELECTION OF DEPENDENT VARIABLES FOR SITE MODELS

As discussed above, two dependent variables are required for the site models, one representing the base-year volume ratio and the other representing its growth through time. For purposes of model calibration, the base year is normally the year for which the most recent data are available from the statewide counting program.

The first dependent variable to be treated herein is the base-year volume ratio. Although this variable is well defined, there remained two issues to be resolved with respect to the model calibration process. The first was how to handle sites at which base-year counts were not made. The second was whether to use a smoothing routine that utilized not only the base-year count but also prior counts to develop an "improved" base-year estimate.

Sites having data in the recent past but not in the base year could be handled by 1) applying a growth factor to the most recent data or 2) fitting a "smoothing" curve to the historical data and obtaining the base-year estimate by extrapolation. Either procedure would seem to be preferable to disregarding these sites in the modeling process; benefits of increasing the sample size outweighed possible loss in accuracy by using extrapolated estimates instead of measured quantities.

Early deliberations suggested that growth factors probably should be applied to the most recent data. The growth factors would be taken from the cross-tabulation cell in which the site was represented in the growth-factor model. The primary advantage of this procedure is that it enables sites having limited data, such as only one or two counts, to be used in modeling base-year volumes. The disadvantages are primarily two in number. First, the processes of creating the data base and modeling are somewhat complex. The growth-factor model would have to be completely developed before the base-year data base could be constructed. Second, the growth factor necessary for the extrapolation would represent a cell average, not conditions at the site in question. When coupled with the availability of an alternative, these disadvantages were judged to be compelling and the growth-factor method of extrapolation was abandoned.

The alternative was to perform the extrapolation using a trend line obtained by least-squares calibration based only on data at the particular site. The form of the growth curve should be the same as that used to obtain growth-factor estimates. For some sites, estimates of the base-year volume would be impossible or unwise to make. For example, fitting the growth curve requires a minimum of two or more data points, depending on the complexity of the growth model. Furthermore, estimates become increasingly questionable as the number of data points diminishes. In response to these and similar matters, it was decided to apply the same filtering criteria for both volume-ratio and growth-factor estimates. Ultimately, two such criteria were specified for data selection: 1) a minimum of four counts were required and 2) the available counts could not be widely scattered about the line of best fit.

For sites at which base-year counts were taken, the choice was whether to use the actual count or an estimate based on least-squares calibration of the trend line. The trend-line approach is desirable since it minimizes random and short-term variations observed when comparing volumes from year to year. On the other hand, if the estimate of the base-year count is a reliable one, certainly it should be used instead of an estimate of uncertain accuracy. Although the net effect of these factors is unclear, it was ultimately decided to use the trend-line estimate.

Regarding the second dependent variable, the growth factor, early thoughts favored the use of factors that did not require the assumption of a specific growth model for calibration. There would be one growth factor for each period of growth from 1 to a maximum of 20 years. Such factors would be developed, without extrapolation, from a smoothed curve fit to the actual volume-ratio data at each site. One difficulty with this approach stems from the assertion that future growth will mirror past growth. Incongruities, such as evident from the hypothetical example of Figure 4 at the transition from the smoothed curve in 1975 to the projection in 1976, unfortunately may be anticipated with this approach. As a result, its use was concluded to be of dubious merit and it was subsequently abandoned.

As an alternative, consideration was given to fitting a "generalized" curve to the historical data and developing growth factors from extrapolated estimates. For simplicity, the tested equation was a quadratic. Two specific problems, both related to the extrapolation, soon surfaced. Whether volume ratios were increasing or decreasing through time, the estimated change was unacceptably large for extrapolations sometimes not much beyond an interval as small as five years. The other problem involved historical data that exhibited a reversal in the direction of volume-ratio change. In such a case, the quadratic very adequately fit the historical data, but rapid change with time rendered the extrapolation useless.

Discouragement with these attempts turned attention to the more traditional approach in which growth factors are developed from simple additive or multiplicative models as shown below:

$$VR = a + b(\text{Year}) \tag{5}$$

and

$$VR = c\,(d)^{\text{Year}} \tag{6}$$

in which VR = the volume ratio, Year = the calendar year, and a, b, c, and d are constants.

In the additive model of Equation 5, the growth factor is the value of b. However for optimum effectiveness, the following normalization is required:

$$b' = \frac{b}{a + b(\text{Base Year})} \tag{7}$$

in which b' is the additive growth factor expressed as a fraction of the base-year volume. In the multiplicative model of Equation 6, the growth factor is the value of d, a number near one, that when multiplied by a preceding-year volume ratio yields the volume ratio for the following year.

Given the possibility of using either an additive or multiplicative growth model, it was necessary to ascertain if either was consistently superior in the accuracy with which it fit historical data. To evaluate this question, data accumulated from 1964 through 1984 at 33 ATR stations were evaluated. ATR stations that had been operated in Kentucky during this period were excluded from the analysis only if there were indications that their patterns of growth were "abnormal", typically because of the opening of parallel highways.

For each ATR station, both additive and multiplicative models were calibrated using least-squares procedures. The measure of merit was a coefficient of determination calculated as follows:

$$\text{Coefficient of Determination } (R^2) = \frac{\text{SUM}(AVR-MVR)^2 - \text{SUM}(AVR-PVR)^2}{\text{SUM}(AVR-MVR)^2} \tag{8}$$

in which $\text{SUM}(AVR-MVR)^2$ = the sum of the squares of the difference between the actual and mean volume ratios and $\text{SUM}(AVR-PVR)^2$ = the sum of the squares of the difference between the actual and predicted volume ratios. The coefficient of determination is an estimation of the fraction of the variance that is explained by the calibrated model. In the ideal environment, the coefficient of determination is bounded by 0 and 1. However, because a logarithmic transformation was used in the calibration of the multiplicative model, the coefficient of determination as calculated by Equation 8 may be negative. This indicates, of course, only that in such instances estimates from the multiplicative model are inferior to estimates based solely on the mean volume ratio. One situation in which this will always be true is when the volume ratio is unaffected by time: its mean historical value serves as the "best" estimate of its future value.

A summary of the results of this calibration process is included in Table 4. Detailed examination of this table reveals that coefficients of determination for the multiplicative model are generally slightly larger than those for the additive model. The same conclusion is evident from the graphical presentation of Figure 5. It must be noted, however, that the differences are quite small: they are certainly not large enough to indicate a clear preference for the multiplicative model in terms of its degree of fit to the historical data.

Fit to historical data is only one criterion useful in evaluating alternative growth models. Others include ease of use and likely success in forecasting future conditions. With respect to ease of use, the multiplicative model is probably slightly superior although the differences between model types must be considered to be so small as to be inconsequential. There is no good way to evaluate the extent to which model extrapolations will accurately forecast future conditions: almost certainly, the model that is superior under some circumstances will prove inferior under others.

It is useful, however, to examine extreme conditions. Regardless of whether the trend in volume ratio is increasing or decreasing, the multiplicative model is expected to yield a larger forecast of volume ratio. While this may be a conservative approach, the multiplicative model yields increasingly large annual growth increments when the overall trend is upward. Since there is no upper bound on the model estimates--as might, for example, reflect in situ highway capacity constraints--unrealistically large estimates will be made for years some distance into the future.

If the volume-ratio trend is downward and the annual decrements have historically been large, the additive model can produce unrealistic negative estimates of future conditions. The multiplicative model attenuates the decrement thus yielding more reasonable estimates.

One alternative that largely eliminates the above problems would be to use the additive model for growth situations and the multiplicative model for decay situations. One significant sacrifice by such a procedure is the added complexity of the model and the dual effort required during model calibration.

Although the above analysis suggested no strong preference for either the additive or multiplicative model of traffic volume growth, the multiplicative model was selected for use herein. Growth was expressed in the traditional way, by an annual percentage increment. Future volume ratios are thus calculated as follows:

$$VR_{fy} = VR_{by} \times (1 + GF/100)^n \qquad (9)$$

in which VR_{fy} = forecasted future-year volume ratio, VR_{by} = base-year volume ratio, GF = annual rate of growth in volume ratio expressed as a percent, and n = number of years of traffic growth from the base year to the future year.

SELECTION OF EXPLANATORY (INDEPENDENT) VARIABLES FOR SITE MODELS

Explanatory variables in the traffic growth models are of two types. One type includes variables that affect statewide travel generally. As a result of prior work, personal income, fuel price, and statewide highway mileage were selected to represent this type. The other type--used in the site models--is intended to represent local conditions that cause individual sites to differ from statewide average travel, either in terms of base-year quantity or growth trend. It is the purpose of this section to address the selection of explanatory variables of the second type.

Criteria for selecting the explanatory variables generally included the following:

- There should be a logical relationship between the dependent and the explanatory variables,
- The explanatory variables should be simple and well understood,
- The dependent variables should have a large mathematical correlation with the explanatory variables, and
- The explanatory variables should not have large mathematical correlations with each other.

In addition to the above general considerations, the large number of sites (cases) in the volume data base mandated the use of secondary, computer-accessible sources for collecting data to describe the explanatory variables. That is, it was impractical to collect new data on a site-specific basis. The most promising secondary source--and the only comprehensive one that encompassed all sites--was the Statewide Mileage Tape.

Potential explanatory variables coded on the Statewide Mileage Tape are identified on Table 2. The most promising of these variables were chosen subjectively using the above criteria: they are identified by a "Yes" in the rightmost column of Table 2.

To this set of six potential variables were added four others: base-year volume and three variables determined by the county within which the site is located including population change in prior 10 years, location within or outside a Standard Metropolitan Statistical Area (SMSA), and geographic area. The same geographic-area variable was employed as had been used in earlier work: the state was subdivided into four areas, East, North Central, South Central, and West (13).

Only base-year volume and county population change are continuous variables; all others are discrete or categorical in nature. Primarily for purposes of consistency, volume and population change were converted somewhat arbitrarily to categorical quantities. Originally four volume categories were evaluated based on ADT: less than 2,500 vehicles per day, 2,500 to 4,999 vehicles per day, 5,000 to 10,000 vehicles per day, and more than 10,000 vehicles per day. Later, the number of volume categories was expanded to eight to recognize the widely varying nature of travel on Kentucky roadways. County population change during the preceding 10 years was expressed as a three-level variable: more than 15 percent, from five to 15 percent, and less than five percent. These intervals were set to approximately equalize both the number of counties and the statewide population component in each of the three groups.

The quantitative assessment of the 10 potential explanatory variables was based primarily on the use of ANOVA. Initially, simple correlations were sought between each pair of the dependent and explanatory variables. While the volume ratio was reasonably correlated with several explanatory variables, particularly functional classification (Table 5), no explanatory variable was well correlated with the growth factor (Table 6). That the mean volume ratio was obviously impacted by the levels of the various explanatory variables much more significantly than the mean growth factor corroborates these findings (Table 7).

After an extensive investigation eliminated data processing errors as a reason for the lack of correlation between growth factors and the potential explanatory variables, attention was directed to other possibilities. An obvious one is scatter inherent in volume data and the often wide variations in volume at a particular site from year-to-year. One supposition was that estimates of the growth factor for individual sites would be weakest where the number of past observations of volume ratio was smallest. To test this notion, a filtering scheme that allowed separate model calibrations depending upon the number of data points available for each site was applied; this was varied from a minimum of four years of data to a minimum of 10 years of data. The regression model for this analysis employed volume and county population growth as explanatory variables. The original supposition that accuracy would improve with greater site selectivity was generally confirmed. Unfortunately, greater site selectivity also reduced the sample size, a factor that tended to reduce accuracy of the model. Ultimately, it was decided that the reduction in sample size resulting from greater selectivity could not be tolerated.

One significant result of this exercise was a rather large increase in the coefficients of determination, R^2 (Table 8). The increase, thought to be due primarily to inclusion of multiple explanatory variables in the model, was only slightly diminished when a cross-tabulation model was calibrated using the same explanatory variables. Cross-tabulation models also were calibrated using the following sets of explanatory variables:

Functional classification and volume code;
Functional classification, rural/urban code, SMSA code, and population growth code;
Federal-aid classification and SMSA code;
Federal-aid classification and volume code;
Federal-aid classification, SMSA code, and volume code; and
Route signing code, population growth code, and volume code.

None of these models proved to be as good as the original model that incorporated functional classification, volume code, and population growth code. Despite its low accuracy, no potential improvements to the model--short of searching for a new set of potentially significant explanatory variables--could be identified. A search for other new variables was impractical both due to time constraints and the lack of a secondary data base that might yield more valuable information than the Statewide Mileage Tape. Judgments of the traffic estimator, assisted by the high- and low-growth estimates provided by the model, are expected to yield more accurate estimates than indicated by such measures as the coefficient of determination alone.

Since there was no compelling reason to use the same explanatory variables in the volume-ratio model as in the growth-factor model, the volume-ratio cross-tabulation model was calibrated for several sets of explanatory variables identified as follows:

Functional classification, rural/urban code, SMSA code, and population growth code;
Functional classification and SMSA code;
Functional classification and geographic area code;
Functional classification, SMSA code, and geographic area code;
Federal-aid classification and rural/urban code;
Federal-aid classification and geographical area code; and
Federal-aid classification, geographical area code, and rural/urban code.

Coefficients of determination ranged from a low of 0.50 to a high of 0.71. That model yielding the largest coefficient of determination was selected as being the preferred one: it incorporated functional classification, rural/urban code, SMSA code, and population growth code as exploratory variables.

In summary, categorical explanatory variables serving as the basis for the volume-ratio model included the following:

- Development density (rural, small urban, and urbanized),
- Urbanization (SMSA county or non-SMSA county),
- Local population growth (more than 15-percent growth in county population during prior 10 years, 5 to 15 percent, and less than 5 percent), and
- Functional classification (in rural areas, Interstate, other principal arterial, minor arterial, major collector, minor collector, and local:

in small urban and urbanized areas, Interstate, other freeway or expressway, other principal arterial, minor arterial, collector, and local).

All combinations of the above levels of the explanatory variables were included in the model, yielding a matrix with a 108-cell maximum possible size.

Categorical explanatory variables serving as the basis for the growth-factor model included the following:

- o Development density (rural and urban--small urban and urbanized areas were collapsed into one category to compensate for the reduced cell size stemming from the addition of volume as an explanatory variable),
- o Volume level (ADT ranges of less than 625, 625-1,249, 1,250-2,499, 2,500-4,999, 5,000-9,999, 10,000-19,999, 20,000-40,000, and more than 40,000 vehicles per day),
- o Local population growth (more than 15-percent growth in county population during prior 10 years, 5 to 15 percent, and less than 5 percent), and
- o Functional classification (in rural areas, Interstate, other principal arterial, minor arterial, major collector, minor collector, and local: in small urban and urbanized areas, Interstate, other freeway or expressway, other principal arterial, minor arterial, collector, and local).

Eliminating the county population growth variable for Interstate highways because of its presumed lack of association with Interstate volume growth yields a growth-factor model matrix containing a maximum of 256 cells.

CALIBRATION OF STATEWIDE MODEL

The statewide volume model relates the traffic volume (AADT) on the typical Kentucky road or street to three explanatory variables: statewide personal income, fuel price, and total highway mileage. The process of model calibration requires information about two other variables: motor vehicle registrations and total vehicle miles of travel. The model is linear and is calibrated using standard regression techniques. Two variables, personal income and fuel price, must be adjusted to remove inflationary effects. Estimates of these monetary quantities, both for calibration and execution of the model, must be expressed in constant dollars; 1982 was chosen as the base year. Conversion of current-year estimations to the 1982 base requires use of a price deflator. Sources of data necessary for the complete model calibration are shown in Table 9.

The type of fuel used in the original statewide travel model (8) was leaded regular. Its cost was based on purchases at full-service locations in Frankfort, expressed in current dollars. Two changes were implemented herein. The first was to change the fuel type to unleaded regular, a type gradually replacing leaded fuel as a result of legal mandates by Congress. The second was to express the fuel cost in 1982 dollars. In addition to minimizing possibly confusing effects of inflation by using units of constant purchasing power, the fuel-price coefficient of the statewide model exhibited improved year-to-year stability as the model was recalibrated for the 1982 equivalent prices. Table 10 documents the conversion from the current price of leaded regular to the equivalent 1982 price of unleaded regular. Table 11 documents the conversion of personal income from current-year to 1982 dollars.

An independent estimate of statewide AADT may be made by extrapolating the historical trend line. Such an estimate may serve either as a check on estimates made using the statewide volume model or as a substitute for them if reasonable projections of the explanatory variables are impossible.

Figure 6 depicts the trend in statewide AADT from 1964 through 1985 and includes the results of fitting, by least-squares procedures, both additive and multiplicative models to the data. A growth factor of 2.48 percent of the 1985 AADT results from the additive model and a growth factor of 3.67 percent from the multiplicative.

As indicated by the coefficient of determination, the fit of the additive model is slightly better than that of the multiplicative model, a factor favoring the additive model. When extrapolations are made to the year 2000 (Figure 7), the multiplicative model yields an estimate significantly greater, approximately 32 percent, than that of the additive model. Although obviously a matter of opinion, the larger increase associated with the multiplicative model does not seem to be realistic. Accordingly, projections using the additive model were selected for use. Thus, in addition to calibrating the constants of Equations 2 and 3, the statewide volume model calibration also determines the annual, additive increment in statewide AADT.

The process of calibrating or recalibrating the statewide volume model is described further in APPENDIX D.

CALIBRATION OF SITE MODELS

Calibration of the volume-ratio and growth-factor models requires the use of five input files including the Traffic Volume Summary file, the Statewide Mileage Tape, two county files identifying whether or not each county is located in an SMSA and listing for each county the percentage change in population during the prior 10 years, and a file containing the statewide AADT. The Traffic Volume Summary file and the Statewide Mileage Tape are maintained as a routine matter by the Division of Planning and require no modifications prior to being used in recalibrating the two site models. The county files and the statewide AADT file, each of which contains not only current-year but also historical data, must be updated prior to each recalibration.

A computer program, written in FORTRAN for mainframe application, processes these files and prepares a SAS input file describing the dependent and explanatory variables for each site for which usable volume data are available. This intermediate file is then independently processed by two SAS applications, one of which calibrates the volume-ratio model and the other of which calibrates the growth-factor model. The output of each of these two SAS applications is a paper file containing the calibrated model.

With one exception, the dependent variables of the site models are computed based on fitting a multiplicative growth curve to historical data. The one exception is the use of actual base-year volume ratios in circumstances where data necessary to fit the curve are either unavailable or potentially inaccurate. At each specific site, a minimum of two counts must be available--representing volumes during two different years. Because the accuracy of the least-squares calibration increases with the number of counts, it was decided to require data for at least four years during the most recent 20-year period.

A second stipulation was developed for the purpose of identifying potentially inaccurate data, data that, because of sampling or other error, do not appear to accurately represent in situ conditions. Calibrations obtained with such data would likely be inaccurate--as indicated by low coefficients of determination--suggesting the coefficient of determination might be used in the site filtering process. As used herein, such coefficients are computed from Equation 8.

Coefficients of determination, based on multiplicative growth, were computed for a sample of 945 sites. These sites represented all from a larger sample of 1,600 that satisfied the criterion of four counts in the most recent 20 years. As expected, wide variation in the coefficient of determination was observed (Figure 8). Generally speaking though, a distinct pattern was evident: larger coefficients were obtained with larger growth factors. For sites demonstrating zero growth, the multiplicative curve yields a less accurate prediction than the simple mean, and negative coefficients of determination were occasionally obtained in this region. This pattern suggested that a simple criterion, such as requiring a minimum coefficient of determination, would be unacceptable.

A reasonably simple alternative would identify potentially inaccurate data as that whose coefficients of determination failed to meet the following criterion:

$$\text{Coefficient of Determination} \geq a * ABS(GF) - b \quad (10)$$

in which ABS = the absolute value function, GF = the growth factor in percent, and a and b = constants. This criterion demands a larger coefficient of determination for sites having rapidly growing or rapidly decaying volume ratios.

The constants "a" and "b" may be selected to assure that the number of rejected sites is not excessive and that there is some balance in the rejection of large-growth and large-decay sites. The effect of using an "a" of 12 and a "b" of 20 is demonstrated by Figure 8. Only four percent of the 945 sites--certainly a reasonable proportion of potentially inaccurate conditions--is rejected with such a criterion: large-growth and large-decay sites are rejected with approximately equal frequencies.

Similar analyses were performed using this criterion on eight subsets of the 945-site sample, grouped according to the number of counts used in fitting the growth curve. This analysis confirmed that the above criterion is acceptable for all sites, regardless of the extent of data available at each.

In summary, the following criteria were applied for selecting sites to be used in the model calibration process:

- Four counts must be available within the most recent 20 years and
- The coefficient of determination must exceed 12 * ABS(GF) - 20.

Of the approximately 15,000 sites represented in the 1986 Traffic Volume Summary file, approximately 28.7 percent was unacceptable because fewer than four counts were available during the 20-year calibration period. Only 3.7 percent was rejected as a result of the accuracy criterion. Thus, approximately 67.6 percent of the original sites remained for use in calibrating the models.

Another issue to be resolved before the models could be calibrated was selection of the year(s) at which values of the explanatory variables would be evaluated. For the volume-ratio model, this selection was quickly made: explanatory variables together with the volume ratio would be evaluated in the base year. For the growth-factor model, the issue was much less clear. Base-year values would better reflect current conditions and might be more accurate, but values from earlier years would more logically be representative of conditions explaining or "causing" the growth that had been observed. Although it could be argued that conditions 20 years ago were responsible for the growth that was being modeled, a compromise was struck by evaluating explanatory variables at mid-year of the 20-year evaluation period. Actually, it was possible to use mid-year conditions only for volume and population-growth variables. The other two explanatory variables, functional classification and rural/urban designation, were taken from the Statewide Mileage Tape, which contained only current information.

It was clear from the beginning of this study that no workable models could be developed that would capture the full effects of all socioeconomic, demographic, land use, and transportation system effects on traffic volume and its growth through time. This meant that, while the models would provide indispensable information, the traffic estimator would still be required to exercise considerable professional judgment in evaluating the host of conditions, both qualitative and quantitative, not explained by the models' parameters. This task could be eased somewhat by providing not only most likely estimates based on averages experienced at sites of similar attributes but also by providing estimates of extreme conditions. While a number of possibilities existed, 75th and 25th percentiles were selected to represent extreme conditions and 50th percentiles as average conditions.

When the volume-ratio and growth-factor models were first calibrated, considerable variability was noted from cell to adjacent cell, particularly for cells in which the sample size was relatively small. One way to reduce this variability and probably to improve predictive accuracy as well was to use a smoothing procedure. For both models, a linear least-squares procedure was used for smoothing with weights assigned on the basis of the sample size in each cell. For the volume-ratio model, the only explanatory variable available for smoothing--that is, the only one for which a uniform and monotonic effect could be hypothesized--was county population growth. Population growth was entered in the least-square equations as a variable represented by the codes, 1, 2, and 3 for slow-, moderate-, and fast-growing categories, respectively. For the growth-factor model, volume was available as a second explanatory variable. It was represented in a linear fashion by the codes 1 through 8, representing the eight volume categories of the model.

Output of the calibration process consists of cross-tabulation matrices containing both smoothed and unsmoothed estimates of 75th, 50th, and 25th percentiles. Also available to assist the traffic estimator in evaluating available information is the number of sites in each cell of the matrices. For the 1986 base year, the calibrated volume-ratio model is included in APPENDIX E. The corresponding growth-factor model is included in APPENDIX F.

The process of calibrating or recalibrating the volume-ratio and growth-factor models is described further in APPENDIX G.

FORECASTING PROCEDURES

Forecasts of future traffic volumes at a specific location on the Kentucky road and street system require the use of two types of models, one for forecasting average travel (AADT) on all Kentucky highways and the second for forecasting volume ratio and its growth at locations similar to the one under investigation. Accurate forecasts require up-to-date recalibration of these two models: a one-year recalibration cycle is recommended. Assuming that recently recalibrated models are available, the procedure for forecasting future travel (ADT) at a specific site may be generally described as follows:

- Estimate the base-year (current) average volume on all Kentucky roads;
- Estimate the base-year volume at the project site;
- Calculate the base-year volume ratio at the site, that is, the ratio of volume at the site to the statewide volume;
- Calculate the future-year volume ratio at the site by applying the forecasted growth to the base-year volume ratio;
- Forecast the future-year average volume on Kentucky roads; and
- Calculate the future-year volume at the site.

A detailed discussion of the forecasting sequence follows.

FORECAST OF STATEWIDE AADT

Forecasts of future-year statewide AADT do not vary from project to project. They are required only after recalibration and updating of the volume models unless there is reason to believe that significant changes in statewide travel are occurring in the interim. To assure consistency in volume estimates, statewide travel forecasts should be generated by a single central office. These forecasts may be distributed to others for use in preparing project-level forecasts.

Figure 9--a worksheet for documenting the statewide AADT forecasts--

outlines the general procedure. This worksheet provides space for forecasting average volumes for as many as 20 future years. The base year--which may be different from that used in formulating site-specific forecasts--is normally the year for which most recent data are available for calibrating the statewide model. The base-year statewide AADT and the annual change in AADT are taken directly from the model calibration.

Two methods are provided for generating future estimates of statewide AADT. One--termed Method 1 on the worksheet--entails a linear extrapolation of the volume trend. The future volume is the base-year volume to which is added an increment representative of past "growth". The second method--termed Method 2 and outlined on Sheet 2 of the worksheet--is a more complex procedure intended to reflect the effects of both economic conditions and extent of the street and highway system on future travel. The three input variables necessary for making forecasts using Method 2 include the future values of statewide Kentucky personal income in millions of 1982 dollars, the price per gallon of fuel in 1982 cents (unleaded regular at full-service locations in the Frankfort area), and the miles of roads and streets. Unfortunately, exogenous forecasts are available for only one of these variables, personal income (14). Estimates of future fuel price and highway mileage must be generated by the travel forecaster.

An example that demonstrates the procedure for forecasting future statewide average volumes in included as Figure 10. Estimates of the base-year volume and the incremental yearly change were taken from the calibrated statewide model (Table 12). Calculations to obtain Method 1 estimates were straightforward. Method 2 estimates were taken from Sheet 2 of Figure 10. U.S. Bureau of Economic Analysis forecasts (14) of statewide personal income were used, supplemented as necessary by linear interpolations to provide data for intermediate years (Table 13). Future fuel price was assumed to gradually increase from its present level to the level indicated by a linear projection of the 1964 to 1986 trend (Figure 11). While there has been a historical decline in highway mileage (Figure 12), the effect has been slight and there is little reason to believe that the decline will continue in the future. Accordingly, highway mileage was projected to remain constant at 69,500 miles, slightly below its 1986 level. Having thus established the level of all the independent variables in the statewide volume model, future-year estimates were obtained by the calculations indicated on the worksheet (Figure 10).

Method 1 estimates represent a compounded annual growth in statewide AADT of about 1.7 percent and Method 2, 1.6 percent. As a result of larger initial estimates, Method 2 estimates exceed those of Method 1 by approximately 11 percent. Since there were no overwhelming reasons for preferring one method to the other, the estimates recommended for design purposes were averages of the two independent estimates.

FORECAST OF SITE ADT

Once estimates of base-year and future-year statewide average volumes have been obtained, attention may be directed to the task of estimating site-specific volumes. The base-year site volume is preferably an actual count or the projection to the base year of a series of annual counts taken during the recent past. Once obtained, this volume is converted to a volume ratio through division by the statewide average volume.

If reliable site counts are unavailable, the base-year volume ratio may be estimated directly from the volume-ratio model. Four variables--representative of base-year conditions--are necessary to define the appropriate cells in the model: location in a rural, urban, or small urbanized area; functional classification of the facility; the rate of population growth in the county during the prior 10 years; and the location of the county with respect to SMSA boundaries. Following determination of these variables, estimates are available for the 75th-, 50th-, and 25th-percentile volume ratios. Normally the 50th-percentile estimate would be used unless there is reason to believe the site has a significantly larger (75th percentile) or smaller (25th percentile) volume than similar sites elsewhere.

The growth-factor model yields estimates of the growth (annual compounded percentage) in volume ratio as a function of local conditions. Local conditions--representative of those existing during the base year--are defined by functional classification of the facility, county population growth in the prior 10 years, and volume level. As before, estimates are obtained for 75th-, 50th-, and 25th-percentile levels, and independent judgments must be formed about the relationship between rate of traffic growth at the design site and those at similar sites elsewhere.

Finally, the future-year volume is calculated as follows:

$$ADT_{fy} = VR_{by} \times (1 + GF/100)^{n} \times AADT_{fy} \quad (11)$$

in which ADT_{fy} = future-year site ADT, VR_{by} = base-year site volume ratio, GF = annual growth factor expressed as a percentage, n = number of years between the base and future years, and $AADT_{fy}$ = future-year statewide AADT. A worksheet (Figure 13) is available for documenting the estimates.

To illustrate the procedure for estimating site volumes, a worksheet has been prepared for an example location, US 460 in Franklin County (Figure 14). Statewide average volumes, both base-year and future-year, were obtained from the example of Figure 10. Prior counts at the US-460 site were judged to be sufficiently reliable to yield an acceptable estimate of the base-year volume, in this case, 2,108 vehicles per day or a volume ratio of 1.830. Local condition codes representative of this site and used as independent variables in the forecasting procedure were recorded on Sheet 2 of Figure 14. SMSA and population-growth coding were facilitated by output created in the early volume ratio and growth factor model recalibration process (Table 14). Although unnecessary in this case because of the availability of acceptable historical volume counts, estimates were made using the volume-ratio model of the 75th-, 50th-, and 25th-percentile volume ratios at comparable sites elsewhere (Figures 15-17). These estimates showed that the base-year volume ratio (and volume) at the US-460 site was smaller than expected based on the pattern observed at similar sites elsewhere.

The growth-factor model (Figures 18-20) yielded estimates of the 75th-, 50th-, and 25th-percentile growth rates that, in turn, were used to produce similar percentile estimates of the future-year site volume (Sheet 2 of Figure 14). Because of nearby industrial development, even the 75th-percentile estimate (representing annual compounded growth of about 3.4 percent) was considered to underestimate future volume. Based on such judgment, a design volume of 6,100 vehicles per day, representing annual growth of approximately 4.5 percent, is recommended.

In applying the volume-ratio and growth-factor models, a word of caution is necessary. These models are of the cross-tabulation type and their accuracy is dependent on the size of the sample used to estimate each cell entry. A small sample size is likely to result in spurious estimates. In an attempt to produce less variable estimates, a smoothing routine based on a least-squares linear fit has been used. The estimator has at his disposal two sets of cross-tabulation matrices, one containing actual percentiles and the other containing the smoothed estimates of these percentiles. In deciding which set to use, consideration should be given to the sample size on which the cell percentiles were based. In either case, reliable project-level forecasts demand considerable judgment by the travel forecaster in evaluating the many site-specific effects not captured by the cross-tabulation models. The models should be relied upon only to provide first estimates and to bracket the most likely range in values.

IMPLEMENTATION

Results from this research study are a historical data base of traffic volume data and models to forecast traffic volumes. It is anticipated that engineers and planners will be able to use these results to review historical trends in volume at a specific site or to forecast project-level volumes. Historical, current, and future traffic volumes are used by several offices in the Kentucky Transportation Cabinet, as well as various local highway and planning organizations. Each of these agencies should be able to replace or supplement their present method of accessing and forecasting traffic volumes with the data base and models developed in this study.

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TABLE 1. SUMMARY OF VEHICLE-MILES TRAVELED, HIGHWAY MILES, AND AADT FOR KENTUCKY AND UNITED STATES

Year	Kentucky			United States		
	Vehicle-Miles Traveled (Millions)	Highway Miles	AADT (VPD)	Vehicle-Miles Traveled (Millions)	Highway Miles	AADT (VPD)
1966	14,773	70,085	577.5	930,497	3,697,950	689.4
1967	15,741	70,225	614.1	965,132	3,704,914	713.7
1968	15,691	69,909	614.9	1,015,649	3,684,085	755.3
1969	17,866	69,615	703.1	1,070,575	3,710,299	790.5
1970	18,897	69,071	749.6	1,120,705	3,730,082	823.2
1971	20,355	69,123	806.8	1,186,289	3,758,942	864.6
1972	21,775	69,639	856.7	1,268,342	3,786,713	917.7
1973	23,096	69,791	906.7	1,308,562	3,806,883	941.7
1974	22,543	69,933	883.2	1,289,645	3,815,807	926.0
1975	23,372	70,131	913.0		3,838,146	
1976	24,843	69,806	976.4	1,409,163	3,857,356	1,000.9
1977	25,732	69,938	1,008.0	1,476,567	3,867,400	1,046.0
1978	26,607	68,781	1,059.8	1,548,213	3,885,452	1,091.7
1979	25,994	68,952	1,032.8	1,538,283	3,902,861	1,079.8
1980	25,244	69,321	997.7	1,530,409	3,955,387	1,060.0
1981	25,195	68,429	1,008.7	1,550,271	3,852,697	1,102.4
1982	25,627	68,674	1,022.4	1,592,481	3,866,296	1,128.5
1983	26,719	69,150	1,058.6	1,649,106	3,879,638	1,164.6
1984	27,873	69,339	1,101.3	1,716,768	3,891,781	1,208.6
1985	28,520	69,460	1,124.9	1,774,762	3,861,934	1,259.0

TABLE 2. POTENTIAL EXPLANATORY VARIABLES FROM STATEWIDE MILEAGE TAPE

Variable	Number of Categories	Examples	Survived Initial Screening?
Place type	4	Incorporated, unincorporated	
Route signing	7	US, state, county	Yes
Domain	9	Private, state, Forest Service	
Government level of control	17	Similar to domain	
Administrative classification	6	Primary, rural secondary	Yes
Traffic status	4	Open or closed to traffic	
Federal-aid system	5	Interstate, primary, secondary	Yes
Toll	2	Toll, non-toll	
Development density	3	Rural, small urban, urbanized	Yes
Functional classification	12	Rural minor arterial, urban local	Yes
Special systems	13	ADH, Great River Rd, Forest	
Reversible lanes	3	None, lanes, roadway	
Special HOV lanes	9	HOV w/flow, buses only contra-flow	
Access control	3	Full, partial, none	Yes
Trucks/commercial vehicles	4	Permitted, prohibited, pkwy or not	
Public road	2	Public, non-public	
Right-of-way width	Continuous		
Shoulder (by dir)	10	W/ or w/o shldr, w/ or w/o frontage	
Pavement type (by dir)	24	Gravel, primitive, mixed bitumen	
Pavement width (by dir)	Continuous		
No. of lanes (by dir)	Integer		
Median type	10	1-way, divided w/NJ, undivided	
Urban area	44	Bardstown, Louisville	
Section subdivision			
Interstate lanes open 5 yr			
Defense highway network			

TABLE 3. LISTING OF NUMBER OF STATIONS BY COUNTY IN THE TRAFFIC VOLUME SUMMARY FILE FOR 1963-1986

County Name	Number of Stations	County Name	Number of Stations	County Name	Number of Stations
Adair	145	Grant	88	Mason	117
Allen	88	Graves	241	Meade	120
Anderson	72	Grayson	146	Menifee	54
Ballard	83	Green	98	Mercer	80
Barren	184	Greenup	126	Metcalfe	98
Bath	78	Hancock	82	Monroe	111
Bell	160	Hardin	268	Montgomery	112
Boone	136	Harlan	180	Morgan	105
Bourbon	80	Harrison	90	Muhlenburg	164
Boyd	144	Hart	142	Nelson	169
Boyle	97	Henderson	168	Nicholas	68
Bracken	68	Henry	115	Ohio	130
Breathitt	115	Hickman	130	Oldham	97
Breckinridge	149	Hopkins	243	Owen	101
Bullitt	114	Jackson	83	Owsley	61
Butler	105	Jefferson	449	Pendleton	79
Caldwell	135	Jessamine	101	Perry	130
Calloway	164	Johnson	121	Pike	242
Campbell	150	Kenton	205	Powell	117
Carlisle	100	Knott	70	Pulaski	273
Carroll	72	Knox	153	Robertson	42
Carter	166	Larue	99	Rockcastle	126
Casey	120	Laurel	196	Rowan	80
Christian	223	Lawrence	108	Russell	111
Clark	126	Lee	61	Scott	129
Clay	101	Leslie	58	Shelby	131
Clinton	116	Letcher	133	Simpson	85
Crittenden	85	Lewis	86	Spencer	51
Cumberland	66	Lincoln	126	Taylor	156
Daviess	247	Livingston	79	Todd	97
Edmonson	83	Logan	161	Trigg	103
Elliott	76	Lyon	68	Trimble	45
Estill	100	McCracken	208	Union	173
Fayette	236	McCreary	103	Warren	184
Fleming	142	McLean	138	Washington	111
Floyd	134	Madison	188	Wayne	112
Franklin	134	Magoffin	85	Webster	158
Fulton	161	Marion	110	Whitley	161
Gallatin	51	Marshall	166	Wolfe	88
Garrard	74	Martin	55	Woodford	93

TABLE 4. SUMMARY OF GROWTH FACTORS AND COEFFICIENTS OF DETERMINATION FOR ADDITIVE AND MULTIPLICATIVE MODELS

Station	Growth Factor (%)		Coefficient of Determination (%)	
	Additive	Multiplicative	Additive	Multiplicative
ATR 01	-2.03	-1.58	66.4	68.7
ATR 06	-2.99	-2.01	34.8	37.5
ATR 07	-0.99	-0.84	22.1	22.8
ATR 08	-2.72	-1.98	79.6	82.8
ATR 11	-0.78	-0.71	9.4	10.0
ATR 12	1.88	2.41	96.3	97.3
ATR 15	-4.24	-2.58	63.4	67.7
ATR 16	0.14	0.14	1.9	1.9
ATR 18	2.08	3.20	47.5	46.7
ATR 19	-0.04	0.05	0.0	-0.6
ATR 21	-6.41	-3.63	90.0	92.9
ATR 22	-0.22	-0.19	4.9	4.9
ATR 23	-0.85	-0.73	27.1	26.5
ATR 24	-3.63	-2.45	76.6	79.7
ATR 25	-0.44	-0.39	21.1	21.4
ATR 26	-1.59	-1.29	71.8	74.0
ATR 27	-1.70	-1.40	68.5	69.3
ATR 29	-1.70	-1.41	82.2	83.2
ATR 30	-1.45	-1.15	47.0	49.0
ATR 31	-2.88	-2.09	82.3	85.1
ATR 32	-2.32	-1.67	52.8	55.5
ATR 33	-2.31	-1.81	82.9	83.9
ATR 35	-0.97	-0.80	15.4	14.8
ATR 36	-2.22	-1.75	88.8	90.2
ATR 37	-4.82	-3.08	71.9	72.6
ATR 38	-2.10	-1.65	88.4	90.7
ATR 39	-4.09	-2.76	84.3	85.1
ATR 40	-0.50	-0.45	16.0	16.2
ATR 41	-0.11	-0.10	2.0	2.0
ATR 42	-0.01	-0.02	0.0	-0.1
ATR 45	-2.52	-1.88	75.4	78.6
ATR 84	1.43	1.76	73.3	71.6
ATR 99	-3.52	-2.49	85.7	86.8

TABLE 5. ANOVA RESULTS FOR CORRELATING VOLUME RATIO WITH POTENTIAL EXPLORATORY VARIABLES

Variable	Number of Categories	R^2	Means Statistically Different at 0.01 Probability?
Functional Class	12	0.69	Yes
Base-Year Volume	4	0.62	Yes
Federal-Aid System	5	0.49	Yes
Administrative Class	6	0.44	Yes
Route Signing	7	0.42	Yes
Development Density	3	0.33	Yes
Access Control	3	0.25	Yes
Urbanization	2	0.13	Yes
Geographic Area	4	0.06	Yes
County Population Growth	3	0.01	Yes

TABLE 6. ANOVA RESULTS FOR CORRELATING GROWTH FACTOR WITH POTENTIAL EXPLANATORY VARIABLES

Variable	Number of Categories	R^2	Means Statistically Different at 0.01 Probability?
Functional Class	12	0.02	Yes
Base-Year Volume	4	0.01	Yes
Federal-Aid System	5	0.01	Yes
Administrative Class	6	0.02	Yes
Route Signing	7	0.01	Yes
Development Density	3	0.00	No
Access Control	3	0.01	Yes
Urbanization	2	0.00	Yes
Geographic Area	4	0.03	Yes
County Population Growth	3	0.02	Yes

TABLE 7. EFFECT OF POTENTIAL EXPLANATORY VARIABLES ON DEPENDENT VARIABLES

Category	Code	Sample Size	Means: Volume Ratio	Means: Growth Factor
Functional Class[a]				
Rural, Principal, Interstate	1	114	18.11	0.59
Rural, Principal, Other	2	432	6.64	0.92
Rural, Minor Arterial	6	878	3.58	-0.25
Rural, Major Collector	7	3,154	1.89	-0.29
Rural, Minor Collector	8	3,252	0.60	-0.10
Rural, Local	9	752	0.72	-0.41
Urban, Principal, Interstate	11	66	52.80	-0.61
Urban, Principal, Other X-ways	12	38	16.37	2.71
Urban, Principal, Other	14	502	12.98	-0.40
Urban, Minor Arterial	16	795	8.03	-0.58
Urban, Collector	17	206	3.73	-0.08
Urban, Local	19	25	2.09	-1.26
Base-Year Volume				
<625 vpd	1	3,757	0.32	-0.38
625-1,249 vpd	2	1,684	0.95	0.06
1,250-2,499 vpd	3	1,566	1.87	0.00
2,500-4,999 vpd	4	1,364	3.80	0.05
5,000-9,999 vpd	5	1,011	7.37	-0.11
10,000-19,999 vpd	6	624	13.71	-0.62
20,000-40,000 vpd	7	194	25.89	-0.70
>40,000 vpd	8	42	66.51	-0.56
Federal-Aid System				
Interstate	1	180	30.83	0.59
Other Federal-Aid Primary	2	1,816	6.90	0.08
Federal-Aid Urban	3	1,052	7.73	-0.56
Federal-Aid Secondary (Rural)	4	3,154	1.89	-0.29
Non-Federal Aid	8	4,040	0.64	-0.16
Administrative Class				
Primary	1	180	30.83	0.59
Secondary	2	77	4.95	2.29
Local	3	1,817	7.51	-0.09
Other	4	3,803	2.97	-0.38
Rural Secondary	5	3,569	0.84	0.00
Unclassified	6	796	1.10	-0.74

TABLE 7. EFFECT OF POTENTIAL EXPLANATORY VARIABLES ON DEPENDENT VARIABLES (CONTINUED)

Category	Code	Sample Size	Means: Volume Ratio	Means: Growth Factor
Route Signing				
Interstate	1	180	30.83	0.59
US	2	1,999	7.23	-0.53
State	3	8,063	1.83	-0.12
County	4	0		
Township	5	0		
Municipal	6	0		
None of the above	7	0		
Development Density				
Rural	1	8,582	1.93	-0.15
Small Urban	2	987	7.55	-0.37
Urbanized	3	673	16.01	-0.37
Access Control				
Full	1	282	22.79	1.19
Partial	2	27	13.54	0.71
None	3	9,933	2.81	-0.23
Urbanization				
Inside SMSA	1	2,047	7.49	-0.08
Outside SMSA	0	8,195	2.37	-0.21
Geographic Area				
West	1	2,029	2.68	-0.70
South-Central	2	2,616	2.28	-0.40
North-Central	3	2,658	6.13	-0.20
East	4	2,939	2.68	0.50
County Population Growth[b]				
< 5% in 10 years	1	4,642	3.37	-0.73[c]
5-15% in 10 years	2	4,405	3.27	-0.34[d]
> 15% in 10 years	3	1,195	3.93	0.25[e]

[a] Excludes 28 locations having functional classification code of 15.

[b] Ending in base year for volume-ratio estimation and midyear of 20-year period for growth-factor estimation.

[c] Sample size--1,703

[d] Sample size--4,766

[e] Sample size--3,773

TABLE 8. REGRESSION MODELS FOR GROWTH-FACTOR ESTIMATION

	N	n	a_0	a_1	a_2	R^2
Rural						
Principal Interstate	9	108	0.235	0.025		0.048
Principal Other	4	429	-0.671	0.105	0.070	0.116
Minor Arterial	8	414	-2.149	0.286	0.057	0.186
Major Collector	8	1389	-1.403	0.320	0.027	0.111
Minor Collector	7	443	-1.293	0.608	0.042	0.124
Local	10	7	2.794	-0.425	0.008	0.254
Urban						
Principal Interstate	10	52	2.933	-0.038		0.245
Principal Other X-way	9	27	3.613	-0.071	0.073	0.271
Principal Other	9	88	-2.184	0.072	0.094	0.226
Minor Arterial	4	735	-1.076	0.037	0.026	0.021
Collector	9	5	0.603	-0.115	0.199	0.338
Local	4	20	-3.218	0.500	0.028	0.179

Legend: N = minimum number of years of data; n = sample size; a_0, a_1, a_2 = constants in following equation:

Growth Factor = $a_0 + a_1$ (ADT/1000) + a_2 (% Population Change)

TABLE 9. SOURCES OF DATA FOR STATEWIDE MODEL CALIBRATION

Data	Source
Motor Vehicle Registrations	U.S. Department of Transportation, Federal Highway Administration, Highway Statistics, Annual
Vehicle Miles of Travel	Same as above
Miles of Streets and Highways	Same as above
Personal Income (Current-Year Dollars)	U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, August Issue
Price Deflator	U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, Monthly (See entry under "Personal Consumption Expenditures" in Table 7.4, "Implicit Price Deflator for Gross National Product," National Income and Product Accounts Tables)
Fuel Price (Current-Year Dollars)	Kentucky Department of Highways, Division of Planning

TABLE 10. HISTORICAL FUEL PRICES

Year	Leaded Regular Current Cents	Unleaded Regular Current Cents	Ratio Leaded to Unleaded	Unleaded Regular Extrapolated	Price Deflator (1982 = 100)	Unleaded Regular 1982 Cents
1964	33.9			35.2	35.0	100.6
1965	33.9			35.2	35.6	98.9
1966	33.9			35.2	36.7	95.9
1967	34.9			36.2	37.6	96.3
1968	35.9			37.3	39.3	94.9
1969	35.9			37.3	41.0	91.0
1970	37.9			39.3	42.9	91.6
1971	37.9			39.3	44.9	87.5
1972	39.9			41.4	46.7	88.6
1973	51.9			53.9	49.6	108.7
1974	55.9			58.0	54.8	105.8
1975	58.9			61.2	59.2	103.4
1976	64.9			67.4	62.6	107.7
1977	67.9			70.5	66.7	105.7
1978	71.9			74.6	71.6	104.2
1979	103.0			106.9	78.2	136.7
1980	127.3	131.9	1.0361	131.9	86.6	152.3
1981	139.0	143.1	1.0295	143.1	94.6	151.3
1982	133.2	139.0	1.0435	139.0	100.0	139.0
1983	130.8	135.8	1.0382	135.8	104.1	130.4
1984	128.7	134.1	1.0419	134.1	108.1	124.0
1985	128.9	134.1	1.0403	134.1	111.9	119.8
1986	99.1	105.9	Outlier	105.9	114.2	92.7
AVERAGE			1.0382			

TABLE 11. KENTUCKY PERSONAL INCOME DURING 1964-1986

Year	Statewide Personal Income in Current-Year Dollars (Millions)	Price Deflator (1982=100)	Statewide Personal Income in 1982 Dollars (Millions)
1964	5,976	35.0	17,074
1965	6,491	35.6	18,233
1966	7,098	36.7	19,340
1967	7,665	37.6	20,386
1968	8,373	39.3	21,305
1969	9,204	41.0	22,449
1970	10,003	42.9	23,317
1971	10,824	44.9	24,107
1972	11,965	46.7	25,621
1973	13,477	49.6	27,171
1974	15,426	54.8	28,150
1975	16,609	59.2	28,056
1976	18,582	62.6	29,684
1977	20,725	66.7	31,072
1978	22,944	71.6	32,045
1979	25,853	78.2	33,060
1980	27,994	86.6	32,326
1981	31,465	94.6	33,261
1982	33,515	100.0	33,515
1983	34,604	104.1	33,241
1984	38,347	108.1	35,474
1985	40,328[a]	111.9	36,039
1986	41,496[a]	114.2	36,336

[a]Preliminary estimates.

TABLE 12. STATEWIDE AVERAGE VOLUME MODEL

CALIBRATION OF STATEWIDE AVERAGE VOLUME MODEL

Date of Calibration: September 15, 1987
Name of Calibrator: John A. Deacon

YEAR	MOTOR-VEHICLE REGISTRATIONS (Thousands)	VEHICLE MILES (Millions)	HIGHWAY MILES	PERSONAL INCOME (1982 Million$)	FUEL PRICE (1982 Cents)	AVERAGE ADT
1964	1418.8	13114	69849	17074	100.6	514.4
1965	1500.0	13969	70145	18233	98.9	545.6
1966	1574.6	14773	70085	19340	95.9	577.5
1967	1632.4	15741	70225	20386	96.3	614.1
1968	1690.6	15691	69909	21305	94.9	614.9
1969	1712.8	17866	69615	22449	91.0	703.1
1970	1762.5	18897	69071	23317	91.6	749.6
1971	1860.0	20355	69123	24107	87.5	806.8
1972	1967.6	21775	69639	25621	88.6	856.7
1973	2090.7	23096	69791	27171	108.7	906.7
1974	2164.1	22543	69933	28150	105.8	883.2
1975	2245.1	23372	70131	28056	103.4	913.0
1976	2350.1	24843	69706	29684	107.7	976.4
1977	2449.7	25732	69938	31072	105.7	1008.0
1978	2543.9	26607	68781	32045	104.2	1059.8
1979	2605.5	25994	68952	33060	136.7	1032.8
1980	2592.7	25244	69321	32326	152.3	997.7
1981	2593.4	25195	68429	33261	151.3	1008.7
1982	2615.3	25627	68674	33515	139.0	1022.4
1983	2620.8	26719	69150	33241	130.4	1058.6
1984	2576.6	27873	69339	35474	124.0	1101.3
1985	2614.8	28520	69460	36039	119.8	1124.9
1986	2680.9	29252	69596	36336	92.7	1151.5

Least-squares calibration using the most recent 20 years of data yields the following:

Vehicle Registrations = a + b (Personal Income)

a = 143.3679   b = 7.245322E-02

Vehicle Miles = c (Vehicle Registrations) + d (Fuel Price)

c = 13.05204   d = -54.6365

Annual additive increments

Statewide ADT: 25.91696 vehicles per day
Statewide highway miles: -38.00301 miles

TABLE 13. KENTUCKY PERSONAL INCOME PROJECTIONS FOR 1991-2010

Year	Statewide Personal Income in 1972 Dollars (Millions)	Statewide Personal Income in 1982 Dollars (Millions)
1991	20,553	44,012
1992	20,980	44,926
1993	21,407	45,840
1994	21,834	46,754
1995	22,261	47,668
1996	22,664	48,530
1997	23,066	49,392
1998	23,469	50,254
1999	23,871	51,116
2000	24,274	51,979
2001	24,685	52,858
2002	25,095	53,737
2003	25,506	54,616
2004	25,916	55,495
2005	26,327	56,375
2006	26,712	57,200
2007	27,097	58,024
2008	27,483	58,849
2009	27,868	59,674
2010	28,253	60,499

TABLE 14. SMSA AND POPULATION GROWTH CATEGORIES FOR KENTUCKY COUNTIES

COUNTY NO.	SMSA CODE 1=SMSA 0=NON-SMSA	PERCENT GROWTH IN COUNTY POPULATION FOR 10-YEAR PERIOD ENDING IN EACH OF MOST RECENT FIVE YEARS (82-86)				
1	0	8	7	9	8	6
2	0	7	7	6	6	7
3	0	26	27	26	24	25
4	0	-2	0	0	0	-4
5	0	13	13	11	7	4
6	0	6	7	5	4	4
7	0	6	4	4	1	-1
8	1	38	37	34	33	31
9	1	2	1	2	1	3
10	1	3	4	3	1	0
11	0	8	8	9	7	5
12	0	1	0	-1	0	-1
13	0	14	11	9	5	2
14	0	8	9	7	7	4
15	1	45	41	34	32	26
16	0	8	8	10	7	2
17	0	3	2	1	0	0
18	0	8	6	4	0	0
19	1	-6	-5	-3	-5	-4
20	0	0	0	0	-4	-7
21	0	12	5	8	6	6
22	1	22	20	17	11	8
23	0	13	9	8	4	3
24	1	15	0	-5	-3	-4
25	1	10	10	9	8	7
26	0	19	18	16	11	8
27	0	10	12	11	10	10
28	0	0	0	-1	0	-2
29	0	8	5	6	5	4
30	1	8	7	7	6	5
31	0	6	15	19	16	10
32	0	14	15	12	8	4
33	0	6	11	11	9	7
34	1	12	11	8	9	7
35	0	5	6	6	4	2
36	0	25	25	23	18	12
37	0	19	17	17	14	12
38	0	-14	-11	-10	-12	-13
39	0	12	8	8	6	6
40	0	19	17	17	11	14
41	0	24	23	24	22	18
42	0	4	3	1	0	0
43	0	19	21	21	14	11
44	0	3	3	3	1	0
45	1	13	13	11	8	4
46	0	8	12	11	8	8
47	0	13	30	22	15	8
48	0	6	5	4	2	0
49	0	8	6	5	5	5
50	0	6	4	8	9	3
51	1	13	12	13	13	12
52	0	17	18	18	14	13
53	0	-6	-10	-11	-8	-9
54	0	15	13	9	6	4
55	0	19	16	15	14	11

TABLE 14. SMSA AND POPULATION GROWTH CATEGORIES FOR KENTUCKY COUNTIES (CONTINUED)

56	1	-3	-3	-3	-3	-3
57	1	42	37	29	27	26
58	0	27	30	29	22	15
59	1	5	3	3	3	3
60	0	14	15	13	10	5
61	0	19	16	13	11	5
62	0	7	5	8	6	6
63	0	37	35	33	29	23
64	0	22	25	24	18	10
65	0	9	11	12	9	5
66	0	21	20	21	15	9
67	0	16	20	14	6	1
68	0	14	14	9	7	4
69	0	8	10	9	6	4
70	0	14	11	8	4	0
71	0	8	11	11	13	13
72	0	11	7	6	7	4
73	0	2	3	3	2	0
74	0	20	16	17	15	12
75	0	3	4	2	0	-2
76	0	21	19	14	12	10
77	0	28	24	25	18	13
78	0	6	6	5	4	2
79	0	19	19	16	13	11
80	0	38	36	31	23	17
81	0	3	0	0	0	-2
82	0	24	24	21	21	15
83	0	20	19	17	14	12
84	0	14	8	7	6	5
85	0	16	18	16	15	12
86	0	2	1	3	0	0
87	0	21	19	16	14	11
88	0	17	16	12	8	3
89	0	10	8	7	4	2
90	0	18	17	18	18	17
91	0	11	9	6	2	0
92	0	9	6	8	5	0
93	1	92	82	75	63	54
94	0	14	17	14	14	11
95	0	5	9	7	4	1
96	0	3	3	0	3	3
97	0	21	22	18	13	9
98	0	23	23	20	13	9
99	0	44	38	35	31	28
100	0	22	22	20	17	13
101	0	-1	1	1	-2	-4
102	0	9	9	12	9	9
103	0	6	6	7	5	2
104	0	21	24	22	20	14
105	1	20	18	14	14	12
106	1	20	20	18	16	13
107	0	8	7	2	4	2
108	0	6	7	4	4	6
109	0	15	17	17	16	12
110	0	4	1	-2	-5	-5
111	0	9	5	4	6	5
112	0	18	13	8	5	5
113	0	14	11	8	7	4
114	0	27	30	29	27	26
115	0	0	0	-2	-3	-2
116	0	18	14	13	11	11
117	0	8	7	6	6	2
118	0	28	31	26	21	16
119	0	17	16	15	12	4
120	1	20	18	14	9	9

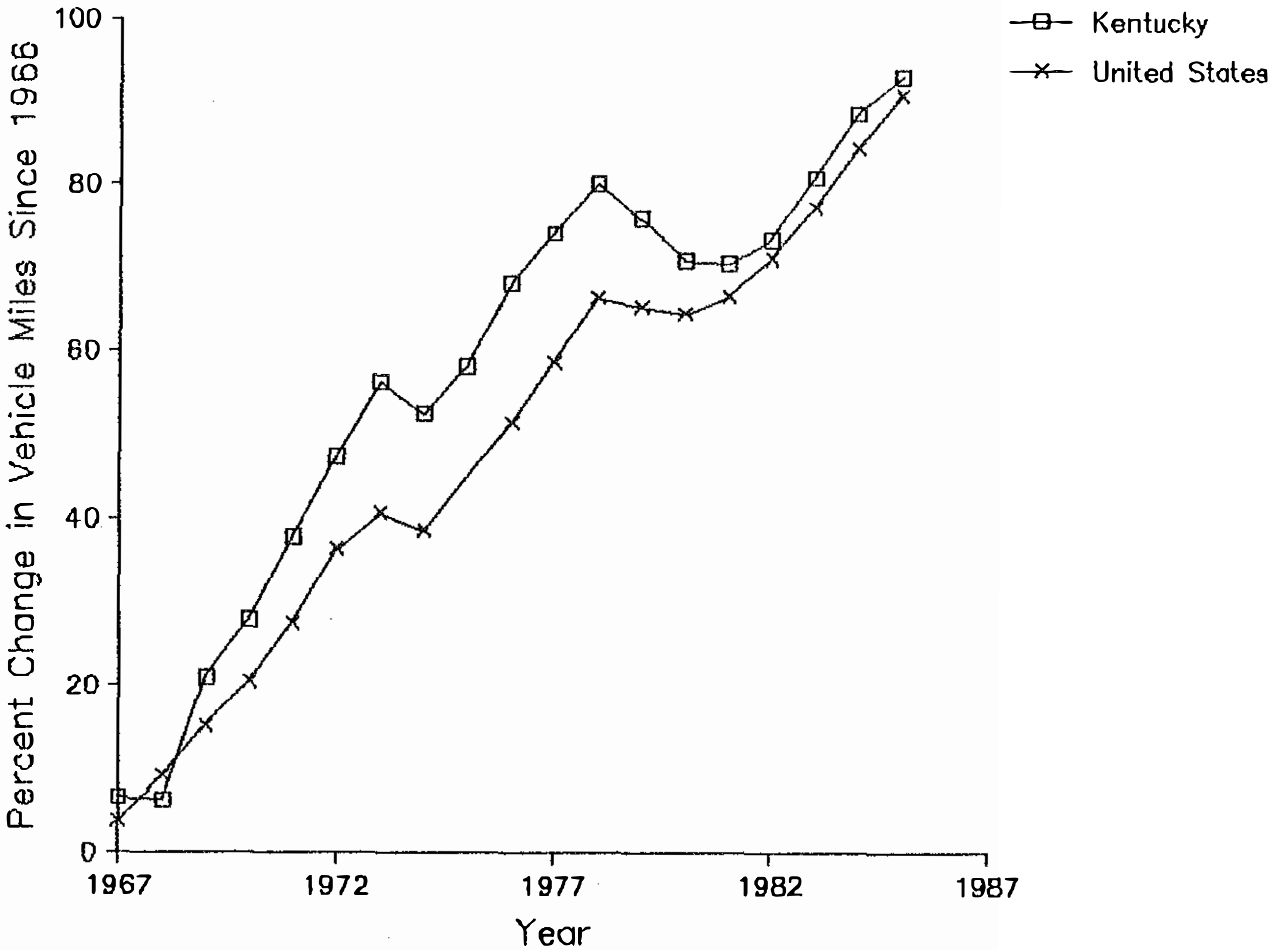


FIGURE 1. GROWTH IN VEHICLE MILES OF TRAVEL IN KENTUCKY AND THE UNITED STATES

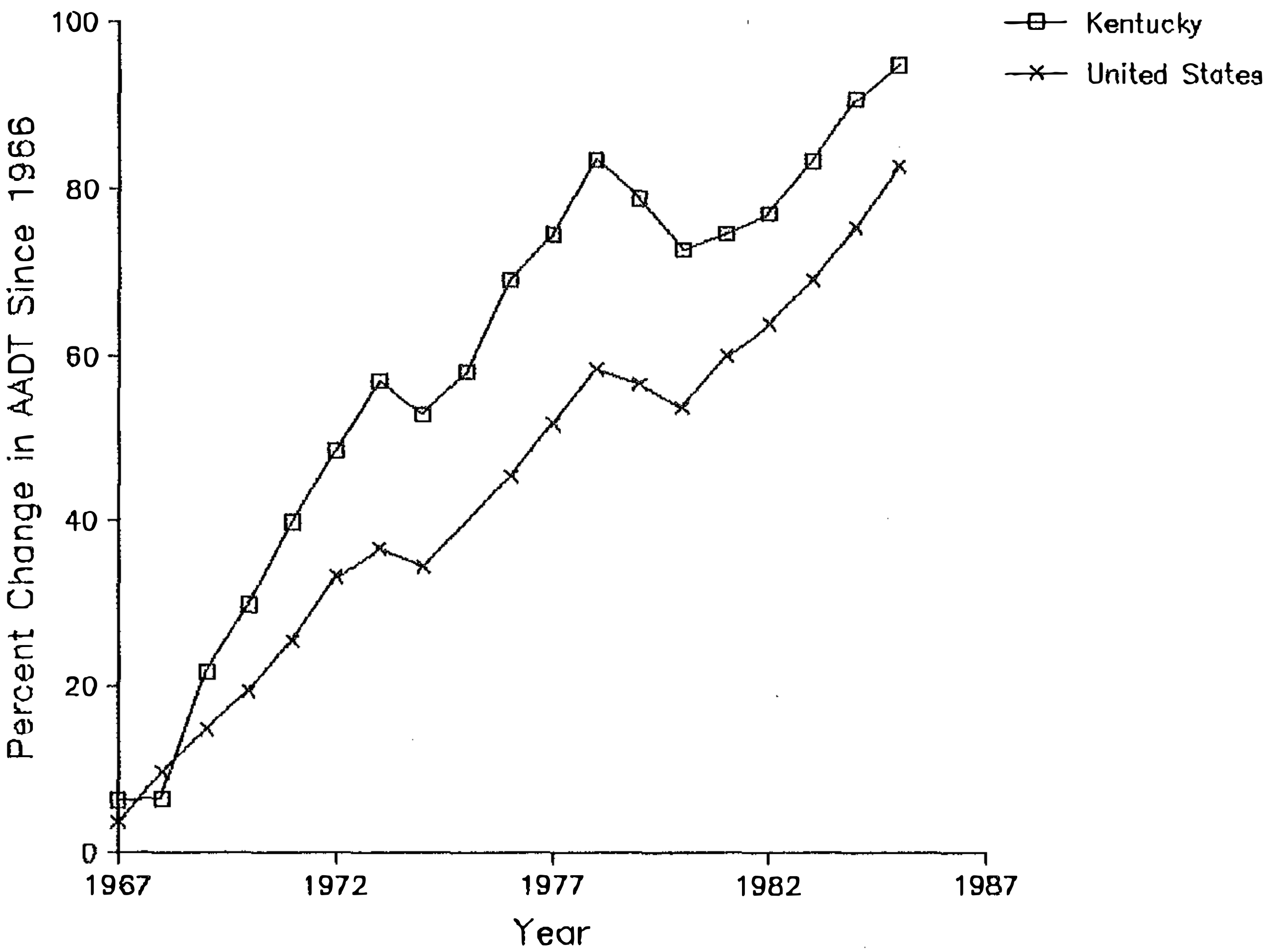


FIGURE 2. GROWTH IN ANNUAL AVERAGE DAILY TRAFFIC IN KENTUCKY AND THE UNITED STATES

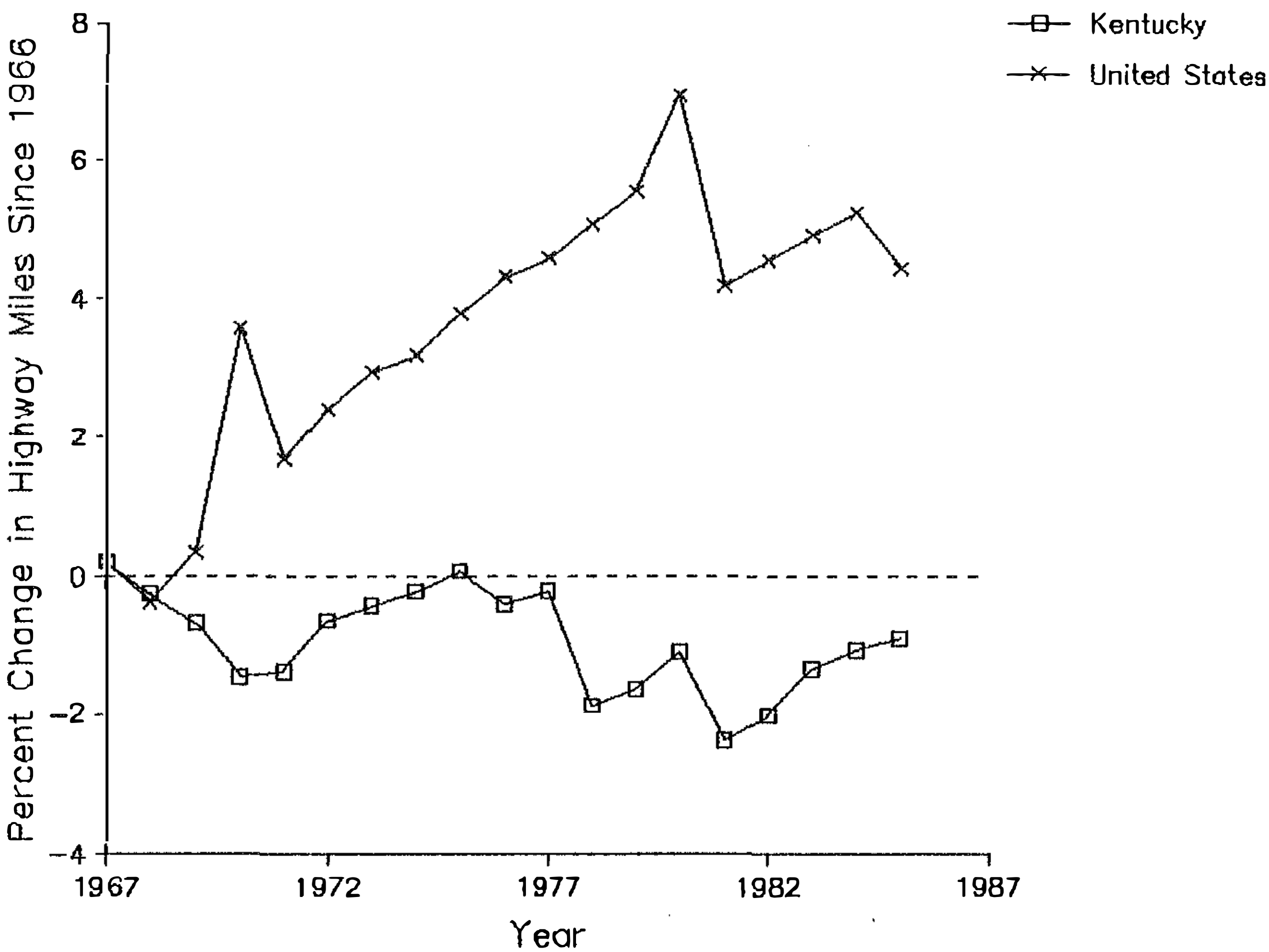


FIGURE 3. GROWTH IN MILES OF ROADS AND STREETS IN KENTUCKY AND THE UNITED STATES

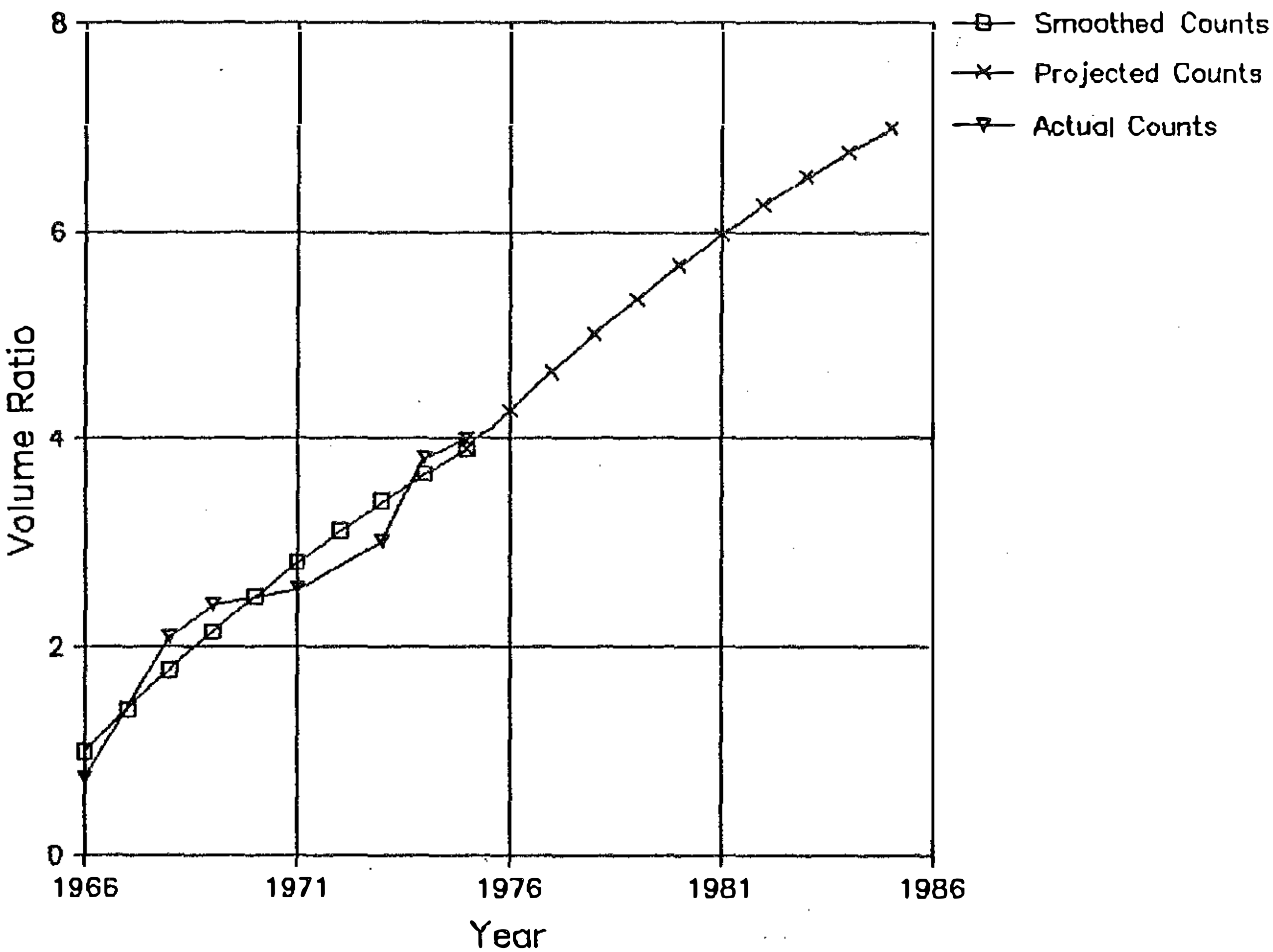


FIGURE 4. ILLUSTRATION OF INCONGRUITY LIKELY WITH NUMERICALLY DERIVED GROWTH FACTORS

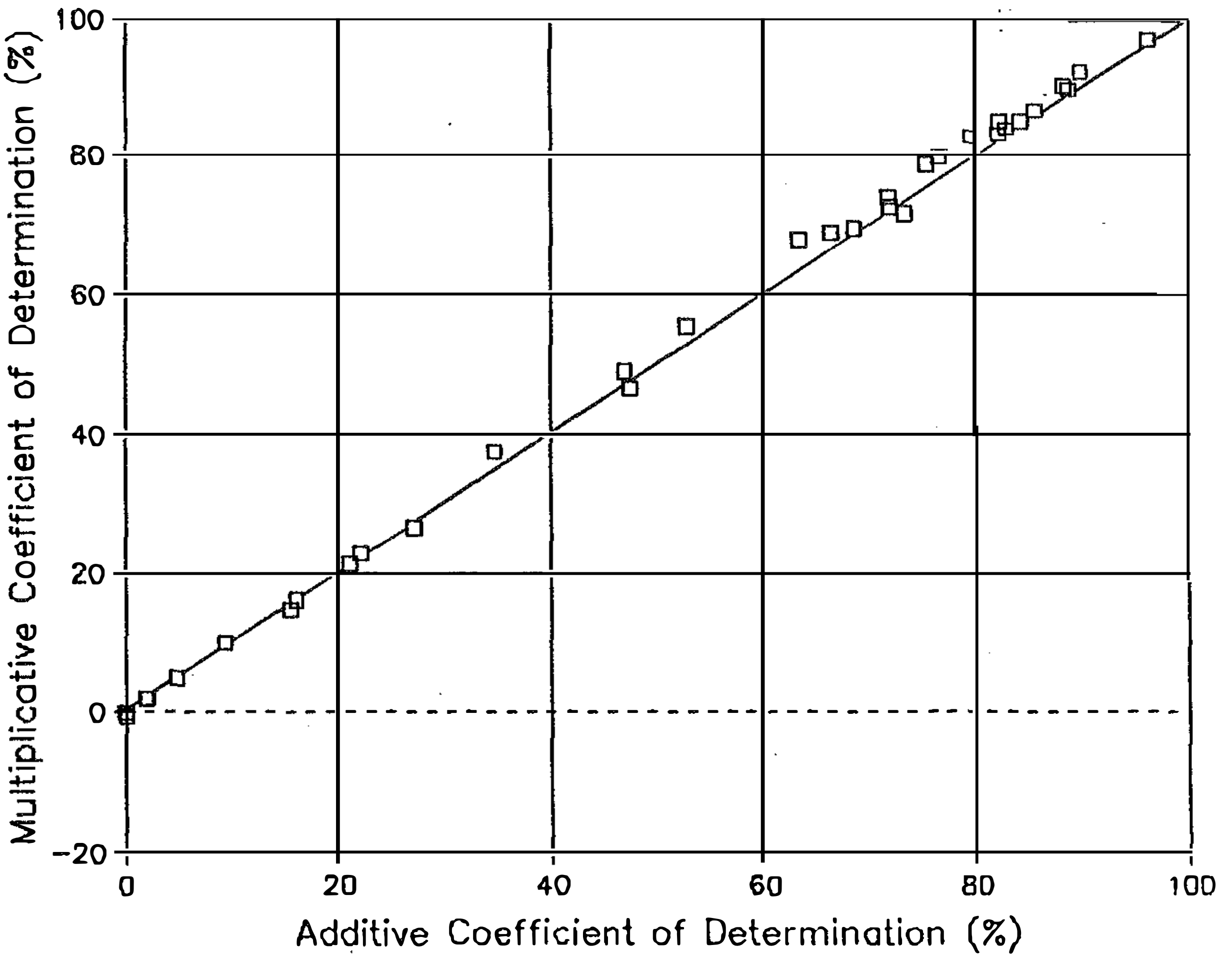
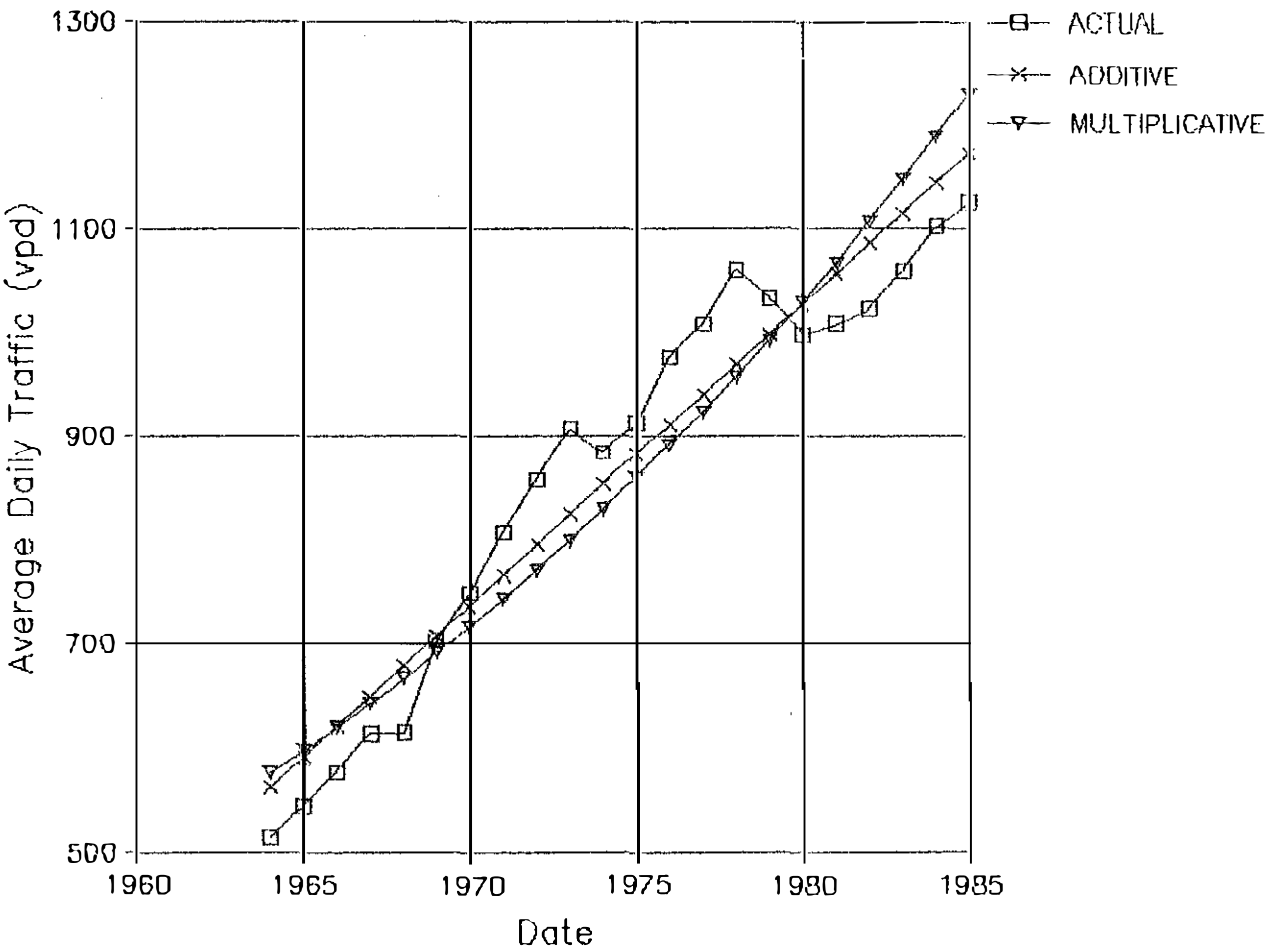


FIGURE 5. COMPARISON OF COEFFICIENTS OF DETERMINATION FOR ADDITIVE AND MULTIPLICATIVE MODELS OF TRAFFIC GROWTH



RESULTS OF LEAST-SQUARES CURVE FITTING

	Additive	Multiplicative
Coefficient of Determination	92.70862	86.67210
a	-56391.4	1.00e-28
b	28.99898	1.036723
b'	.0247518	

FIGURE 6. CALIBRATION OF STATEWIDE AADT TREND LINE

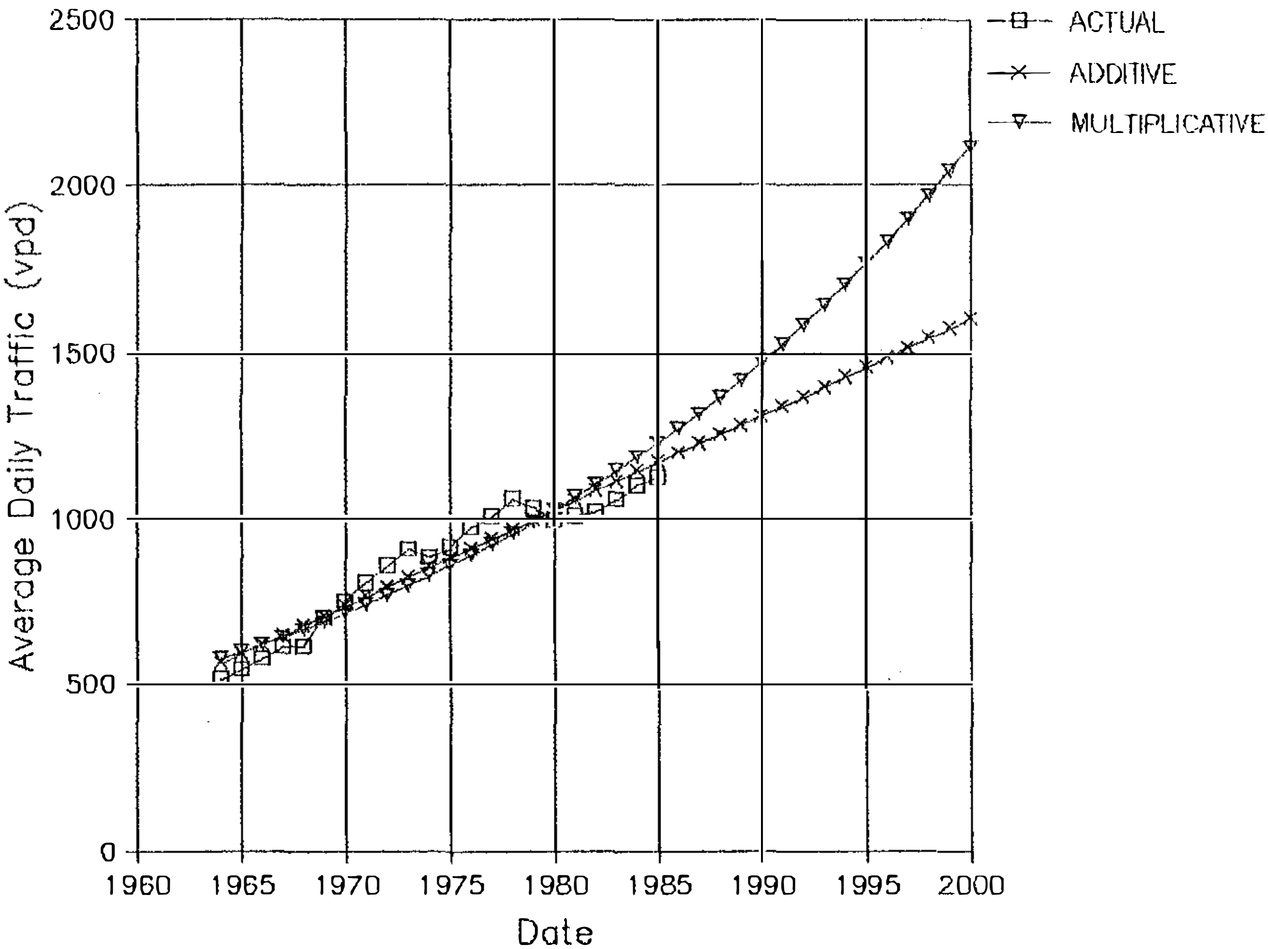


FIGURE 7. PROJECTION OF STATEWIDE AADT TO THE YEAR 2000

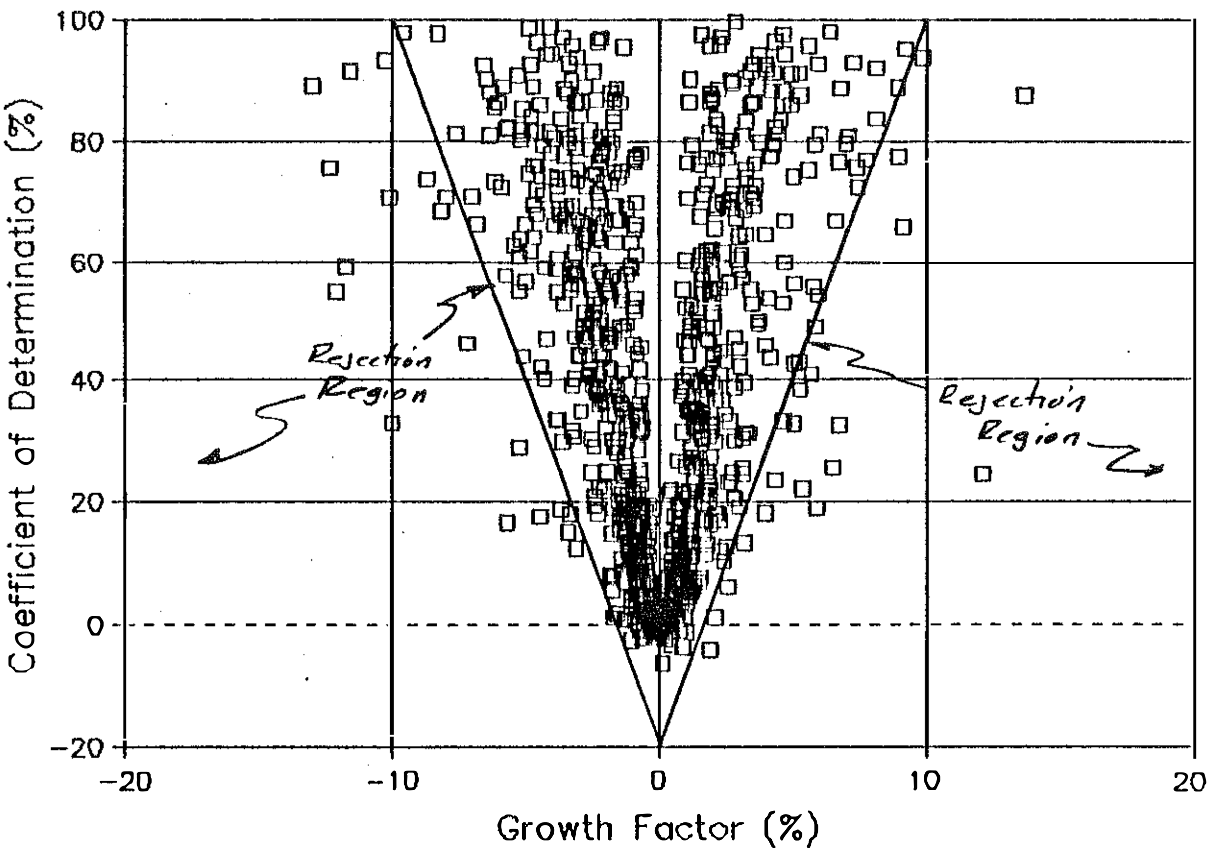


FIGURE 8. VARIATION IN COEFFICIENT OF DETERMINATION WITH GROWTH FACTOR

FORECAST OF STATEWIDE AADT

Date of Forecast____________________ Name of Forecaster____________________

FUTURE-YEAR STATEWIDE AADT

Base-Year Statewide AADT______________ **Date of Base Year**________
(From Statewide Model)

Historical Yearly Change in Statewide AADT__________
(From Statewide Model)

Future Date	Method 1 (Projection Based on Trends)			Method 2 (From Sheet 2)	Future-Year Statewide AADT
	Number of Years from Base Year	Total Change in AADT[a]	Future-Year Statewide AADT[b]	Future-Year Statewide AADT	

[a]Total Change = Yearly Change x Number of Years

[b]Future-Year Statewide AADT = Base-Year AADT + Total Change

FIGURE 9. WORKSHEET FOR FORECASTING STATEWIDE AVERAGE VOLUME

FUTURE-YEAR STATEWIDE AADT						
Method 2 (Projection Based on Statewide Model)						
Future Year	Statewide Personal Income (1982 $1,000,000)[a]	Fuel Price[a] (1982 Cents/ Gallon)	Vehicle Registrations (1,000)[b]	Vehicle Miles (1,000,000)[c]	Highway Miles[a]	Statewide AADT[d]

[a] Independent Projection

[b] Vehicle Registrations = ________ (a) + ________ (b) x Income

[c] Vehicle Miles = ________ (c) x Registrations + ________ (d) x Fuel Price

(Above Constants (a, b, c, d) from Statewide Model)

[d] Statewide AADT = Vehicle Miles x 1,000,000 / 365 / Highway Miles

FIGURE 9. WORKSHEET FOR FORECASTING STATEWIDE AVERAGE VOLUME (CONTINUED)

FORECAST OF STATEWIDE AADT

Date of Forecast September 15, 1987 Name of Forecaster John A. Deacon

FUTURE-YEAR STATEWIDE AADT

Base-Year Statewide AADT 1,152
(From Statewide Model)

Date of Base Year 1986

Historical Yearly Change in Statewide AADT 26
(From Statewide Model)

Future Date	Method 1 (Projection Based on Trends): Number of Years from Base Year	Method 1: Total Change in AADT[a]	Method 1: Future-Year Statewide AADT[b]	Method 2 (From Sheet 2): Future-Year Statewide AADT	Future-Year Statewide AADT
1991	5	130	1,282	1,435	1,358
1992	6	156	1,308	1,461	1,384
1993	7	182	1,334	1,488	1,411
1994	8	208	1,360	1,516	1,438
1995	9	234	1,386	1,544	1,465
1996	10	260	1,412	1,570	1,491
1997	11	286	1,438	1,596	1,517
1998	12	312	1,464	1,623	1,544
1999	13	338	1,490	1,650	1,570
2000	14	364	1,516	1,677	1,596
2001	15	390	1,542	1,706	1,624
2002	16	416	1,568	1,734	1,651
2003	17	442	1,594	1,762	1,678
2004	18	468	1,620	1,791	1,706
2005	19	494	1,646	1,820	1,733
2006	20	520	1,672	1,846	1,759
2007	21	546	1,698	1,873	1,786
2008	22	572	1,724	1,900	1,812
2009	23	598	1,750	1,927	1,838
2010	24	624	1,776	1,954	1,865

[a] Total Change = Yearly Change x Number of Years

[b] Future-Year Statewide AADT = Base-Year AADT + Total Change

FIGURE 10. EXAMPLE FORECAST OF STATEWIDE AVERAGE VOLUMES

FUTURE-YEAR STATEWIDE AADT						
Method 2 (Projection Based on Statewide Model)						
Future Year	Statewide Personal Income (1982 $1,000,000)[a]	Fuel Price[a] (1982 Cents/ Gallon)	Vehicle Registrations (1,000)[b]	Vehicle Miles (1,000,000)[c]	Highway Miles[a]	Statewide AADT[d]
1991	44,012	129.9	3,332	36,394	69,500	1,435
1992	44,926	133.4	3,398	37,065	69,500	1,461
1993	45,840	136.7	3,465	37,751	69,500	1,488
1994	46,754	139.8	3,531	38,449	69,500	1,516
1995	47,668	142.6	3,597	39,157	69,500	1,544
1996	48,530	145.3	3,660	39,825	69,500	1,570
1997	49,392	147.9	3,722	40,500	69,500	1,596
1998	50,254	150.3	3,784	41,181	69,500	1,623
1999	51,116	152.7	3,847	41,868	69,500	1,650
2000	51,979	154.9	3,909	42,560	69,500	1,677
2001	52,858	157.1	3,973	43,272	69,500	1,706
2002	53,737	159.2	4,037	43,998	69,500	1,734
2003	54,616	161.3	4,100	44,707	69,500	1,762
2004	55,495	163.3	4,164	45,430	69,500	1,791
2005	56,375	165.2	4,228	46,156	69,500	1,820
2006	57,200	167.1	4,288	46,833	69,500	1,846
2007	58,024	168.9	4,347	47,512	69,500	1,873
2008	58,849	170.7	4,407	48,194	69,500	1,900
2009	59,674	172.5	4,467	48,879	69,500	1,927
2010	60,499	174.2	4,527	49,565	69,500	1,954

[a]Independent Projection

[b]Vehicle Registrations = 143.3679 (a) + 0.07245322 (b) x Income

[c]Vehicle Miles = 13.05204 (c) x Registrations + 54.6365 (d) x Fuel Price

(Above Constants (a, b, c, d) from Statewide Model)

[d]Statewide AADT = Vehicle Miles x 1,000,000 / 365 / Highway Miles

FIGURE 10. EXAMPLE FORECAST OF STATEWIDE AVERAGE VOLUMES (CONTINUED)

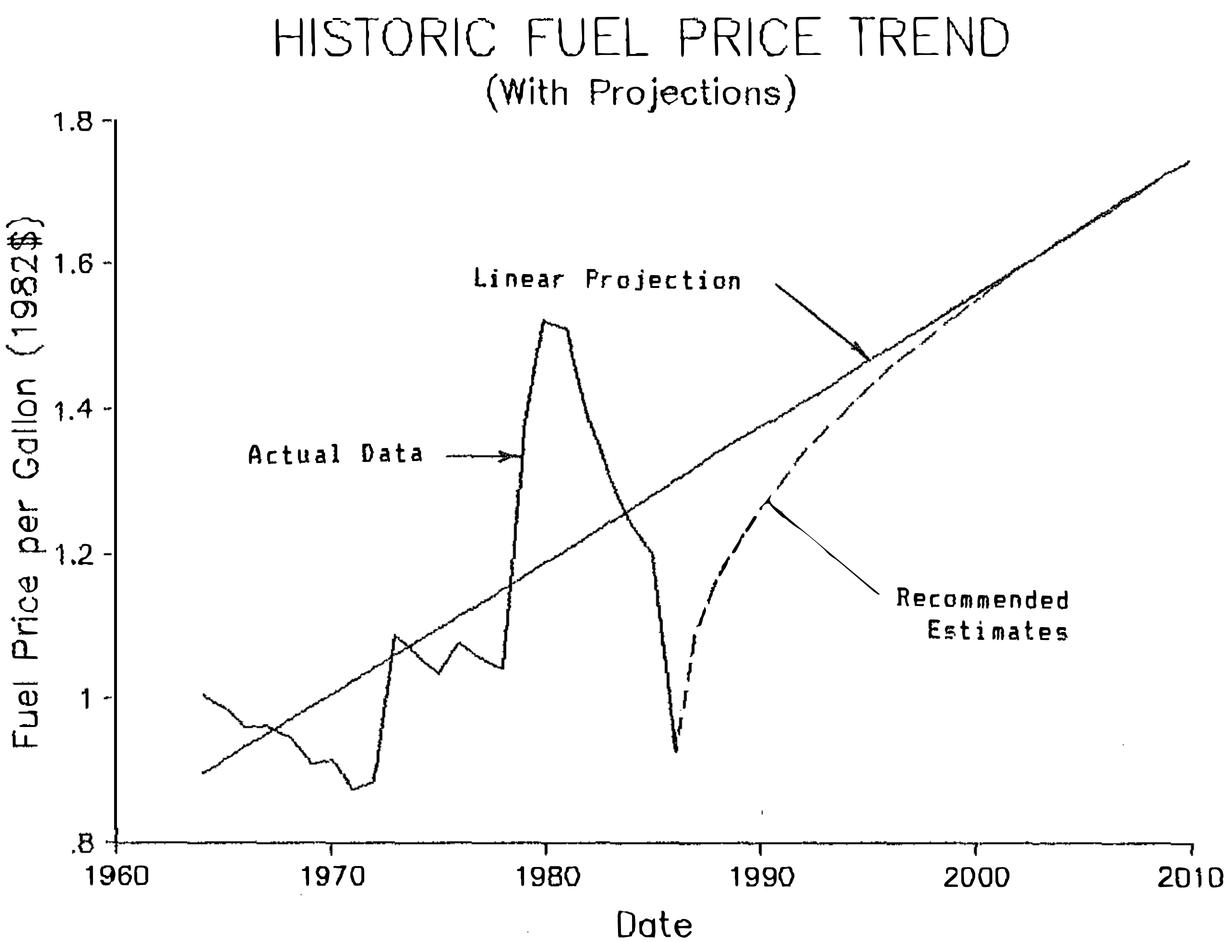


FIGURE 11. TREND IN FUEL PRICE

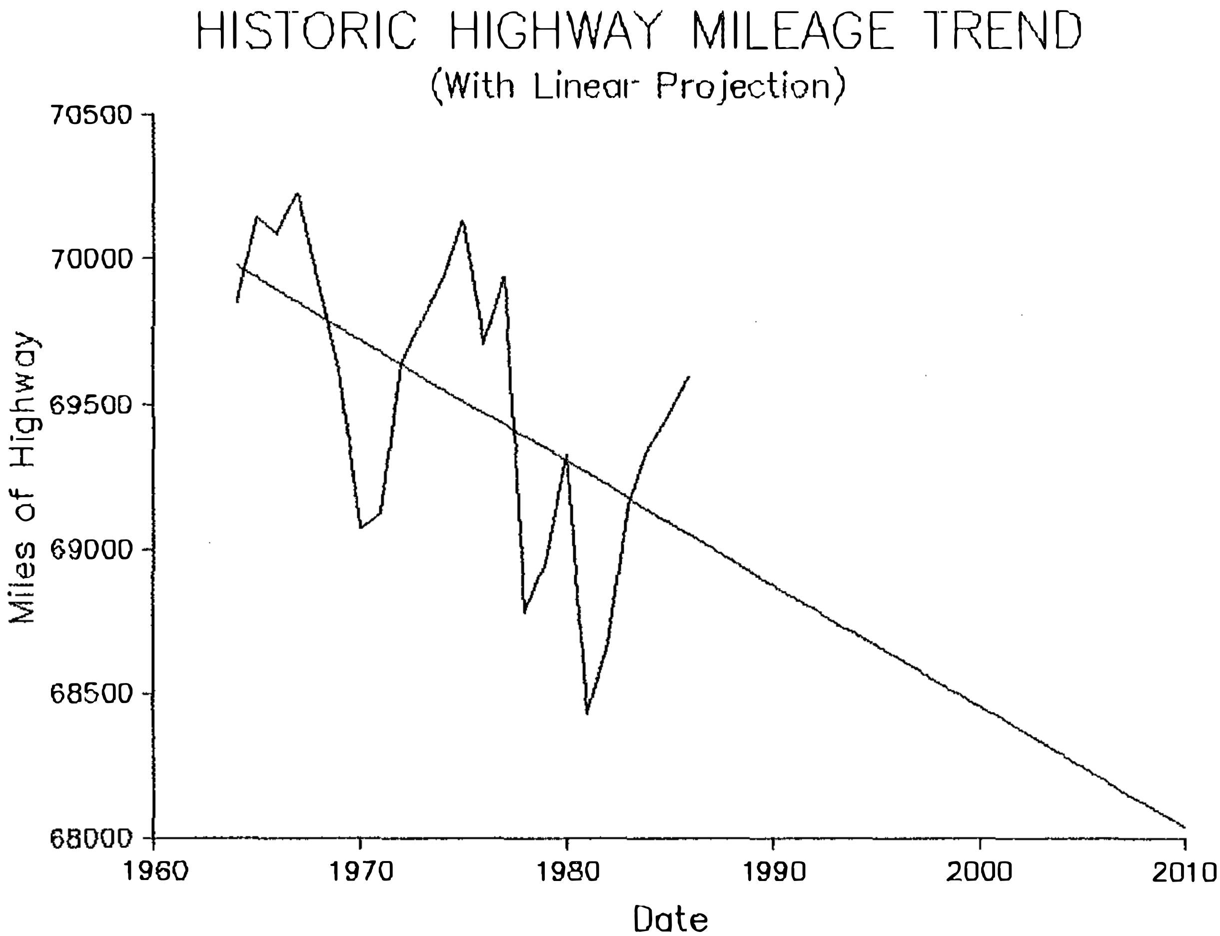


FIGURE 12. TREND IN MILES OF HIGHWAYS

FORECAST OF SITE ADT

Date of Forecast______________________ **Name of Forecaster**_______________________

ROUTE IDENTIFICATION

Road Name____ **Route No**________________

County_______________________ **Project No**______________________________________

Project Limits____

____

Reference Stations____

BASE-YEAR SITE ADT

Date of Base Year_________________ **Base-Year Statewide AADT**_______________
(From Statewide Model)

Method 1 (Preferred) (Projection Based on Actual Count)	Method 2 (Projection Based on Volume Ratio Model)			
	(Record Local Conditions on Sheet 2)			
Base-Year Site ADT____________ (As Counted)		Minimum (25%)	Likely (50%)	Maximum (75%)
Base-Year Site Volume Ratio_______ (Site ADT/Statewide AADT)	**Base-Year Site Volume Ratio** (From Volume Ratio Model)	______	______	______

Comments:____

____

____

____

____

____

____

Base-Year Site Volume Ratio____________

FIGURE 13. WORKSHEET FOR FORECASTING SITE VOLUME

LOCAL CONDITIONS

Functional Class

___ Rural, Principal Interstate	___ Urban, Principal Interstate
___ Rural, Principal Other	___ Urban, Principal Other Expressway
___ Rural, Minor Arterial	___ Urban, Principal Other
___ Rural, Major Collector	___ Urban, Minor Arterial
___ Rural, Minor Collector	___ Urban, Collector
___ Rural, Local	___ Urban, Local

Within SMSA	County Population Growth In Prior 10 Years	Area Type	Base-Year ADT	
___ Yes	___ Slow (< 5%)	___ Rural	___ < 625	___ 5000-9999
___ No	___ Moderate (5-15%)	___ Small Urban	___ 625-1249	___ 10000-19999
	___ Fast (> 15%)	___ Urbanized	___ 1250-2499	___ 20000-40000
			___ 2500-4999	___ > 40000

FUTURE-YEAR SITE ADT

Date of Future Year______________ **Years from Base Year** (n)__________

	Minimum (25%)	Likely (50%)	Maximum (75%)
Base-Year Site Volume Ratio__________ (From Sheet 1)			
Annual Percent Growth in Volume Ratio (From Growth Factor Model)	______	______	______
Future-Year Site Volume Ratio (Base-Year Volume Ratio x $(1+\text{Growth}/100)^n$)	______	______	______
Future-Year Statewide AADT__________ (From Statewide Forecast)			
Future-Year Site ADT (Volume Ratio x Statewide AADT)	______	______	______

Comments:____

____

____

____

____

Future-Year Site ADT______________

FIGURE 13. WORKSHEET FOR FORECASTING SITE VOLUME (CONTINUED)

FORECAST OF SITE ADT

Date of Forecast September 15, 1987 **Name of Forecaster** John A. Deacon

ROUTE IDENTIFICATION

Road Name Frankfort - Georgetown **Route No** US 460

County Franklin **Project No** —

Project Limits MP 2.987 at Redding Road to MP 5.121 at KY 1685

Reference Stations 274

BASE-YEAR SITE ADT

Date of Base Year 1986 **Base-Year Statewide AADT** 1,152
(From Statewide Model)

Method 1 (Preferred) (Projection Based on Actual Count)	Method 2 (Projection Based on Volume Ratio Model)			
	(Record Local Conditions on Sheet 2)			
Base-Year Site ADT 2,108 (Est) (As Counted)		Minimum (25%)	Likely (50%)	Maximum (75%)
Base-Year Site Volume Ratio 1.830 (Site ADT/Statewide AADT)	**Base-Year Site Volume Ratio** (From Volume Ratio Model)	2.02	3.02	5.10

Comments: Although the 1986 volume at this site is considerably less than at comparable sites elsewhere, historical counts are stable: 2102 (1985), 2027 (1984), 2229 (1983), 2415 (1982), 1941 (1979), and 2162 (1977). Therefore the estimated base-year ADT is acceptable.

Base-Year Site Volume Ratio 1.830

FIGURE 14. EXAMPLE FORECAST OF SITE VOLUME

LOCAL CONDITIONS

Functional Class

___ Rural, Principal Interstate	___ Urban, Principal Interstate
___ Rural, Principal Other	___ Urban, Principal Other Expressway
✓ Rural, Minor Arterial	___ Urban, Principal Other
___ Rural, Major Collector	___ Urban, Minor Arterial
___ Rural, Minor Collector	___ Urban, Collector
___ Rural, Local	___ Urban, Local

Within SMSA	County Population Growth In Prior 10 Years	Area Type	Base-Year ADT	
___ Yes	___ Slow (< 5%)	✓ Rural	___ < 625	___ 5000-9999
✓ No	___ Moderate (5-15%)	___ Small Urban	___ 625-1249	___ 10000-19999
	✓ Fast (> 15%)	___ Urbanized	✓ 1250-2499	___ 20000-40000
			___ 2500-4999	___ > 40000

FUTURE-YEAR SITE ADT

Date of Future Year 2010 **Years from Base Year** (n) 24

	Minimum (25%)	Likely (50%)	Maximum (75%)
Base-Year Site Volume Ratio 1.830 (From Sheet 1)			
Annual Percent Growth in Volume Ratio (From Growth Factor Model)	-1.16	-0.08	1.38
Future-Year Site Volume Ratio (Base-Year Volume Ratio x $(1+\text{Growth}/100)^n$)	1.38	1.80	2.54
Future-Year Statewide AADT 1,865 (From Statewide Forecast)			
Future-Year Site ADT (Volume Ratio x Statewide AADT)	2574	3,357	4,737

Comments: The Toyota plant is expected to have significant impact on the volume at this site. Coupled with comparatively low initial volume, the volume here is expected to grow even faster than the 75%tile rate. A volume of 6,100 vpd -- representing a 4.5% growth rate -- is selected for design purposes.

Future-Year Site ADT 6,100

FIGURE 14. EXAMPLE FORECAST OF SITE VOLUME (CONTINUED)

VOLUME RATIO - 75TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	SMSA – POPULATION CATEGORY – SLOW – VOLUME RATIO	SMSA – POPULATION CATEGORY – MOD. – VOLUME RATIO	SMSA – POPULATION CATEGORY – FAST – VOLUME RATIO	NON-SMSA – POPULATION CATEGORY – SLOW – VOLUME RATIO	NON-SMSA – POPULATION CATEGORY – MOD. – VOLUME RATIO	NON-SMSA – POPULATION CATEGORY – FAST – VOLUME RATIO
RURAL	PRINCIPAL INT.	15.90	21.76	27.63	18.63	20.39	22.16
	PRINCIPAL OTHER	11.84	12.37	12.91	7.12	8.86	10.60
	MINOR ARTERIAL	5.19	6.79	8.38	4.31	4.71	5.10
	MAJOR COLLECTOR	1.57	3.51	5.45	1.75	2.40	3.06
	MINOR COLLECTOR	0.55	0.77	0.99	0.56	0.69	0.81
	LOCAL	0.19	0.69	1.19	0.36	0.72	1.08
SMALL URBAN	PRINCIPAL INT.	.	20.42	.	25.32	26.63	27.93
	PRINCIPAL OTHER	8.89	12.39	.	12.86	13.96	15.07
	MINOR ARTERIAL	8.25	12.23	16.22	7.74	9.47	11.20
	LOCAL	.	7.39	.	2.35	2.89	.
	PR. OTHER X-WAY	9.75	.	.	8.14	9.69	11.24
	COLLECTOR	9.32	.	6.73	3.57	4.33	5.09
URBANIZED	PRINCIPAL INT.	76.49	66.50	56.51	.	.	.
	PRINCIPAL OTHER	20.93	25.18	.	.	.	.
	MINOR ARTERIAL	13.35	14.88	16.42	.	.	.
	LOCAL	3.21	.	.	.	.	.
	PR. OTHER X-WAY	14.21	37.67	.	.	.	.
	COLLECTOR	4.45	6.16	7.87	.	.	.

FIGURE 15. EXAMPLE VOLUME-RATIO MODEL (75TH PERCENTILE WITH SMOOTHING)

VOLUME RATIO - 50TH PERCENTILE (SMOOTHED)

		SMSA			NON-SMSA		
		POPULATION CATEGORY			POPULATION CATEGORY		
		SLOW	MOD.	FAST	SLOW	MOD.	FAST
		VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO
RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION						
RURAL	PRINCIPAL INT.	11.13	16.50	21.87	17.60	18.60	19.81
	PRINCIPAL OTHER	7.63	8.51	9.39	4.21	5.86	7.50
	MINOR ARTERIAL	1.90	3.23	4.56	2.70	2.86	3.02
	MAJOR COLLECTOR	1.04	1.92	2.80	0.99	1.26	1.53
	MINOR COLLECTOR	0.35	0.45	0.55	0.31	0.38	0.44
	LOCAL	0.18	0.30	0.43	0.17	0.24	0.32
SMALL URBAN	PRINCIPAL INT.	.	20.30	.	18.91	21.57	24.23
	PRINCIPAL OTHER	6.02	9.36	.	8.71	9.81	10.92
	MINOR ARTERIAL	5.93	6.64	7.36	4.87	5.69	6.50
	LOCAL	.	7.39	.	1.16	1.84	.
	PR. OTHER X-WAY	9.75	.	.	7.08	8.84	10.61
	COLLECTOR	4.32	.	6.73	2.34	2.86	3.37
URBANIZED	PRINCIPAL INT.	63.85	53.72	43.58	.	.	.
	PRINCIPAL OTHER	14.14	19.26	.	.	.	.
	MINOR ARTERIAL	8.44	9.09	9.75	.	.	.
	LOCAL	0.77	.	.	.	.	.
	PR. OTHER X-WAY	10.39	20.32	.	.	.	.
	COLLECTOR	2.07	2.91	3.75	.	.	.

FIGURE 16. EXAMPLE VOLUME-RATIO MODEL (50TH PERCENTILE WITH SMOOTHING)

VOLUME RATIO - 25TH PERCENTILE (SMOOTHED)

		SMSA			NON-SMSA		
		POPULATION CATEGORY			POPULATION CATEGORY		
		SLOW	MOD.	FAST	SLOW	MOD.	FAST
		VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO
RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION						
RURAL	PRINCIPAL INT.	9.49	12.36	15.23	7.74	13.52	19.30
	PRINCIPAL OTHER	4.31	5.05	5.79	2.56	3.49	4.41
	MINOR ARTERIAL	1.29	2.23	3.17	1.58	1.80	2.02
	MAJOR COLLECTOR	0.66	0.96	1.25	0.59	0.68	0.76
	MINOR COLLECTOR	0.22	0.26	0.30	0.19	0.22	0.26
	LOCAL	0.11	0.15	0.19	0.10	0.12	0.15
SMALL URBAN	PRINCIPAL INT.	.	20.17	.	16.82	20.09	23.26
	PRINCIPAL OTHER	3.82	7.17	.	5.91	6.39	6.88
	MINOR ARTERIAL	3.44	3.76	4.08	3.51	3.48	3.44
	LOCAL	.	7.39	.	0.93	1.33	.
	PR. OTHER X-WAY	9.75	.	.	5.55	7.61	9.66
	COLLECTOR	1.91	.	6.73	1.51	1.58	1.65
URBANIZED	PRINCIPAL INT.	42.69	28.27	13.86	.	.	.
	PRINCIPAL OTHER	8.76	10.34	.	.	.	.
	MINOR ARTERIAL	5.22	5.01	4.61	.	.	.
	LOCAL	0.56	.	.	.	.	.
	PR. OTHER X-WAY	5.51	11.19	.	.	.	.
	COLLECTOR	1.39	1.23	1.07	.	.	.

FIGURE 17. EXAMPLE VOLUME-RATIO MODEL (25TH PERCENTILE WITH SMOOTHING)

GROWTH FACTORS - 75TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	POPULATION CATEGORY	VOLUME (VPD) <625 GROWTH FACTOR	625-1,249 GROWTH FACTOR	1,250-2,499 GROWTH FACTOR	2,500-4,999 GROWTH FACTOR	5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR
RURAL	PRINCIPAL OTHER	SLOW	.	.	2.73	2.23	1.73	1.23	.
		MOD.	.	3.79	3.29	2.79	2.29	1.79	.
		FAST	.	.	3.85	3.35	2.85	2.35	1.85
	MINOR ARTERIAL	SLOW	0.33	0.39	0.45	0.52	0.58	0.65	.
		MOD.	0.79	0.85	0.92	0.98	1.05	1.11	.
		FAST	1.25	1.32	1.38	1.45	1.51	1.58	.
	MAJOR COLLECTOR	SLOW	0.19	0.27	0.35	0.43	0.51	0.60	.
		MOD.	0.77	0.85	0.93	1.02	1.10	1.18	.
		FAST	1.35	1.43	1.52	1.60	1.68	1.76	.
	MINOR COLLECTOR	SLOW	0.54	0.90	1.27	1.64	2.00	.	.
		MOD.	1.16	1.52	1.89	2.26	2.62	2.99	.
		FAST	1.78	2.14	2.51	2.88	3.24	3.61	.
	LOCAL	SLOW	0.48	0.67	0.85	1.03	1.21	.	.
		MOD.	1.13	1.31	1.49	1.68	1.86	.	.
		FAST	1.78	1.96	2.14	2.32	2.50	2.68	.

FIGURE 18. EXAMPLE GROWTH-FACTOR MODEL (75TH PERCENTILE WITH SMOOTHING)

GROWTH FACTORS - 50TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	POPULATION CATEGORY	VOLUME (VPD) <625 GROWTH FACTOR	625-1,249 GROWTH FACTOR	1,250-2,499 GROWTH FACTOR	2,500-4,999 GROWTH FACTOR	5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR
RURAL	PRINCIPAL OTHER	SLOW	.	.	0.35	0.41	0.48	0.54	.
		MOD.	.	0.64	0.70	0.76	0.83	0.89	.
		FAST	.	.	1.05	1.11	1.17	1.24	1.30
	MINOR ARTERIAL	SLOW	-1.23	-1.07	-0.92	-0.77	-0.62	-0.47	.
		MOD.	-0.81	-0.66	-0.50	-0.35	-0.20	-0.05	.
		FAST	-0.39	-0.24	-0.08	0.07	0.22	0.37	.
	MAJOR COLLECTOR	SLOW	-1.16	-1.08	-1.00	-0.91	-0.83	-0.75	.
		MOD.	-0.61	-0.53	-0.45	-0.37	-0.28	-0.20	.
		FAST	-0.07	0.01	0.10	0.18	0.26	0.34	.
	MINOR COLLECTOR	SLOW	-0.92	-0.59	-0.27	0.05	0.37	.	.
		MOD.	-0.41	-0.09	0.23	0.55	0.87	1.20	.
		FAST	0.10	0.42	0.74	1.06	1.38	1.70	.
	LOCAL	SLOW	-0.85	-0.68	-0.51	-0.35	-0.18	.	.
		MOD.	-0.50	-0.34	-0.17	-0.00	0.16	.	.
		FAST	-0.16	0.01	0.17	0.34	0.51	0.67	.

FIGURE 19. EXAMPLE GROWTH-FACTOR MODEL (50TH PERCENTILE WITH SMOOTHING)

GROWTH FACTORS - 25TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	POPULATION CATEGORY	VOLUME (VPD) <625 GROWTH FACTOR	625-1,249 GROWTH FACTOR	1,250-2,499 GROWTH FACTOR	2,500-4,999 GROWTH FACTOR	5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR
RURAL	PRINCIPAL OTHER	SLOW	.	.	-1.54	-1.47	-1.39	-1.32	.
		MOD.	.	-1.17	-1.10	-1.02	-0.95	-0.88	.
		FAST	.	.	-0.65	-0.58	-0.51	-0.43	-0.36
	MINOR ARTERIAL	SLOW	-2.00	-2.10	-2.21	-2.31	-2.41	-2.52	.
		MOD.	-1.48	-1.58	-1.69	-1.79	-1.89	-1.99	.
		FAST	-0.96	-1.06	-1.16	-1.27	-1.37	-1.47	.
	MAJOR COLLECTOR	SLOW	-2.11	-2.10	-2.09	-2.08	-2.07	-2.05	.
		MOD.	-1.78	-1.76	-1.75	-1.74	-1.73	-1.72	.
		FAST	-1.44	-1.43	-1.42	-1.41	-1.40	-1.38	.
	MINOR COLLECTOR	SLOW	-2.32	-2.09	-1.85	-1.62	-1.39	.	.
		MOD.	-1.86	-1.62	-1.39	-1.16	-0.93	-0.70	.
		FAST	-1.40	-1.16	-0.93	-0.70	-0.47	-0.24	.
	LOCAL	SLOW	-3.03	-2.98	-2.94	-2.90	-2.86	.	.
		MOD.	-2.48	-2.43	-2.39	-2.35	-2.30	.	.
		FAST	-1.92	-1.88	-1.84	-1.79	-1.75	-1.71	.

FIGURE 20. EXAMPLE GROWTH-FACTOR MODEL (25TH PERCENTILE WITH SMOOTHING)

APPENDIX A

EDITING OF TRAFFIC VOLUME FILE AND HISTORICAL VOLUME FILE

Before the programs, ED.PRG and COUNTS.PRG, were written, it was necessary to merge the Traffic Volume file and the Historical Volume file. The Traffic Volume file--initially prepared by the Division of Planning and including only the most recent year of data--was checked in the following manner:

1. FORMAT CHECK

   A check of the basic format of the file was made to insure that data entered were of the correct form and did not exceed the range acceptable for that field.

2. CODING CHECK

   Coding for route suffix, route prefix, station direction, and station type were checked by comparing with the Traffic Volume file initially prepared by the Division of Planning and the Statewide Mileage Tape.

3. MISSING DATA CHECK

   Missing data such as descriptive information, ADT, and station number were flagged and the file was sent to the Division of Planning for correction where possible.

The second file, the Historical Volume file, was checked in the following manner:

1. AVERAGE CHECK

   The average volume was computed for each station in the Historical Volume file. The historical average at a specific station was compared with each annual volume entry at that specific station. If the volume was not in the range of 1/3 of the average to 3 times the average then it was checked with original data from the paper file.

2. RANDOM CHECK

   Some stations were randomly selected from the computer file and volumes from those stations were checked with corresponding volumes in the original paper file.

Checks made on the Traffic Volume Summary file, the file created by merging the Traffic Volume file and the Historical Volume file, included the following:

1. ADT CHECK

   After the two files were merged, the most recent volumes from the Traffic Volume Summary file were compared with corresponding volumes in the Historical Volume file. If the two volumes did not match, they were checked with the original data from the paper file.

2. <u>LOCATION CHECK</u>

A check was made to determine if all milepoint sections and stations matched between the Traffic Volume Summary file and the Historical Volume file. Unmatched sections or stations were flagged for correction.

3. <u>AVERAGE CHECK</u>

Another check of the Traffic Volume Summary file was made to insure that the current volume data did not fall outside the range of 1/3 of the average to 3 times the average for data at each station.

APPENDIX B

PROCEDURES FOR ACCESSING AND USING THE TRAFFIC VOLUME SUMMARY FILE

The Traffic Volume Summary file and other files related to its use are accessible by microcomputer. The executable program necessary to use these files is a compiled version of a dBASE III Plus routine. Assuming that all files and the executable program are located on a hard disk within a directory labelled "COUNTS", the following steps are necessary:

1. Once the computer is on and at the C: prompt, type:

   CD\COUNTS <return> (Make sure that the "CAPS LOCK" key is on: all input must be in uppercase).

2. To start the program that extracts historical traffic volumes from the file at a specific station and produces estimates for missing years at this station, type the following:

   CTS <return>.

3. Once into the program, prompts for certain input will appear. Among the input search alternatives are county, city, route, milepoints, station number, station type, volume year, estimates, years used to produce estimates, and print options. A screen display showing the arrangement of possible input data is attached as Figure B1.

4. A minimum amount of input is required to search the Traffic Volume Summary file. A search for available data will be performed if either county, city, route, or station number is entered. It should be noted that, if a minimum amount of descriptive data is input, the search process may be longer than usual because the entire file may have to be searched. If no match is found for the descriptive location information, then the message "DATA NOT FOUND" is displayed on the screen.

5. In the county position, either the county name or its number may be entered (Table B1).

6. In the city position, either the city name or number may be entered. Table B2 identifies those cities that are included in the file.

7. Route has three input areas associated with it: route prefix, route number, and route suffix. The route prefix for toll roads is TR.

8. Milepoint is a numeric input. Both beginning and ending milepoints must be supplied. If, in the file, the beginning milepoint or the ending milepoint or both are in the range of the input beginning and the input ending milepoints, then that record becomes a match for the specified information provided other descriptive information matches.

9. Station number is the number assigned by the Division of Planning.

10. Station type is identified as follows: 1) permanent count station

(ATR), 2) coverage count station, 3) flow map station, or 4) HPMS.

11. Volume years has two inputs. One is a FROM and the other is a TO. The range is initialized to the range of years in the file. The range of years may be changed. For example, if in the data base the default range of years is from 64 to 87, then in the slots would appear 64 and 87, respectively. These values may be changed to any years between that range of years. When the file is updated, the range of years will extend to include added years.

12. Estimates require a Y(es) or N(o) answer. If Y is specified, then estimates of missing volumes will be included in the output. Obviously, if N is specified, then estimates will not be included. Estimates are identified in the output file by asterisks.

13. Years used to produce estimates are requested as input when Y(es) is entered for estimates on the computer screen. The areas of input are initialized to the earliest and latest year in the file. Estimated volumes will be produced only if there are at least four years of data within the specified range of years. Estimates will be produced up to six years before or after each actual count and six years before or beyond the specified range (in no case are estimates produced before the beginning year of the file or beyond the ending year).

14. Print options specify whether the output is to be directed to the printer, the screen, or both.

When the information is requested and displayed on the screen, the stop pause function may be evoked by holding down the "Ctrl" key and hitting the "NUM LOCK" key. The program may be started again by hitting the "Return" key.

To stop execution of the program as it displays stations on the screen, strike the spacebar once; striking the spacebar again returns the user to the main menu. Use of the spacebar allows the user to pause the scrolling of the screen but does not allow continuation of execution. As noted above, use of "CTRL" "Num Lock" keys to stop and then the "RETURN" key allows continuation of execution.

Once into the program, you may exit or quit after the search process has been completed by pressing the ESC key. During the search process, you may quit by simultaneously pressing the ALT and C keys.

TABLE B1. COUNTIES IDENTIFIED IN TRAFFIC VOLUME SUMMARY FILE

County	Code	County	Code	County	Code
ADAIR	1	GRANT	41	MASON	81
ALLEN	2	GRAVES	42	MEADE	82
ANDERSON	3	GRAYSON	43	MENIFEE	83
BALLARD	4	GREEN	44	MERCER	84
BARREN	5	GREENUP	45	METCALFE	85
BATH	6	HANCOCK	46	MONROE	86
BELL	7	HARDIN	47	MONTGOMERY	87
BOONE	8	HARLAN	48	MORGAN	88
BOURBON	9	HARRISON	49	MUHLENBURG	89
BOYD	10	HART	50	NELSON	90
BOYLE	11	HENDERSON	51	NICHOLAS	91
BRACKEN	12	HENRY	52	OHIO	92
BREATHITT	13	HICKMAN	53	OLDHAM	93
BRECKINRIDGE	14	HOPKINS	54	OWEN	94
BULLITT	15	JACKSON	55	OWSLEY	95
BUTLER	16	JEFFERSON	56	PENDLETON	96
CALDWELL	17	JESSAMINE	57	PERRY	97
CALLOWAY	18	JOHNSON	58	PIKE	98
CAMPBELL	19	KENTON	59	POWELL	99
CARLISLE	20	KNOTT	60	PULASKI	100
CARROLL	21	KNOX	61	ROBERTSON	101
CARTER	22	LARUE	62	ROCKCASTLE	102
CASEY	23	LAUREL	63	ROWAN	103
CHRISTIAN	24	LAWRENCE	64	RUSSELL	104
CLARK	25	LEE	65	SCOTT	105
CLAY	26	LESLIE	66	SHELBY	106
CLINTON	27	LETCHER	67	SIMPSON	107
CRITTENDEN	28	LEWIS	68	SPENCER	108
CUMBERLAND	29	LINCOLN	69	TAYLOR	109
DAVIESS	30	LIVINGSTON	70	TODD	110
EDMONSON	31	LOGAN	71	TRIGG	111
ELLIOTT	32	LYON	72	TRIMBLE	112
ESTILL	33	MCLEAN	75	UNION	113
FAYETTE	34	MCCRACKEN	73	WARREN	114
FLEMING	35	MCCREARY	74	WASHINGTON	115
FLOYD	36	MADISON	76	WAYNE	116
FRANKLIN	37	MAGOFFIN	77	WEBSTER	117
FULTON	38	MARION	78	WHITLEY	118
GALLATIN	39	MARSHALL	79	WOLFE	119
GARRARD	40	MARTIN	80	WOODFORD	120

TABLE B2. CITIES IDENTIFIED IN TRAFFIC VOLUME SUMMARY FILE

City	Code	County	City	Code	County
ALBANY	47	CLINTON	EKRON	81	MEADE
ALEXANDRIA	177	CAMPBELL	ELIZABETHTOWN	15	HARDIN
ASHLAND	1	BOYD	ELKHORN CITY	82	PIKE
ASHLAND	1	GREENUP	ELKTON	83	TODD
BARBOURVILLE	48	KNOX	EMINENCE	84	HENRY
BARDSTOWN	7	NELSON	FAIRFIELD	85	NELSON
BARDWELL	49	CARLISLE	FALMOUTH	86	PENDLETON
BEATTYVILLE	50	LEE	FLEMINGSBURG	87	FLEMING
BEAVER DAM	51	OHIO	FORDSVILLE	88	OHIO
BEDFORD	52	TRIMBLE	FRANKFORT	16	FRANKLIN
BENTON	53	MARSHALL	FRANKLIN	17	SIMPSON
BEREA	8	MADISON	FRENCHBURG	89	MENIFEE
BLOOMFIELD	54	NELSON	FULTON	18	FULTON
BONNIEVILLE	55	HART	GEORGETOWN	19	SCOTT
BOONEVILLE	56	OWSLEY	GLASGOW	20	BARREN
BOWLING GREEN	9	WARREN	GRATZ	94	NELSON
BRANDENBURG	57	MEADE	GRAYSON	91	CARTER
BRODHEAD	58	ROCKCASTLE	GREENSBURG	92	GREEN
BROOKSVILLE	59	BRACKEN	GREENUP	93	GREENUP
BROWNSVILLE	60	EDMONSON	GREENVILLE	94	MUHLENBURG
BURKESVILLE	61	CUMBERLAND	HARTFORD	97	OHIO
BURNSIDE	62	PULASKI	HARDINSBURG	95	BRECKINRIDGE
CADIZ	63	TRIGG	HARLAN	96	HARLAN
CALHOUN	64	MCLEAN	HARRODSBURG	21	MERCER
CALVERT CITY	65	MARSHALL	HAWESVILLE	98	HANCOCK
CAMPBELLSBURG	66	LESLIE	HAZARD	22	PERRY
CAMPBELLSVILLE	10	TAYLOR	HAZEL GREEN	99	WOLFE
CAMPTON	67	WOLFE	HENDERSON	3	HENDERSON
CARLISLE	68	NICHOLAS	HICKMAN	100	FULTON
CARROLLTON	69	CARROLL	HINDMAN	101	KNOTT
CAVE CITY	70	BARREN	HODGENVILLE	102	LARUE
CENTRAL CITY	11	MUHLENBURG	HOPKINSVILLE	23	CHRISTIAN
CLARKSON	71	GRAYSON	HORSE CAVE	103	HART
CLAY	72	WEBSTER	HYDEN	104	LESLIE
CLAY CITY	73	POWELL	INEZ	105	MARTIN
CLINTON	74	HICKMAN	IRVINE-RAVENNA	106	ELLIOTT
CLOVERPORT	75	BRECKINRIDGE	IRVINGTON	107	BRECKINRIDGE
COLUMBIA	76	ADAIR	ISLAND	188	MCLEAN
CORBIN	12	KNOX	JACKSON	109	BREATHITT
CORBIN	12	LAUREL	JAMESTOWN	110	RUSSELL
CORBIN	12	WHITLEY	JENKINS	111	LETCHER
COVINGTON-NEWPORT	2	BOONE	LAGRANGE	112	OLDHAM
COVINGTON-NEWPORT	2	CAMPBELL	LANCASTER	113	GARRARD
COVINGTON-NEWPORT	2	KENTON	LAWRENCEBURG	24	ANDERSON
CUMBERLAND	77	HARLAN	LEBANON	25	MARION
CYNTHIANA	13	HARRISON	LEBANON JUNCTION	114	BULLITT
DANVILLE	14	BOYLE	LEBANON JUNCTION	114	OWSLEY
DAWSON SPRINGS	78	HOPKINS	LEITCHFIELD	115	GRAYSON
EARLINGTON	79	HOPKINS	LEWISPORT	116	HANCOCK

TABLE B2. CITIES IDENTIFIED IN TRAFFIC VOLUME SUMMARY FILE (CONTINUED)

City	Code	County	City	Code	County
LEXINGTON	4	FAYETTE	RUSSELLVILLE	40	LOGAN
LIBERTY	117	CASEY	SACRAMENTO	145	MCLEAN
LIVERMORE	118	MCLEAN	SANDY HOOK	147	ELLIOTT
LIVINGSTON	119	ROCKCASTLE	SALYERSVILLE	146	MAGOFFIN
LONDON	120	LAUREL	SCIENCE HILL	148	PULASKI
LOUISA	121	LAWRENCE	SCOTTSVILLE	149	ALLEN
LOUISVILLE	5	JEFFERSON	SEBREE	150	WEBSTER
MACKVILLE	122	WASHINGTON	SHARPSBURG	151	BATH
MADISONVILLE	26	HOPKINS	SHELBYVILLE	41	SHELBY
MANCHESTER	123	CLAY	SHEPHERDSVILLE	152	BULLITT
MARION	124	CRITTENDEN	SMITHLAND	153	LIVINGSTON
MAYFIELD	27	GRAVES	SOMERSET/FERGUSON	42	PULASKI
MAYSVILLE	28	MASON	SOUTH WILLIAMSON	43	PIKE
MCKEE	125	JACKSON	SPARTA	176	GALLATIN
MIDDLESBORO	29	BELL	SPRINGFIELD	154	WASHINGTON
MIDDLESBORO	7	CUMBERLAND	STANFORD	155	LINCOLN
MIDWAY	126	WOODFORD	STANTON	156	POWELL
MONTEREY	127	OWEN	STURGIS	157	UNION
MONTICELLO	30	WAYNE	TAYLORSVILLE	155	SPENCER
MOREHEAD	31	ROWAN	TOMKINSVILLE	159	MONROE
MORGANFIELD	128	UNION	UNIONTOWN	160	UNION
MORGANTOWN	129	BUTLER	UPTON	161	HARDIN
MOUNT STERLING	32	MONTGOMERY	VANCEBURG	162	LEWIS
MT. OLIVET	130	ROBERTSON	VERSAILLES	44	WOODFORD
MT. VERNON	131	ROCKCASTLE	VINE GROVE	163	HARDIN
MT. WASHINGTON	132	BULLITT	WARSAW	175	GALLATIN
MUNFORDVILLE	133	HART	WASHINGTON	165	MASON
MURRAY	33	CALLOWAY	WAVERLY	166	UNION
NEW HAVEN	135	METCALFE	WEST LIBERTY	167	MORGAN
NEWCASTLE	134	HENRY	WEST POINT	168	HARDIN
NEWPORT-COVINGTON	2	BOONE	WHITESBURG	169	LETCHER
NEWPORT-COVINGTON	2	CAMPBELL	WHITESVILLE	170	DAVIESS
NEWPORT-COVINGTON	2	KENTON	WHITLEY CITY	171	MCCREARY
NICHOLASVILLE	34	JESSAMINE	WICKLIFFE	172	BALLARD
OLIVE HILL	136	CARTER	WILLIAMSBURG	45	WHITLEY
OWENSBORO	6	DAVIESS	WILLISBURG	173	WASHINGTON
OWENTON	137	OWEN	WILMORE	174	JESSAMINE
OWINGSVILLE	138	BATH	WINCHESTER	46	CLARK
PADUCAH	35	MCCRACKEN			
PAINTSVILLE	139	JOHNSON			
PARIS	36	BOURBON			
PIKEVILLE	140	PIKE			
PINEVILLE	141	BELL			
PRESTONSBURG	142	FLOYD			
PRINCETON	37	CALDWELL			
PROVIDENCE	143	WEBSTER			
RADCLIFF	38	HARDIN			
RICHMOND	39	MADISON			
RUSSELL SPRINGS	144	RUSSELL			

```
          Hit the 'ESC' key to exit program!
COUNTY ██████████████ CITY ███████████████████

ROUTE ██ ████ ██

BEGINNING MILE POINT      ██████         ENDING MILE POINT      ██████

STATION NUMBER ███  STATION TYPE █

VOLUME YEAR:   FROM ██     TO ██

ESTIMATES █

                                                          PRINT OPTIONS
                                                          ----- -------
                                                            SCREEN █
                                                           PRINTER █
```

FIGURE B1. SCREEN DISPLAY OF INPUT SPECIFICATION ALTERNATIVES

APPENDIX C

PROCEDURES FOR UPDATING COUNTS VOLUME FILE AND COUNTY FILE

There is a program for updating the Counts Volume file and the County file. The County file is a file that contains county number, county name, city number, and city name. The program also has an option for reorganizing the data in the County file into two different indexes, identified as follows:

1. HISTORIC.NDX, which is indexed on county, route, and milepoint.
2. HIS.NDX, which is indexed on the county in which the station is located (i.e., CONUMBER in the file), station number, county in which the section is located, and milepoint.

Edits to the Counts Volume file and the County file include adding a record and modifying a record. Deletion of records needs to be accomplished manually through dBASE III PLUS. To do this, the data base must be accessed with the USE command. Be sure to use the file with both indexes (i.e., USE HISTORIC INDEX HISTORIC,HIS). Once into the data base, it is necessary to mark any record(s) that should be deleted. The command for marking a record for deletion will be displayed in the help window at the top of the screen. Once all records that should be deleted have been marked, use the Ctrl W command to exit the file. To exit the file without saving the changes, hit the ESC key. To delete records, type: PACK <return>. The computer will then begin processing. Once the computer has finished processing, the data should then be reorganized using the edit program. The edit program is called ED.PRG and may be accessed by typing: DO ED <return>.

Each year the data base will need to be updated so it has a record for the new volume year. To do this, enter the file via the USE command as before, but leave off the index and the files that follow. Then type: MODI STRUCT <return>. At this point, the user will be in a mode for editing the structure of the data base. Use the cursor to go all the way to the end of the list. After progressing past the last item, a blank line will be available for adding the new information for the new year. Then strike Ctrl W to exit and let the computer change the structure of the data base. If you do not wish to save the changes, exit with the ESC key. Be sure to watch the bottom of the screen for information as to what is occurring. After exiting and the "." prompt is displayed, type: USE <return>. Again, the data should be reorganized via the organize feature of ED.PRG.

FILE LIST

The following program files must be present in a subdirectory called COUNTS for the programs to run correctly:

1. CHECK.PRG
2. COUNTS.PRG
3. ED.PRG
4. ESTEM.PRG
5. ORGANIZE.PRG
6. ORG2.PRG
7. SCR.PRG
8. ADJUST.PRG

The following data base files should be present:

1. COUNTS.DBF
2. COUNTY.DBF

There are also two .NDX (index) files that may appear in the file. If you run the edit program and choose the organize option, then the old files will be erased and new ones created. If when running the edit program and the organize option is selected but the files do not exist, then new ones will be created.

APPENDIX D

DOCUMENTATION OF STATEWIDE VOLUME MODEL

The statewide volume model is comprised of the following three equations:

$$\text{Vehicle Registrations} = a + b\,(\text{Personal Income}) \qquad \text{(D1)}$$

$$\text{Vehicle Miles} = c\,(\text{Vehicle Registrations}) + d\,(\text{Fuel Price}) \qquad \text{(D2)}$$

$$\text{Annual Average Daily Traffic} = \frac{\text{Vehicle Miles}}{365 \times \text{Miles of Highway}} \qquad \text{(D3)}$$

To assure that the above model represents current conditions as accurately as possible, annual recalibration using only the most recent 20 years of data is envisioned. The recalibration process involves determining the constants, a, b, c, and d using standard regression techniques. This may be accomplished using an executable computer program, STATE.EXE, which not only recalibrates the model but also updates a data base essential to future recalibrations.

STATE.EXE is an executable version of a BASIC program, STATE.BAS, designed for use on IBM PC's and their compatibles. The basic data base accessed by the program is in a file labeled STATE.DAT. Each record of this file contains the following information for one calendar year:

- YR = Date of year
- TVR = Total annual motor-vehicle registrations in thousands
- TVM = Total annual vehicle-miles traveled in millions
- THM = Total miles of streets and highways
- PCC = Total personal income expressed in 1982 dollars in millions
- FPC = Equivalent retail price of fuel in 1982 cents per gallon (unleaded regular at full-service dispensers in Frankfort area)

A comma-delimited format is used with fields ordered as listed above. Records are ordered from earliest to most recent year.

Input to STATE.EXE includes STATE.DAT and current-year information for the above variables. The source of current-year information is identified in Table 9. Output from STATE.EXE includes an updated STATE.DAT file and an optional printout as exemplified by Figure D1. Although STATE.DAT contains information beginning in 1964, only the most recent 20 years of data are used in the model recalibration.

For execution, STATE.EXE and STATE.DAT must be placed on the default drive. Execution is initiated by entering STATE. Necessary instructions for successful execution are displayed on the monitor. If erroneous data are unknowingly entered, the file STATE.DAT may be corrected using any text editor.

CALIBRATION OF STATEWIDE AVERAGE VOLUME MODEL

Date of Calibration: September 15, 1987
Name of Calibrator: John A. Deacon

YEAR	MOTOR-VEHICLE REGISTRATIONS (Thousands)	VEHICLE MILES (Millions)	HIGHWAY MILES	PERSONAL INCOME (1982 Million$)	FUEL PRICE (1982 Cents)	AVERAGE ADT
1964	1418.8	13114	69849	17074	100.6	514.4
1965	1500.0	13969	70145	18233	98.9	545.6
1966	1574.6	14773	70085	19340	95.9	577.5
1967	1632.4	15741	70225	20386	96.3	614.1
1968	1690.6	15691	69909	21305	94.9	614.9
1969	1712.8	17866	69615	22449	91.0	703.1
1970	1762.5	18897	69071	23317	91.6	749.6
1971	1860.0	20355	69123	24107	87.5	806.8
1972	1967.6	21775	69639	25621	88.6	856.7
1973	2090.7	23096	69791	27171	108.7	906.7
1974	2164.1	22543	69933	28150	105.8	883.2
1975	2245.1	23372	70131	28056	103.4	913.0
1976	2350.1	24843	69706	29684	107.7	976.4
1977	2449.7	25732	69938	31072	105.7	1008.0
1978	2543.9	26607	68781	32045	104.2	1059.8
1979	2605.5	25994	68952	33060	136.7	1032.8
1980	2592.7	25244	69321	32326	152.3	997.7
1981	2593.4	25195	68429	33261	151.3	1008.7
1982	2615.3	25627	68674	33515	139.0	1022.4
1983	2620.8	26719	69150	33241	130.4	1058.6
1984	2576.6	27873	69339	35474	124.0	1101.3
1985	2614.8	28520	69460	36039	119.8	1124.9
1986	2680.9	29252	69596	36336	92.7	1151.5

Least-squares calibration using the most recent 20 years of data yields the following:

Vehicle Registrations = a + b (Personal Income)

a = 143.3679 b = 7.245322E-02

Vehicle Miles = c (Vehicle Registrations) + d (Fuel Price)

c = 13.05204 d = -54.6365

Annual additive increments

Statewide ADT: 25.91696 vehicles per day
Statewide highway miles: -38.00301 miles

FIGURE D1. SAMPLE PRINTOUT FROM STATE.EXE

APPENDIX E

VOLUME-RATIO MODEL FOR 1986

VOLUME RATIO - NUMBER OF ENTRIES PER CELL

		SMSA			NON-SMSA		
		POPULATION CATEGORY			POPULATION CATEGORY		
		SLOW	MOD.	FAST	SLOW	MOD.	FAST
		COUNT	COUNT	COUNT	COUNT	COUNT	COUNT
RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION						
RURAL	PRINCIPAL INT.	6	26	15	18	32	17
	PRINCIPAL OTHER	32	24	3	161	180	32
	MINOR ARTERIAL	34	34	13	370	375	52
	MAJOR COLLECTOR	129	283	131	1249	1082	300
	MINOR COLLECTOR	149	221	84	1285	1198	315
	LOCAL	17	38	4	361	281	53
SMALL URBAN	PRINCIPAL INT.	.	2	.	1	3	3
	PRINCIPAL OTHER	28	19	.	107	114	41
	MINOR ARTERIAL	45	25	22	157	214	55
	LOCAL	.	1	.	8	13	.
	PR. OTHER X-WAY	1	.	.	8	5	2
	COLLECTOR	5	.	1	54	43	5
URBANIZED	PRINCIPAL INT.	50	3	4	.	.	.
	PRINCIPAL OTHER	112	81	.	.	.	.
	MINOR ARTERIAL	170	78	31	.	.	.
	LOCAL	3	.	.	.	.	.
	PR. OTHER X-WAY	4	18	.	.	.	.
	COLLECTOR	63	24	11	.	.	.

VOLUME RATIO - 75TH PERCENTILE (SMOOTHED)

		SMSA			NON-SMSA		
		POPULATION CATEGORY			POPULATION CATEGORY		
		SLOW	MOD.	FAST	SLOW	MOD.	FAST
		VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO
RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION						
RURAL	PRINCIPAL INT.	15.90	21.76	27.63	18.63	20.39	22.16
	PRINCIPAL OTHER	11.84	12.37	12.91	7.12	8.86	10.60
	MINOR ARTERIAL	5.19	6.79	8.38	4.31	4.71	5.10
	MAJOR COLLECTOR	1.57	3.51	5.45	1.75	2.40	3.06
	MINOR COLLECTOR	0.55	0.77	0.99	0.56	0.69	0.81
	LOCAL	0.19	0.69	1.19	0.36	0.72	1.08
SMALL URBAN	PRINCIPAL INT.	.	20.42	.	25.32	26.63	27.93
	PRINCIPAL OTHER	8.89	12.39	.	12.86	13.96	15.07
	MINOR ARTERIAL	8.25	12.23	16.22	7.74	9.47	11.20
	LOCAL	.	7.39	.	2.35	2.89	.
	PR. OTHER X-WAY	9.75	.	.	8.14	9.69	11.24
	COLLECTOR	9.32	.	6.73	3.57	4.33	5.09
URBANIZED	PRINCIPAL INT.	76.49	66.50	56.51	.	.	.
	PRINCIPAL OTHER	20.93	25.18	.	.	.	.
	MINOR ARTERIAL	13.35	14.88	16.42	.	.	.
	LOCAL	3.21	.	.	.	.	.
	PR. OTHER X-WAY	14.21	37.67	.	.	.	.
	COLLECTOR	4.45	6.16	7.87	.	.	.

VOLUME RATIO - 75TH PERCENTILE (ACTUAL)

		SMSA			NON-SMSA		
		POPULATION CATEGORY			POPULATION CATEGORY		
		SLOW	MOD.	FAST	SLOW	MOD.	FAST
		VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO
RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION						
RURAL	PRINCIPAL INT.	18.32	20.64	28.60	19.32	19.62	22.90
	PRINCIPAL OTHER	12.44	10.77	19.34	6.70	9.61	8.49
	MINOR ARTERIAL	5.62	5.93	9.51	4.39	4.56	5.64
	MAJOR COLLECTOR	1.85	3.23	5.73	1.80	2.28	3.28
	MINOR COLLECTOR	0.54	0.78	0.97	0.57	0.67	0.84
	LOCAL	0.27	0.61	1.55	0.35	0.75	1.00
SMALL URBAN	PRINCIPAL INT.	.	20.42	.	15.55	33.14	24.68
	PRINCIPAL OTHER	8.89	12.39	.	12.29	15.03	13.58
	MINOR ARTERIAL	8.87	10.01	17.48	7.25	10.19	9.79
	LOCAL	.	7.39	.	2.35	2.89	.
	PR. OTHER X-WAY	9.75	.	.	6.95	13.50	8.48
	COLLECTOR	9.32	.	6.73	3.60	4.27	5.35
URBANIZED	PRINCIPAL INT.	77.54	31.58	69.60	.	.	.
	PRINCIPAL OTHER	20.93	25.18	.	.	.	.
	MINOR ARTERIAL	13.28	15.17	16.06	.	.	.
	LOCAL	3.21	.	.	.	.	.
	PR. OTHER X-WAY	14.21	37.67	.	.	.	.
	COLLECTOR	4.70	4.84	9.31	.	.	.

VOLUME RATIO - 50TH PERCENTILE (SMOOTHED)

		SMSA			NON-SMSA		
		POPULATION CATEGORY			POPULATION CATEGORY		
		SLOW	MOD.	FAST	SLOW	MOD.	FAST
RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO
RURAL	PRINCIPAL INT.	11.13	16.50	21.87	17.60	18.60	19.61
	PRINCIPAL OTHER	7.63	8.51	9.39	4.21	5.86	7.50
	MINOR ARTERIAL	1.90	3.23	4.56	2.70	2.86	3.02
	MAJOR COLLECTOR	1.04	1.92	2.80	0.99	1.26	1.53
	MINOR COLLECTOR	0.35	0.45	0.55	0.31	0.38	0.44
	LOCAL	0.18	0.30	0.43	0.17	0.24	0.32
SMALL URBAN	PRINCIPAL INT.	.	20.30	.	18.91	21.57	24.23
	PRINCIPAL OTHER	6.02	9.36	.	8.71	9.81	10.92
	MINOR ARTERIAL	5.93	6.64	7.36	4.87	5.69	6.50
	LOCAL	.	7.39	.	1.16	1.84	.
	PR. OTHER X-WAY	9.75	.	.	7.08	8.84	10.61
	COLLECTOR	4.32	.	6.73	2.34	2.86	3.37
URBANIZED	PRINCIPAL INT.	63.85	53.72	43.58	.	.	.
	PRINCIPAL OTHER	14.14	19.26	.	.	.	.
	MINOR ARTERIAL	8.44	9.09	9.75	.	.	.
	LOCAL	0.77	.	.	.	.	.
	PR. OTHER X-WAY	10.39	20.32	.	.	.	.
	COLLECTOR	2.07	2.91	3.75	.	.	.

VOLUME RATIO - 50TH PERCENTILE (ACTUAL)

		SMSA			NON-SMSA		
		POPULATION CATEGORY			POPULATION CATEGORY		
		SLOW	MOD.	FAST	SLOW	MOD.	FAST
RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO
RURAL	PRINCIPAL INT.	12.38	15.92	22.38	18.87	17.18	20.95
	PRINCIPAL OTHER	8.34	6.61	16.98	3.92	6.38	6.01
	MINOR ARTERIAL	2.11	2.80	5.12	2.78	2.72	3.53
	MAJOR COLLECTOR	1.18	1.78	2.94	1.01	1.20	1.62
	MINOR COLLECTOR	0.35	0.45	0.55	0.32	0.38	0.45
	LOCAL	0.21	0.27	0.57	0.16	0.26	0.28
SMALL URBAN	PRINCIPAL INT.	.	20.30	.	15.55	23.81	23.11
	PRINCIPAL OTHER	6.02	9.36	.	8.46	10.28	10.27
	MINOR ARTERIAL	6.15	5.83	7.82	4.96	5.56	6.76
	LOCAL	.	7.39	.	1.16	1.84	.
	PR. OTHER X-WAY	9.75	.	.	5.99	12.34	6.25
	COLLECTOR	4.32	.	6.73	2.29	2.98	2.86
URBANIZED	PRINCIPAL INT.	64.66	26.74	53.70	.	.	.
	PRINCIPAL OTHER	14.14	19.26	.	.	.	.
	MINOR ARTERIAL	8.45	9.01	9.85	.	.	.
	LOCAL	0.77	.	.	.	.	.
	PR. OTHER X-WAY	10.39	20.32	.	.	.	.
	COLLECTOR	2.23	2.04	4.70	.	.	.

VOLUME RATIO - 25TH PERCENTILE (SMOOTHED)

		SMSA			NON-SMSA		
		POPULATION CATEGORY			POPULATION CATEGORY		
		SLOW	MOD.	FAST	SLOW	MOD.	FAST
RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO
RURAL	PRINCIPAL INT.	9.49	12.36	15.23	7.74	13.52	19.30
	PRINCIPAL OTHER	4.31	5.05	5.79	2.56	3.49	4.41
	MINOR ARTERIAL	1.29	2.23	3.17	1.58	1.80	2.02
	MAJOR COLLECTOR	0.66	0.96	1.25	0.59	0.68	0.76
	MINOR COLLECTOR	0.22	0.26	0.30	0.19	0.22	0.26
	LOCAL	0.11	0.15	0.19	0.10	0.12	0.15
SMALL URBAN	PRINCIPAL INT.	.	20.17	.	16.92	20.09	23.26
	PRINCIPAL OTHER	3.82	7.17	.	5.91	6.39	6.88
	MINOR ARTERIAL	3.44	3.76	4.08	3.51	3.48	3.44
	LOCAL	.	7.39	.	0.93	1.33	.
	PR. OTHER X-WAY	9.75	.	.	5.55	7.61	9.66
	COLLECTOR	1.91	.	6.73	1.51	1.58	1.65
URBANIZED	PRINCIPAL INT.	42.69	28.27	13.86	.	.	.
	PRINCIPAL OTHER	8.76	10.34	.	.	.	.
	MINOR ARTERIAL	5.22	5.01	4.81	.	.	.
	LOCAL	0.58	.	.	.	.	.
	PR. OTHER X-WAY	5.51	11.19	.	.	.	.
	COLLECTOR	1.39	1.23	1.07	.	.	.

VOLUME RATIO - 25TH PERCENTILE (ACTUAL)

		SMSA			NON-SMSA		
		POPULATION CATEGORY			POPULATION CATEGORY		
		SLOW	MOD.	FAST	SLOW	MOD.	FAST
RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO	VOLUME RATIO
RURAL	PRINCIPAL INT.	8.78	12.69	14.95	8.33	12.85	19.93
	PRINCIPAL OTHER	4.36	4.90	6.38	2.57	3.48	4.43
	MINOR ARTERIAL	1.43	1.96	3.53	1.63	1.68	2.44
	MAJOR COLLECTOR	0.71	0.91	1.30	0.60	0.66	0.79
	MINOR COLLECTOR	0.21	0.27	0.28	0.20	0.21	0.27
	LOCAL	0.10	0.16	0.15	0.09	0.13	0.12
SMALL URBAN	PRINCIPAL INT.	.	20.17	.	15.55	21.00	22.81
	PRINCIPAL OTHER	3.82	7.17	.	6.05	6.12	7.26
	MINOR ARTERIAL	3.44	3.76	4.08	3.49	3.51	3.37
	LOCAL	.	7.39	.	0.93	1.33	.
	PR. OTHER X-WAY	9.75	.	.	4.64	10.53	6.01
	COLLECTOR	1.91	.	6.73	1.49	1.64	1.39
URBANIZED	PRINCIPAL INT.	43.14	13.15	19.53	.	.	.
	PRINCIPAL OTHER	8.76	10.34	.	.	.	.
	MINOR ARTERIAL	5.28	4.73	5.15	.	.	.
	LOCAL	0.58	.	.	.	.	.
	PR. OTHER X-WAY	5.51	11.19	.	.	.	.
	COLLECTOR	1.39	1.27	1.03	.	.	.

APPENDIX F

GROWTH-FACTOR MODEL FOR 1986

GROWTH FACTORS - NUMBER OF ENTRIES PER CELL

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME (VPD) 5,000-9,999 COUNT	10,000 19,999 COUNT	20,000 40,000 COUNT	>40,0-00 COUNT
RURAL	PRINCIPAL INTERSTATE	19	69	25	1

GROWTH FACTORS - NUMBER OF ENTRIES PER CELL

RURAL-URBAN DESIGNAT-ION	FUNCTION-AL CLASSIFI-CATION	POPULATION CATEGORY	VOLUME (VPD) <625 COUNT	625-1,249 COUNT	1,250-2,499 COUNT	2,500-4,999 COUNT	5,000-9,999 COUNT	10,000 19,999 COUNT	20,000 40,000 COUNT
RURAL	PRINCIPAL OTHER	SLOW	.	.	9	21	8	4	.
		MOD.	.	3	36	89	59	19	.
		FAST	.	.	19	58	75	29	3
	MINOR ARTERIAL	SLOW	5	10	76	73	27	5	.
		MOD.	7	50	143	149	76	3	.
		FAST	5	21	64	94	54	16	.
	MAJOR COLLECTOR	SLOW	120	192	124	45	13	2	.
		MOD.	363	463	389	187	73	7	.
		FAST	181	306	331	250	90	18	.
	MINOR COLLECTOR	SLOW	455	70	26	13	4	.	.
		MOD.	1226	227	56	14	5	1	.
		FAST	788	234	99	24	7	3	.
	LOCAL	SLOW	114	6	3	2	1	.	.
		MOD.	327	30	27	14	1	.	.
		FAST	150	21	21	17	17	1	.

GROWTH FACTORS - NUMBER OF ENTRIES PER CELL

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME (VPD) 5,000-9,999 COUNT	10,000 19,999 COUNT	20,000 40,000 COUNT	>40,0-00 COUNT
URBAN	PRINCIPAL INTERSTATE	1	8	21	36

GROWTH FACTORS - NUMBER OF ENTRIES PER CELL

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	POPULATION CATEGORY	VOLUME (VPD) <625 COUNT	625-1,249 COUNT	1,250-2,499 COUNT	2,500-4,999 COUNT	5,000-9,999 COUNT	10,000 19,999 COUNT	20,000 40,000 COUNT	>40,0-00 COUNT
URBAN	PRINCIPAL OTHER X-WAY	SLOW	.	.	.	1	.	.	.	.
		MOD.	.	.	.	7	8	4	.	.
		FAST	.	.	.	2	7	1	8	.
	PRINCIPAL OTHER	SLOW	.	.	1	22	24	63	12	.
		MOD.	.	.	.	13	78	74	37	5
		FAST	.	1	1	14	56	66	35	.
	MINOR ARTERIAL	SLOW	.	2	8	29	45	18	1	.
		MOD.	.	1	23	68	108	76	17	.
		FAST	3	9	39	93	121	109	25	.
	COLLECTOR	SLOW	.	4	11	16	4	4	.	.
		MOD.	6	15	32	23	9	5	1	.
		FAST	6	13	16	20	14	7	.	.
	LOCAL	MOD.	1	4	6	3	.	.	.	.
		FAST	.	1	5	2	3	.	.	.

GROWTH FACTORS - 75TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME (VPD) 5,000-9,999 GROWTH FACTOR	10,000-19,999 GROWTH FACTOR	20,000-40,000 GROWTH FACTOR	>40,000 GROWTH FACTOR
RURAL	PRINCIPAL INTERSTATE	2.00	1.33	0.66	-0.01

GROWTH FACTORS - 75TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	POPULATION CATEGORY	VOLUME (VPD) <625 GROWTH FACTOR	625-1,249 GROWTH FACTOR	1,250-2,499 GROWTH FACTOR	2,500-4,999 GROWTH FACTOR	5,000-9,999 GROWTH FACTOR	10,000-19,999 GROWTH FACTOR	20,000-40,000 GROWTH FACTOR
RURAL	PRINCIPAL OTHER	SLOW	.	.	2.73	2.23	1.73	1.23	.
		MOD.	.	3.79	3.29	2.79	2.29	1.79	.
		FAST	.	.	3.85	3.35	2.85	2.35	1.85
	MINOR ARTERIAL	SLOW	0.33	0.39	0.45	0.52	0.58	0.65	.
		MOD.	0.79	0.85	0.92	0.98	1.05	1.11	.
		FAST	1.25	1.32	1.38	1.45	1.51	1.58	.
	MAJOR COLLECTOR	SLOW	0.19	0.27	0.35	0.43	0.51	0.60	.
		MOD.	0.77	0.85	0.93	1.02	1.10	1.18	.
		FAST	1.35	1.43	1.52	1.60	1.68	1.76	.
	MINOR COLLECTOR	SLOW	0.54	0.90	1.27	1.64	2.00	.	.
		MOD.	1.16	1.52	1.89	2.26	2.62	2.99	.
		FAST	1.78	2.14	2.51	2.88	3.24	3.61	.
	LOCAL	SLOW	0.48	0.67	0.85	1.03	1.21	.	.
		MOD.	1.13	1.31	1.49	1.68	1.86	.	.
		FAST	1.78	1.96	2.14	2.32	2.50	2.68	.

GROWTH FACTORS - 75TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME (VPD) 5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,0-00 GROWTH FACTOR
URBAN	PRINCIPAL INTERSTATE	5.52	4.05	2.58	1.10

GROWTH FACTORS - 75TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	POPULATION CATEGORY	VOLUME (VPD) <625 GROWTH FACTOR	625-1,249 GROWTH FACTOR	1,250-2,499 GROWTH FACTOR	2,500-4,999 GROWTH FACTOR	5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,0-00 GROWTH FACTOR
URBAN	PRINCIPAL OTHER X-WAY	SLOW	.	.	.	3.85	.	.	.	.
		MOD.	.	.	.	4.10	3.95	3.79	.	.
		FAST	.	.	.	4.35	4.20	4.05	3.89	.
	PRINCIPAL OTHER	SLOW	.	.	2.21	1.62	1.03	0.44	-0.15	.
		MOD.	.	.	.	2.27	1.68	1.09	0.50	-0.09
		FAST	.	4.10	3.51	2.92	2.33	1.74	1.15	.
	MINOR ARTERIAL	SLOW	.	2.30	1.52	0.73	-0.05	-0.83	-1.62	.
		MOD.	.	2.92	2.14	1.36	0.57	-0.21	-1.00	.
		FAST	4.33	3.55	2.76	1.98	1.19	0.41	-0.38	.
	COLLECTOR	SLOW	.	0.69	0.40	0.11	-0.19	-0.48	.	.
		MOD.	2.34	2.04	1.75	1.46	1.16	0.87	0.58	.
		FAST	3.69	3.39	3.10	2.81	2.51	2.22	.	.
	LOCAL	MOD.	-1.05	-0.03	0.99	2.01	.	.	.	.
		FAST	.	-1.01	0.01	1.02	2.04	.	.	.

GROWTH FACTORS - 50TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME (VPD) 5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,0-00 GROWTH FACTOR
RURAL	PRINCIPAL INTERSTATE	0.94	0.49	0.04	-0.41

GROWTH FACTORS - 50TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	POPULATION CATEGORY	VOLUME (VPD) <625 GROWTH FACTOR	625-1,249 GROWTH FACTOR	1,250-2,499 GROWTH FACTOR	2,500-4,999 GROWTH FACTOR	5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR
RURAL	PRINCIPAL OTHER	SLOW	.	.	0.35	0.41	0.48	0.54	.
		MOD.	.	0.64	0.70	0.76	0.83	0.89	.
		FAST	.	.	1.05	1.11	1.17	1.24	1.30
	MINOR ARTERIAL	SLOW	-1.23	-1.07	-0.92	-0.77	-0.62	-0.47	.
		MOD.	-0.81	-0.66	-0.50	-0.35	-0.20	-0.05	.
		FAST	-0.39	-0.24	-0.08	0.07	0.22	0.37	.
	MAJOR COLLECTOR	SLOW	-1.16	-1.08	-1.00	-0.91	-0.83	-0.75	.
		MOD.	-0.61	-0.53	-0.45	-0.37	-0.28	-0.20	.
		FAST	-0.07	0.01	0.10	0.18	0.26	0.34	.
	MINOR COLLECTOR	SLOW	-0.92	-0.59	-0.27	0.05	0.37	.	.
		MOD.	-0.41	-0.09	0.23	0.55	0.87	1.20	.
		FAST	0.10	0.42	0.74	1.06	1.38	1.70	.
	LOCAL	SLOW	-0.85	-0.68	-0.51	-0.35	-0.18	.	.
		MOD.	-0.50	-0.34	-0.17	-0.00	0.16	.	.
		FAST	-0.16	0.01	0.17	0.34	0.51	0.67	.

GROWTH FACTORS - 50TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME (VPD) 5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,0-00 GROWTH FACTOR
URBAN	PRINCIPAL INTERSTATE	3.57	2.17	0.77	-0.64

GROWTH FACTORS - 50TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNAT-ION	FUNCTION-AL CLASSIFI-CATION	POPULATION CATEGORY	VOLUME (VPD) <625 GROWTH FACTOR	625-1,249 GROWTH FACTOR	1,250-2,499 GROWTH FACTOR	2,500-4,999 GROWTH FACTOR	5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,0-00 GROWTH FACTOR
URBAN	PRINCIPAL OTHER X-WAY	SLOW	.	.	.	3.93	.	.	.	.
		MOD.	.	.	.	3.86	3.08	2.31	.	.
		FAST	.	.	.	3.78	3.01	2.23	1.46	.
	PRINCIPAL OTHER	SLOW	.	.	0.17	-0.28	-0.73	-1.18	-1.63	.
		MOD.	.	.	.	0.17	-0.28	-0.73	-1.18	-1.63
		FAST	.	1.51	1.06	0.61	0.16	-0.29	-0.74	.
	MINOR ARTERIAL	SLOW	.	0.37	-0.19	-0.76	-1.33	-1.90	-2.46	.
		MOD.	.	0.82	0.25	-0.32	-0.88	-1.45	-2.02	.
		FAST	1.83	1.26	0.69	0.13	-0.44	-1.01	-1.58	.
	COLLECTOR	SLOW	.	-0.49	-0.84	-1.20	-1.55	-1.91	.	.
		MOD.	0.74	0.39	0.03	-0.32	-0.68	-1.03	-1.39	.
		FAST	1.61	1.26	0.90	0.55	0.19	-0.16	.	.
	LOCAL	MOD.	0.31	-0.57	-1.44	-2.32	.	.	.	.
		FAST	.	-0.45	-1.32	-2.20	-3.07	.	.	.

GROWTH FACTORS - 25TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME (VPD) 5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,0-00 GROWTH FACTOR
RURAL	PRINCIPAL INTERSTATE	0.50	-0.02	-0.53	-1.05

GROWTH FACTORS - 25TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNAT-ION	FUNCTION-AL CLASSIFI-CATION	POPULATION CATEGORY	VOLUME (VPD) <625 GROWTH FACTOR	625-1,249 GROWTH FACTOR	1,250-2,499 GROWTH FACTOR	2,500-4,999 GROWTH FACTOR	5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR
RURAL	PRINCIPAL OTHER	SLOW	.	.	-1.54	-1.47	-1.39	-1.32	.
		MOD.	.	-1.17	-1.10	-1.02	-0.95	-0.88	.
		FAST	.	.	-0.65	-0.58	-0.51	-0.43	-0.36
	MINOR ARTERIAL	SLOW	-2.00	-2.10	-2.21	-2.31	-2.41	-2.52	.
		MOD.	-1.48	-1.58	-1.69	-1.79	-1.89	-1.99	.
		FAST	-0.96	-1.06	-1.16	-1.27	-1.37	-1.47	.
	MAJOR COLLECTOR	SLOW	-2.11	-2.10	-2.09	-2.08	-2.07	-2.05	.
		MOD.	-1.78	-1.76	-1.75	-1.74	-1.73	-1.72	.
		FAST	-1.44	-1.43	-1.42	-1.41	-1.40	-1.38	.
	MINOR COLLECTOR	SLOW	-2.32	-2.09	-1.85	-1.62	-1.39	.	.
		MOD.	-1.86	-1.62	-1.39	-1.16	-0.93	-0.70	.
		FAST	-1.40	-1.16	-0.93	-0.70	-0.47	-0.24	.
	LOCAL	SLOW	-3.03	-2.98	-2.94	-2.90	-2.86	.	.
		MOD.	-2.48	-2.43	-2.39	-2.35	-2.30	.	.
		FAST	-1.92	-1.88	-1.84	-1.79	-1.75	-1.71	.

GROWTH FACTORS - 25TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME (VPD) 5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,0-00 GROWTH FACTOR
URBAN	PRINCIPAL INTERSTATE	1.43	0.43	-0.57	-1.57

GROWTH FACTORS - 25TH PERCENTILE (SMOOTHED)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	POPULATION CATEGORY	VOLUME (VPD) <625 GROWTH FACTOR	625-1,249 GROWTH FACTOR	1,250-2,499 GROWTH FACTOR	2,500-4,999 GROWTH FACTOR	5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,0-00 GROWTH FACTOR
URBAN	PRINCIPAL OTHER X-WAY	SLOW	.	.	.	3.08	.	.	.	.
		MOD.	.	.	.	2.92	2.01	1.10	.	.
		FAST	.	.	.	2.76	1.86	0.95	0.04	.
	PRINCIPAL OTHER	SLOW	.	.	-2.53	-2.92	-3.32	-3.72	-4.12	.
		MOD.	.	.	.	-1.67	-2.07	-2.47	-2.87	-3.26
		FAST	.	0.37	-0.02	-0.42	-0.82	-1.22	-1.61	.
	MINOR ARTERIAL	SLOW	.	-1.06	-1.61	-2.16	-2.71	-3.26	-3.81	.
		MOD.	.	-0.70	-1.25	-1.80	-2.35	-2.90	-3.45	.
		FAST	0.20	-0.34	-0.89	-1.44	-1.99	-2.54	-3.09	.
	COLLECTOR	SLOW	.	-2.63	-2.89	-3.16	-3.43	-3.70	.	.
		MOD.	-1.35	-1.62	-1.88	-2.15	-2.42	-2.69	-2.96	.
		FAST	-0.34	-0.60	-0.87	-1.14	-1.41	-1.68	.	.
	LOCAL	MOD.	-1.26	-2.06	-2.87	-3.68	.	.	.	.
		FAST	.	-2.26	-3.07	-3.88	-4.68	.	.	.

GROWTH FACTORS - 75TH PERCENTILE (ACTUAL)

		VOLUME (VPD)			
		5,000-9,999	10,000 19,999	20,000 40,000	>40,0-00
		GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR
RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION				
RURAL	PRINCIPAL INTERSTATE	1.68	1.51	0.41	0.02

GROWTH FACTORS - 75TH PERCENTILE (ACTUAL)

			VOLUME (VPD)						
			<625	625-1,249	1,250-2,499	2,500-4,999	5,000-9,999	10,000 19,999	20,000 40,000
			GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR
RURAL-URBAN DESIGNAT-ION	FUNCTION-AL CLASSIFI-CATION	POPULATION CATEGORY							
RURAL	PRINCIPAL OTHER	SLOW	.	.	4.86	1.60	3.20	2.37	.
		MOD.	.	1.23	3.33	2.41	2.40	1.18	.
		FAST	.	.	4.24	3.04	3.52	2.00	-0.56
	MINOR ARTERIAL	SLOW	1.28	4.95	0.47	0.37	1.07	2.67	.
		MOD.	1.67	0.20	0.42	0.90	0.79	2.10	.
		FAST	-0.06	1.70	1.52	2.13	1.62	0.56	.
	MAJOR COLLECTOR	SLOW	0.42	0.32	0.65	1.28	0.86	0.59	.
		MOD.	0.49	0.84	0.82	0.73	0.89	-1.63	.
		FAST	1.27	1.58	1.68	1.91	1.30	1.09	.
	MINOR COLLECTOR	SLOW	0.80	1.05	1.37	1.81	-0.33	.	.
		MOD.	0.95	1.58	2.08	1.84	1.92	-3.08	.
		FAST	1.80	2.32	3.89	1.43	-0.41	-0.66	.
	LOCAL	SLOW	0.59	1.13	3.28	2.94	-3.94	.	.
		MOD.	1.01	2.23	0.98	0.82	-2.03	.	.
		FAST	1.61	4.03	2.48	2.11	2.40	3.41	.

GROWTH FACTORS - 75TH PERCENTILE (ACTUAL)

		VOLUME (VPD)			
		5,000-9,999	10,000 19,999	20,000 40,000	>40,0-00
		GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR
RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION				
URBAN	PRINCIPAL INTERSTATE	-0.06	3.12	4.08	0.59

GROWTH FACTORS - 75TH PERCENTILE (ACTUAL)

			VOLUME (VPD)							
			<625	625-1,249	1,250-2,499	2,500-4,999	5,000-9,999	10,000 19,999	20,000 40,000	>40,0-00
			GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR	GROWTH FACTOR
RURAL-URBAN DESIGNAT-ION	FUNCTION-AL CLASSIFI-CATION	POPULATION CATEGORY								
URBAN	PRINCIPAL OTHER X-WAY	SLOW	.	.	.	4.97	.	.	.	.
		MOD.	.	.	.	3.71	4.18	3.46	.	.
		FAST	.	.	.	3.91	4.71	1.97	3.95	.
	PRINCIPAL OTHER	SLOW	.	.	0.51	1.77	0.81	1.20	0.40	.
		MOD.	.	.	.	1.80	1.34	0.36	-0.03	0.67
		FAST	.	3.76	1.97	4.54	2.44	1.97	1.41	.
	MINOR ARTERIAL	SLOW	.	4.61	0.47	0.55	-0.18	-2.29	-4.38	.
		MOD.	.	1.47	2.51	1.56	0.78	0.43	-1.23	.
		FAST	1.96	3.51	3.16	1.68	1.06	0.41	-0.73	.
	COLLECTOR	SLOW	.	3.80	-0.14	-0.43	3.69	-2.31	.	.
		MOD.	2.32	0.46	2.11	1.71	-0.48	4.46	-8.28	.
		FAST	3.98	4.18	3.71	1.53	2.28	4.08	.	.
	LOCAL	MOD.	2.73	-0.08	0.01	2.77	.	.	.	.
		FAST	.	-4.47	0.66	0.37	2.53	.	.	.

GROWTH FACTORS - 50TH PERCENTILE (ACTUAL)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME (VPD) 5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,0-00 GROWTH FACTOR
RURAL	PRINCIPAL INTERSTATE	0.57	0.70	-0.27	0.02

GROWTH FACTORS - 50TH PERCENTILE (ACTUAL)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	POPULATION CATEGORY	VOLUME (VPD) <625 GROWTH FACTOR	625-1,249 GROWTH FACTOR	1,250-2,499 GROWTH FACTOR	2,500-4,999 GROWTH FACTOR	5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR
RURAL	PRINCIPAL OTHER	SLOW	.	.	3.10	0.19	0.90	0.47	.
		MOD.	.	0.39	0.70	0.40	0.67	0.67	.
		FAST	.	.	0.97	0.51	2.18	0.96	-1.35
	MINOR ARTERIAL	SLOW	-0.80	0.04	-0.54	-0.94	-0.81	1.57	.
		MOD.	-0.42	-1.34	-0.76	-0.21	-0.48	-0.49	.
		FAST	-0.59	-0.21	0.27	0.24	0.27	-0.01	.
	MAJOR COLLECTOR	SLOW	-1.32	-0.99	-0.61	-0.53	-1.81	-1.00	.
		MOD.	-0.93	-0.47	-0.34	-0.51	-0.43	-2.78	.
		FAST	-0.25	0.28	0.13	0.37	-0.16	-0.88	.
	MINOR COLLECTOR	SLOW	-0.82	-0.46	-0.12	0.21	-2.35	.	.
		MOD.	-0.53	0.19	0.38	0.41	-0.67	-3.08	.
		FAST	0.06	0.64	1.65	-0.10	-1.30	-3.20	.
	LOCAL	SLOW	-0.75	-1.20	0.71	-1.67	-3.94	.	.
		MOD.	-0.58	1.10	-0.97	-0.21	-2.03	.	.
		FAST	-0.19	-0.33	0.76	0.36	0.57	3.41	.

GROWTH FACTORS - 50TH PERCENTILE (ACTUAL)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME (VPD) 5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,0-00 GROWTH FACTOR
URBAN	PRINCIPAL INTERSTATE	-0.06	1.98	1.43	-0.88

GROWTH FACTORS - 50TH PERCENTILE (ACTUAL)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	POPULATION CATEGORY	VOLUME (VPD) <625 GROWTH FACTOR	625-1,249 GROWTH FACTOR	1,250-2,499 GROWTH FACTOR	2,500-4,999 GROWTH FACTOR	5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,0-00 GROWTH FACTOR
URBAN	PRINCIPAL OTHER X-WAY	SLOW	.	.	.	4.97	.	.	.	.
		MOD.	.	.	.	3.18	3.52	2.11	.	.
		FAST	.	.	.	3.32	3.58	1.97	1.24	.
	PRINCIPAL OTHER	SLOW	.	.	0.51	-0.25	-0.77	-1.05	-1.57	.
		MOD.	.	.	.	-0.70	-0.02	-1.21	-0.99	-1.45
		FAST	.	3.76	1.97	0.28	0.34	-0.32	-0.66	.
	MINOR ARTERIAL	SLOW	.	3.14	-0.80	-0.91	-1.26	-2.94	-4.38	.
		MOD.	.	1.47	0.46	-0.08	-0.97	-1.12	-1.72	.
		FAST	-0.07	1.54	0.98	-0.22	-0.50	-0.76	-2.26	.
	COLLECTOR	SLOW	.	2.54	-1.23	-2.18	1.36	-4.33	.	.
		MOD.	-0.71	-0.26	0.71	0.02	-1.64	2.28	-8.28	.
		FAST	1.46	0.33	1.66	0.85	-0.35	-0.66	.	.
	LOCAL	MOD.	2.73	-0.56	-1.56	-2.90	.	.	.	.
		FAST	.	-4.47	-1.00	-1.08	-3.01	.	.	.

GROWTH FACTORS - 25TH PERCENTILE (ACTUAL)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME (VPD) 5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,0-00 GROWTH FACTOR
RURAL	PRINCIPAL INTERSTATE	0.47	0.02	-0.64	0.02

GROWTH FACTORS - 25TH PERCENTILE (ACTUAL)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	POPULATION CATEGORY	VOLUME (VPD) <625 GROWTH FACTOR	625-1,249 GROWTH FACTOR	1,250-2,499 GROWTH FACTOR	2,500-4,999 GROWTH FACTOR	5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR
RURAL	PRINCIPAL OTHER	SLOW	.	.	0.60	-1.34	-0.00	-3.86	.
		MOD.	.	-0.23	-0.75	-1.83	-0.69	-1.12	.
		FAST	.	.	-0.49	-1.10	0.21	-0.46	-1.35
	MINOR ARTERIAL	SLOW	-3.60	-1.64	-1.76	-3.03	-3.42	-1.58	.
		MOD.	-0.95	-2.22	-1.62	-1.08	-1.88	-0.92	.
		FAST	-3.06	-1.54	-1.18	-0.99	-1.98	-2.51	.
	MAJOR COLLECTOR	SLOW	-2.27	-2.30	-1.39	-1.72	-3.12	-2.58	.
		MOD.	-2.14	-1.68	-1.52	-1.80	-2.12	-4.77	.
		FAST	-1.76	-0.97	-1.48	-1.21	-2.15	-2.19	.
	MINOR COLLECTOR	SLOW	-2.42	-1.86	-2.55	-1.27	-4.94	.	.
		MOD.	-1.86	-1.00	-1.20	-2.81	-1.31	-3.08	.
		FAST	-1.58	-0.76	-0.44	-1.74	-3.28	-3.62	.
	LOCAL	SLOW	-3.01	-3.68	-1.24	-6.28	-3.94	.	.
		MOD.	-2.43	-1.60	-3.67	-2.10	-2.03	.	.
		FAST	-2.10	-0.97	-2.11	-1.89	-1.40	3.41	.

GROWTH FACTORS - 25TH PERCENTILE (ACTUAL)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	VOLUME (VPD) 5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,000 GROWTH FACTOR
URBAN	PRINCIPAL INTERSTATE	-0.06	0.83	-0.66	-1.57

GROWTH FACTORS - 25TH PERCENTILE (ACTUAL)

RURAL-URBAN DESIGNATION	FUNCTIONAL CLASSIFICATION	POPULATION CATEGORY	VOLUME (VPD) <625 GROWTH FACTOR	625-1,249 GROWTH FACTOR	1,250-2,499 GROWTH FACTOR	2,500-4,999 GROWTH FACTOR	5,000-9,999 GROWTH FACTOR	10,000 19,999 GROWTH FACTOR	20,000 40,000 GROWTH FACTOR	>40,000 GROWTH FACTOR
URBAN	PRINCIPAL OTHER X-WAY	SLOW	.	.	.	4.97	.	.	.	.
		MOD.	.	.	.	2.09	2.03	1.59	.	.
		FAST	.	.	.	2.73	2.49	1.97	-0.40	.
	PRINCIPAL OTHER	SLOW	.	.	0.51	-2.79	-3.28	-4.38	-2.99	.
		MOD.	.	.	.	-1.98	-1.74	-2.59	-2.08	-3.02
		FAST	.	3.76	1.97	-1.14	-0.79	-1.33	-1.91	.
	MINOR ARTERIAL	SLOW	.	1.68	-1.55	-3.27	-3.02	-4.77	-4.38	.
		MOD.	.	1.47	-1.14	-0.76	-2.25	-2.34	-3.08	.
		FAST	-0.92	1.07	-1.26	-1.64	-2.50	-2.41	-2.99	.
	COLLECTOR	SLOW	.	-2.10	-5.06	-2.74	-3.63	-4.65	.	.
		MOD.	-1.73	-2.24	-0.71	-1.56	-3.09	-0.50	-8.28	.
		FAST	0.20	-1.11	-1.66	-0.56	-2.48	-1.72	.	.
	LOCAL	MOD.	2.73	-1.71	-3.82	-3.57	.	.	.	.
		FAST	.	-4.47	-3.58	-2.54	-3.98	.	.	.

APPENDIX G

DOCUMENTATION OF SITE VOLUME MODELS

This APPENDIX provides instructions to users having minimal knowledge of the University of Kentucky IBM mainframe computer, JCL, and CMS for running the software for the calibration of volume-ratio and growth-factor models. The software consists of a system of three programs, "GROWTH PROG", "SMOOTH VRALL" and "SMOOTH GROWALL".

A. OVERVIEW

1. OBJECTIVE OF PROGRAMS

In future years, updating of the model calibration data base and recalibration of the traffic growth model will require execution of three main programs having the following functions:

"GROWTH PROG" was developed to merge relevant portions of the Traffic Volume Summary file, hereinafter termed the "D-BASE" file, with relevant portions of the Statewide Mileage Tape, hereinafter termed the "SWMILE" file, and also to compute growth factors and volume ratios for stations satisfying minimum standards of acceptability.

"SMOOTH VRALL" was developed to create the cross-tabulation model for estimating volume ratios.

"SMOOTH GROWALL" was developed to create the cross-tabulation model for estimating growth factors.

2. PROGRAM NARRATIVES

"GROWTH PROG" is a FORTRAN program that consists of two stages. In the first stage, the "SWMILE" file and the "D-BASE" file are merged. Growth factors and volume ratios are computed in the second stage of the program. Calculations of growth factors are limited to those sites for which at least four volume counts are available in the 20-year study period and which do not exhibit excessive variability from year to year. This process produces the model-calibration data base used for recalibration of the cross-tabulation volume-ratio and growth-factor models.

"SMOOTH VRALL" is a SAS program that produces the cross-tabulation matrix for the volume-ratio model. The dependent variable for each cell is the current (base-year) median volume ratio. In addition to this 50th-percentile matrix, cross-tabulation matrices for 75th and 25th percentiles of the current volume ratio also are produced. To assure internal consistency within the models and to provide estimates for otherwise empty cells, linear smoothing is used to produce the final model. In addition to the smoothed cross-tabulation model, three matrices for 25th, 50th, and 75th percentiles of the current volume ratio are also produced based on its actual rather than smoothed values.

"SMOOTH GROWALL" is a SAS program that produces the cross-tabulation matrix for the growth-factor model. The dependent variable for each cell is the median growth factor, representative of conditions during the prior 20 years. Cross-tabulation matrices for 75th and 25th percentiles also are produced. To assure internal consistency within the models and to provide estimates for otherwise empty cells, linear smoothing is used to produce the final model. In addition to the smoothed cross-tabulation model, three matrices for 25th, 50th, and 75th percentiles of the growth factor also are produced based on its actual rather than smoothed values.

Figure G1 is a simple but complete picture of the processing procedure that converts raw data to the final output. First, the raw volume data and raw station description and classification data are used to produce the merged file "DBSW YR86". This file along with three others ("POP DATA", "AADT DATA", and "SMSA DATA") is then used to update the model calibration data base, "NEW86 DATA". The "NEW86 DATA" file is then converted to a SAS data file to be utilized as an input to the SAS programs. For convenience, all printed output is routed to the CMS User ID reader and stored temporarily for review and printing.

3. PROGRAMMING LANGUAGE

"GROWTH PROG" is written in FORTRAN. "SMOOTH VRALL" and "SMOOTH GROWALL" are both written in SAS.

4. OPERATING ENVIRONMENT

Programs are designed to be executed by the IBM 3081 at the University of Kentucky, Lexington, Kentucky. A particular program may be run by submitting, from CMS, a batch job consisting of JCL, which identifies the appropriate load module and input and output files. Example JCL files are stored on OS disk at the University of Kentucky Computing Center (UKCC). The FORTRAN sources for the system programs are stored in the OS disk library UKU.@KTR05.

5. PREPARING THE JCL

JCL files may be created on a CMS user ID manually or, more efficiently, by using the CMS command OSXEDIT to copy the example files from OS to CMS files. In most cases, the new JCL may be created from the old files by shifting the DD record numbers and adding the DD records for the new files.

B. PROGRAM "GROWTH PROG"

1. INPUT

a. INTERNAL DATA AND PARAMETER SPECIFICATION

No internal data or parameters are required.

b. EXTERNAL DATA

One of the external input data bases utilized in the first stage of the "GROWTH PROG" program is the "D-BASE" file. This file from which the dependent variables are developed is updated periodically by the Department of Highways' Division of Planning in Frankfort. The updating process includes the addition of new traffic volumes to the file. The other external data base used in the first stage of the program is the "SWMILE" file from which several potential independent variables are extracted. Resulting output from merging these two files, "DBSW YR86" (Figure G2), is then utilized as the first input file to the following stage of the program. The second file used in the following stage of the program is "POP DATA", which contains the county populations in the state of Kentucky for the period of 1960-1986. This file must be updated annually. The third file to be utilized is "AADT DATA", which consists of the average annual daily traffic (AADT). To update this file, the most recent year's statewide average annual daily traffic (AADT) must be added to the file. The new AADT is obtained by executing the program named "STATE.EXE" on a microcomputer (See APPENDIX D). The fourth and final file, "SMSA DATA", identifies those counties contained within the SMSA's in the state of the Kentucky for the period of 1964-1986. After preparation is complete, the program is submitted to compute volume ratios and growth factors and to produce the model calibration data base, "NEW86 DATA" (Figure G3). For easy access, this data base is converted to a SAS data file, which is used as an input file to the SAS programs ("SMOOTH VRALL" and "SMOOTH GROWALL") for recalibration of the cross-tabulation models.

2. OUTPUT

a. FILES

One file, "NEW86 DATA", which consists of potential explanatory variables and the two dependent variables (volume ratios and growth factors), is produced.

b. REPORTS

Three reports are produced. The first identifies all route segments for which matches could not be found in the two primary data bases. The second yields the following two numbers:

COUNTN = number of stations rejected because of fewer than four years of data in the 20-year study period and

NOR2 = number of stations rejected because R^2 was less than the minimum requirement.

The third lists for each county its status relative to SMSA boundaries and tabulates county population growth for 10-year periods ending in each of the most recent five years (see example of Table 14).

3. USING THE PROGRAM

a. PRELIMINARIES

(1) After receiving the updated "D-BASE" file, an internal data sort must be utilized to assure the correct order in the classification of data records. The "D-BASE" file must be sorted based on county number, route number, route suffix, and milepoint. To be consistent with the sorting order of the "SWMILE" file, the route prefix is not included in the sorting fields of the "D-BASE" file. Sort fields for the "D-BASE" file are as follows: 1,3,ch,a,11,6,ch,a,17,15,ch,a. The following illustrates the JCL:

```
===================================================================================
/*CLASS A
//MERGE JOB (5035-51110),'AHMAD',REGION=350K
..INCLUDE 51110 PASSWORD
//STEP4 EXEC SD,CYL=16
//SORTIN  DD  UNIT=RENTAL,DSN=UKU.@KTR05.D-BASE.DATA,DISP=(OLD,KEEP)
//SORTOUT DD  UNIT=RENTAL,DISP=(NEW,CATLG),DSN=UKU.@KTR05.D-BASE.SORT,
//  DCB=(RECFM=FB,LRECL=222,BLKSIZE=222),SPACE=(TRK,(300,100),RLSE)
//SYSIN  DD  *
 SORT  FIELDS=(1,3,CH,A,11,6,CH,A,17,15,CH,A)
 END
/*
===================================================================================
```

(2) The "SWMILE" file must be edited. A check of the basic format of the file must be made to insure that every item is typed correctly in its field. Mistyped items must be flagged and corrected properly. The FORTRAN G program, "READ2 STATE2", is used to perform these checks. In previous runs, frequently mistyped items were route numbers and route suffixes. JCL and the source program listing are as follows:

```
================================================================================
 /*CLASS A
 //MERGE JOB (5035-51110),'AHMAD',REGION=350K
 ..INCLUDE 51110 PASSWORD
 /*JOBPARM  P=R,T=(0,30),L=10
 //S      EXEC FORTGCLG
 //FORT.SYSIN DD *
 CJOB           ,T=(0,30)
       REAL*8 WCORP1,WDIR1,WFUNC1,WUAC1,WAADT1
       REAL WSLEN1,WBMP1
       INTEGER WRTID1,WFAID1,WTORN1,WRUD1,WACC1,WPLAN1,WCONO1
      *,WADCL1,WROW1,WPVWP1,WNLP1,WMEDT1,WPVWO1,WNLO1,
      *WURA1,WRTNO1,WRTNO2
       REAL*8 WCORP2,WDIR2,WFUNC2,WUAC2,WAADT2
       REAL WSLEN2,WBMP2
       INTEGER WRTID2,WFAID2,WTORN2,WRUD2,WACC2,WPLAN2,WCONO2
      *,WADCL2,WROW2,WPVWP2,WNLP2,WMEDT2,WPVWO2,WNLO2,WURA2
C-----------------------------------------------------------------------
C                  READ THE STATE-WIDE MILEAGE
C-----------------------------------------------------------------------
                   I=0
  100          CONTINUE
                 I=I+1
  200 READ(11,19,END=80)WCONO1,WCORP1,WSLEN1,WBMP1,WRTID1,WRTNO1
     *,WDIR1,WADCL1,WFAID1,WTORN1,WRUD1,WFUNC1,WACC1,WROW1,WPVWP1,
     *WNLP1,WMEDT1,WPVWO1,WNLO1,WURA1
   19 FORMAT(4X,I3,A5,1X,F6.3,7X,F6.3,I1,1X,I4,A1,3X,I1,1X,3I1,A2,4X,I1
     *,8X,I4,3X,I2,I1,I1,3X,I2,I1,19X,I5)
      CALL ERRSET(215,256,256,1)
      GO TO 100
   80 STOP
      END
 /*
 //GO.FT11F001  DD UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTRO5.SWMILE.DATA
================================================================================
```

(3) All Interstates in the "SWMILE" file are recorded with a (9) preceding the route number (e.g., Interstate (0075) is recorded as (9075)); therefore, prior to using the "SWMILE" file the (9) must be converted to (0) to match with corresponding section in the "D-BASE" file. This modification is not required for toll roads (9001-9010). JCL and the source program listing are as follows:

```
================================================================================
/*CLASS A
//MERGE JOB (5035-51110),'AHMAD',REGION=350K
..INCLUDE 51110 PASSWORD
/*JOBPARM  P=R,T=(3,21),L=10
//FILONE EXEC WATFIV
//GO.FT11F001 DD UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.SWMILE.DATA1
//GO.FT16F001 DD UNIT=RENTAL,DISP=(NEW,CATLG),
//  DSN=UKU.@KTR05.SWMILE.DATA,DCB=(RECFM=FB,LRECL=120,BLKSIZE=120),
//  SPACE=(TRK,(500,250),RLSE)
//GO.SYSIN DD *
$JOB           ,T=(3,21)
C*****************************************************************
C*    THIS PROGRAM READS THE "SWMILE" FILE AND CONVERTS         *
C*  THE (9) WHICH PRECEEDS THE ROUTE NO. TO (0) FOR ALL         *
C*  INTERSTATES.                                                 *
C*****************************************************************
      CHARACTER*34 PART1,PART2*82
      INTEGER RTNO
                   I=0
 50             CONTINUE
                  I=I+1
C-------------------------------------------------------------------
C                 READ THE SWMILE
C-------------------------------------------------------------------
      READ(11,100,END=75)PART1,I,RTNO,PART2
 100  FORMAT(A34,I1,I3,A82)
         IF(I.EQ.9.AND.RTNO.GE.11) THEN DO
            WRITE(16,200)PART1,RTNO,PART2
 200        FORMAT(A34,'0',I3,A82)
         ELSE DO
            WRITE(16,300)PART1,I,RTNO,PART2
 300        FORMAT(A34,I1,I3,A82)
         ENDIF
        GO TO 50
  75  STOP
      END
C$ENTRY
C$STOP
/*
================================================================================
```

(4) The "SWMILE" file must be sorted based on county number, route number, and milepoint. Notice that route number includes only the number and its suffix (direction). Sort fields for the "SWMILE" file are 5,3,ch,a,35,5,ch,a,27,6,ch,a. A copy of the "SWMILE" file including corrected data for 1986 is stored on the OS disk under the name "SWMILE SORT". The following illustrates the JCL:

```
/*CLASS A
//MERGE JOB (5035-51110),'AHMAD',REGION=350K
..INCLUDE 51110 PASSWORD
//SORT EXEC SD,CYL=16
//SORTIN DD UNIT=RENTAL,DSN=UKU.@KTRO5.SWMILE.DATA,DISP=(OLD,KEEP)
//SORTOUT DD UNIT=RENTAL, DISP=(NEW,CATLG),DSN=UKU.@KTRO5.SWMILE.SORT,
//  DCB=(RECFM=FB,LRECL=120,BLKSIZE=6120),SPACE=(TRK,(500,200),RLSE)
//SYSIN  DD  *
 SORT  FIELDS=(5,3,CH,A,35,5,CH,A,27,6,CH,A)
 END
/*
```

(5) When processing data for 1986 or later, 20 consecutive years of data are used, including the current year. Therefore, it is important to set the "LASTYR" variable in the "GROWTH PROG" source code so that it corresponds to the current or base year (last two digits). This variable may be changed with a text editor. Note that the same modification must be applied to the second stage of the program.

(6) Three data files must be updated before running "GROWTH PROG". One, the "POP DATA" file, contains information concerning county populations in the state of Kentucky. To update this file, new populations must be added annually. This information may be obtained from the "U.S. Department of Commerce, Bureau of Census" and also the "University of Louisville Urban Studies Center". For the 1960-1986 period, county populations have been recorded to the file in the following format:

NAME	BEGIN COL	END COL	DATA TYPE	COMMENTS
- COUNTY NO.	1	3	I3	
- COUNTY POPULATION	4	193	I7	Data for 27 years

There is one record in this file for each county: population data for future years are added to the end of each record in an I7 format. Thus, 1987 populations will be entered with a text editor in Columns 194-200.

The "SMSA DATA" file is used as an input file to the second stage of the "GROWTH PROG" program. This file contains information about the SMSA status for each county for the period 1964-1986. Counties in SMSA's are coded as '1' and those not in SMSA's are coded as '0'. Each year new information must be added to the file. This information may be obtained from the "U.S. Department of Commerce, Bureau of Census" and also the "University of Louisville Urban Studies Center". There is one record in this file for each county and each record contains the following:

NAME	BEGIN COL	END COL	DATA TYPE	COMMENTS
- COUNTY NO.	1	3	I3	
- SMSA CODE	4	72	I3	Data for 23 years

SMSA data for future years are added to the end of each record in an I3 format. Thus, 1987 data will be entered with a text editor in Columns 73-75.

The "AADT DATA" file also is used as an input data file to the second stage of the "GROWTH PROG" program. This file contains statewide AADT for the 1966-1986 period and must be updated annually. The new AADT value may be obtained by executing the program "STATE.EXE", which has been prepared for periodical recalibration of the statewide travel model and also for calculating the statewide AADT. There is one record in this file for each year, and each record contains the following information:

NAME	BEGIN COL	END COL	DATA TYPE	COMMENTS
- YEAR	1	4	I4	
- AADT	6	11	F6.1	

To update the file in future years, a new record is added with a text editor.

(7) Job control language records must be prepared for processing of each year's data. In the first stage of the "GROWTH PROG" program, the DD record beginning with GO.FT10F001 must correspond to the sorted "D-BASE" file, the DD record beginning with GO.FT11F001 must correspond to the sorted "SWMILE" file, and the resulting output file from the merging of these two files, "DBSW YR86", must correspond to DD record beginning with GO.FT16F001. In the second stage of the program, the GO.FT10F001 DD record must correspond to the resulting output file from the previous stage, "DBSW YR86", the GO.FT11F001 DD record must correspond to the updated "AADT DATA" file, the GO.FT12F001 DD record must correspond to the updated "POP DATA" file, the GO.FT14F001 DD record must correspond to the updated "SMSA DATA" file, and finally GO.FT16F001 DD record corresponds to the calibration data base "NEW86 DATA" to be created using this program. JCL for the 1986 processing for both stages follows:

```
==============================================================================
 /*CLASS A
 //MERGE JOB (5035-51110),'NAME',REGION=350K
 ..INCLUDE 51110 PASSWORD
 /*JOBPARM  P=R,T=(6,15),L=10
 //FILONE EXEC WATFIV
 //GO.FT10F001 DD UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.D-BASE.SORT
 //GO.FT11F001 DD UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.SWMILE.SORT
 //GO.FT16F001 DD UNIT=RENTAL,DISP=(NEW,CATLG),DSN=UKU.@KTR05.DBSW.YR86,
 //  DCB=(RECFM=FB,LRECL=248,BLKSIZE=248),SPACE=(TRK,(500,250),RLSE)
 //GO.SYSIN DD *
 $JOB           ,T=(6,15)

        FIRST STAGE OF THE "GROWTH PROG" PROGRAM
       -----------------------------------------
 C$ENTRY
 C$STOP
 /*
 //STEP2 EXEC WATFIV
 //GO.FT10F001 DD UNIT=RENTAL,DISP=(OLD,DELETE),DSN=UKU.@KTR05.DBSW.YR86
 //GO.FT11F001 DD UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.AADT.DATA
 //GO.FT12F001 DD UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.POP.DATA
 //GO.FT14F001 DD UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.SMSA.DATA
 //GO.FT16F001 DD UNIT=RENTAL,DISP=(NEW,CATLG),
 //  DSN=UKU.@KTR05.NEW86.DATA,DCB=(RECFM=FB,LRECL=95,BLKSIZE=95),
 //  SPACE=(TRK,(500,250),RLSE)
 //GO.SYSIN DD *
 $JOB           ,T=(6,15)

       SECOND STAGE OF THE "GROWTH PROG" PROGRAM
      ------------------------------------------
C$ENTRY
C$STOP
/*
==============================================================================
```

b. PROGRAM EXECUTION

JCL must be prepared as indicated and submitted to run the program.

c. PROGRAM LISTING

The code listing for "GROWTH PROG" is included as Figure G4.

C. CONVERTING THE "NEW86 DATA" FILE TO A SAS DATA FILE

The generated file, "NEW86 DATA", must be converted to a SAS data file. This process is accomplished by submitting the "STEPWISE PGMB" routine. The DD record beginning with the name DATA must correspond to the "NEW86 DATA" file and the DD record beginning with the name OUT must correspond to the "SAS FILES". Both names, DATA and OUT, are called the 'fileref'. 'fileref' is a short name for the file one wishes to process. For example, the "NEW86 DATA" file is referenced by the name DATA and the "SAS FILES" is referenced by the name OUT. Notice that the DATA statement at the beginning of the routine (DATA

OUT.NEW86;) gives a name to the SAS data set that is created. A complete SAS file name consists of two words separated by a period, (e.g. OUT.NEW86). The first word is called the first-level name or 'libref'; it indicates where the file is stored. The second word, the second level name, identifies the specific file. The following shows example JCL used during 1986 processing:

```
================================================================================
/*CLASS Z
//STEPWISE JOB  5035-51110,'NAME',REGION=700K
/*JOBPARM P=R,W,T=(,20)
..INC 51110 PASSWORD
//A EXEC SAS
//DATA DD DSN=UKU.@KTR05.NEW86.DATA,DISP=SHR
//OUT  DD DSN=UKU.@KTR05.SAS.FILES,DISP=OLD
//SYSIN DD *
DATA OUT.NEW86;
================================================================================
```

D. CREATING THE MODEL CROSS-TABULATION MATRICES

After the "NEW86 DATA" file is stored into a SAS data file, it must be utilized as input to the "SMOOTH VRALL" and "SMOOTH GROWALL" to produce the model cross-tabulation matrices. The DD record beginning with name HEAT1 must correspond to the "SAS FILES". The DD record beginning with SASLIB must correspond to the "CLASS FORMATS". The DD records beginning with FT20F001, FT21F001, and FT22F001 are only temporary data files. Both HEAT1 and SASLIB are called 'fileref'. The SET statement at the beginning of the programs must correspond to the most recent file stored to the "SAS FILES". A SET statement tells the SAS system to read observations from a SAS data set. For example, the statement (SET HEAT1.NEW86;) asks SAS to read a file called "NEW86" in the storage location referenced by the name HEAT1. The following shows JCL used for each program, "SMOOTH VRALL" and "SMOOTH GROWALL", during 1986 processing:

```
================================================================================
//REGRESS JOB  5035-51110,'NAME',TIME=(0,50),REGION=700K
..INCLUDE 51110 PASSWORD
//S EXEC SAS82
//HEAT1 DD DSN=UKU.@KTR05.SAS.FILES,DISP=SHR
//IN DD DSN=UKU.@KTR05.SAS.FILE1,DISP=(OLD)
//SASLIB DD DSN=UKU.@KTR05.CLASS.FORMATS,DISP=SHR
//FT20F001 DD UNIT=SYSDA,SPACE=(TRK,(5,5))
//FT21F001 DD UNIT=SYSDA,SPACE=(TRK,(5,5))
//FT22F001 DD UNIT=SYSDA,SPACE=(TRK,(5,5))
//SYSIN DD *
DATA HEATED1;
SET HEAT1.NEW86;
================================================================================
```

Code listings for "SMOOTH VRALL" and "SMOOTH GROWALL" are included as Figure G5 and Figure G6, respectively.

```
 --------------------          ----------------------
|      UPDATED       |        |    "SWMILE DATA"     |
| "D-BASE DATA" FILE |        |        FILE          |
 --------------------          ----------------------
          |                              |
          |                              |
          ---------------------------------
                        |
                        |
             *********************
             * FIRST STAGE OF THE *
             *   "GROWTH PROG"    *
             *********************
                        |
                        |
 -------------   ----------------   ---------------   -------------
|  UPDATED    | |    UPDATED     | |    UPDATED    | |  UPDATED    |
|"AADT DATA"  | |  "DBSW YR86"   | |  "POP DATA"   | |"SMSA DATA"  |
 -------------   ----------------   ---------------   -------------
      |                 |                  |                |
      |                 |                  |                |
      -------------     |     ---------------------------------
                |       |       |
                |       |       |
             **********************
             * SECOND STAGE OF THE *
             *    "GROWTH PROG"    *
             **********************
                        |
                        |
             ----------------------
             |    "NEW86 DATA"    |
             ----------------------
                        |
                        |
             **********************
             *    "SAS ROUTINE"    *
             **********************
                        |
                        |
             ----------------------
             |   SAS COPY OF THE   |
             | "NEW86 DATA"  FILE  |
             ----------------------
                    |        |
                    |        |
               ------        ------
               |                  |
               |                  |
  ******************     ******************
  *"SMOOTH GROWALL" *    * "SMOOTH VRALL"  *
  ******************     ******************
```

FIGURE G1. AN OVERVIEW OF THE PROCESSING PROCEDURE

NAME	BEGIN COL	END COL	DATA TYPE	COMMENTS
- COUNTY NO.	1	3	I3	Standard county numbers
- CITY NO.	4	8	I5	Standard city numbers
- ROUTE PREFIX	9	10	A2	Route prefix codes
- ROUTE NO.	11	14	I4	Standard four-digit route numbers
- ROUTE SUFFIX	15	16	A2	Route suffix codes
- BEGINNING MILEPOINT	17	23	F7.3	Beginning milepoint for the break point of traffic count segment
- ENDING MILEPOINT	25	31	F7.3	Ending milepoint for the break point of traffic count segment
- TYPE	32	32	I1	Identifies whether the segment is a 'from' or 'to' record
- DESCRIPTION OF ENDING POINT	33	62	A30	Description of break point
- COUNTY NO.	63	65	I3	County number where the count station for the segment is located
- STATION NO.	66	68	A3	Station number
- DIRECTION	69	69	I1	direction code for the station
- STATION TYPE	70	70	I1	Identifies the type of count station
- ADT	71	76	I6	ADT for the most recent count made at this station location
- COUNT YEAR	77	78	I2	The last two-digits of the year the most recent count was made
- VOLUME	79	198	I6	Traffic volumes for the last 20 years

FIGURE G2. FORMAT OF MERGED FILE "DBSW Y86"

NAME	BEGIN COL	END COL	DATA TYPE	COMMENTS
- COUNTY NO	199	201	I3	
- CITY OR PLACE	202	206	A5	
- SECTION LENGTH	207	212	F6.3	
- BEGINNING MILEPOINT	214	219	F6.3	
- ROUTE IDENTIFICATION	220	220	I1	
- ROUTE NO	221	224	I4	
- DIRECTION	225	225	A1	
- ROUTE SIGNING IDENTIFIER	226	226	I1	
- ADMINISTRATIVE CLASSIFICATION	227	227	I1	
- FEDERAL-AID SYSTEM	228	228	I1	
- TOLL	229	229	I1	
- RURAL/URBAN DESIGNATION	230	231	A2	
- FUNCTIONAL CLASSIFICATION	232	232	I1	
- ACCESS CONTROL	233	236	I4	
- R/W WIDTH	237	238	I2	
- PAVEMENT WIDTH (PRIMARY DIR)	239	239	I1	
- NO OF LANES (PRIMARY DIR)	240	240	I1	
- MEDIAN TYPE	241	242	I2	
- NO OF LANES (OTHER DIR)	243	243	I1	
- URBAN AREA CODE	244	248	I5	

FIGURE G2. FORMAT OF MERGED FILE "DBSW Y86" (CONTINUED)

NAME	BEGIN COL	END COL	DATA TYPE	COMMENTS
- COUNTY NO.	1	3	I3	
- DESCRIPTIVE INFORMATION	4	31	A28	
- TYPE	32	32	I1	
- ROUTE IDENTIFICATION	34	34	I1	
- ADMINISTRATIVE CLASSIFICATION	35	35	I1	
- FEDERAL-AID SYSTEM	36	36	I1	
- RURAL/URBAN	37	37	I1	
- FUNCTIONAL CLASSIFICATION	38	39	A2	
- ACCESS CONTROL	40	40	I1	
- SMSA	42	42	I1	
- 10-YEAR POP GROWTH TO LATEST YEAR	44	48	F5.1	
- POP GROWTH CATEGORY (TO LATEST YEAR)	49	50	I2	
- 10-YEAR POP GROWTH TO MIDYEAR	51	55	F5.1	
- POP GROWTH CATEGORY (TO MIDYEAR)	56	57	I2	
- R-SQUARE	58	67	F10.6	
- GROWTH FACTOR	68	77	F10.6	
- PREDICTED VOLUME RATIO	78	85	F8.4	
- PREDICTED VOLUME	86	92	I7	
- NUMBER OF DATA POINTS	93	95	I3	

FIGURE G3. FORMAT OF "NEW86 DATA"

```
/*CLASS A
//MERGE JOB (5035-51110),'AHMAD',REGION=350K
..INCLUDE 51110 PASSWORD
/*JOBPARM  P=R,T=(6,10),L=10
//FILONE EXEC WATFIV
//GO.FT10F001 DD UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.D-BASE.SORT
//GO.FT11F001 DD UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.SWMILE.SORT
//GO.FT16F001 DD UNIT=RENTAL,DISP=(NEW,CATLG),DSN=UKU.@KTR05.DBSW.YR86,
//  DCB=(RECFM=FB,LRECL=248,BLKSIZE=248),SPACE=(TRK,(500,250),RLSE)
//GO.SYSIN DD *
$JOB          ,T=(6,10)
C*******************************************************************
C*                 --------------------                           *
C*                      STAGE ONE                                 *
C*                 --------------------                           *
C*                                                                *
C*      THIS STAGE OF THE PROGRAM MERGES THE "SWMILE" FILE WITH   *
C*  THE "D-BASE" FILE WHICH IS RECIEVED FROM FRANKFORT EVERY YEAR. *
C*  BEFORE EXECUTING THE PROGRAM BOTH FILES MUST BE SORTED        *
C*  BASED ON COUNTY NO., ROUTE NO., AND MILE POINTS.              *
C*      THE "LASTYR" VARIABLE MUST BE SET EQUAL TO THE YEAR FOR   *
C*  WHICH THE MODEL IS CONSTRUCTED (BASE-YEAR).                   *
C*                                                                *
C*******************************************************************
      INTEGER DCONO1,DCITN1,VOL(80),DTYPE1,DSTYP1,DDIR1,DADT1,
     *DCONT1,DCONOB,DRTNO1
      INTEGER WRTID1,WFAID1,WTORN1,WRUD1,WACC1,WPLAN1,WCONO1
     *,WADCL1,WROW1,WPVWP1,WNLP1,WMEDT1,WPVWO1,WNLO1,
     *WURA1,WRTNO1,WRTNO2
      INTEGER WRTID2,WFAID2,WTORN2,WRUD2,WACC2,WPLAN2,WCONO2
     *,WADCL2,WROW2,WPVWP2,WNLP2,WMEDT2,WPVWO2,WNLO2,WURA2
      CHARACTER*3 DSTNO1,DRPRE1*2,DRSUF1*1,DDESC1*30,D*1
      CHARACTER*5 WCORP1,WDIR1*1,WFUNC1*2,WUAC1*5,WAADT1*6
      CHARACTER*5 WCORP2,WDIR2*1,WFUNC2*2,WUAC2*5,WAADT2*6
      REAL DBMP1,DEMP1,MIDPT1
      REAL WSLEN1,WBMP1
      REAL WSLEN2,WBMP2
C-------------------------------------------------------------------
C                    SET "LASTYR" = BASE-YEAR
C
C          (INPUT ONLY THE LAST TWO DIGITS OF THE YEAR)
C                (EX. FOR 1987 SET  LASTYR=87)
C-------------------------------------------------------------------
                              K=0
                           LASTYR=86
                       NUMYR=LASTYR-63+1
C-------------------------------------------------------------------
C                 READ THE "D-BASE" FILE
C-------------------------------------------------------------------
  100 READ(10,18,END=65)DCONO1,DCITN1,DRPRE1,DRTNO1,DRSUF1,D,DBMP1,
     *DEMP1,DTYPE1,DDESC1,DCONOB,DSTNO1,DDIR1,DSTYP1,DADT1,DCONT1,
     *(VOL(J),J=1,NUMYR)
   18 FORMAT(I3,I5,A2,I4,A1,A1,F7.3,1X,F7.3,I1,A30,I3,A3,I1,I1,I6,I2,
     *50I6)
      IF(DTYPE1.EQ.1) GO TO 100
```

FIGURE G4. LISTING OF "GROWTH PROG" CODE

```
          DO 41 I=1,20
              VOL(I)=VOL(NUMYR-20+I)
   41     CONTINUE
C------------------------------------------------------------------------
C                  READ THE "SWMILE" FILE
C------------------------------------------------------------------------
  200 READ(11,19,END=75)WCONO1,WCORP1,WSLEN1,WBMP1,WRTID1,WRTNO1,
     *WDIR1,WADCL1,WFAID1,WTORN1,WRUD1,WFUNC1,WACC1,WROW1,WPVWP1,
     *WNLP1,WMEDT1,WPVWO1,WNLO1,WURA1
      IF(WRTNO1.EQ.0)GO TO 200
        GO TO 50
  201 READ(11,19,END=75)WCONO2,WCORP2,WSLEN2,WBMP2,WRTID2,WRTNO2,
     *WDIR2,WADCL2,WFAID2,WTORN2,WRUD2,WFUNC2,WACC2,WROW2,WPVWP2,
     *WNLP2,WMEDT2,WPVWO2,WNLO2,WURA2
   19 FORMAT(4X,I3,A5,1X,F6.3,7X,F6.3,I1,1X,I4,A1,3X,I1,1X,3I1,A2,4X,I1
     *,8X,I4,3X,I2,I1,I1,3X,I2,I1,19X,I5)
      IF(WRTNO2.EQ.0)GO TO 201
      IF(WCONO2.NE.WCONO1.OR.WRTNO2.NE.WRTNO1.OR.WDIR2.NE.WDIR1)THEN DO
      WRITE(16,33)DCONO1,DCITN1,DRPRE1,DRTNO1,DRSUF1,D,DBMP1,DEMP1,
     *DTYPE1,DDESC1,DCONOB,DSTNO1,DDIR1,DSTYP1,DADT1,DCONT1,(VOL(I),I=1
     *,20),WCONO1,WCORP1,WSLEN1,WBMP1,WRTID1,WRTNO1,WDIR1,WADCL1,WFAID1
     *,WTORN1,WRUD1,WFUNC1,WACC1,WROW1,WPVWP1,WNLP1,WMEDT1,WPVWO1,
     *WNLO1,WURA1
  102 READ(10,18,END=65)DCONO1,DCITN1,DRPRE1,DRTNO1,DRSUF1,D,DBMP1,
     *DEMP1,DTYPE1,DDESC1,DCONOB,DSTNO1,DDIR1,DSTYP1,DADT1,DCONT1,
     *(VOL(J),J=1,NUMYR)
        IF(DTYPE1.EQ.1) GO TO 102
          DO 42 I=1,20
              VOL(I)=VOL(NUMYR-20+I)
   42     CONTINUE
            END IF
          WCONO1=WCONO2
          WCORP1=WCORP2
          WSLEN1=WSLEN2
          WBMP1=WBMP2
          WRTID1=WRTID2
          WRTNO1=WRTNO2
          WDIR1=WDIR2
          WADCL1=WADCL2
          WFAID1=WFAID2
          WTORN1=WTORN2
          WRUD1=WRUD2
          WFUNC1=WFUNC2
          WACC1=WACC2
          WROW1=WROW2
          WPVWP1=WPVWP2
          WNLP1=WNLP2
          WMEDT1=WMEDT2
          WPVWO1=WPVWO2
          WNLO1=WNLO2
          WURA1=WURA2
            GO TO 50
  300 WRITE(6,77)DCONO1,DCITN1,DRPRE1,DRTNO1,DRSUF1,D,DBMP1,DEMP1,
     *DTYPE1,DDESC1,DCONOB,DSTNO1,DDIR1,DSTYP1,DADT1,DCONT1
   77 FORMAT(2X,I3,I5,A2,I4,A1,A1,F7.3,1X,F7.3,I1,A30,I3,A3,I1,I1,I6,I2
```

FIGURE G4. LISTING OF "GROWTH PROG" CODE (CONTINUED)

```
     *,'  NO MATCHHHHH')
        K=K+1
  325 READ(10,18,END=65)DCONO1,DCITN1,DRPRE1,DRTNO1,DRSUF1,D,DBMP1,
     *DEMP1,DTYPE1,DDESC1,DCONOB,DSTNO1,DDIR1,DSTYP1,DADT1,DCONT1,
     *(VOL(J),J=1,NUMYR)
         IF(DTYPE1.EQ.1) GO TO 325
           DO 43 I=1,20
               VOL(I)=VOL(NUMYR-20+I)
   43      CONTINUE
C-----------------------------------------------------------------------
C     RT. SUFFIX OF 'EX' IN THE "D-BASE" FILE IS EQUIVALENT TO RT. SUFFIX
C                'V' IN THE "SWMILE" FILE
C-----------------------------------------------------------------------
   50      IF(DRSUF1.EQ.'E'.AND.D.EQ.'X')THEN DO
                        DRSUF1='V'
                         END IF
C-----------------------------------------------------------------------
C      PROCEDURE OF MATCHING EQUIVALENT ROUTE SEGMENTS OF THE "D-BASE"
C                 FILE AND THE "SWMILE" FILE
C-----------------------------------------------------------------------
              IF(DCONO1.GT.WCONO1)GO TO 200
              IF(DCONO1.LT.WCONO1)GO TO 300
              IF(DRTNO1.GT.WRTNO1)GO TO 200
              IF(DRTNO1.LT.WRTNO1)GO TO 300
              IF(DRSUF1.GT.WDIR1) GO TO 200
              IF(DRSUF1.LT.WDIR1) GO TO 300
                    WEMP1=WBMP1+WSLEN1
                    DSECT=DEMP1-DBMP1
                     DAVE=DSECT/2.0
                   MIDPT1=DBMP1+DAVE
              IF(MIDPT1.LT.WBMP1)  GO TO 300
              IF(MIDPT1.GT.WEMP1)  GO TO 201
        WRITE(16,33)DCONO1,DCITN1,DRPRE1,DRTNO1,DRSUF1,D,DBMP1,DEMP1,
     *DTYPE1,DDESC1,DCONOB,DSTNO1,DDIR1,DSTYP1,DADT1,DCONT1,(VOL(I),I=1
     *,20),WCONO1,WCORP1,WSLEN1,WBMP1,WRTID1,WRTNO1,WDIR1,WADCL1,WFAID1
     *,WTORN1,WRUD1,WFUNC1,WACC1,WROW1,WPVWP1,WNLP1,WMEDT1,WPVWO1,
     *WNLO1,WURA1
   33 FORMAT(I3,I5,A2,I4,A1,A1,F7.3,1X,F7.3,I1,A30,I3,A3,I1,I1,I6,I2,
     *20I6,I3,A5,F6.3,1X,F6.3,I1,I4,A1,4I1,A2,I1,I4,I2,2I1,I2,I1,I5)
                        GO TO 325
   75 WRITE(6,24)DCONO1,DCITN1,DRPRE1,DRTNO1,DRSUF1,D,DBMP1,DEMP1,
     *DTYPE1,DDESC1,DCONOB,DSTNO1,DDIR1,DSTYP1,DADT1,DCONT1
   24 FORMAT(2X,I3,I5,A2,I4,A1,A1,F7.3,1X,F7.3,I1,A30,I3,A3,I1,I1,I6,I2
     *,'  NO MATCH')
        K=K+1
      READ(10,18,END=65)DCONO1,DCITN1,DRPRE1,DRTNO1,DRSUF1,D,DBMP1,
     *DEMP1,DTYPE1,DDESC1,DCONOB,DSTNO1,DDIR1,DSTYP1,DADT1,DCONT1,
     *(VOL(J),J=1,NUMYR)
       GO TO 75
   65 WRITE(6,29)K
   29 FORMAT(1X,'NO OF UNMATCHED SECTIONS = ',I6)
      STOP
      END
C$ENTRY
C$STOP
```

FIGURE G4. LISTING OF "GROWTH PROG" CODE (CONTINUED)

```
/*
//STEP2  EXEC WATFIV
//GO.FT10F001 DD UNIT=RENTAL,DISP=(OLD,DELETE),DSN=UKU.@KTR05.DBSW.YR86
//GO.FT11F001 DD UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.AADT.DATA
//GO.FT12F001 DD UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.POP.DATA
//GO.FT14F001 DD UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.SMSA.DATA
//GO.FT16F001 DD UNIT=RENTAL,DISP=(NEW,CATLG),
//  DSN=UKU.@KTR05.NEW86.DATA,DCB=(RECFM=FB,LRECL=95,BLKSIZE=95),
//  SPACE=(TRK,(500,250),RLSE)
//GO.SYSIN DD *
$JOB           ,T=(6,15)
C*********************************************************************
C*                   ----------------------                          *
C*                         STAGE TWO                                 *
C*                   ----------------------                          *
C*                                                                   *
C*         THIS STAGE OF THE PROGRAM COMPUTES GROWTH FACTORS AND     *
C*    VOLUME RATIOS FOR STATIONS SATISFYING MINIMUM STANDARDS OF     *
C*    ACCEPTABILITY AND PRODUCES THE MODEL-CALIBRATION DATABASE      *
C*    WHICH IS USED FOR RECALIBRATION OF THE CROSS-TABULATION        *
C*    VOLUME-RATIO AND GROWTH-FACTOR MODEL.                          *
C*         IT IS IMPORTANT TO SET THE "LASTYR" VARIABLE EQUAL TO THE *
C*    THE YEAR FOR WHICH THE MODEL IS CONSTRUCTED (BASE-YEAR).       *
C*                                                                   *
C*********************************************************************
      INTEGER SX,SX2,X2,TYPE,POP(120,99),SMSA(120,99),
     *GA(120),CO,VOL(99),COUNTN,VOLCAT,POPCAV,POPCAG,PRED,POPIN1(120,99)
      CHARACTER*31 PART1,PART2*50,PART3*46,TOP*5,FUNC*2,LINE1*5
      REAL*8 MGF(20),VR(99),VOLU(99),
     *SXY,XY,ADT(99),YHATL(99),YDIFL(99),
     *YDLSQ(99),YDMSQ(99),YHATN(99),YDIFN(99),YDNSQ(99),
     *YDIFM(99),AGF,C,CPOPVR(120),CPOPGR(120),YHATVR,YHATGR,
     *POPIN2(120,99)
C---------------------------------------------------------------------
C                 SET "LASTYR" = BASE-YEAR
C
C           INPUT ONLY THE LAST 2 DIGITS OF THE YEAR)
C               (EX. FOR 1987 SET "LASTYR=87")
C---------------------------------------------------------------------
            LASTYR=86
              IYRS=LASTYR-20+1
             NUMYR=LASTYR-66+1
              IYR5=LASTYR-5+1
            ITENYR=LASTYR-10
            I20YR =LASTYR-20
             IYRX5=ITENYR-5+1
C---------------------------------------------------------------------
C           READ THE "AADT DATA" FILE
C---------------------------------------------------------------------
         DO 79 I=1,NUMYR
      READ(11,11,END=99)ADT(I)
   11 FORMAT(5X,F6.1)
   79     CONTINUE
   99     DO 80 I=1,20
       ADT(I)=ADT(NUMYR-20+I)
```

FIGURE G4. LISTING OF "GROWTH PROG" CODE (CONTINUED)

```
   80       CONTINUE
C------------------------------------------------------------------
C              READ THE "POP DATA" FILE
C------------------------------------------------------------------
      READ(12,16)TOP
   16 FORMAT(A5)
      READ(12,18)TOP
   18 FORMAT(A5)
            DO 33 ICO=1,120
      READ(12,12)(POP(ICO,IYR),IYR=60,LASTYR)
   12 FORMAT(3X,60I7)
      CPOPVR(ICO)=(POP(ICO,LASTYR)-POP(ICO,ITENYR))*100./POP(ICO,ITENYR)
      CPOPGR(ICO)=(POP(ICO,ITENYR)-POP(ICO,I20YR))*100./POP(ICO,I20YR)
   33       CONTINUE
C------------------------------------------------------------------
C              READ THE "SMSA DATA" FILE
C------------------------------------------------------------------
      READ(14,17)LINE1
   17 FORMAT(A5)
         DO 35 ICO=1,120
      READ(14,14)(SMSA(ICO,IYR),IYR=64,LASTYR)
   14 FORMAT(3X,60I3)
   35    CONTINUE
C------------------------------------------------------------------
C          SET THE FOLLOWING VARIABLES EQUAL TO ZERO
C------------------------------------------------------------------
C 101      ICNTY5=0
C          ICNTY1=0
           COUNTN=0
             NOR2=0
              I1=0
  100       CONTINUE
              I1=I1+1
               SX=0
              SX2=0
             SX2Y=0
              SXY=0
             SXYL=0
               SY=0
              SYL=0
           SUMLSQ=0
           SUMMSQ=0
           SUMNSQ=0
             PRED=0
C------------------------------------------------------------------
C          READ THE "DBSW DATA" FILE
C ------------------------------------------------------------------
  500 READ(10,10,END=65)CO,PART1,TYPE,PART3,(VOL(J),J=IYRS,LASTYR),
     *IRTID,IADCL,IFAID,IRUD,FUNC,IACC
   10 FORMAT(I3,A28,I1,A46,20I6,21X,I1,5X,2I1,1X,I1,A2,I1)
C------------------------------------------------------------------
C         ASSIGN THE POPULATION CATEGORY CODE
C------------------------------------------------------------------
              POPCAV=1
      IF(CPOPVR(CO).GE.5)POPCAV=2
```

FIGURE G4. LISTING OF "GROWTH PROG" CODE (CONTINUED)

```
      IF(CPOPVR(CO).GT.15)POPCAV=3
              POPCAG=1
      IF(CPOPGR(CO).GE.5)POPCAG=2
      IF(CPOPGR(CO).GT.15)POPCAG=3
C----------------------------------------------------------------------
C         COMPUTE THE VOLUME RATIO
C----------------------------------------------------------------------
            N=0
         DO 400 J=IYRS,LASTYR
            VR(J)=VOL(J)/ADT(J-IYRS+1)
            IF(VR(J).GT.0) N=N+1
  400    CONTINUE
C----------------------------------------------------------------------
C                COMPUTE THE "COUNTN" VALUE
C    COUNTN=NO OF STA. REJECTED BECAUSE OF FEWER THAN 4 YRS. OF DATA
C----------------------------------------------------------------------
         IF(N.GE.4)GO TO 1040
         COUNTN=COUNTN+1
           GO TO 100
C----------------------------------------------------------------------
C         COMPUTE THE GROWTH FACTORS FOR THE STATIONS WHICH MEET
C         THE REQUIRED CONDITIONS. (USING LEAST SQUARE METHOD)
C----------------------------------------------------------------------
 1040          DO 40 J=IYRS,LASTYR
                  IF(VR(J).EQ.0)GO TO 40
                 VOLU(J)=DLOG(VR(J))
                      X2=J*J
                      XY=J*VR(J)
                     XYL=J*VOLU(J)
                      SX=SX+J
                     SX2=SX2+X2
                      SY=SY+VR(J)
                     SYL=SYL+VOLU(J)
                     SXY=SXY+XY
                    SXYL=SXYL+XYL
                    YAVE=SY/N
                   YAVEL=SYL/N
                    XAVE=SX/N
  40           CONTINUE
       D=(SXYL-SX*SYL/N)/(SX2-SX*SX/N)
         AGF=EXP(D)
         H=YAVEL-D*XAVE
         C=EXP(H)
C----------------------------------------------------------------------
C    COMPUTE VOLUME RATIOS (YHATVR AND YHATGR) AND VOLUME (PRED)
C----------------------------------------------------------------------
         YHATVR=C*AGF**LASTYR
         YHATGR=C*AGF**ITENYR
         PRED=YHATGR*ADT(10)
C----------------------------------------------------------------------
C          COMPUTE  R-SQUARE
C----------------------------------------------------------------------
      DO 444 J=IYRS,LASTYR
         IF(VR(J).EQ.0)GO TO 444
         YDIFM(J)=VR(J)-YAVE
```

FIGURE G4. LISTING OF "GROWTH PROG" CODE (CONTINUED)

```
         YDMSQ(J)=YDIFM(J)**2
         SUMMSQ=SUMMSQ+YDMSQ(J)
         YHATN(J)=C*AGF**J
         YDIFN(J)=VR(J)-YHATN(J)
         YDNSQ(J)=YDIFN(J)**2
         SUMNSQ=SUMNSQ+YDNSQ(J)
  444 CONTINUE
      RSQ2=(SUMMSQ-SUMNSQ)/SUMMSQ
C-----------------------------------------------------------------------
C          CHECK FOR R-SQURE AND COMPUTE THE "NOR2" VALUE
C       NOR2 = NO. OF STA. WITH R-SQUARE LESS THAN MIN. REQUIREMENT
C-----------------------------------------------------------------------
         DIFFN=AGF*100.-100.
       CHECK=12.*ABS(DIFFN)-20.
         PRSQ2=RSQ2*100.
     IF(PRSQ2.LT.CHECK)THEN DO
          NOR2=NOR2+1
        GO TO 100
          END IF
      WRITE(16,77)CO,PART1,TYPE,IRTID,IADCL,IFAID,IRUD,FUNC,IACC,
     *SMSA(CO,LASTYR),CPOPVR(CO),POPCAV,CPOPGR(CO),POPCAG,RSQ2
     *,AGF,YHATVR,PRED,N
   77 FORMAT(I3,A28,I1,1X,4I1,A2,I1,
     *1X,I1,1X,F5.1,I2,F5.1,I2,F10.6,F10.6,F8.4,I7,I3)
        GO TO 100
   65 WRITE(6,*)
      WRITE(6,*)
      WRITE(6,*)
      WRITE(6,22)COUNTN
   22 FORMAT(' NO. OF STA. WITH LESS THAN 4 YEARS OF DATA IN 20-YR. PERI
     *OD=',I6)
      WRITE(6,*)
      WRITE(6,*)
      WRITE(6,43)NOR2
   43 FORMAT(' NO. OF STA. WITH R-SQUARE LESS THAN THE MIN. REQUIREMENT=
     *',I6)
      WRITE(6,*)
      WRITE(6,*)
      WRITE(6,23)
   23 FORMAT('1','==================================================
     *===========================')
      WRITE(6,24)IYR5,LASTYR
   24 FORMAT(1X,'COUNTY NO.',2X,'SMSA CODE',2X,'COUNTY POPULATION GROWTH
     * (%) FOR THE PAST 5 YEARS  (',I3,' -',I3,' )')
      WRITE(6,41)
   41 FORMAT(12X,' 1=SMSA')
      WRITE(6,42)
   42 FORMAT(12X,' 0=NON-SMSA')
      WRITE(6,26)
   26 FORMAT(' -----------------------------------------------------
     *--------------------------------')
      WRITE(6,*)
C-----------------------------------------------------------------------
C       COMPUTE COUNTY POPULATION GROWTH FOR THE PAST 5 YEARS
C-----------------------------------------------------------------------
```

FIGURE G4. LISTING OF "GROWTH PROG" CODE (CONTINUED)

```
            DO  68  ICO=1,120
          DO 34 IYR=IYR5,LASTYR
                IYRE=IYR-10
      POPIN1(ICO,IYR)=(POP(ICO,IYR)-POP(ICO,IYRE))*100/POP(ICO,IYRE)
   34      CONTINUE
      WRITE(6,31)ICO,SMSA(ICO,LASTYR),(POPIN1(ICO,IYR),IYR=IYR5,LASTYR)
   31 FORMAT(4X,I3,9X,I1,14X,5(I6,2X))
   68       CONTINUE
      WRITE(6,*)
      WRITE(6,45)
   45 FORMAT(' =========================================================
     *===============================')
      WRITE(6,*)
      WRITE(6,*)
      WRITE(6,*)
      WRITE(6,*)
      STOP
      END
C$ENTRY
C$STOP
/*
```

FIGURE G4. LISTING OF "GROWTH PROG" CODE (CONTINUED)

```
//REGRESS JOB  5035-51110,'AHMAD',TIME=(0,40),REGION=700K
..INCLUDE 51110 PASSWORD
//S EXEC SAS82
//HEAT1 DD DSN=UKU.@KTR05.SAS.FILES,DISP=SHR
//IN DD DSN=UKU.@KTR05.SAS.FILE1,DISP=(OLD)
//SASLIB DD DSN=UKU.@KTR05.CLASS.FORMATS,DISP=SHR
//FT20F001 DD UNIT=SYSDA,SPACE=(TRK,(5,5))
//FT21F001 DD UNIT=SYSDA,SPACE=(TRK,(5,5))
//FT22F001 DD UNIT=SYSDA,SPACE=(TRK,(5,5))
//SYSIN DD *
DATA HEATED1;
SET HEAT1.NEW86;
OPTIONS NODATE NOSOURCE;
IF FUNC=15 THEN DELETE;
IF SMSA=0  THEN SMSA=2;
PROC FORMAT;
   VALUE  RUDFMT 1='RURAL'
                 2='SMALL URBAN'
                 3='URBANIZED';
   VALUE  FUNCFMT 1='PRINCIPAL INT.'
                 2='PRINCIPAL OTHER'
                 6='MINOR ARTERIAL'
                 7='MAJOR COLLECTOR'
                 8='MINOR COLLECTOR'
                 9='LOCAL'
                11='PRINCIPAL INT.'
                12='PR. OTHER X-WAY'
                14='PRINCIPAL OTHER'
                15=' @@@ '
                16='MINOR ARTERIAL'
                17='COLLECTOR'
                19='LOCAL';
   VALUE  POPFMT  1='SLOW '
                  2='MOD.  '
                  3='FAST  ';
   VALUE  SMSAFMT  1='SMSA'
                  2='NON-SMSA';
PROC SORT;BY RUD FUNC SMSA POPCAV;
PROC TABULATE DATA=HEATED1 F=12.0;
TITLE1 ' VOLUME RATIO - NUMBER OF ENTRIES PER CELL ';
      CLASS RUD FUNC SMSA POPCAV;
        VAR   VR;
       FORMAT RUD  RUDFMT.;
       FORMAT FUNC FUNCFMT.;
       FORMAT POPCAV POPFMT.;
       FORMAT SMSA   SMSAFMT.;
TABLE RUD*FUNC,SMSA=' '*POPCAV*VR=' '*(N='COUNT');
DATA FIRST;
SET HEATED1;
PROC UNIVARIATE NOPRINT;
     VAR VR;
     BY RUD FUNC SMSA POPCAV;
OUTPUT OUT=IN.PART2 N=N Q1=Q25TH MEDIAN=Q50TH Q3=Q75TH;
PROC PRINTTO UNIT=21 NEW;
PROC GLM  DATA=IN.PART2 ;
```

FIGURE G5. LISTING OF "SMOOTH VRALL" CODE

```
  ID POPCAV;
  MODEL Q75TH=POPCAV  /  P;
  WEIGHT N;
  BY RUD FUNC SMSA;
OUTPUT OUT=IN.NEW2 P=VR75TH ;
PROC PRINTTO;
PROC TABULATE DATA=IN.NEW2 F=12.2;
TITLE1 ' VOLUME RATIO - 75TH PERCENTILE (SMOOTHED) ';
     CLASS RUD  FUNC SMSA POPCAV ;
     VAR VR75TH;
     FORMAT RUD    RUDFMT.;
     FORMAT FUNC FUNCFMT.;
     FORMAT SMSA  SMSAFMT.;
     FORMAT POPCAV  POPFMT.;
TABLE RUD*FUNC,SMSA=' '*POPCAV*VR75TH=' '*(MEAN='VOLUME RATIO');
PROC PRINTTO UNIT=22 NEW;
PROC GLM  DATA=IN.PART2 ;
  ID POPCAV;
  MODEL Q50TH=POPCAV  /  P;
  WEIGHT N;
  BY RUD FUNC SMSA;
OUTPUT OUT=IN.NEW3 P=VR50TH ;
PROC PRINTTO;
PROC TABULATE DATA=IN.NEW3 F=12.2;
TITLE1' VOLUME RATIO - 50TH PERCENTILE (SMOOTHED) ';
     CLASS RUD  FUNC SMSA POPCAV ;
     VAR VR50TH;
     FORMAT RUD    RUDFMT.;
     FORMAT FUNC FUNCFMT.;
     FORMAT SMSA  SMSAFMT.;
     FORMAT POPCAV  POPFMT.;
TABLE RUD*FUNC,SMSA=' '*POPCAV*VR50TH=' '*(MEAN='VOLUME RATIO');
PROC PRINTTO UNIT=20 NEW;
PROC GLM  DATA=IN.PART2 ;
  ID POPCAV;
  MODEL Q25TH=POPCAV  /  P;
  WEIGHT N;
  BY RUD FUNC SMSA;
OUTPUT OUT=IN.NEW P=VR25TH ;
PROC PRINTTO;
PROC TABULATE DATA=IN.NEW F=12.2;
TITLE1 ' VOLUME RATIO - 25TH PERCENTILE (SMOOTHED) ';
     CLASS RUD  FUNC SMSA POPCAV ;
     VAR VR25TH;
     FORMAT RUD    RUDFMT.;
     FORMAT FUNC FUNCFMT.;
     FORMAT SMSA  SMSAFMT.;
     FORMAT POPCAV  POPFMT.;
TABLE RUD*FUNC,SMSA=' '*POPCAV*VR25TH=' '*(MEAN='VOLUME RATIO');
PROC TABULATE DATA=IN.PART2 F=12.2;
TITLE1 '  VOLUME RATIO - 75TH PERCENTILE (ACTUAL) ';
      CLASS RUD FUNC SMSA POPCAV;
        VAR   Q75TH;
       FORMAT RUD  RUDFMT.;
       FORMAT FUNC FUNCFMT.;
```

FIGURE G5. LISTING OF "SMOOTH VRALL" CODE (CONTINUED)

```
        FORMAT POPCAV POPFMT.;
        FORMAT SMSA   SMSAFMT.;
TABLE RUD*FUNC,SMSA=' '*POPCAV*Q75TH=' '*(MEAN='VOLUME RATIO');
PROC TABULATE DATA=IN.PART2 F=12.2;
TITLE1 '  VOLUME RATIO - 50TH PERCENTILE (ACTUAL) ';
      CLASS RUD FUNC SMSA POPCAV;
        VAR   Q50TH;
        FORMAT RUD  RUDFMT.;
        FORMAT FUNC FUNCFMT.;
        FORMAT POPCAV POPFMT.;
        FORMAT SMSA   SMSAFMT.;
TABLE RUD*FUNC,SMSA=' '*POPCAV*Q50TH=' '*(MEAN='VOLUME RATIO');
PROC TABULATE DATA=IN.PART2 F=12.2;
TITLE1 '  VOLUME RATIO - 25TH PERCENTILE (ACTUAL) ';
      CLASS RUD FUNC SMSA POPCAV;
        VAR   Q25TH;
        FORMAT RUD  RUDFMT.;
        FORMAT FUNC FUNCFMT.;
        FORMAT POPCAV POPFMT.;
        FORMAT SMSA   SMSAFMT.;
TABLE RUD*FUNC,SMSA=' '*POPCAV*Q25TH=' '*(MEAN='VOLUME RATIO');
DATA VR75;
SET IN.NEW2;
PROC SORT;BY  RUD  FUNC SMSA POPCAV ;
PROC MEANS NOPRINT MEAN; BY RUD FUNC SMSA POPCAV;
     VAR  VR75TH;
OUTPUT OUT=PASS MEAN=MEAN;
DATA _NULL_;
SET PASS;FILE PUNCH;
PUT RUD 1-3 FUNC 5-6 SMSA 8 POPCAV 10 MEAN 8.2  @21 '75';
DATA VR50;
SET IN.NEW3;
PROC SORT;BY  RUD  FUNC SMSA POPCAV ;
PROC MEANS NOPRINT MEAN; BY RUD FUNC SMSA POPCAV;
     VAR  VR50TH;
OUTPUT OUT=PASS MEAN=MEAN;
DATA _NULL_;
SET PASS;FILE PUNCH;
PUT RUD 1-3 FUNC 5-6 SMSA 8 POPCAV 10 MEAN 8.2  @21 '50';
DATA VR25;
SET IN.NEW;
PROC SORT;BY  RUD  FUNC SMSA POPCAV ;
PROC MEANS NOPRINT MEAN; BY RUD FUNC SMSA POPCAV;
     VAR  VR25TH;
OUTPUT OUT=PASS MEAN=MEAN;
DATA _NULL_;
SET PASS;FILE PUNCH;
PUT RUD 1-3 FUNC 5-6 SMSA 8 POPCAV 10 MEAN 8.2  @21 '25';
DATA VRNO;
SET HEATED1;
PROC SORT;BY  RUD  FUNC SMSA POPCAV ;
PROC MEANS NOPRINT MEAN; BY RUD FUNC SMSA POPCAV;
     VAR  VR;
OUTPUT OUT=PASS N=N;
DATA _NULL_;
```

FIGURE G5. LISTING OF "SMOOTH VRALL" CODE (CONTINUED)

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```
SET PASS;FILE PUNCH;
PUT RUD 1-3 FUNC 5-6 SMSA 8 POPCAV 10  N 12-17;
```

FIGURE G5. LISTING OF "SMOOTH VRALL" CODE (CONTINUED)

```
//REGRESS JOB  5035-51110,'AHMAD',TIME=(0,55),REGION=700K
..INCLUDE 51110 PASSWORD
//S EXEC SAS82
//HEAT1 DD DSN=UKU.@KTR05.SAS.FILES,DISP=SHR
//IN DD DSN=UKU.@KTR05.SAS.FILE1,DISP=(OLD)
//SASLIB DD DSN=UKU.@KTR05.CLASS.FORMATS,DISP=SHR
//FT20F001 DD UNIT=SYSDA,SPACE=(TRK,(5,5))
//FT21F001 DD UNIT=SYSDA,SPACE=(TRK,(5,5))
//FT22F001 DD UNIT=SYSDA,SPACE=(TRK,(5,5))
//SYSIN DD *
DATA HEATED1;
SET HEAT1.NEW86;
OPTIONS NODATE NOSOURCE;
IF FUNC=15 THEN DELETE;
IF  RUD=3 THEN RUD=2;
     AGFPCT=(AGF-1)*100;
     IF VOL<625 THEN VOL=1;
     IF VOL>=625   AND VOL<=1249   THEN VOL=2;
     IF VOL>=1250  AND VOL<=2499   THEN VOL=3;
     IF VOL>=2500  AND VOL<=4999   THEN VOL=4;
     IF VOL>=5000  AND VOL<=9999   THEN VOL=5;
     IF VOL>=10000 AND VOL<=19999  THEN VOL=6;
     IF VOL>=20000 AND VOL<=40000 THEN VOL=7;
     IF VOL>40000 THEN VOL=8;
PROC FORMAT;
   VALUE  FUNCFMT 1='PRINCIPAL INTERSTATE'
                  2='PRINCIPAL OTHER'
                  6='MINOR ARTERIAL'
                  7='MAJOR COLLECTOR'
                  8='MINOR COLLECTOR'
                  9='LOCAL'
                 11='PRINCIPAL INTERSTATE'
                 12='PRINCIPAL OTHER X-WAY'
                 14='PRINCIPAL OTHER'
                 15=' @@@ '
                 16='MINOR ARTERIAL'
                 17='COLLECTOR'
                 19='LOCAL';
   VALUE  POPFMT  1='SLOW '
                  2='MOD. '
                  3='FAST ';
   VALUE  VOLFMT     1='<625'
                   2='625-1,249'
                   3='1,250-2,499'
                   4='2,500-4,999'
                   5='5,000-9,999'
                   6='10,000-19,999'
                   7='20,000-40,000'
                   8='>40,000';
   VALUE RUDFMT    1='RURAL'
                   2=' URBAN';
DATA FIRST;
SET HEATED1;
IF RUD=1 AND FUNC=1 ;
PROC TABULATE F=6.0 DATA=FIRST;
TITLE1 '  GROWTH FACTORS - NUMBER OF ENTRIES PER CELL ';
     CLASS RUD FUNC  VOL;
     VAR AGFPCT;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
```

FIGURE G6. LISTING OF "SMOOTH GROWALL" CODE

```
          FORMAT    VOL  VOLFMT.;
          FORMAT  RUD      RUDFMT.;
     TABLE RUD*FUNC,VOL*AGFPCT=' '*(N='COUNT');
     DATA FIRST;
     SET HEATED1;
     IF FUNC¬=1 AND RUD=1;
     PROC TABULATE F=6.0 DATA=FIRST;
     TITLE1 '  GROWTH FACTORS - NUMBER OF ENTRIES PER CELL ';
          CLASS RUD FUNC POPCAG  VOL;
          VAR AGFPCT;
          FORMAT FUNC FUNCFMT.;
          FORMAT POPCAG POPFMT.;
          FORMAT    VOL  VOLFMT.;
          FORMAT  RUD      RUDFMT.;
     TABLE RUD*FUNC*POPCAG,VOL*AGFPCT=' '*(N='COUNT');
     DATA SECOND;
     SET HEATED1;
     IF RUD=2  AND FUNC=11 ;
     PROC TABULATE F=6.0 DATA=SECOND;
     TITLE1 '  GROWTH FACTORS - NUMBER OF ENTRIES PER CELL ';
          CLASS  RUD FUNC   VOL;
          VAR AGFPCT;
          FORMAT FUNC FUNCFMT.;
          FORMAT POPCAG POPFMT.;
          FORMAT    VOL   VOLFMT.;
          FORMAT  RUD     RUDFMT.;
     TABLE RUD*FUNC,VOL*AGFPCT=' '*(N='COUNT');
     DATA SECOND;
     SET HEATED1;
     IF RUD=2 AND FUNC¬=11;
     PROC TABULATE F=6.0 DATA=SECOND;
     TITLE1 '  GROWTH FACTORS - NUMBER OF ENTRIES PER CELL ';
          CLASS RUD FUNC POPCAG VOL;
          VAR AGFPCT;
          FORMAT FUNC FUNCFMT.;
          FORMAT POPCAG POPFMT.;
          FORMAT    VOL  VOLFMT.;
          FORMAT  RUD      RUDFMT.;
     TABLE RUD*FUNC*POPCAG,VOL*AGFPCT=' '*(N='COUNT');
     PROC SORT DATA=HEATED1;BY RUD FUNC  VOL;
     DATA FIRST;
     SET HEATED1;
     IF RUD=1 AND FUNC=1 ;
     PROC UNIVARIATE NOPRINT;
          VAR AGFPCT;
          BY RUD  FUNC  VOL;
     OUTPUT OUT=IN.RURALP N=N Q1=Q25TH MEDIAN=Q50TH Q3=Q75TH;
     PROC PRINTTO UNIT=20 NEW;
     PROC GLM DATA=IN.RURALP;
          ID  VOL;
          MODEL Q75TH=VOL / P;
          WEIGHT N;
          BY  RUD FUNC ;
     OUTPUT OUT=IN.RURALP2  P=AGF75TH;
     PROC PRINTTO;
     PROC TABULATE F=6.2 DATA=IN.RURALP2;
     TITLE1 ' GROWTH FACTORS - 75TH PERCENTILE (SMOOTHED) ';
          CLASS RUD  FUNC  VOL;
          VAR AGF75TH;
          FORMAT RUD  RUDFMT.;
```

FIGURE G6. LISTING OF "SMOOTH GROWALL" CODE (CONTINUED)

```
        FORMAT FUNC FUNCFMT.;
        FORMAT POPCAG POPFMT.;
        FORMAT     VOL  VOLFMT.;
   TABLE RUD*FUNC,VOL*AGF75TH=' '*(MEAN='GROWTH FACTOR');
         DATA ROW1R75;
         SET IN.RURALP2;
   PROC SORT;BY RUD FUNC VOL;
   PROC MEANS NOPRINT MEAN;BY RUD FUNC VOL;
           VAR AGF75TH;
   OUTPUT  OUT=PASS  MEAN=MEAN;
       DATA _NULL_ ;
   SET PASS;FILE PUNCH;
   PUT RUD 1-3 FUNC 5-6 @8 '4'  VOL 10 MEAN 8.2  @21 '75';
   PROC SORT DATA=HEATED1;BY RUD FUNC POPCAG VOL;
   DATA FIRST;
   SET HEATED1;
   IF FUNC¬=1 AND RUD=1;
   PROC UNIVARIATE NOPRINT;
        VAR AGFPCT;
        BY RUD  FUNC POPCAG VOL;
   OUTPUT OUT=IN.RURAL1 N=N Q1=Q25TH MEDIAN=Q50TH Q3=Q75TH;
   PROC PRINTTO UNIT=20 NEW;
   PROC GLM DATA=IN.RURAL1;
        ID  VOL;
        MODEL Q75TH=VOL POPCAG/ P;
        WEIGHT N;
        BY RUD FUNC ;
   OUTPUT OUT=IN.RURAL2  P=AGF75TH;
   PROC PRINTTO;
   PROC TABULATE F=6.2 DATA=IN.RURAL2;
   TITLE1 ' GROWTH FACTORS - 75TH PERCENTILE (SMOOTHED) ';
        CLASS RUD FUNC POPCAG VOL;
        VAR AGF75TH;
        FORMAT RUD  RUDFMT.;
        FORMAT FUNC FUNCFMT.;
        FORMAT POPCAG POPFMT.;
        FORMAT     VOL  VOLFMT.;
   TABLE RUD*FUNC*POPCAG,VOL*AGF75TH=' '*(MEAN='GROWTH FACTOR');
         DATA ROWNR75;
         SET IN.RURAL2;
   PROC SORT;BY RUD FUNC POPCAG VOL;
   PROC MEANS NOPRINT MEAN;BY RUD FUNC POPCAG VOL;
           VAR AGF75TH;
   OUTPUT  OUT=PASS  MEAN=MEAN;
       DATA _NULL_ ;
   SET PASS;FILE PUNCH;
   PUT RUD 1-3 FUNC 5-6 POPCAG 8 VOL 10 MEAN 8.2  @21 '75';
   PROC SORT DATA=HEATED1;BY RUD FUNC VOL;
   DATA SECOND;
   SET HEATED1;
   IF RUD=2 AND FUNC=11 ;
   PROC UNIVARIATE NOPRINT;
        VAR AGFPCT;
        BY RUD  FUNC  VOL;
   OUTPUT OUT=IN.URBANP N=N Q1=Q25TH MEDIAN=Q50TH Q3=Q75TH;
   PROC PRINTTO UNIT=21 NEW;
   PROC GLM DATA=IN.URBANP;
        ID  VOL;
        MODEL Q75TH=VOL / P;
        WEIGHT N;
```

FIGURE G6. LISTING OF "SMOOTH GROWALL" CODE (CONTINUED)

```
     BY RUD FUNC ;
OUTPUT OUT=IN.URBANP2  P=AGF75TH;
PROC PRINTTO;
PROC TABULATE F=6.2 DATA=IN.URBANP2;
TITLE1 ' GROWTH FACTORS - 75TH PERCENTILE (SMOOTHED) ';
     CLASS RUD  FUNC  VOL;
     VAR AGF75TH;
     FORMAT  RUD RUDFMT.;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT    VOL  VOLFMT.;
TABLE RUD*FUNC,VOL*AGF75TH=' '*(MEAN='GROWTH FACTOR');
      DATA ROW1U75;
      SET IN.URBANP2;
PROC SORT;BY RUD FUNC VOL;
PROC MEANS NOPRINT MEAN;BY RUD FUNC  VOL;
        VAR AGF75TH;
OUTPUT  OUT=PASS  MEAN=MEAN;
   DATA _NULL_ ;
SET PASS;FILE PUNCH;
PUT RUD 1-3 FUNC 5-6  @8 '4'  VOL 10 MEAN 8.2  @21 '75';
PROC SORT DATA=HEATED1 ;BY RUD  FUNC POPCAG VOL;
DATA SECOND;
SET HEATED1;
IF RUD=2 AND FUNC¬=11 ;
PROC SORT;BY RUD FUNC POPCAG VOL;
PROC UNIVARIATE NOPRINT;
     VAR AGFPCT;
     BY RUD FUNC POPCAG VOL;
OUTPUT OUT=IN.URBAN1 N=N Q1=Q25TH MEDIAN=Q50TH Q3=Q75TH;
PROC PRINTTO UNIT=20 NEW;
PROC GLM DATA=IN.URBAN1;
     ID  VOL;
     MODEL Q75TH=VOL POPCAG/ P;
     WEIGHT N;
     BY RUD FUNC ;
OUTPUT OUT=IN.URBAN2  P=AGF75TH;
PROC PRINTTO;
PROC TABULATE F=6.2 DATA=IN.URBAN2;
TITLE1 ' GROWTH FACTORS - 75TH PERCENTILE (SMOOTHED) ';
     CLASS RUD FUNC POPCAG VOL;
     VAR AGF75TH;
     FORMAT RUD RUDFMT.;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT    VOL  VOLFMT.;
TABLE RUD*FUNC*POPCAG,VOL*AGF75TH=' '*(MEAN='GROWTH FACTOR');
      DATA ROWNU75;
      SET IN.URBAN2;
PROC SORT;BY RUD FUNC POPCAG VOL;
PROC MEANS NOPRINT MEAN;BY RUD FUNC POPCAG VOL;
        VAR AGF75TH;
OUTPUT  OUT=PASS  MEAN=MEAN;
   DATA _NULL_ ;
SET PASS;FILE PUNCH;
PUT RUD 1-3 FUNC 5-6 POPCAG 8 VOL 10 MEAN 8.2  @21 '75';
PROC PRINTTO UNIT=20 NEW;
PROC GLM DATA=IN.RURALP;
     ID  VOL;
     MODEL Q50TH=VOL / P;
```

FIGURE G6. LISTING OF "SMOOTH GROWALL" CODE (CONTINUED)

```
        WEIGHT N;
        BY  RUD FUNC ;
   OUTPUT OUT=IN.RURALP2  P=AGF50TH;
   PROC PRINTTO;
   PROC TABULATE F=6.2 DATA=IN.RURALP2;
   TITLE1 ' GROWTH FACTORS - 50TH PERCENTILE (SMOOTHED) ';
        CLASS RUD  FUNC  VOL;
        VAR AGF50TH;
        FORMAT RUD  RUDFMT.;
        FORMAT FUNC FUNCFMT.;
        FORMAT POPCAG POPFMT.;
        FORMAT    VOL  VOLFMT.;
   TABLE RUD*FUNC,VOL*AGF50TH=' '*(MEAN='GROWTH FACTOR');
         DATA ROW1R50;
         SET IN.RURALP2;
   PROC SORT;BY RUD FUNC VOL;
   PROC MEANS NOPRINT MEAN;BY RUD FUNC VOL;
           VAR AGF50TH;
   OUTPUT  OUT=PASS  MEAN=MEAN;
       DATA _NULL_ ;
   SET PASS;FILE PUNCH;
   PUT RUD 1-3 FUNC 5-6 @8 '4'  VOL 10 MEAN 8.2  @21 '50';
   PROC PRINTTO UNIT=20 NEW;
   PROC GLM DATA=IN.RURAL1;
        ID  VOL;
        MODEL Q50TH=VOL POPCAG/ P;
        WEIGHT N;
        BY RUD FUNC ;
   OUTPUT OUT=IN.RURAL2  P=AGF50TH;
   PROC PRINTTO;
   PROC TABULATE F=6.2 DATA=IN.RURAL2;
   TITLE1 ' GROWTH FACTORS - 50TH PERCENTILE (SMOOTHED) ';
        CLASS RUD FUNC POPCAG VOL;
        VAR AGF50TH;
        FORMAT RUD  RUDFMT.;
        FORMAT FUNC FUNCFMT.;
        FORMAT POPCAG POPFMT.;
        FORMAT    VOL  VOLFMT.;
   TABLE RUD*FUNC*POPCAG,VOL*AGF50TH=' '*(MEAN='GROWTH FACTOR');
         DATA ROWNR50;
         SET IN.RURAL2;
   PROC SORT;BY RUD FUNC POPCAG VOL;
   PROC MEANS NOPRINT MEAN;BY RUD FUNC POPCAG VOL;
           VAR AGF50TH;
   OUTPUT  OUT=PASS  MEAN=MEAN;
       DATA _NULL_ ;
   SET PASS;FILE PUNCH;
   PUT RUD 1-3 FUNC 5-6 POPCAG 8 VOL 10 MEAN 8.2  @21 '50';
   PROC PRINTTO UNIT=21 NEW;
   PROC GLM DATA=IN.URBANP;
        ID  VOL;
        MODEL Q50TH=VOL / P;
        WEIGHT N;
        BY RUD FUNC ;
   OUTPUT OUT=IN.URBANP2  P=AGF50TH;
   PROC PRINTTO;
   PROC TABULATE F=6.2 DATA=IN.URBANP2;
   TITLE1 ' GROWTH FACTORS - 50TH PERCENTILE (SMOOTHED) ';
        CLASS RUD  FUNC  VOL;
        VAR AGF50TH;
```

FIGURE G6. LISTING OF "SMOOTH GROWALL" CODE (CONTINUED)

```
      FORMAT  RUD RUDFMT.;
      FORMAT FUNC FUNCFMT.;
      FORMAT POPCAG POPFMT.;
      FORMAT     VOL  VOLFMT.;
 TABLE RUD*FUNC,VOL*AGF50TH=' '*(MEAN='GROWTH FACTOR');
       DATA ROW1U50;
       SET IN.URBANP2;
 PROC SORT;BY RUD FUNC VOL;
 PROC MEANS NOPRINT MEAN;BY RUD FUNC  VOL;
         VAR AGF50TH;
 OUTPUT  OUT=PASS  MEAN=MEAN;
     DATA _NULL_ ;
 SET PASS;FILE PUNCH;
 PUT RUD 1-3 FUNC 5-6 @8 '4' VOL 10  MEAN 8.2  @21 '50';
 PROC PRINTTO UNIT=20 NEW;
 PROC GLM DATA=IN.URBAN1;
      ID  VOL;
      MODEL Q50TH=VOL POPCAG/ P;
      WEIGHT N;
      BY RUD FUNC ;
 OUTPUT OUT=IN.URBAN2  P=AGF50TH;
 PROC PRINTTO;
 PROC TABULATE F=6.2 DATA=IN.URBAN2;
 TITLE1 ' GROWTH FACTORS - 50TH PERCENTILE (SMOOTHED) ';
      CLASS RUD FUNC POPCAG VOL;
      VAR AGF50TH;
      FORMAT RUD RUDFMT.;
      FORMAT FUNC FUNCFMT.;
      FORMAT POPCAG POPFMT.;
      FORMAT     VOL  VOLFMT.;
 TABLE  RUD*FUNC*POPCAG,VOL*AGF50TH=' '*(MEAN='GROWTH FACTOR');
       DATA ROWNU50;
       SET IN.URBAN2;
 PROC SORT;BY RUD FUNC POPCAG VOL;
 PROC MEANS NOPRINT MEAN;BY RUD FUNC POPCAG VOL;
         VAR AGF50TH;
 OUTPUT  OUT=PASS  MEAN=MEAN;
     DATA _NULL_ ;
 SET PASS;FILE PUNCH;
 PUT RUD 1-3 FUNC 5-6 POPCAG 8 VOL 10 MEAN 8.2  @21 '50';
 PROC PRINTTO UNIT=20 NEW;
 PROC GLM DATA=IN.RURALP;
      ID  VOL;
      MODEL Q25TH=VOL / P;
      WEIGHT N;
      BY  RUD FUNC ;
 OUTPUT OUT=IN.RURALP2  P=AGF25TH;
 PROC PRINTTO;
 PROC TABULATE F=6.2 DATA=IN.RURALP2;
 TITLE1 ' GROWTH FACTORS - 25TH PERCENTILE (SMOOTHED) ';
      CLASS RUD  FUNC  VOL;
      VAR AGF25TH;
      FORMAT RUD  RUDFMT.;
      FORMAT FUNC FUNCFMT.;
      FORMAT POPCAG POPFMT.;
      FORMAT     VOL  VOLFMT.;
 TABLE RUD*FUNC,VOL*AGF25TH=' '*(MEAN='GROWTH FACTOR');
       DATA ROW1R25;
       SET IN.RURALP2;
 PROC SORT;BY RUD FUNC VOL;
```

FIGURE G6. LISTING OF "SMOOTH GROWALL" CODE (CONTINUED)

```
PROC MEANS NOPRINT MEAN;BY RUD FUNC VOL;
     VAR AGF25TH;
OUTPUT  OUT=PASS  MEAN=MEAN;
   DATA _NULL_ ;
SET PASS;FILE PUNCH;
PUT RUD 1-3 FUNC 5-6 @8 '4' VOL 10 MEAN 8.2  @21 '25';
PROC PRINTTO UNIT=20 NEW;
PROC GLM DATA=IN.RURAL1;
    ID  VOL;
    MODEL Q25TH=VOL POPCAG/ P;
    WEIGHT N;
    BY RUD FUNC ;
OUTPUT OUT=IN.RURAL2  P=AGF25TH;
PROC PRINTTO;
PROC TABULATE F=6.2 DATA=IN.RURAL2;
TITLE1 ' GROWTH FACTORS - 25TH PERCENTILE (SMOOTHED) ';
    CLASS RUD FUNC POPCAG VOL;
    VAR AGF25TH;
    FORMAT RUD  RUDFMT.;
    FORMAT FUNC FUNCFMT.;
    FORMAT POPCAG POPFMT.;
    FORMAT    VOL  VOLFMT.;
TABLE RUD*FUNC*POPCAG,VOL*AGF25TH=' '*(MEAN='GROWTH FACTOR');
     DATA ROWNR25;
     SET IN.RURAL2;
PROC SORT;BY RUD FUNC POPCAG VOL;
PROC MEANS NOPRINT MEAN;BY RUD FUNC POPCAG VOL;
     VAR AGF25TH;
OUTPUT  OUT=PASS  MEAN=MEAN;
   DATA _NULL_ ;
SET PASS;FILE PUNCH;
PUT RUD 1-3 FUNC 5-6 POPCAG 8 VOL 10 MEAN 8.2  @21 '25';
PROC PRINTTO UNIT=21 NEW;
PROC GLM DATA=IN.URBANP;
    ID  VOL;
    MODEL Q25TH=VOL / P;
    WEIGHT N;
    BY RUD FUNC ;
OUTPUT OUT=IN.URBANP2  P=AGF25TH;
PROC PRINTTO;
PROC TABULATE F=6.2 DATA=IN.URBANP2;
TITLE1 ' GROWTH FACTORS - 25TH PERCENTILE (SMOOTHED) ';
    CLASS RUD  FUNC  VOL;
    VAR AGF25TH;
    FORMAT  RUD RUDFMT.;
    FORMAT FUNC FUNCFMT.;
    FORMAT POPCAG POPFMT.;
    FORMAT    VOL  VOLFMT.;
TABLE RUD*FUNC,VOL*AGF25TH=' '*(MEAN='GROWTH FACTOR');
     DATA ROW1U25;
     SET IN.URBANP2;
PROC SORT;BY RUD FUNC VOL;
PROC MEANS NOPRINT MEAN;BY RUD FUNC  VOL;
     VAR AGF25TH;
OUTPUT  OUT=PASS  MEAN=MEAN;
   DATA _NULL_ ;
SET PASS;FILE PUNCH;
PUT RUD 1-3 FUNC 5-6  @8 '4' VOL 10 MEAN 8.2  @21 '25';
PROC PRINTTO UNIT=20 NEW;
PROC GLM DATA=IN.URBAN1;
```

FIGURE G6. LISTING OF "SMOOTH GROWALL" CODE (CONTINUED)

```
       ID  VOL;
       MODEL Q25TH=VOL POPCAG/ P;
       WEIGHT N;
       BY RUD FUNC ;
  OUTPUT OUT=IN.URBAN2  P=AGF25TH;
  PROC PRINTTO;
  PROC TABULATE F=6.2 DATA=IN.URBAN2;
  TITLE1 ' GROWTH FACTORS - 25TH PERCENTILE (SMOOTHED) ';
       CLASS RUD FUNC POPCAG VOL;
       VAR AGF25TH;
       FORMAT RUD RUDFMT.;
       FORMAT FUNC FUNCFMT.;
       FORMAT POPCAG POPFMT.;
       FORMAT    VOL  VOLFMT.;
  TABLE RUD*FUNC*POPCAG,VOL*AGF25TH=' '*(MEAN='GROWTH FACTOR');
        DATA ROWNU25;
        SET IN.URBAN2;
  PROC SORT;BY RUD FUNC POPCAG VOL;
  PROC MEANS NOPRINT MEAN;BY RUD FUNC POPCAG VOL;
          VAR AGF25TH;
  OUTPUT  OUT=PASS  MEAN=MEAN;
      DATA _NULL_ ;
  SET PASS;FILE PUNCH;
  PUT RUD 1-3 FUNC 5-6 POPCAG 8 VOL 10 MEAN 8.2  @21 '25';
  DATA FIRST;
  SET HEATED1;
  IF RUD=1 AND FUNC=1 ;
  PROC SORT; BY RUD FUNC VOL;
  PROC MEANS NOPRINT MEAN;BY RUD FUNC VOL;
         VAR  AGFPCT;
  OUTPUT  OUT=PASS  N=N;
      DATA _NULL_;
  SET PASS;FILE PUNCH;
  PUT RUD 1-3 FUNC 5-6  @8 '4'  VOL 10  N 12-17;
  DATA FIRST;
  SET HEATED1;
  IF FUNC¬=1 AND RUD=1;
  PROC SORT; BY RUD FUNC POPCAG VOL;
  PROC MEANS NOPRINT MEAN;BY RUD FUNC POPCAG VOL;
         VAR  AGFPCT;
  OUTPUT  OUT=PASS  N=N;
      DATA _NULL_;
  SET PASS;FILE PUNCH;
  PUT RUD 1-3 FUNC 5-6  POPCAG 8   VOL 10  N 12-17;
  DATA SECOND;
  SET HEATED1;
  IF RUD=2  AND FUNC=11 ;
  PROC SORT; BY RUD FUNC VOL;
  PROC MEANS NOPRINT MEAN;BY RUD FUNC VOL;
         VAR  AGFPCT;
  OUTPUT  OUT=PASS  N=N;
      DATA _NULL_;
  SET PASS;FILE PUNCH;
  PUT RUD 1-3 FUNC 5-6  @8 '4'  VOL 10  N 12-17;
  DATA SECOND;
  SET HEATED1;
  IF RUD=2 AND FUNC¬=11;
  PROC SORT; BY RUD FUNC POPCAG VOL;
  PROC MEANS NOPRINT MEAN;BY RUD FUNC POPCAG VOL;
         VAR  AGFPCT;
```

FIGURE G6. LISTING OF "SMOOTH GROWALL" CODE (CONTINUED)

```
OUTPUT  OUT=PASS  N=N;
    DATA _NULL_;
SET PASS;FILE PUNCH;
PUT RUD 1-3 FUNC 5-6  POPCAG 8   VOL 10  N 12-17;
****;
PROC TABULATE F=6.2 DATA=IN.RURALP;
TITLE1 '  GROWTH FACTORS - 75TH PERCENTILE (ACTUAL) ';
     CLASS RUD FUNC  VOL;
     VAR Q75TH;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT    VOL       VOLFMT.;
     FORMAT  RUD     RUDFMT.;
TABLE RUD*FUNC,VOL*Q75TH=' '*(MEAN='GROWTH FACTOR');
PROC TABULATE F=6.2 DATA=IN.RURAL1;
TITLE1 '  GROWTH FACTORS - 75TH PERCENTILE (ACTUAL) ';
     CLASS RUD FUNC POPCAG VOL;
     VAR Q75TH;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT    VOL       VOLFMT.;
     FORMAT  RUD     RUDFMT.;
TABLE RUD*FUNC*POPCAG,VOL*Q75TH=' '*(MEAN='GROWTH FACTOR');
PROC TABULATE F=6.2 DATA=IN.URBANP;
TITLE1 '  GROWTH FACTORS - 75TH PERCENTILE (ACTUAL) ';
     CLASS RUD FUNC  VOL;
     VAR Q75TH;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT    VOL       VOLFMT.;
     FORMAT  RUD     RUDFMT.;
TABLE RUD*FUNC,VOL*Q75TH=' '*(MEAN='GROWTH FACTOR');
PROC TABULATE F=6.2 DATA=IN.URBAN1;
TITLE1 '  GROWTH FACTORS - 75TH PERCENTILE (ACTUAL) ';
     CLASS RUD FUNC POPCAG VOL;
     VAR Q75TH;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT    VOL       VOLFMT.;
     FORMAT  RUD     RUDFMT.;
TABLE RUD*FUNC*POPCAG,VOL*Q75TH=' '*(MEAN='GROWTH FACTOR');
*******;
PROC TABULATE F=6.2 DATA=IN.RURALP;
TITLE1 '  GROWTH FACTORS - 50TH PERCENTILE (ACTUAL) ';
     CLASS RUD FUNC  VOL;
     VAR Q50TH;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT    VOL       VOLFMT.;
     FORMAT  RUD     RUDFMT.;
TABLE RUD*FUNC,VOL*Q50TH=' '*(MEAN='GROWTH FACTOR');
PROC TABULATE F=6.2  DATA=IN.RURAL1;
TITLE1 '  GROWTH FACTORS - 50TH PERCENTILE (ACTUAL) ';
     CLASS RUD FUNC POPCAG VOL;
     VAR Q50TH;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT    VOL       VOLFMT.;
     FORMAT  RUD     RUDFMT.;
TABLE RUD*FUNC*POPCAG,VOL*Q50TH=' '*(MEAN='GROWTH FACTOR');
```

FIGURE G6. LISTING OF "SMOOTH GROWALL" CODE (CONTINUED)

```
PROC TABULATE F=6.2 DATA=IN.URBANP;
TITLE1 '  GROWTH FACTORS - 50TH PERCENTILE (ACTUAL) ';
     CLASS RUD FUNC  VOL;
     VAR Q50TH;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT     VOL        VOLFMT.;
     FORMAT  RUD      RUDFMT.;
TABLE RUD*FUNC,VOL*Q50TH=' '*(MEAN='GROWTH FACTOR');
PROC TABULATE F=6.2 DATA=IN.URBAN1;
TITLE1 '  GROWTH FACTORS - 50TH PERCENTILE (ACTUAL) ';
     CLASS RUD FUNC POPCAG VOL;
     VAR Q50TH;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT     VOL        VOLFMT.;
     FORMAT  RUD      RUDFMT.;
TABLE RUD*FUNC*POPCAG,VOL*Q50TH=' '*(MEAN='GROWTH FACTOR');
*******;
PROC TABULATE F=6.2  DATA=IN.RURALP;
TITLE1 '  GROWTH FACTORS - 25TH PERCENTILE (ACTUAL) ';
     CLASS RUD FUNC  VOL;
     VAR Q25TH;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT     VOL        VOLFMT.;
     FORMAT  RUD      RUDFMT.;
TABLE RUD*FUNC,VOL*Q25TH=' '*(MEAN='GROWTH FACTOR');
PROC TABULATE F=6.2 DATA=IN.RURAL1;
TITLE1 '  GROWTH FACTORS - 25TH PERCENTILE (ACTUAL) ';
     CLASS RUD FUNC POPCAG VOL;
     VAR Q25TH;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT     VOL        VOLFMT.;
     FORMAT  RUD      RUDFMT.;
TABLE RUD*FUNC*POPCAG,VOL*Q25TH=' '*(MEAN='GROWTH FACTOR');
PROC TABULATE F=6.2 DATA=IN.URBANP;
TITLE1 '  GROWTH FACTORS - 25TH PERCENTILE (ACTUAL) ';
     CLASS RUD FUNC  VOL;
     VAR Q25TH;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT     VOL        VOLFMT.;
     FORMAT  RUD      RUDFMT.;
TABLE RUD*FUNC,VOL*Q25TH=' '*(MEAN='GROWTH FACTOR');
PROC TABULATE F=6.2 DATA=IN.URBAN1;
TITLE1 '  GROWTH FACTORS - 25TH PERCENTILE (ACTUAL) ';
     CLASS RUD FUNC POPCAG VOL;
     VAR Q25TH;
     FORMAT FUNC FUNCFMT.;
     FORMAT POPCAG POPFMT.;
     FORMAT     VOL        VOLFMT.;
     FORMAT  RUD      RUDFMT.;
TABLE RUD*FUNC*POPCAG,VOL*Q25TH=' '*(MEAN='GROWTH FACTOR');
```

FIGURE G6. LISTING OF "SMOOTH GROWALL" CODE (CONTINUED)