# Quick Response Community Planning

**Final Report**

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# Quick Response Community Planning


## Abstract

The objective of this report is to present the outcomes of a research project conducted for formulating a unique and shortcut procedure for travel demand modeling and forecasting future traffic for small cities or urban areas with population less than 15,000, using a GIS platform. The TransCAD academic version 3.2 was used as the GIS platform. The major focus has been to reduce the time and cost for the overall travel demand modeling process. Also, the level of detail of the network required for building an appropriate travel demand model for such small areas was determined. As a case study for application of the method, McPherson, a small city in Kansas with population of approximately 13,000 was selected. The city had proposed to divert the traffic passing through the CBD via one of its major arterial by building a new bypass on the north side of the city. The main problems associated with travel demand modeling for such small, midwestern urban areas are the lack of technical resources and unavailability of socioeconomic and demographic data in adequate detail.

Two travel demand models were developed using a different number of Traffic Analysis Zones (TAZs). One consisted of 21 TAZs within the study area and was called the low-density-zoning scheme. The second consisted of 63 TAZs and was called the high-density-zoning scheme. From the resulting values of a screenline analysis and average daily vehicle distances of travel estimated from the traffic volumes assigned to the network by the models, it was concluded that the travel demand model developed from the high-density level of network provided better results as compared to the low-density network. However, in regard to the values of traffic volume assigned to the proposed bypass, the travel demand models for the two levels essentially performed the same.

It was determined that the GIS/TransCAD platform provides useful tools for data organization and analysis of results through graphical features. It was concluded that there is a need of updating technical resources for applying these modern methods of travel demand modeling.

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# Chapter 1: Introduction, Background and Objectives

## Introduction

Urban travel demand forecasting is the process of predicting the impact of various changes in a study area on future travel characteristics and demand. The changes may be due to various policies and programs for development of the study area, which results in change in socioeconomic characteristics, improvement and changes in transportation facilities, and other factors. In general, travel demand forecasting attempts to quantify the amount of travel on transportation system, where, the travel demand is created by separation of urban activities and transportation system is represented by characteristics of highway and transit network. The Traditional process for travel demand forecasting consists of four steps: Trip Generation, Trip Distribution, Mode Split and Traffic Assignment. Figure 1.1 below describes the four step modeling process along with information needs and the feedback process.

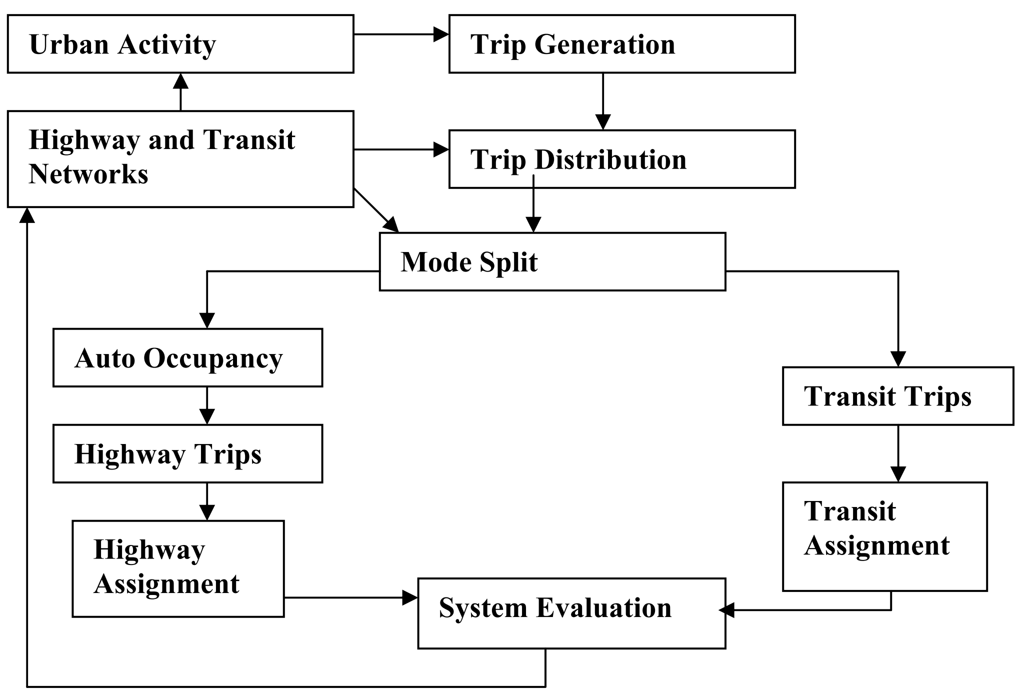



**Figure 1.1 Traditional Travel Demand Forecasting Process [Source: UTPS (2)]**

As shown in the Figure 1.1, the inputs to the four-step model are the urban activities and highway and transit network information for the study area. These parameters may be modified after evaluating the impact of traffic volumes assigned to the highway and transit networks making changes to land use forecasts necessary. The modified parameters again serve as input to the model and the process is carried out until no further changes are made to the input parameters. The four-step travel demand model is calibrated using existing transportation characteristics of the study area and then is used to forecast and study the transportation characteristics in a future year. Figure 1.2 below shows the use of a calibrated model for future trip forecasting.

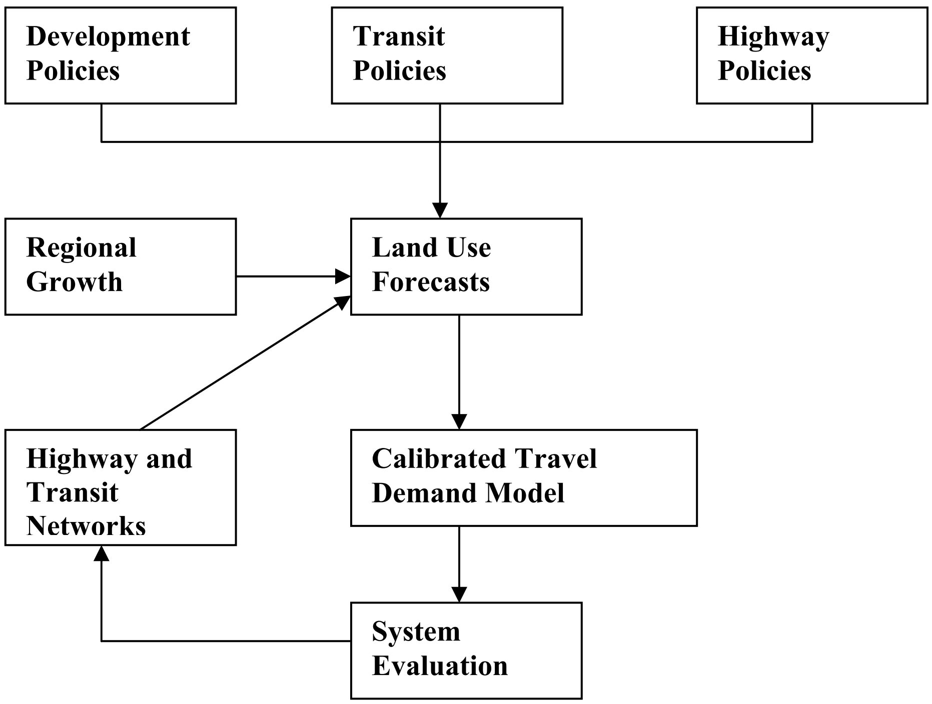



**Figure 1.2 Using A Calibrated Travel Demand Model for Forecasting Future Trips [Source: UTPS (2)]**

It is important to realize that modification in transportation system policies and street networks have impact on land use changes and economic growth (1)*. Therefore the process of feedback of modified input parameters to the model and evaluating the system is necessary for any transportation planning process.

**Information Requirements:** The information required as data input to build the traditional travel demand forecasting model are divided into four broad categories (2) as follows:

- Study area
- Urban activities
- Transportation system
- Travel

* Numbers in Parentheses Indicate References.

The information on the study area should be known before proceeding with collecting any other data. The boundary of the study must be defined at the beginning. The boundary must consider the scope of the project for which the study is being conducted. A general urban study usually includes the surrounding area that is expected to be urban within twenty years. Project specific studies must include the points of decision for routing traffic.

The study area has to be divided into several Traffic Analysis Zones (TAZ s) according to land use, physical barriers and street classification as well as the scope and limit of projects. Urban activities consist of demographic and socioeconomic data of the study area. Some of the specific data include population, dwelling units, automobile ownership, income, household size and employment locations and characteristics. The transportation system consists of the present street classification and characteristics. This information is used to build a transportation network for the study area. Travel information includes how, when and where people are currently travelling. The information is studied to determine the underlying factors causing people to make certain travel decisions so that models can be calibrated and used to forecast how people will travel in the future.

It was realized that conducting manual surveys for collecting this necessary information is expensive and time consuming. Literature reveals the efforts made to develop different techniques for the travel demand forecasting process (3, 4, 5, 7, 8, 10 and 11) to reduce time and money spent for data collection. The advent of computers with larger storage capacities and faster processing speeds helped in a proliferation of different techniques which provide efficient means of data management. The following section discusses some of the present methods for travel demand forecasting.

## Background

### Quick Response Methods and Computer Application:

National Cooperative Highway Research Program (NCHRP) Report 187 (3) provides different transferable parameters, factors and manual techniques to enable simplified and quick response urban travel demand estimation without conducting extensive surveys for data collection. The parameters provided by the report were based on several research results and can be used for computerized methods. Various shortcut manual techniques are suggested in this report.

NCHRP 187 was updated in NCHRP Report 365 (4) , and extensive manual procedures discussed in the former report were excluded. The report provided transferable parameters that can be applied in any available travel demand softwares. Also the use of geographic information systems (GIS) for building travel demand forecasting model database are discussed in the report.

Smith and McFarlene (5) evaluated an internal volume forecasting (IVF) model as a replacement for conventional urban travel demand models in small and medium sized areas. The model used interzonal trip probability factors as a measurement of the magnitude of the trip between zones. The trip probability factors were calculated as a function of production and attraction variables of zones, interzonal travel time impedance and related exponential factors. Instead of conducting surveys and home interviews for estimating productions and attractions for each zone, the model used production and attraction variables such as population, employment and rating for commercial and recreational use of each zone. The model was applied to calibrate a travel demand model for the county of Fond du Lac in Central Wisconsin and a linear regression model was derived for the relationship between link volumes and trip probability factors from observed traffic counts, as given below:

$$V = 181 + 0.031 \times P_i P_j \text{ ----------------------------------------------------(Equation 1.1)}$$

Where, $P_i$ is the population of zone i and $P_j$ is the population of zone j.

The model was used to forecast traffic volumes for future years using trip probability factors, which were calculated from forecasted changes in production and attraction variables. The model used linear regression method for calibration.

Other non-linear models have been proposed by Hogberg (6). Also, the model did not consider intrazonal travel time impedance. The inclusion of origin-zone accessibility was recommended by the study. The major advantage of this approach was the elimination of conducting extensive surveys for collecting socioeconomic data for estimating zonal productions and attractions, and using ground traffic counts for calibration. The study concluded that the model was well suited for application in small urban areas with population less than 50,000.

McPherson, Heimbach and Goode (7) set forth a computerized method for updating data bases for travel demand forecasting. The study focused on development of a computerized system capable of monitoring and recording changes in urban activities that could be used to update transportation planning data bases periodically. Two major analytical techniques were used to develop the model, as follows:

i) *Computerized Geocoding:*This technique provided the mechanism for linking together a variety of diverse data sources that may have only one common link (e.g., street addresses). The process provided a convenient framework for continuous monitoring and updating transportation planning data.

ii) *Income Model Construction Using Harmonic Analysis:* Harmonic analysis was used to express income-estimating model as a Fourier series. Data for calibrating income models were available from the 1970-1980 census urban transportation planning packages.

The study expressed the necessity of developing an income model because of confidentiality requirements by law prohibited state and federal revenue agencies from releasing income tax return files to other agencies. Conclusions of this study were supported by the findings from the system implemented and tested in Greensboro, North Carolina.

Rutherford and Pennock (8) discussed the features and application of the software 'Quick Response Microcomputer System' (QRS) developed by Comsis Corporation, to incorporate the techniques of travel demand forecasting presented in NCHRP 187 (3). The software could be used for rapid calculation of zonal productions and attractions. Some of the limitations of the original software were:

- maximum number of TAZs was limited to 50,
- maximum number of assignment links was limited to 800, and
- maximum travel time allowed was 40 minutes,

The socioeconomic data, such as number of dwelling units, income, auto-ownership, retail and non-retail employment were input to the trip generation procedure. The travel times were calculated from zone types, coordinates of zone centroids, map scale and a circuity factor to convert airline distance to over-the-road distance. Rutherford and Pennock believed that the mode choice model of the software was not a particularly useful tool, as it required inputs which might be less than logical.

Goulias and Kitamura (9) presented a model for forecasting travel demand based on microanalytic simulation and dynamic analysis of travel characteristics. The system consisted of two components: a microsimulator of household socioeconomic and demographic data and a dynamic model system of household auto ownership and mobility. Each component comprised interlinked models formulated at the household level. The interactions and causal paths that underlie life cycle evolution of individual households were replicated in the socioeconomic and demographic microsimulator. Simulation units evolved from year to year, experiencing changes in urban activities. Employment, income, education level, household size were among the variables that were generated in the microsimulation. The parameters of the model for generating the socioeconomic and demographic data were estimated from observed data from Dutch National Mobility Panel Data. The model system provided a flexible tool for forecasting travel demand; however, the process was complex and required a large amount of data for estimating the parameter which triggered the simulation process.

**Application of Geographic Information Systems (GIS):**

Computer based GIS integrates data from diverse disciplines and various formats to generate useful information about an area of earth or physical features on earth such as street networks, location of employment centers, etc. GIS software packages are capable of capturing, organizing, processing and analyzing spatially referenced data. The physical features are associated with related databases and are represented graphically to scale. In recent years, the Census bureau has made census data available to be used with GIS, by producing TIGER (topologically integrated geographic encoding and referencing) files. GIS shows promise as an important tool for transportation professionals.

Mugler and Quinn (10) explained the use of GIS technologies for preparation of demographic forecasts in the Denver Regional Council of Governments (DRCOG). They subdivided the 1990 census tracts based on land use to create TAZs. Demographic attributes of the TAZs were extracted from TIGER files. GIS processing was used to create population and employment estimates from state income tax roles, census data, electric utility records and privately developed databases. The data were geocoded on the TAZ polygon layer and the road base map.

Raley (11) expressed the efforts of Delaware Department of Transportation (DelDOT) in using GIS based census data and TIGER files for cost effective transportation planning. DelDOT had developed modified planning grids in 1960s, which were comprised largely of census geography. The grids were updated to provide current TIGER geography, and were used as building blocks for TAZs. Census data were used for assignment of population and employment forecasts to the modified grid level.

Gan (12) formulated a GIS-aided procedure for creating TAZs from census data and TIGER files. He expressed the problem concerning data disaggregation when census and TAZ boundaries are non-coterminous. For presentation purposes he used the TAZ system of Gainesville, a north cenrtal Florida urbanized area (population over 100,000) covered by 249 TAZs. TransCAD and ARC/INFO were the GIS software used in the study. Non-coterminous boundaries of TAZs and census blocks were detected by overlaying the layer of Gainesville TAZ system over the census block map using TransCAD. Gan suggested redefining TAZ boundaries, if data compatibility over time could be maintained, for reducing the number of non-coterminous boundaries. He also suggested the use of two equivalency tables for a data conversion process that involved data aggregation and disaggregation. In the first equivalency table, every census block was equated to either an existing TAZ or a dummy TAZ (if the block boundary was non-coterminous with that of TAZ). In the second equivalency table, each dummy TAZ was equated to existing TAZs. The process involved developing splitting factors needed to split the data values.

Slavin (13) proposed a fundamental reformulation of the travel demand modeling process based upon a richer spatio-temporal conceptual and empirical approach. The proposed approach focussed on improvements and extensions to traffic assignment models, and combined the following four elements:

- modeling joint choices as super-networks,
- dynamic, stochastic network equilibrium models,

- integration of traffic engineering models, and
- GIS technology for database management and model integration.

He discussed the extensive use of GIS software for defining TAZs and developing zonal attribute data prior to modeling by polygon overlay and spatial aggregation functions. He also mentioned that GIS offers an effective means of improving network characteristics.

**Other Methods for Travel Demand Modeling**

Neumann, Halkias and Elrazaz (14) proposed a method for estimating trip rates from traffic counts on the links of a network. The socioeconomic variables causally related to trip production, such as zonal population and dwelling units, were distributed by gravity model and assigned to the links of the network. Regression analysis was carried out to build a linear regression model for estimating traffic counts on the links from assigned socioeconomic variables on each link, using observed link counts as the dependent variable and socioeconomic variables as independent variables. Trip rates by purpose were calculated from the estimated proportion of trips by purpose of the study area.

Several methods (15, 16, 17, 18, 19) were proposed for estimating an origin-destination (O-D) matrix from traffic counts on the links of a network. One of the problems associated with this technique was that there was no unique O-D matrix which could result in the observed traffic counts. In other words, several O-D matrices could possibly exhibit the same traffic count on the links. Turnquist and Gur (15) expressed the necessity of a good estimate of an initial O-D matrix fed into the iterative process of the calculation in order to arrive at better results.

## Need for Small Urban Area Planning Methodology:

Several methods for travel demand forecasting discussed in the previous section are applicable to medium to large urban areas with population over 50,000. The NCHRP reports (3, 4) for quick response methods in travel demand modeling provide transferable parameters for such areas. Availability of demographic and socioeconomic data such as auto-ownership, as classified by income groups and person trips per households, as cross classified by income and auto-ownership, etc., are limited to small areas where there has been a study conducted previously. GIS based Census Transportation Planing Packages (CTPP) provides useful data for large urban area planning. Unavailability of the census socioeconomic data, geocoded for less than block group level, makes the task of applying GIS for travel demand modeling for small urban areas difficult. In small towns with population less than 15,000 and without major industrial activity, there may be less than 20 block groups, which may not provide a significant level of detail for TAZs. One of the reasons for unavailability of adequate data for small urban areas is that there may not be a significant effect of changes in socioeconomic activities in such areas on the transportation system considered in large scale. Some of the available literatures concerning travel demand modeling for small urban areas are briefly discussed below.

**Travel Demand Modeling in Small Areas**

Souleyrette and Anderson (20) addressed the barriers to technical expertise and the problem of inadequate resources for applying modern methods of travel demand modeling to smaller cities or rural areas. Their study proposed a method for applying GIS to develop travel demand models for small urban areas and implemented it in Ames, Iowa, with population slightly less than 50,000. MapInfo was selected as the GIS software, along with TRANPLAN, which is a mainframe urban transportation modelingpackage modified to run on PC's. Some socioeconomic data are available from census data at the block-group level, employment statistics were available from the Department of Employment and parcel level information was available from the local assessor/ auditor. Data also included digital aerial photography, land use maps, traffic signal locations and traffic counts for the study area. GIS's ability to overlay land-use maps, aerial photography and census block groups helped in identifying non-homogeneous block groups and defining TAZs.

Socioeconomic and demographic data aggregation from census block group level to TAZ was performed using GIS. TRANPLAN was used to run the trip generation model. TIGER files, Iowa DOT computer aided design (CAD) files and local area CAD files were used for defining the network. Transferable parameters for travel demand modeling as provided in NCHRP 187 (3) were used for preparing TRANPLAN files to create and calibrate the travel demand model. The advantages of the visualization tools provided by GIS, such as representing the assigned traffic volumes on links using different bandwidths and colors for identifying problem areas, were expressed in the study. Visualization tools were useful in calibrating the model by comparing the assigned traffic volumes with ground counts. Model calibration was done using screen line analysis, i.e., comparing the computer traffic output on the links to key ground counts.

Schrank and Farnsworth (1) presented a traffic modeling template for small cities in Texas with population over 10,000 and less than 50,000, to link transportation planning and economic development. Needs for improvement in transportation were identified at the beginning, which was followed by information collection and data analysis for network data, employment indicators, demographic information and traffic counts.

Transportation network data were available from the Texas Department of Transportation (TxDOT) district traffic map and databases, which provided current and forecasted traffic volumes and the percentage of trucks. Sites which generated higher than average traffic volumes such as industrials parks, retail centers, etc. were located. After data assembling, level of service (LOS) for the street network was analyzed and possible locations of improvement were identified. Although the study did not provide any method for travel demand modeling and forecasting for small areas, its methodology may be used for initial preparation of future networks based on present network characteristics and socioeconomic activities.

## Objectives of This Study:

As previously mentioned, there are several problems associated with formulating a shortcut procedure for travel demand forecasting for small cities or urban areas with population less than 50,000, such as lack of expertise and resources and unavailability of socioeconomic and demographic data in adequate detail. Urban areas with population more than 50,000 have the benefit of metropolitan planning organizations (MPOs) which were created as a part of the Federal-Aid Highway Act of 1973, and are responsible for transportation planning and programming for such areas. Small urban areas lack this capacity.

Since the regional transportation system may not be significantly affected, little resources are dedicated for travel demand modeling and forecasting for small urban areas except on a case-by-case basis. This leads to the **prime objective of the present research:** *formulating a shortcut procedure for travel demand modeling for small cities or urban areas with population less than 15,000, which will not require much expertise and resources.* As a case study for application of the method, McPherson, a small city in Kansas, with population of approximately 13,000 was selected.

Major milestones of the research were as follows:

***i)*** ***Selection of software:*** One of the objectives of the research was to perform the same steps with several models and compare the ease of use as well as the results obtained. GIS based softwares TransCAD and Maptitude and quick response based software QRSII were selected for the research purpose.

***ii)*** ***Information collection and data preparation:*** This involved obtaining socioeconomic and demographic data, information on street network characteristics and traffic counts and information on present and future land use and transportation policies and preparing it for use.

***iii)*** ***Creating travel demand model:*** This involved creation of TAZs based on land use and socioeconomic activities. Appropriate level of detail required for creating the model was determined by comparison of the model output from using different levels of detail in TAZs. Calibration of the model was done using screenline analysis, i.e., comparison with ground traffic counts. A traditional four step travel demand model was prepared.

***iv)*** ***Traffic Volume Prediction on Bypass:*** The city proposed a bypass on the north side of the city, to divert through traffic on US56 highway (as shown in Figure 1.3) from passing through the CBD of the city. The travel demand model was used to predict the traffic volumes that would use the bypass.

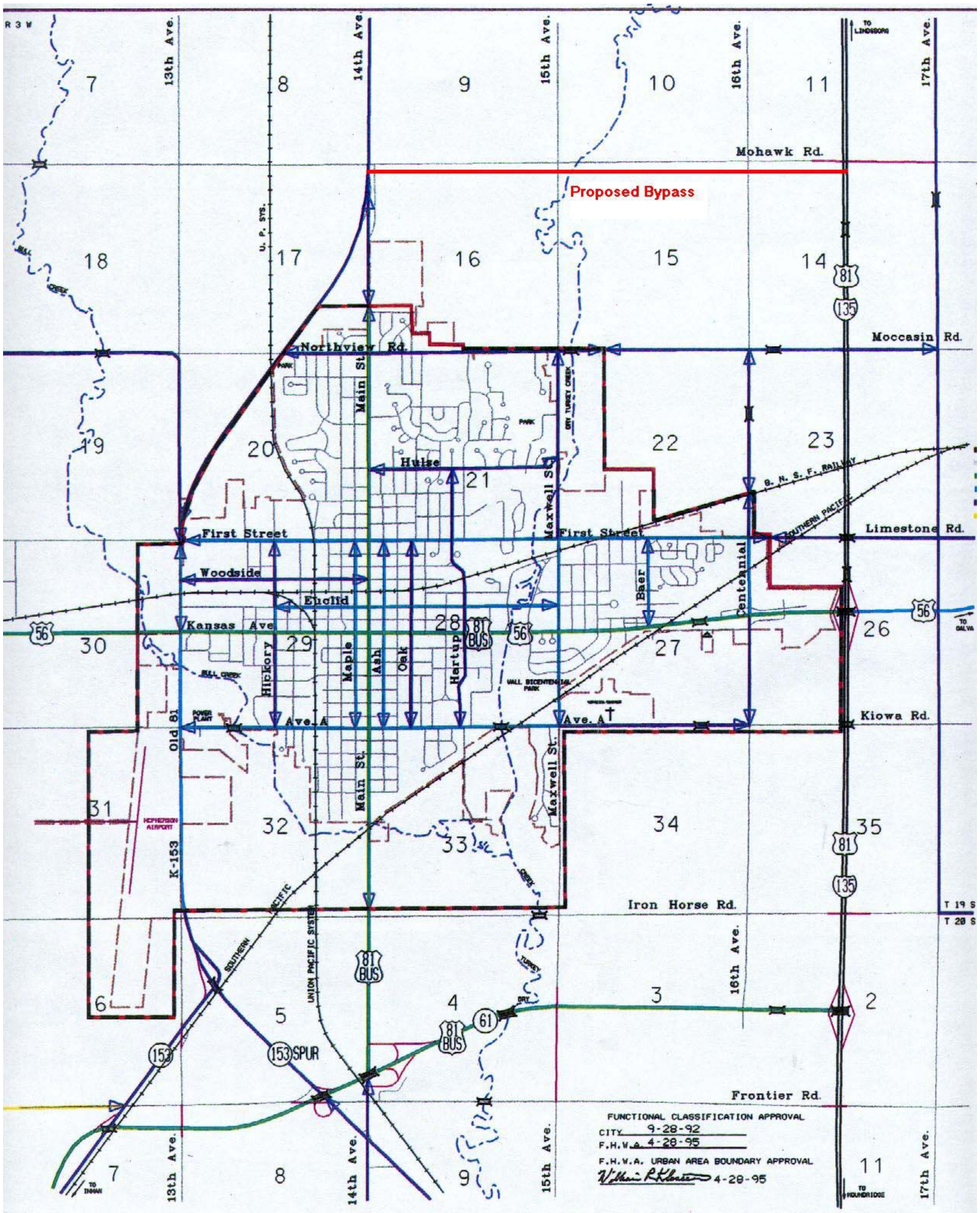



**Figure 1.3 Street Network Within the City Limits of McPherson and Proposed Bypass**

# Chapter 2: Selection of Software

The selection of software for this research project took into consideration researcher familiarity and technical resources of the sponsoring organization, the Kansas Department of Transportation (KDOT). As the mainframe models of the FHWA Urban Planning Battery and the USDOT TRANPLAN were being phased out, KDOT first purchased TModel; however, they made little use of it. The staff then became involved with QRS II and beta tested a number of versions. KDOT has had considerable experience with QRS II over the years. Their interest in this research was to see if TransCAD, with its GIS features, would have advantages over the QRS II routines. The software packages evaluated in this research are Quick Response System/II (QRS II) version 5.1, TransCAD academic version 3.2 and Maptitude version 4.1, EMME/2 and TModel.

## Quick Response System II

QRS II is based on quick response methods (3, 4). A comparison program which is called the General Network Editor (GNE) is used to build the street network, centroids of traffic analysis zones (TAZs) and the centroid connectors. GNE does not support importing GIS layers for street network and census data. An image file containing the streets within the study area may be used as a background on which the street network is drawn. The scale of the network can be set appropriately. The zone centroids are located and connected to the street network using centroid connectors. The demographic and socioeconomic data, such as population, households and employment can be entered as centroid attributes for their respective TAZs.

The software provides no method for data organization to prepare TAZ data. It is necessary to collect information and organize the data to estimate TAZ socioeconomic and demographic data previous to building the network in GNE, for further use for building the travel demand model with QRS II. The software is based on quick response methods (3, 4) and ARSII contains the routines to perform the four usual steps of travel demand modeling, namely, Trip Generation, Trip Distribution, Model Split, and Traffic Assignment. Other balancing converstion routine also are included. It is also familiar to the researchers involved in this study and technical personnel of KDOT.

## TransCAD and Maptitude

TransCAD and Maptitude contain GIS routines that can be used to import, organize and prepare GIS based data useful for travel demand modeling, such as census data and street network data. It can also be used for geocoding data, such as locating records on a geographic layer by matching address with a street network layer.

Maptitude provides a useful tool for preparing socioeconomic and demographic data for TAZs, which may be further used for building a travel demand model using QRS II or any other software designed for this purpose. Maptitude was used to estimate TAZ and street network data, which was then fed to the GNE, and finally to QRS II for building a travel demand model.

TransCAD, other than providing GIS features, also provides tools for building a travel demand model. It is window based GIS software designed for transportation engineering applications. TransCAD academic version 3.2 did not provide all GIS features of the complete commercial software. Therefore Maptitude version 4.1 was purchased to perform tasks using enhanced GIS tools.

It was determined from the research that TransCAD is a powerful software package for travel demand modeling. However, it took a considerable amount of time to gain familiarity in using it. A training course conducted for KDOT by Caliper Corporation, which markets the TransCAD and Maptitude software accelerated the learning process for the research. It was realized that after gaining familiarity in using the software, it could simplify the overall process of travel demand modeling in regards to time and cost of data preparation.

Unlike QRS II, TransCAD is not pre-designed to use quick response methods or transferable parameters (3, 4). The user inputs values of the parameters required for building travel demand models, such as trip production and attraction rates, friction factor developing methods, etc., but at the same time the transferable parameters as provided in the quick response methods (3, 4) may be used without any restriction.

TransCAD proved to be useful in meeting the goals of the research by providing GIS tools for easy data organization, visual tools for developing street network and TAZs, and results that can be easily analyzed.

The other softwares that were evaluated were EMME/2 and TModel. They were not used to model the McPherson Area Network; however, each model was used during the project period on classroom projects. Based on that experience, EMME/2 proved to be a very comprehensive model and would be very useful when several modes were being analyzed. However, it is too complex and the learning curve is too long for use in small urban areas. TModel is a much easier model to use, similar to QRS II, but it did not handle External-Local and Through Trips easily. The through trips had to be manually assigned to the network and treated as base traffic. These procedures did not lend themselves to an analysis of a bypass.

# Chapter 3: Information Collection and Data Preparation

As mentioned in Chapter 1, the four broad categories of information required for building a travel demand model (2) are the study area, the urban activities, the transportation system and the travel information. In this chapter, a detailed discussion is presented of sources for collecting this information and using it to prepare data for building a travel demand model using TransCAD.

## Information Collection

**Study Area:** Information on a study area includes the location of the cordon line, the boundaries of census tracts, the census block groups and blocks, the land use data and the location of major streets and physical barriers. This section presents a list of sources of information on the study area.

***i)*** ***City Comprehensive Plan*** (21) provided the following information:

1. McPherson Planning Area Map provided information for defining the cordon line for the study area.
2. Development Influence Map provided the location of physical features within the study area such as streams, railway tracks and major streets.
3. Present and future land use information and relevant maps were used for defining TAZs.
4. Functional Classification Plan was used for defining the network and TAZs.

***ii)*** ***McPherson County General Highway Map Aerial Photographs*** provided by KDOT for the city of McPherson were used for identifying the locations of major employers and residential areas and their accessibility to major streets. Also, the location of physical features such as streams, railway tracks and streets were identified from the photographs.

**Urban Activities:** The information on urban activities included demographic data such as population and housing and socioeconomic data such as income auto-ownership and employment.
This section presents the sources of such information and data available from them.

***i)*** ***1990 Census Data*** (22) for population and households provided the data on population and household units for each census block within the study area. The census blocks were coded according to the census code.

***ii)*** ***TIGER/LINE 1995 Compact Disc (CD)*** (23) was the source of information on location of census blocks and their census codes. TransCAD was used to import the geographic area layer for census blocks from the CD.

***iii)*** ***Employment Data.*** The data were available from American Business Lists, Inc., Omaha, Nebraska. Search for other vendors providing the information on business research tools or statistics, may be done through the Internet. The data included street addresses, number of employees and standard industrial classification (SIC) codes. KDOT purchased these data and provided them for the project.

**Transportation System:** The information on the transportation system included location, functional classification and characteristics of streets and highways within study area. This section provides the sources for such information and data available from them.

*i)* ***US Streets 97 CD*** (24) provided the geographic line layer for major streets and highways within the United States. TransCAD was used to select the streets within the study area and TransCAD Tools-Export process was run to export them to a standard geographic line layer, which was stored in a geographic file and edited using TransCAD for developing the transportation network. The imported line layer was associated with the data for length, left and right zip code and left and right address number for the beginning and end of each block.

*ii)* ***General Highway Map*** for McPherson County was available from KDOT and was used to identify any major street within the study area but outside city limits of McPherson, which was missing in the line layer imported from US Streets 97 CD (24).

*iii)* ***City Comprehensive Plan*** (21) provided the functional street classification map for the streets within the city limits. The McPherson Public Works Department, provided the geometric characteristics of streets. The data consisted of number of lanes, width and average daily traffic (ADT) counts for the major streets and intersection type for all intersections within city.

*iv)* ***KDOT/KTA Major Corridor Study*** (25) provided the graphical representation of estimated daily LOS of arterials, rural highways, freeways and expressways. The capacity of the links of the network was assumed to be the service volume at LOS B for each type of street or highway.

**Travel Information:** Vehicles using the streets and highways are the result of the travel behavior of people. The traffic counts are compared to the results of the modeling process to determine whether the models are accurately reproducing choices made in daily travel. This section presents the sources of travel information and relevant data.

*i)* ***City Comprehensive Plan*** (21) provided the data on traffic counts for major street within the study area.

*ii)* KDOT provided the data on daily vehicle miles of travel on streets in urban areas according to functional street classification.

## Data Preparation

TransCAD was used for preparing the employment and demographic data, which were further used for building data for TAZs.

**Employment Data:** The employment data, made available by KDOT, provided the street address for all employers. It was then necessary to locate them as point features within the study area. This was done by executing the 'Locate by Address' process in TransCAD. This section presents the sequential method for locating the employers within the study area and creating a point geographic layer in TransCAD for the employment locations.

1. The employment data file, which was available as a Microsoft Excel file, was first converted to dBASE (*.dbf) file format.
2. The geographic line layer representing the streets within the study area, which was imported from US Streets 97 (24) (as mentioned in earlier section), was opened in TransCAD or Maptitude. The data were checked to ensure that the associated data for the streets within the

city limits had the left zip, right zip, starting and ending block numbers for left and right side of each street. These data were required for locating the employers on the correct street and side.

3. The dBASE file containing the employment data were opened in the same workspace. The data file contained 614 records. It was observed that the street name in the address field of the data contained different names for the same street section for many records. For example, the names "Old Highway", "Old 81 Bypass" and "Bypass", in many records in the employment data referred to the same street, the 81 Bypass on the west side of McPherson. All such street addresses were changed to the single name that was used in the dataview associated with the line geographic layer of streets.
4. The 'Locate by Address' command in TransCAD was used to locate the employers within the study area as a geographic point layer. A total of 526 employers were located in the process. Figure 3.1 shows the TransCAD window containing the workspace for locating employers.
5. There were 88 employers whose addresses could not be matched and thus TransCAD failed to locate them. Out of these records, there were only nine employers with ten or more employees. Their location was determined by either calling the company (the phone number for each employer was available as a data field) or by using the web site "http://www.anywho.com". The remaining employers (with ten or fewer employees) were discarded.

The employers were located as points on the existing point geographic layer of located records, as new records. Finally a total of 535 records were used as employment data for building the travel demand model.

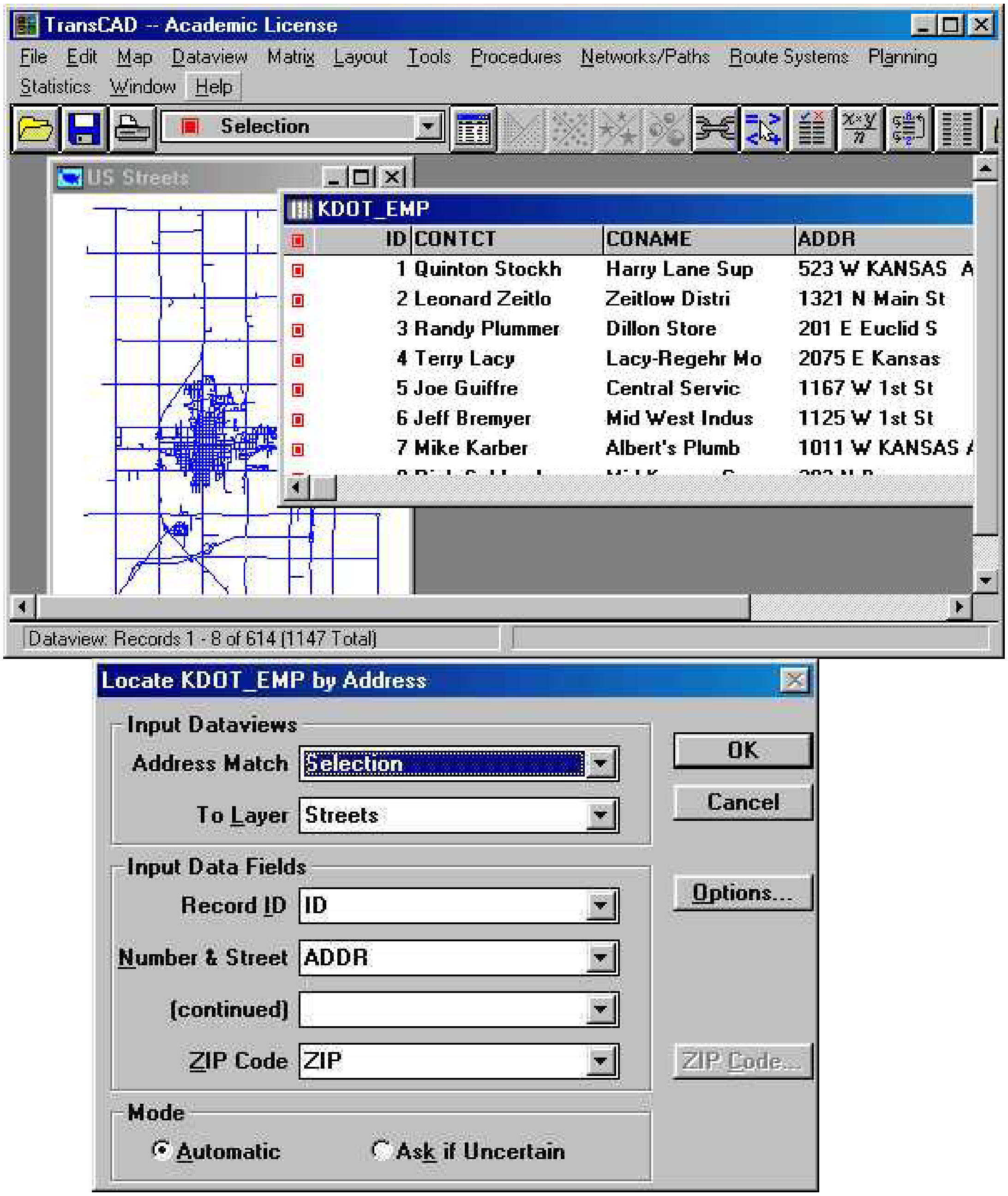



**Figure 3.1 TransCAD Window for Locating Employers by Address Matching**

6. A new field, to specify the employment type for each employer, was added to the dataview of the point geographic layer for employment locations. The employment type consisted of three categories: Non Retail, Service and Retail. The classification was done based on SIC codes available for each record. Table 3.1 provides the employment classification based on SIC codes as specified in NCHRP Report 365 (4). The SIC codes were revised in 1997. Make sure the correct version is used.

**Table 3.1 Employment Categories Based on SIC Code**

| Employment Category | SIC Code (1997) |
|---|---|
| Non-retail | 100000 through 519999<br>900001 through 909999 |
| Service | 600000 through 909999 |
| Retail | 520000 through 599999 |

**Population and Housing Data:** Population and households of the census blocks for the 1990 census were available from the Census Bureau as mentioned earlier. A data field named "code" containing the census code for each block was present in the data. It was then necessary to form an area geographic layer of census blocks which contained the population and household data in the associated dataview in TransCAD. This section describes the sequential method for the process of creating the area geographic layer of census blocks containing population and household data.

1. The area geographic layer for census blocks, which was imported from the TIGER/LINE 1995 CD (23), was opened and the census blocks within the study area were selected and exported to the new area geographic layer. The fields in the associated dataview of the geographic layer contained the area and census code for each block within the study area.
2. The population and housing data were available as a Comma Delimited Text (*.csv) file and was opened in Microsoft Excel. The file type was converted to a dBASE (*.dbf) file format.
3. The dBASE file containing the population and housing data were opened in the same workspace where the area geographic layer of census blocks already existed in TransCAD.
4. The 'Dataview-join' command in TransCAD was used to overlay the area geographic layer of census blocks with the database of population and households, using census block codes as the common field between the two data sets. Figure 3.2 shows the TransCAD window for this process.
5. The 'Tools-export' command was then used to export the joined dataview to a new area geographic layer of census blocks, which contained the population and household data in the associated dataview.

**Street Network:** The line geographic layer imported from US Streets 97 CD (24) consisted of essentially all public roads within the nation. The network was built using links representing major and minor arterials, collectors, freeways and expressways, rural highways and some of the local roads. In this section, the procedure is discussed for building the network using available data.

1. The line geographic layer imported from US Streets 97 CD was opened and the selected portion bounded by the cordon line was exported to a new line layer. This was done to reduce the size of the file to a manageable proportion and to keep the previously imported layer unchanged while building the network using the new layer. All links not included in the network were deleted. TransCAD, 'Tools-Map-Editing' command was used to make any required modification in the links of the network. Note that the selected portion must be exported rather than saved to eliminate the remainder of the national network.
2. The TransCAD 'Tools-Selection' feature was used to select the links of same functional classification and represent them with same color and width.
3. The network attributes were added by modifying the dataview associated with the line geographic layer and adding new fields. Table 3.2 gives the list of attributes

added to the links for building the network.

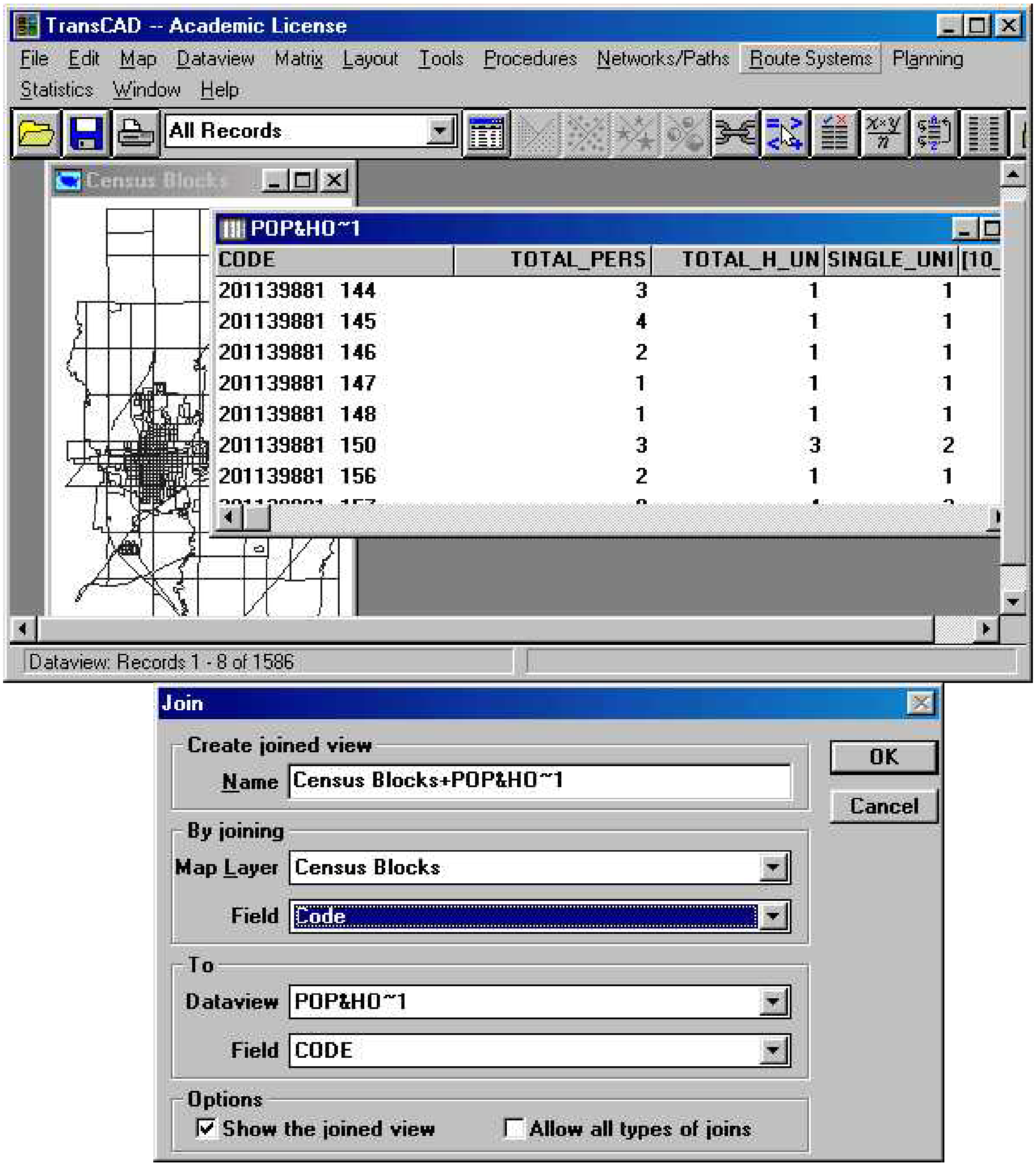



**Figure 3.2 TransCAD Window for Preparing Population and Housing Data for Census Blocks**

**<u>Table 3.2 Network Attributes</u>**

| Field | Description |
|---|---|
| Link Type | Functional Classification |
| AB and BA Speed | Directional speed for each link in miles/hour |

| | |
|---|---|
| AB and BA Travel Time | Directional travel time for each link in minutes |
| AB and BA Capacity | Directional capacity in vehicles per day (vpd) |
| AB and BA Count | Directional traffic counts as observed in vpd |
| Alpha and Beta | Parameters for BPR function used for traffic assignment |

4. The directional speed data for each record of the line layer was assigned with the posted speed limit for the corresponding street represented by the link. Available traffic count data were assigned the observed traffic counts for corresponding streets if available, as provided by the city comprehensive plan (21), it was left blank for those streets were it was not available. The BPR parameters alpha and beta were assigned values of 0.15 and 4.0, respectively, as specified in NCHRP Report 365 (4). The directional free flow travel times for each link were calculated as follows:

   Travel Time = Length *60/AB_Speed -------------------- (Equation 2.1)

5. The directional capacity was determined from the 24-hour service volume at LOS B for different streets according to functional classification in graphs representing the service volume at various LOS provided by KDOT/KTA Corridor study (25). Table 3.3 provides the capacities along each direction for each link type in the network.

**Table 3.3 Capacity for Links Based on Functional Classification**

| Code | Functional Classification | Capacity Direction (vpd) |
|---|---|---|
| 1 | Major Arterial | 8,500 |
| 2 | Minor Arterial | 3,500 |
| 3 | Collector Road | 2,800 |
| 4 | Interstate | 16,000 |
| 5 | Rural Highway | 1,600 |

# Chapter 4: Developing Traffic Analysis Zones

In the last chapter the collection and preparation of the data needed for building a travel demand model were discussed. The next step for building a travel demand model is to develop traffic analysis zones (TAZs) In this chapter the procedure for defining zone boundairies is discussed.

## *Defining TAZs*

As recommended by Garber and Hoel (26), TAZs were defined in such a way that the land use and socioeconomic activities within them were as homogeneous as possible. Physical features such as major streets, railway tracks and streams were used as zone boundaries and where possible the TAZ boundaries were made coterminous with census block boundaries. The information used for defining the TAZs was discussed in Chapter 3.

TAZs were created as an area geographic layer in TransCAD. The line layer representing streets within the study area, and area geographic layer for census blocks, were overlayed, with the area geographic layer used for defining the TAZs.

## *Level of Detail and Zone Numbering*

One of the objectives of this research was to determine how many zones were necessary to produce satisfactory results for different types of projects. Three levels of detail were initially attempted to analyze the level of detail that would be adequate for various projects that might be encountered in a small urban area. However, because of the numerous streams and railroads that bisect the developed area of McPherson, only two levels of networks were developed. One of them consisted of 21 TAZs within the study area, which was named the low-density-zoning scheme and the other consisted of 63 TAZs, and was named the high-density-zoning scheme. It was not possible to include all natural zone barriers such as railway tracks and streams for defining TAZ boundaries in the low-density-zoning scheme, whereas it was done in the high-density-zoning scheme. A more detailed network would have been far too complex for a small urban area and would have taken an excessive amount of time to develop.

For the high-density-zoning scheme, or any area that has a large number of zones, a ring-sector scheme can be used. The rings are numbered from "0" for the CBD out to Ring 4, if necessary. The sectors are numbered clockwise from "1" (North) to "8" (Northwest). A zone in the CBD would be numbered "001" and a zone to the southeast would be "141" or "241." TAZs for each density-zoning scheme were developed in TransCAD as area geographic layers. Figures 4.1, and 4.2 present the TAZs for low-density-scheme and high-density-scheme respectively.

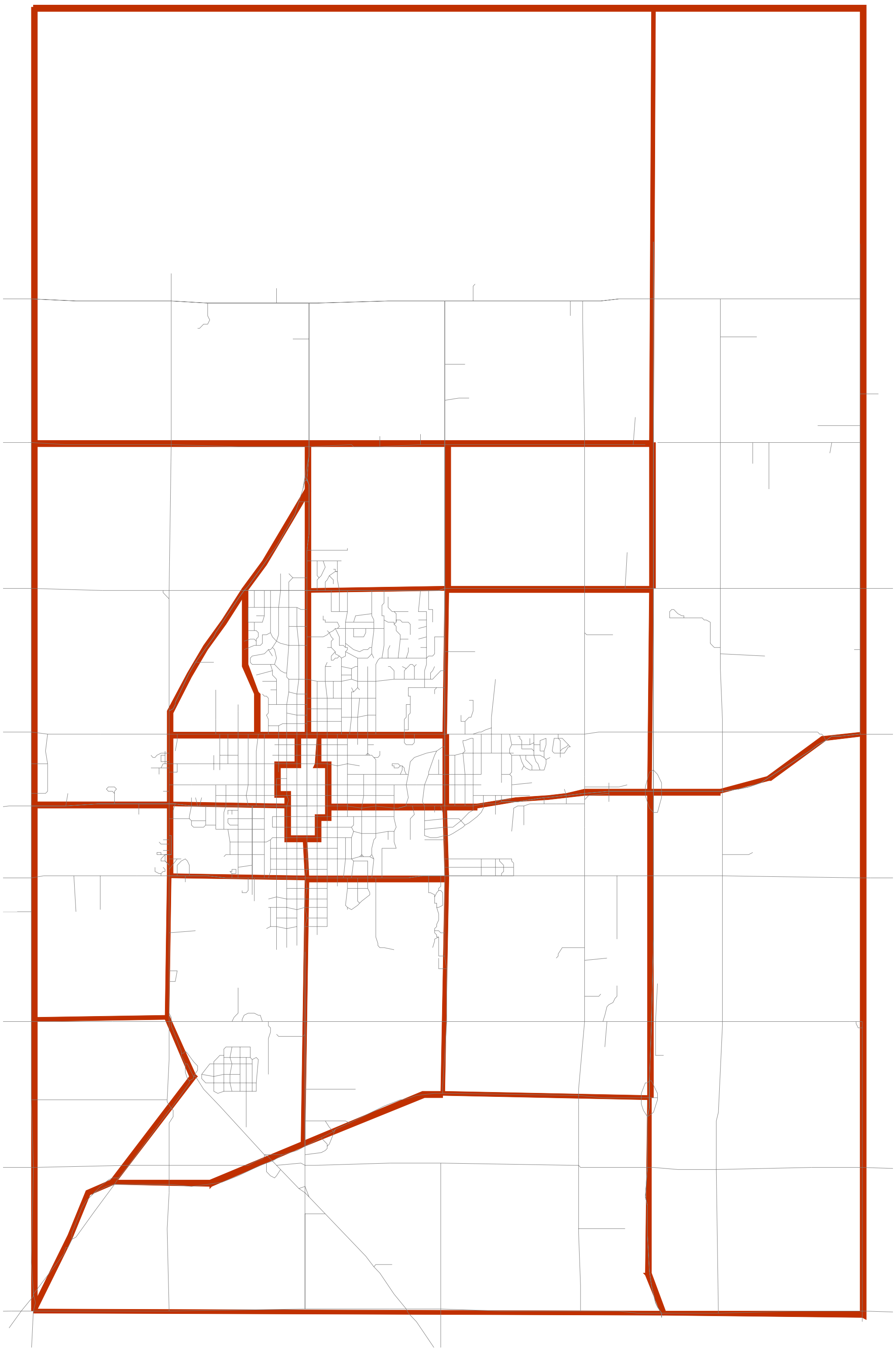


**Figure 4.1 TAZs for the Low-Density-Zoning Scheme**

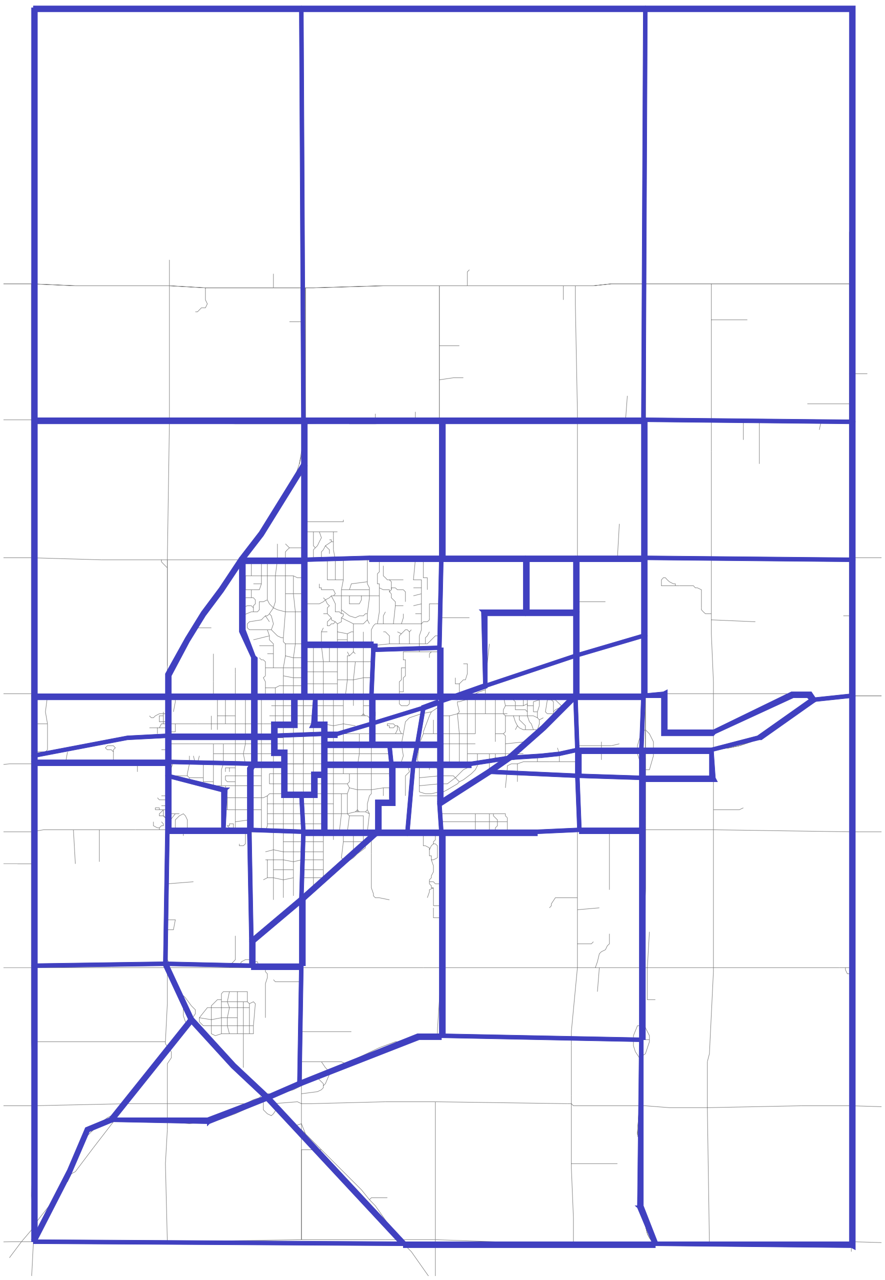


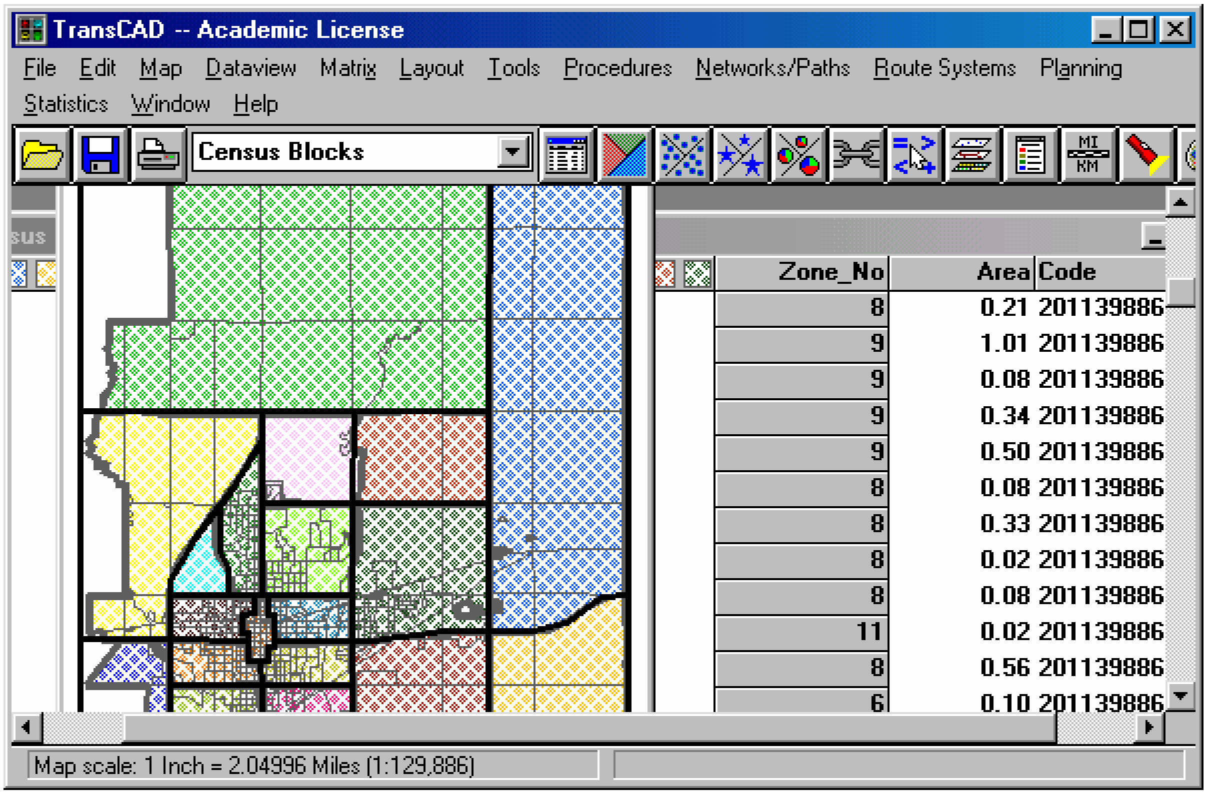
**Figure 4.2 TAZs for the High-Density-Zoning Scheme**

## Data Preparation for TAZs

### Population and Housing Data:

In Chapter 3 it was discussed how the population and housing data for census blocks was prepared from available database and area geographic layer for census blocks from TIGER/LINE 95 CD (23). To prepare the demographic data for the TAZs, the population and number of households for census blocks within each TAZ was aggregated to produce the total population and number of households for each TAZ. This was done in TransCAD by using the "Merge-by-value" feature for creating 'districts' (27). The procedure for preparing demographic data for the TAZs is given as follows:

1. The area geographic layer for the TAZs for the density scheme for which TAZ data were being prepared was opened in TransCAD.
2. The area geographic layer for census blocks with the associated database containing population and household data for each block within the study area was opened as a second layer using the TransCAD "Map-Layers-Add Layer" command. The census blocks were made the active layer. The colors of the two layers that were opened were made different so as to identify them.
3. The associated dataview in TransCAD for the census blocks geographic layer was modified using the TransCAD "Dataview-Modify Table", and a new integer field named 'zone_no' was added. This field was used to give zone numbers to the census blocks.
4. The TransCAD selection tool was activated, and for each TAZ the census blocks within it were selected and the field 'zone_no' in the associated dataview was filled with the zone number of the corresponding TAZ number using the TransCAD "Edit-Fill" command in the dataview for the selected records. In this way, all the census blocks within the study area were designated with the zone number of the corresponding TAZ to which they belonged.
5. The area geographic layer for census blocks was checked to be sure it was the current working layer. The TransCAD "Tools-Merge by Value" feature was used to merge the census blocks based on 'zone_no' and to create a new area geographic layer which merged the area of all the census blocks having the same zone number, i.e., belonging to the same TAZ. The associated database consisted of one record for each zone number containing the total population and households of census blocks of that zone. This process is termed 'creating districts' in TransCAD (27). Figure 4.3 shows TransCAD window for creating districts for low-density-zoning scheme from census blocks.
6. The area geographic layer for the TAZs was joined with the dataview of area geographic layer for census block districts developed in step 5 and exported as new area geographic layer for TAZs containing population and household data using the 'Tools-Export' command.



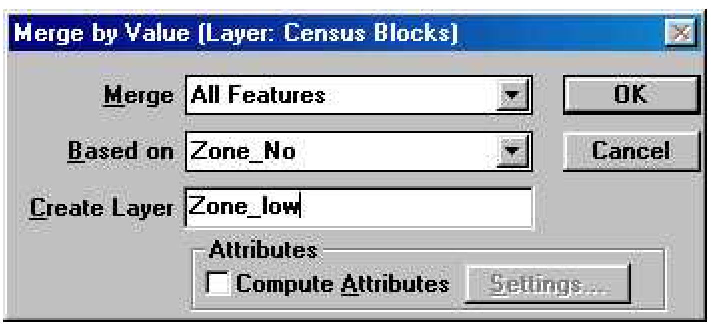




**Figure 4.3 TransCAD Window for Preparing Population and Household Data for TAZs for Low Density Zoning Scheme**

**Employment Data:**

The procedure for locating employment records based on address was discussed in Chapter 3. The results of the locating procedure was a point geographic layer representing the locations of employers within the study area. The associated database consisted of records for each employer. Then the employers were assigned to the respective zones to which they belonged. Thereafter the number of employees in each TAZ was determined according to employment type. In this section, the procedure of assigning employers to their respective zones and determining employment data for the TAZs is discussed.

1. The area geographic layer defining the TAZs for the density scheme for which the TAZ data were being prepared was opened in TransCAD.

2. The point geographic layer representing employment locations was opened as a second layer using the TransCAD "Map-Layers-Add Layer" command. The associated dataview of the point geographic layer was modified using the TransCAD "Dataview-Modify Table" command and a new integer field named 'zone_no' was added. This field was used to assign aTAZ number to each employment record of the TAZ to which an employer belonged.
3. The point geographic layer representing employment locations was made the current working layer. The TransCAD selection tool from the "Tools-Toolbox" was activated and for each TAZ the employers within it were selected and the dataview field 'zone_no' was filled with the corresponding TAZ number using the TransCAD "Edit-Fill" command. This assigned the corresponding TAZ number to each employment record. The dataview was saved as a dBase file using the "File-Save-as" command.
4. The dBase file saved in step 3 was opened in Microsoft Excel. All the fields except those specifying the TAZ number, the number of employees and the employment type for each record were deleted.
5. The Microsoft Excel "Data-filter-Auto filter" command was used to categorize the data according to zone number and employment type. The employment type was specified by 0, 1 or 2 for non-retail, service and retail employment respectively for each record.
6. For each zone number, the total number of employees of each employment type was determined by selecting each type of employment from the scroll-down list in the data field for the employment type in the MS-Excel worksheet, and then summing up the total number of employees for that employment type.
7. The area geographic layer for the TAZs containing population and household data were opened in TransCAD, and the associated dataview was modified by adding three integer fields named 'Non-Retail', 'Service' and 'Retail' and was filled with the employment data obtained from step 6 for each zone. Figure 4.4 shows the MS-Excel worksheet for calculating the number of retail employees (employment type = 1) for TAZ number 10, which is equal to 28.

This completed the preparation of TAZs and their associated data for the two different levels of zoning scheme that would be used for building the travel demand model. The associated dataview for the area geographic layer developed in step 7 contained the fields: TAZ number, total population, total households, non-retail, service and retail employees for each TAZ, for two different levels of TAZs.

## Developing the Street Network

Building the street network using different links from the line geographic file imported from US Streets 97 CD was discussed in Chapter 3. After defining the TAZs, centroids and centroid connectors were added to the network. In this section, the procedure for modifying the network by adding zone centroids and centroid connectors is discussed.

1. The street network that was developed as discussed in Chapter 3 was opened in TransCAD. The line geographic layer representing the streets was associated with a point geographic layer representing the intersections. The point layer was made the current working layer and a formula field named 'temp' was added to the associated dataview using the TransCAD "Dataview-Formula fields" command. The line geographic layer was then made the current layer and was exported to two new geographic layers to be used for modifying networks for two different levels of zoning. The point layer was modified in order to make the associated dataview for intersections layer in the two new street layers modifiable, so that new fields could be added to the dataview of the associated point geographic layer. The field 'temp' was renamed as 'zone_no' in both the networks.

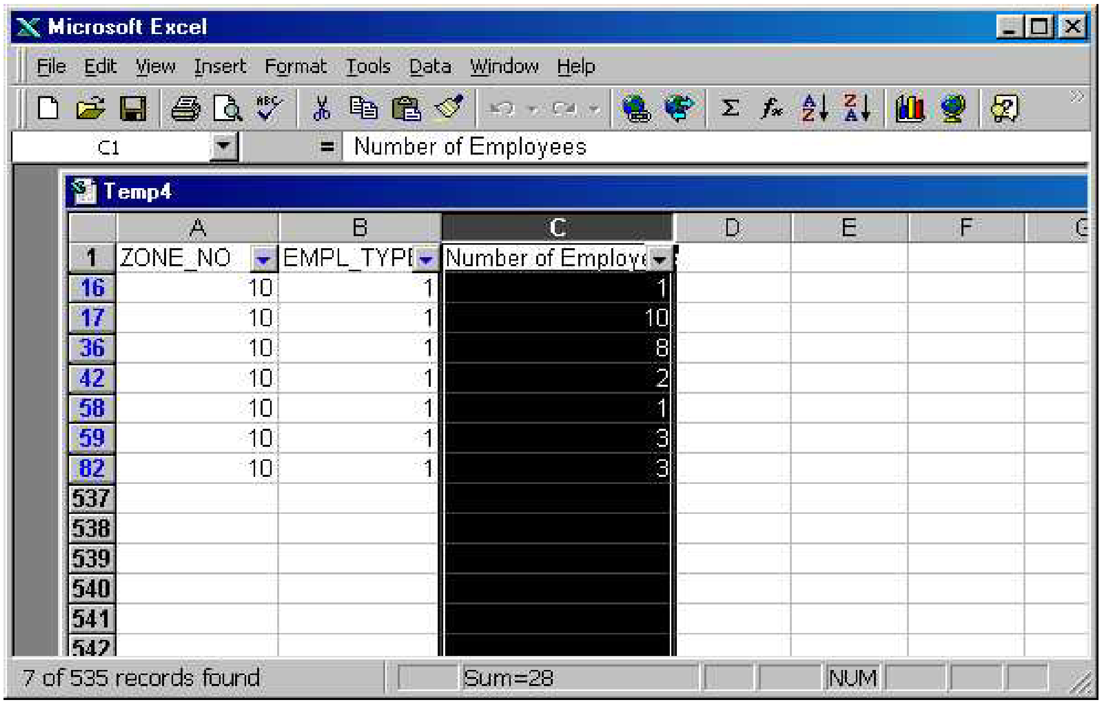



**Figure 4.4 Microsoft Excel Window for Calculating the Number of Employees for Different Employment Types for Each TAZ in Low - Density Zoning Scheme**

2. The area geographic layer for the TAZs for the level of zoning for which the network was being prepared was opened as a second layer using the TransCAD "Map-Layers-Add Layer" command. The line geographic layer was made the current working layer.
3. The aerial photographs, employment locations and residential zones within each TAZ was used to determine the position of the zone centroid and location of centroid connectors. The centroid for each TAZ was located at the apparent center of activity of each TAZ.
4. The network was modified by adding centroid connectors and updating the associated database of the line geographic layer. A travel speed of 15 miles per hour was assigned to the links representing centroid connectors. The 'zone_no' data field in the associated dataview for the points representing centroids was assigned the corresponding TAZ number.
5. The TransCAD 'Network-Create' command was used to create network from the line geographic layer and its associated intersection layer.

## Addition of External Stations:

A total of eleven external stations for external-internal and through trips was selected for the study based on information provided for the transportation network and travel activities. The major streets extending through the cordon line connecting to the external stations were identified from the street network geographic layer as being present in the US Streets 97 CD (24), McPherson planning area map in the city comprehensive plan (21) and aerial photographs. The area geographic layer for TAZs was opened in TransCAD and dummy areas for the external station were added to the layer using the 'Tools-Map editing' feature in TransCAD. The street network was modified by adding centroids to the external stations and connecting them to the network using centroid connectors. Figures 4.5 and 4.6 show the TAZs with external stations added and Figures 4.7 and 4.8 show the network for low-density-zoning and high-density zoning schemes respectively.

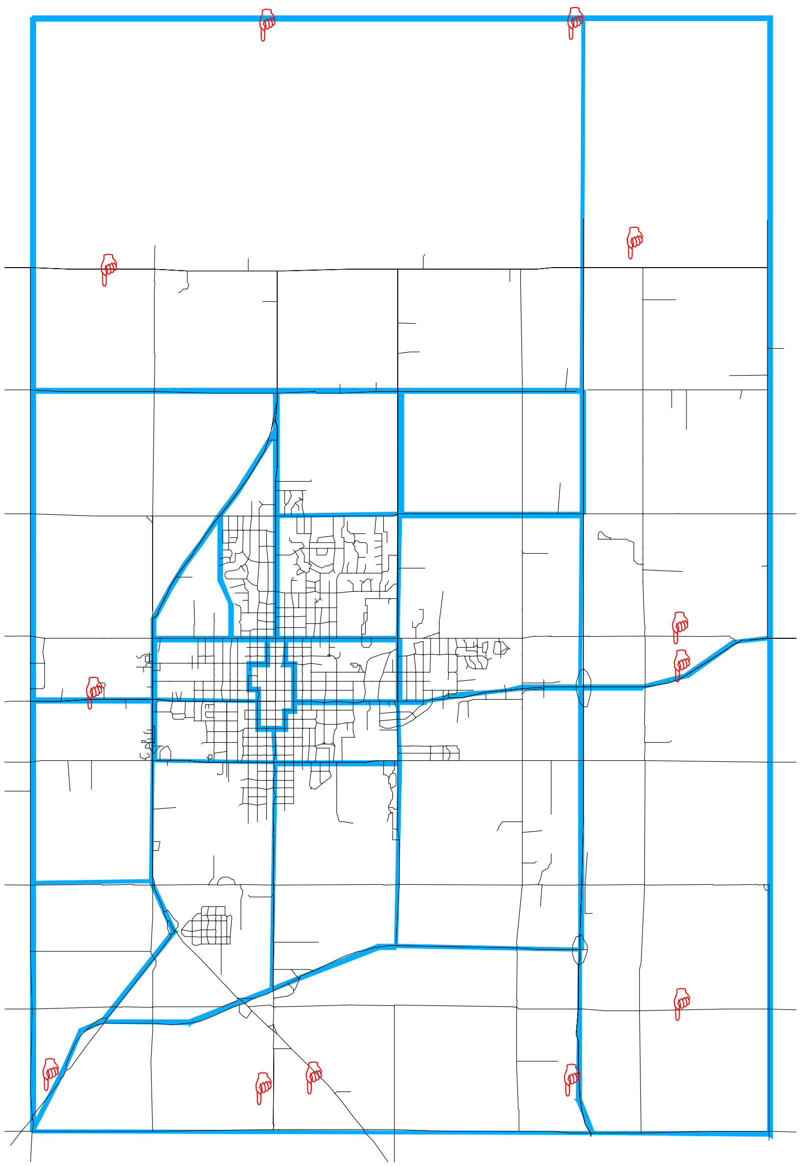


**Figure 4.5 TAZs and External Stations for Low Density Zoning**

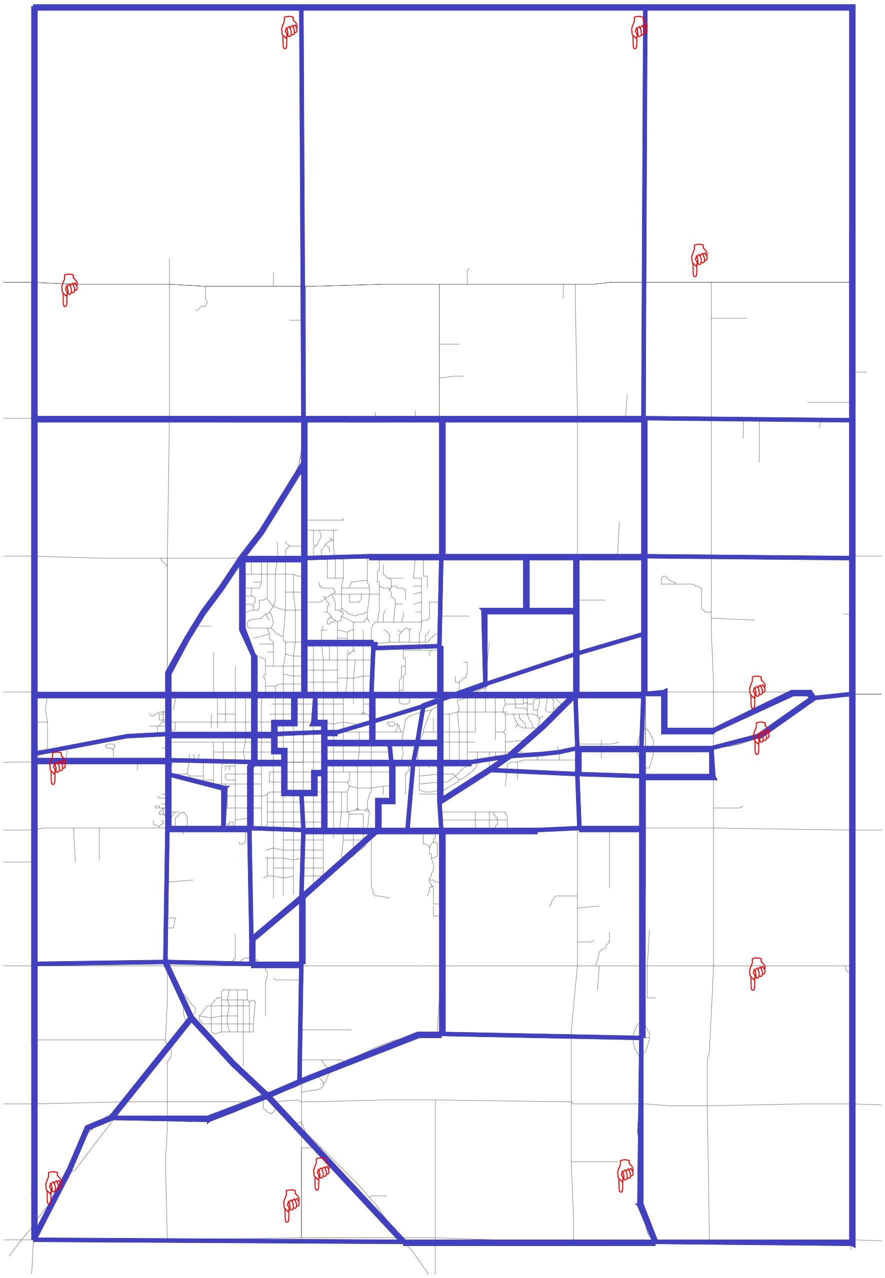


**Figure 4.6 TAZs and External Stations for High Density Zoning**

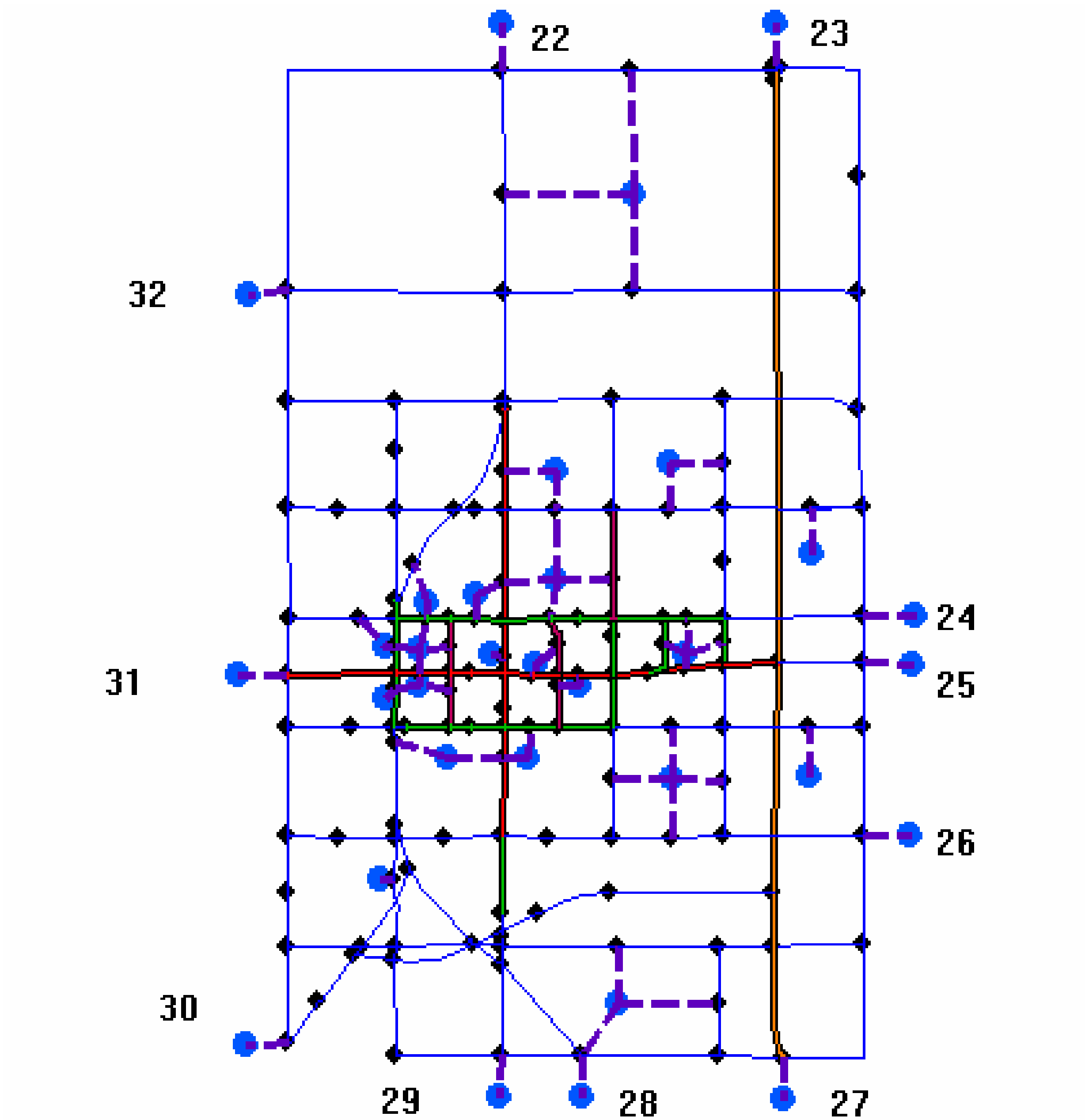



**Figure 4.7 Street Network for Low Density Zoning**

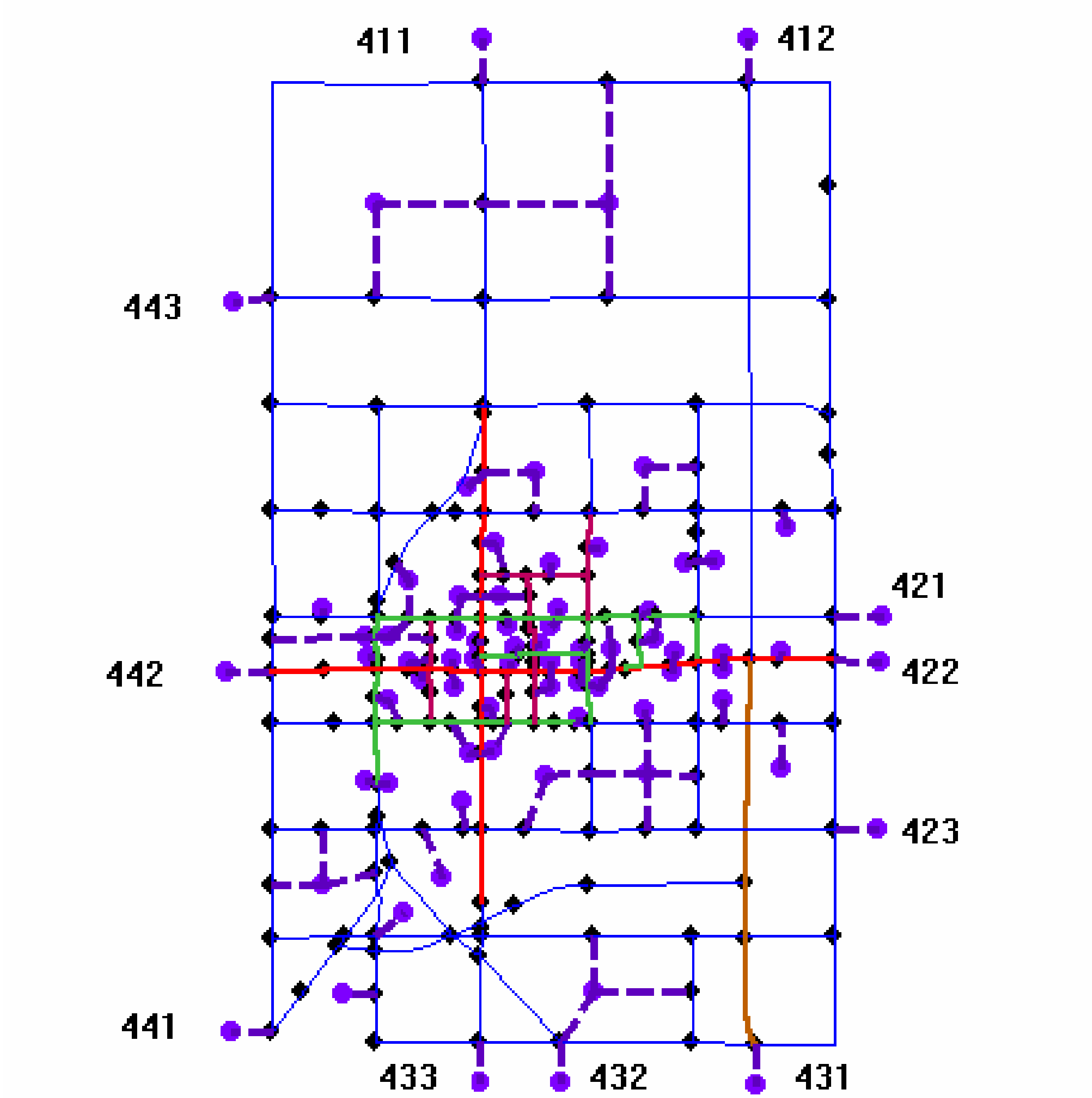



**Figure 4.8a Steet Network for High Density Zoning; for the Whole Study Area**

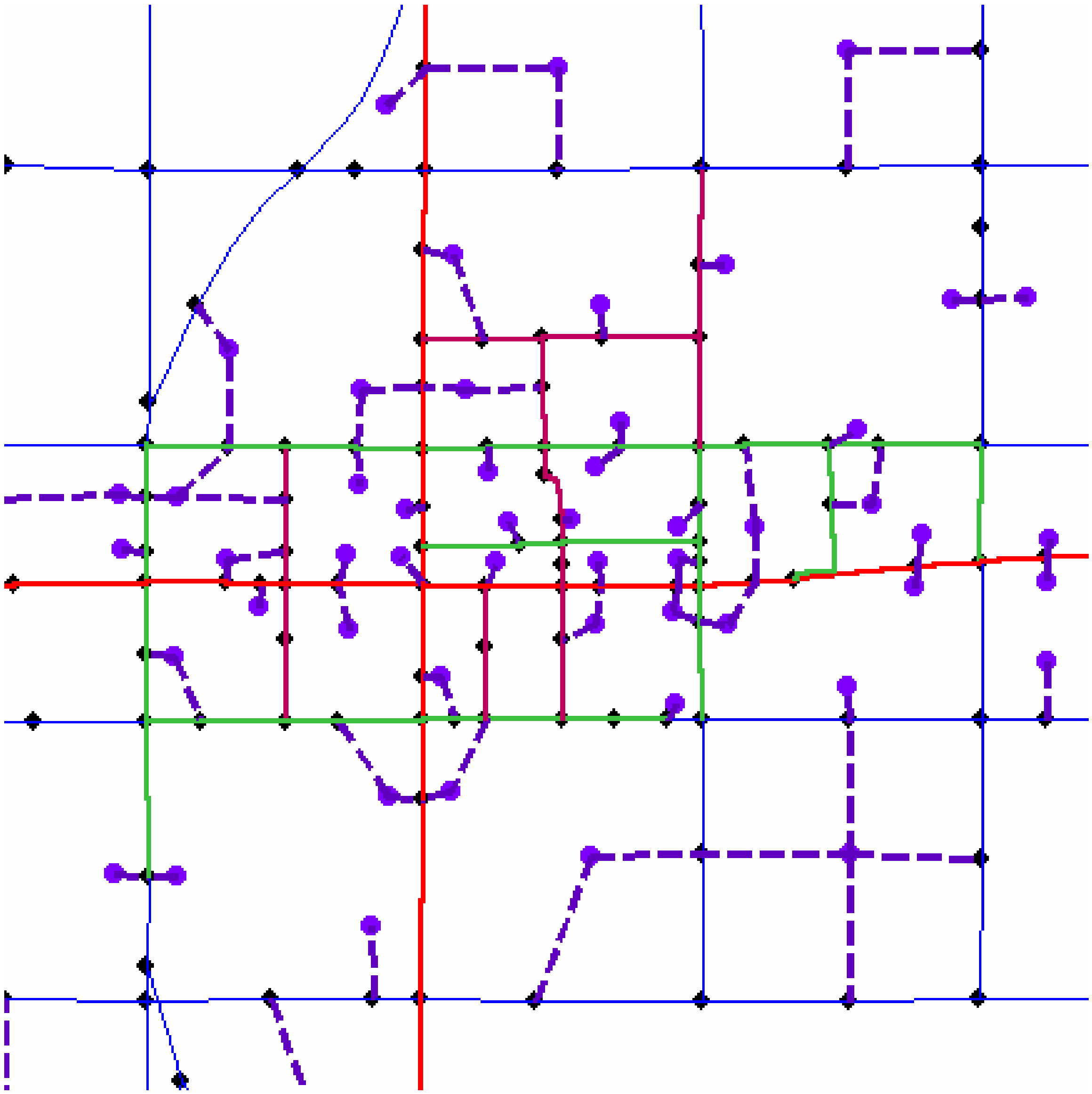


**Figure 4.8b Steet Network for High Density Zoning; Expanded view for the Central Area.**

# Chapter 5: Building A Travel Demand Model

After defining and preparing the data for the TAZs and building the street network for two different levels of zoning, as discussed in Chapter 4, the next step was to build the travel demand models for two levels of detail in TAZs and calibrate them using available information. In this chapter, the sequential procedures followed to build and calibrate the travel demand models for the study area is discussed.

## Trip Generation

**Trip Production:** The trip rates by trip purpose used for estimating trips productions were obtained from Table 9 of NCHRP Report 365 (4) using the parameters for urban area with population size 50,000 – 199,999. Although the study area for this research had total population of approximately 13,000, the parameters for trip rates were not available for urban areas with such low population range, therefore the parameters for population range 50,000 – 199,999 were used. It was observed that the median income for all TAZs was within the range of $20,000 to $39,999, which was categorized as medium income level by the table. The following data were used for internal trip production by trip purpose for all TAZs, for both levels of detail:

i) 9.3 average daily person trips per household, and
ii) percentage average daily person trips by purpose:
Home Based Work (HBW); 21%
Home Based Other (HBO); 56%
Non - Home Based (NHB); 23%

The external-internal trips produced by external stations were categorized as NHB, and the data were available from KDOT.

**Trip Attractions:** Trip attraction rates for estimating zonal trip attractions were available from Table 8 of NCHRP Report 365 (4). The trips attractions for TAZs were estimated from the employment and household data and the trip rate parameters. The external stations were assumed to have no attractions.

**NHB Trip Productions for External Stations:** The non-home-based trips produced by the external stations were available from KDOT (29) and the values were added to the records.

**Balancing Productions and Attractions:** The productions and attractions of both internal trips and external-internal trips were balanced by holding productions constant and balancing attractions to equate the total attraction to production for each trip purpose. TransCAD (27) was used for this procedure.

## Trip Distribution

**Friction Factors:** Friction factors were estimated by applying a gamma function to zone-to-zone impedance (4). The zone-to-zone impedance matrix was developed by applying multiple shortest path procedures on the network. The network for each level of detail was opened and the centroids of all TAZs were selected from the associated intersection layer with the line layer representing the street network.

TransCAD "Networks/Paths-Multiple paths" procedure was run to develop a matrix consisting of minimum free-flow travel time between each pair of centroids. This matrix was used as the impedance matrix. The gamma functions for each trip purpose, obtained from Table 14 of the NCHRP Report 365 (4), were applied to the values in each cell of the matrix and three new matrices were obtained containing friction factors for each pair of centroids, i.e., zone-to-zone friction factors for each respective trip purpose. The TransCAD 'Planning-Trip Distribution- Synthetic friction factors' procedure was run to generate the friction factor.

**Trip Distribution:** The gravity model was used for trip distribution using zonal productions and attractions and zone-to-zone friction factors, for both levels of TAZ. The TransCAD "Planning-Gravity evaluation" command was used to run the procedure and the resulting production-attraction (P-A) matrices were obtained consisting of zone-to-zone productions and attractions for each of the three trip purposes. The TransCAD "Matrix-Quick sum" command was used for cell-by-cell addition of the three matrices and obtain a single P-A matrix.

**P-A to O-D Conversion:** The 24 hour P-A matrix obtained from trip distribution procedure was converted to a 24 hour origin-destination (O-D) matrix by using the TransCAD "Planning-PA to OD" command. As discussed in an earlier section of this chapter, the trip rates used to estimate productions and attractions were average daily person trips per household. It was necessary to incorporate the option of converting person trips to vehicle trips in the P-A to O-D conversion procedure in TransCAD. The factor for this conversion used in this research was 1.15, which was obtained by dividing the person trip rate, taken from Table 9 of the NCHRP Report 365 (4) as discussion in trip productions, by the corresponding vehicle trip rate.

**Adding Through Trips:** The values for the station-to-station truck and auto trips were obtained from KDOT for the external stations (29). An O-D matrix for the through trips between external stations was prepared and was added to the previously prepared O-D matrix of the internal and external-internal trips. This final O-D matrix was used for traffic assignment as discussed in the next section.

**Traffic Assignment**

The TransCAD workspace for the street network for each detail and the respective O-D matrices were used for running the traffic assignment procedure. The user equilibrium method for traffic assignment (27) was applied through TransCAD and the default values for the parameters alpha and beta in the BPR function for volume-to-capacity analysis were assigned 0.15 and 4.0, respectively, as obtained from NCHRP Report 365 (4).

**Model Evaluation**

**Screenline Analysis:** Screenline analysis was done by comparing the traffic counts for the streets crossed by the railway track passing through the CBD of the city, with the assigned traffic volumes from the model, as shown in Figure 5.1.

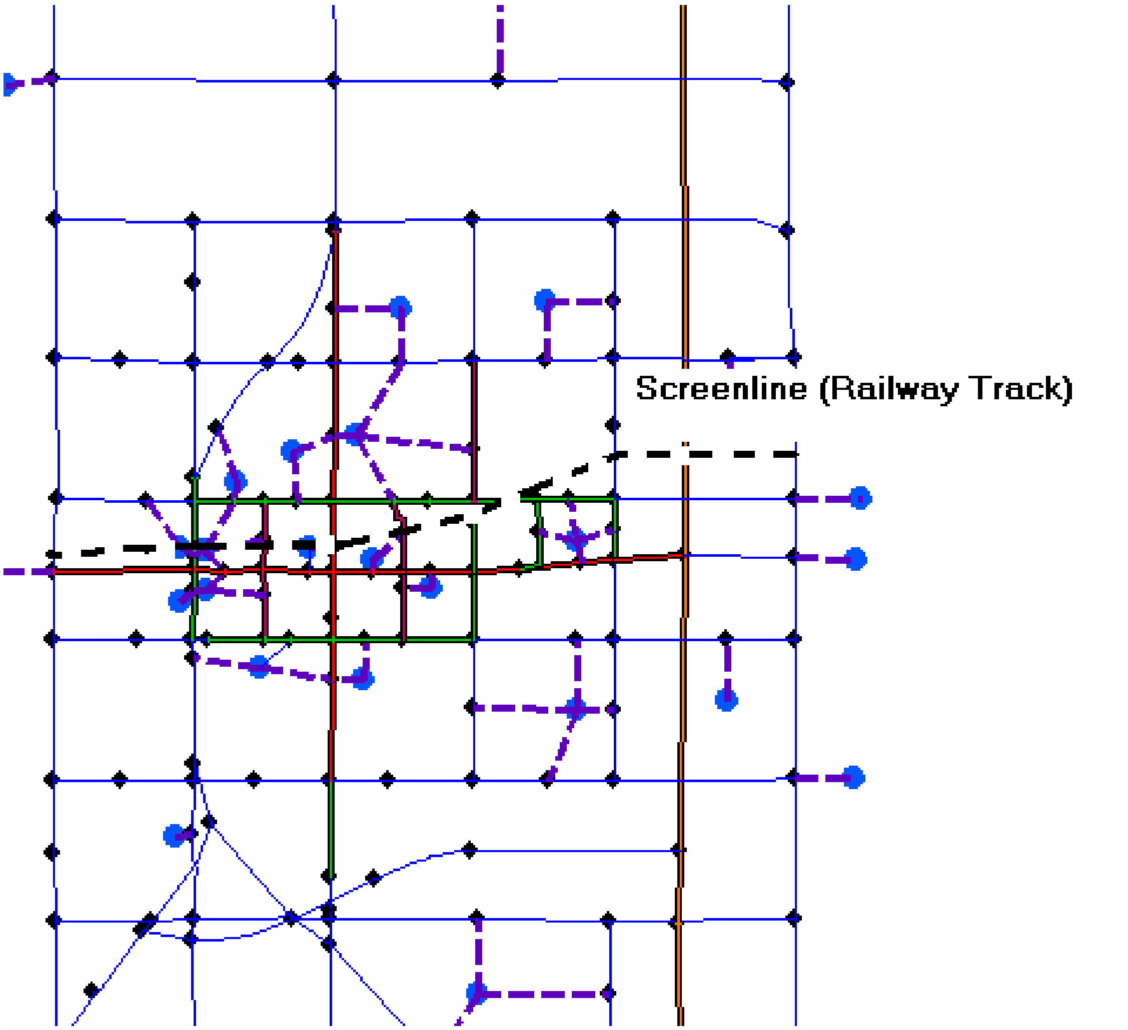



**Figure 5.1 Screenline Used for Model Evaluation**

The streets with volumes considerably higher or lower than the respective traffic count were noted and some modifications were made to the network by adding or removing centroid connectors to those streets from nearby TAZs, to make the trips from the zones more realistic. It was observed that the Old 81 Bypass on the west part of the town had low traffic volumes assigned because the centroids of the adjacent TAZs were closer to the US 56 highway, and thus the trips were loaded via that street. But in reality, there existed a number of employers along the two sides of the bypass, and for them the trips were made via that street. To account for this situation, the respective centroids were located closer to the bypass. Also, it was observed that Hickory street was loaded with high traffic volume because it was connected to an adjacent zone, which in reality had access mainly through Kansas Avenue. The corresponding centroid connector was deleted.

It was observed that the total traffic volume on the streets on the screenline, as assigned by the model, was less than the total traffic count. The trip productions for both levels of detail in TAZs were increased by a factor equal to the ratio of the total volume from traffic counts on the streets on the screenline to the assigned volume, and the models were rerun to assign the increased trips to their respective networks. The results are discussed in Chapter 6.

**Miles and Daily Vehicle Miles of Travel:** The total length of different streets according to their functional classification and corresponding total daily vehicle miles of travel, as obtained from traffic volumes loaded by the model, was compared with the observed data for McPherson which was available from KDOT (28). The daily vehicle miles from the model was estimated by multiplying the length of each link times the associated directional volumes loaded, for each type of street within the study area according to their functional classification,. The results are discussed in Chapter 6.

**Regression Analysis:** Regression analysis was done to estimate the slope of the least square line and the value of R-Square for the data set, using traffic counts as the independent variable and the assigned traffic volumes on the corresponding links as the dependent variables. The intercept of the regression line was forced through zero in the analysis. This was done to avoid non-negative intercepts of the regression line.

# Chapter 6: Results

## Demographic and Socioeconomic Data of TAZs:

The socioeconomic data such as auto-ownership, income and employment, and the demographic data such as total population and households for each TAZ in both levels of detail of the zoning schemes are shown in Tables 6.1 and 6.2.

### Table 6.1 Demographic and Socioeconomic Data for the Low Density Level of Zoning

| Zone No | Pop-ulation | House-holds | Non-Retail Emp | Retail Emp | Service Emp | Income | Autos per HH |
|---|---|---|---|---|---|---|---|
| **1** | 151 | 56 | 27 | 0 | 0 | 29015 | 2.03 |
| **2** | 113 | 45 | 376 | 0 | 0 | 28448 | 2.11 |
| **3** | 47 | 15 | 0 | 0 | 0 | 26430 | 1.64 |
| **4** | 30 | 9 | 0 | 0 | 0 | 26511 | 1.98 |
| **5** | 5 | 1 | 0 | 2 | 17 | 26430 | 1.64 |
| **6** | 770 | 266 | 615 | 8 | 157 | 26430 | 1.64 |
| **7** | 6 | 3 | 105 | 2 | 45 | 26430 | 1.64 |
| **8** | 627 | 218 | 23 | 306 | 67 | 26430 | 1.64 |
| **9** | 262 | 105 | 89 | 28 | 39 | 26430 | 1.64 |
| **10** | 1017 | 450 | 126 | 54 | 39 | 26430 | 1.64 |
| **11** | 1440 | 655 | 84 | 4 | 164 | 23802 | 1.62 |
| **12** | 1392 | 602 | 49 | 654 | 100 | 23802 | 1.62 |
| **13** | 333 | 165 | 205 | 117 | 634 | 23802 | 1.62 |
| **14** | 506 | 214 | 572 | 164 | 142 | 26430 | 1.64 |
| **15** | 2903 | 1237 | 100 | 24 | 650 | 33333 | 1.71 |
| **16** | 1528 | 559 | 441 | 0 | 405 | 33333 | 1.71 |
| **17** | 0 | 0 | 373 | 0 | 0 | 26430 | 1.64 |
| **18** | 90 | 33 | 27 | 0 | 0 | 26430 | 1.64 |
| **19** | 252 | 86 | 5 | 0 | 1 | 33333 | 1.71 |
| **20** | 31 | 6 | 0 | 225 | 0 | 33333 | 1.71 |
| **21** | 1634 | 645 | 719 |  | 219 | 33333 | 1.71 |

## Table 6.2 Demographic and Socioeconomic Data for the High Density Level of Zoning

| Zone No | Pop-ulation | House-holds | Non Retail Emp | Retail Emp | Service Emp | Income | Autos per HH |
|---|---|---|---|---|---|---|---|
| 101 | 227 | 106 | 164 | 490 | 553 | 23802 | 1.62 |
| 111 | 232 | 91 | 22 | 0 | 18 | 23802 | 1.62 |
| 112 | 106 | 59 | 41 | 172 | 81 | 23802 | 1.62 |
| 113 | 44 | 26 | 17 | 5 | 8 | 23802 | 1.62 |
| 121 | 369 | 161 | 6 | 0 | 7 | 33333 | 1.71 |
| 122 | 270 | 122 | 14 | 0 | 42 | 33333 | 1.71 |
| 123 | 151 | 69 | 35 | 0 | 3 | 26430 | 1.98 |
| 124 | 191 | 84 | 0 | 0 | 25 | 26430 | 1.98 |
| 125 | 110 | 39 | 0 | 0 | 3 | 26430 | 1.98 |
| 126 | 83 | 29 | 0 | 0 | 16 | 26430 | 1.98 |
| 127 | 132 | 54 | 0 | 0 | 0 | 26430 | 1.98 |
| 128 | 86 | 44 | 0 | 0 | 4 | 26430 | 1.98 |
| 131 | 0 | 0 | 0 | 0 | 0 | 26430 | 1.98 |
| 132 | 235 | 120 | 3 | 25 | 13 | 26430 | 1.98 |
| 133 | 827 | 373 | 0 | 12 | 141 | 26430 | 1.98 |
| 134 | 378 | 162 | 81 | 17 | 10 | 23802 | 1.62 |
| 141 | 463 | 183 | 52 | 3 | 16 | 23802 | 1.62 |
| 211 | 149 | 68 | 71 | 109 | 92 | 26430 | 1.98 |
| 212 | 81 | 29 | 462 | 3 | 28 | 26430 | 1.98 |
| 213 | 0 | 0 | 623 | 0 | 0 | 26430 | 1.98 |
| 214 | 1329 | 511 | 191 | 24 | 349 | 33333 | 1.71 |
| 215 | 199 | 48 | 0 | 0 | 50 | 33333 | 1.71 |
| 216 | 252 | 86 | 5 | 0 | 1 | 33333 | 1.71 |
| 217 | 240 | 58 | 0 | 0 | 131 | 33333 | 1.71 |
| 218 | 1300 | 500 | 0 | 149 | 54 | 33333 | 1.71 |
| 219 | 876 | 389 | 3 | 0 | 455 | 33333 | 1.71 |
| 220 | 487 | 290 | 97 | 7 | 12 | 33333 | 1.71 |
| 221 | 31 | 6 | 0 | 0 | 0 | 33333 | 1.71 |
| 222 | 956 | 379 | 80 | 13 | 145 | 26430 | 1.98 |
| 223 | 1 | 1 | 80 | 0 | 0 | 26430 | 1.98 |
| 225 | 8 | 2 | 0 | 0 | 0 | 33333 | 1.71 |
| 226 | 17 | 4 | 0 | 0 | 0 | 33333 | 1.71 |
| 227 | 2 | 1 | 0 | 80 | 0 | 26430 | 1.98 |
| 228 | 2 | 1 | 0 | 125 | 68 | 26430 | 1.98 |
| 229 | 647 | 256 | 61 | 7 | 6 | 26430 | 1.98 |
| 230 | 0 | 0 | 498 | 0 | 0 | 33333 | 1.71 |
| 231 | 0 | 0 | 60 | 9 | 4 | 26430 | 1.98 |
| 232 | 2 | 1 | 10 | 266 | 21 | 26430 | 1.98 |
| 233 | 2 | 1 | 15 | 31 | 14 | 26430 | 1.98 |
| 234 | 4 | 3 | 0 | 0 | 0 | 26430 | 1.98 |
| 235 | 221 | 90 | 4 | 0 | 0 | 26430 | 1.98 |
| 236 | 33 | 10 | 0 | 0 | 0 | 26430 | 1.98 |
| 237 | 4 | 3 | 0 | 0 | 6 | 26430 | 1.98 |
| 238 | 623 | 215 | 23 | 2 | 61 | 26430 | 1.98 |
| 242 | 472 | 230 | 59 | 25 | 23 | 26430 | 1.98 |
| 243 | 731 | 248 | 2 | 2 | 157 | 26430 | 1.98 |
| 244 | 0 | 0 | 432 | 0 | 0 | 26430 | 1.98 |
| 245 | 39 | 18 | 256 | 0 | 0 | 26430 | 1.98 |
| 246 | 0 | 0 | 0 | 0 | 0 | 26430 | 1.98 |
| 311 | 34 | 12 | 0 | 0 | 0 | 26430 | 1.98 |
| 312 | 28 | 8 | 0 | 0 | 0 | 26430 | 1.98 |
| 313 | 28 | 11 | 27 | 0 | 0 | 33333 | 1.71 |
| 314 | 21 | 10 | 0 | 0 | 0 | 29015 | 2.03 |
| 315 | 130 | 46 | 0 | 0 | 0 | 29015 | 2.03 |
| 321 | 113 | 45 | 376 | 0 | 0 | 28448 | 2.10 |
| 323 | 0 | 0 | 0 | 0 | 0 | 26430 | 1.98 |
| 331 | 47 | 15 | 0 | 0 | 0 | 28448 | 2.10 |
| 332 | 25 | 8 | 0 | 0 | 0 | 26511 | 1.98 |
| 341 | 5 | 1 | 0 | 0 | 0 | 26511 | 1.98 |
| 342 | 0 | 0 | 0 | 0 | 0 | 26430 | 1.98 |
| 343 | 5 | 1 | 0 | 0 | 17 | 26430 | 1.98 |
| 344 | 6 | 3 | 5 | 8 | 45 | 26430 | 1.98 |

## **Speed and Capacity of Streets**

The links of the street network were represented by different widths and colors according to their directional speed and capacities. This was done to check for any missing or improper value of speed or capacities of the links. Figures 6.1 and 6.2 show the scaled representation of links according to speed and capacity, respectively, for the low-density level of TAZ. The centroid connectors are not shown in the figures; only the major streets of the network are shown.

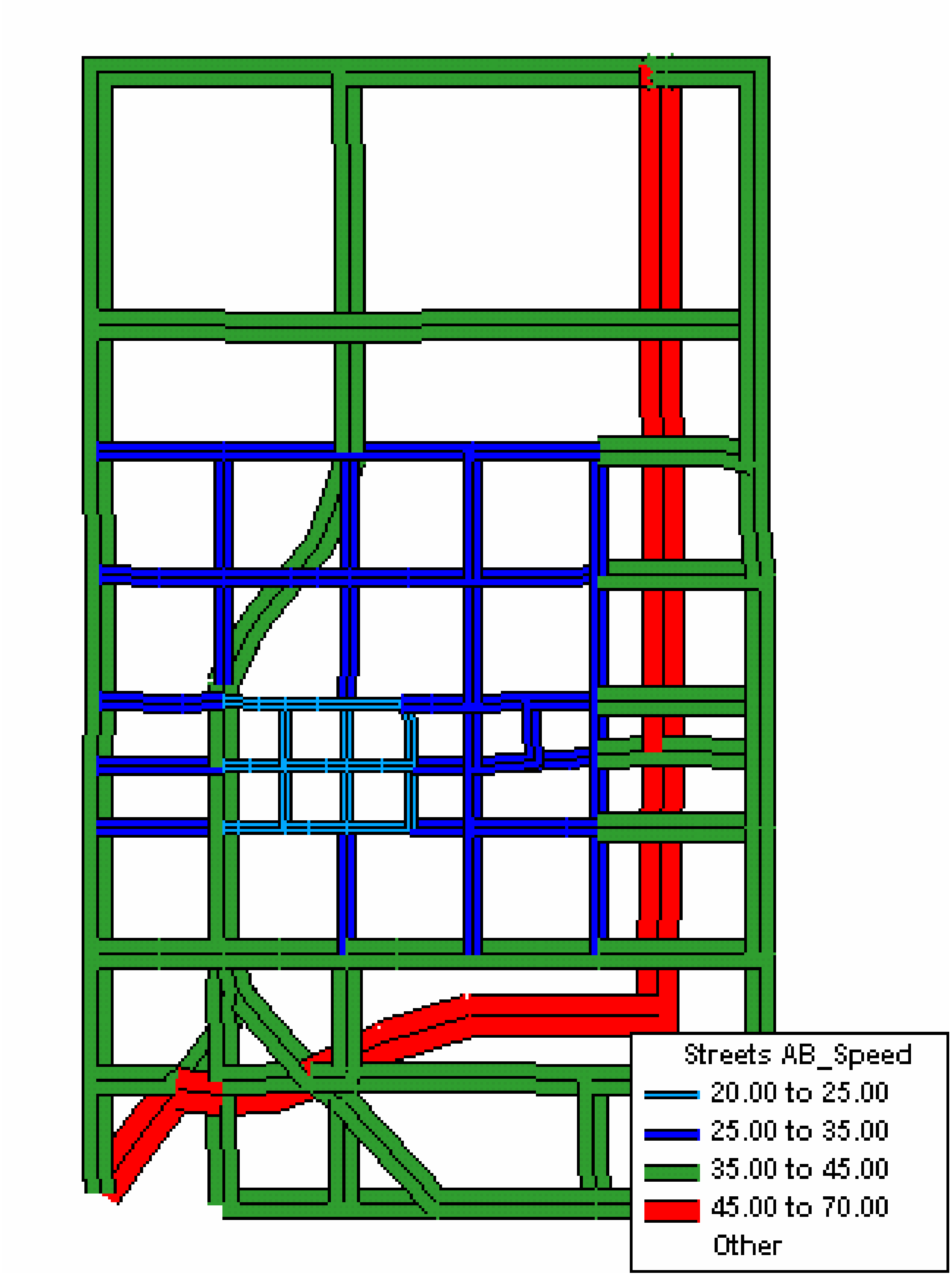



**Figure 6.1 Scaled Representation of Links According to Directional Speed**

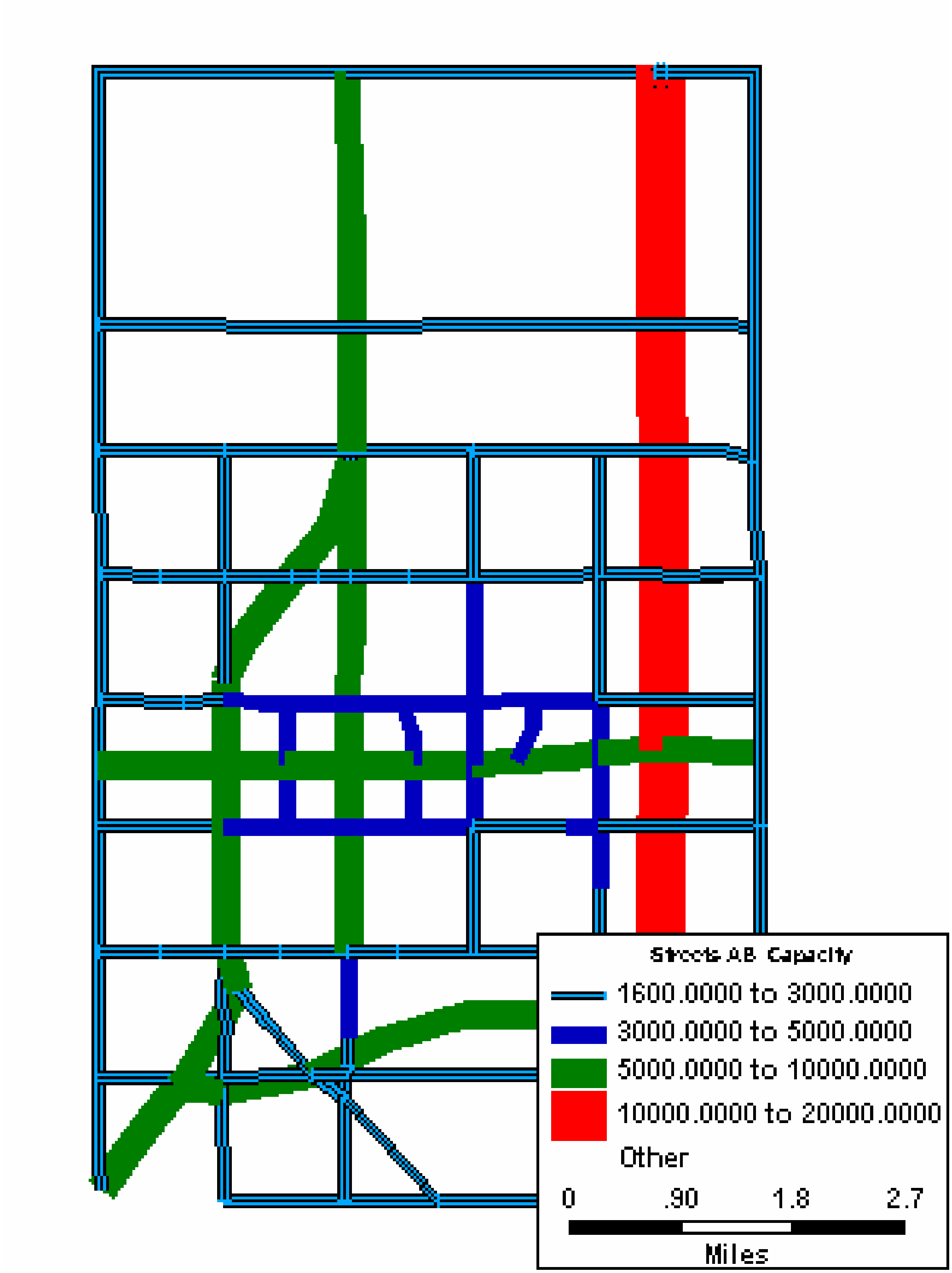



**Figure 6.2 Scaled Representation of Links According to Directional Capacity**

## Screenline Analysis

Table 6.3 and Figure 6.3 present the screenline analysis results by comparing the assigned traffic volumes from the travel demand models for low and high density TAZs with the observed traffic counts on the streets at the screenline. As mentioned in Chapter 5, the trip productions were increased by a factor equal to the ratio of the total observed traffic count on the streets at the screenline to the total traffic volume assigned by the respective models for low and high density networks of TAZs. Table 6.4 and Figure 6.4 present the screenline analysis results after the trip productions were increased.

**Table 6.3 Screenline Analysis for Assigned Traffic Volumes from Original TAZ Data**

| Street Name | Observed Count | Assigned Volume by Model | |
|---|---|---|---|
| | | Low Density Level | High Density Level |
| 12th Avenue | --- | 100 | 580 |
| US 81 Bypass | 5,500 | 2,540 | 2,900 |
| Hickory | 1,000 | 475 | 1,950 |
| Main | 8,500 | 7,780 | 6,950 |
| Hartup | 2,100 | 2,380 | 1,400 |
| Maxwell | 1,300 | 1,100 | 1,600 |
| 1st Street | 7,500 | 7,000 | 6,000 |
| Centennial | 2,000 | 650 | 1,700 |
| I 135 | 11,000 | 11,475 | 10,900 |
| 17th Avenue | --- | 390 | 550 |
| Total | 38,900 | 33,885 | 34,530 |

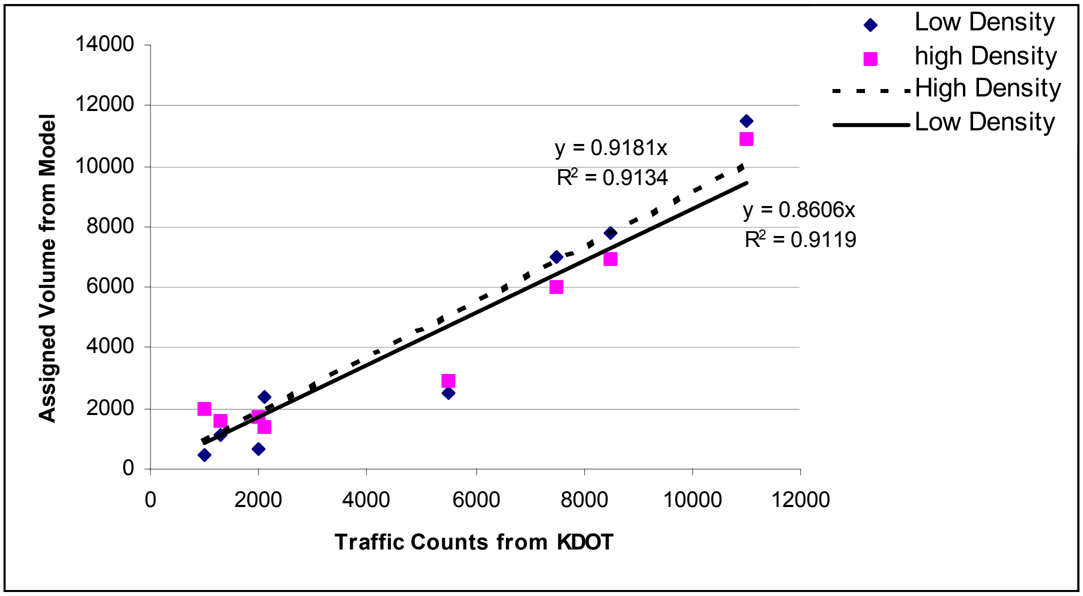



**Figure 6.3 Plot of Assigned Traffic Volumes vs. Traffic Counts on Streets on the Screenline and the Respective Regression Lines**

**Table 6.4 Screenline Analysis Results after Increasing Trip Productions**

| Street Name | Observed Count | Assigned Volume by Model | |
|---|---|---|---|
| | | Low Density Level | High Density Level |
| 12th Avenue | --- | 100 | 580 |
| US 81 Bypass | 5,500 | 2,800 | 3,500 |
| Hickory | 1,000 | 525 | 2,150 |
| Main | 8,500 | 8,700 | 7,800 |
| Hartup | 2,100 | 2,700 | 1,550 |
| Maxwell | 1,300 | 1,320 | 1,725 |
| 1st Street | 7,500 | 7,600 | 6,300 |
| Centennial | 2,000 | 725 | 1,850 |
| I 135 | 11,000 | 11,500 | 10,900 |
| 17th Avenue | --- | 400 | 550 |
| Total | 38,900 | 36,370 | 36,905 |

*** Trip Productions Increased by a Factor 1.15**
**** Trip Productions Increased by a Factor 1.13**

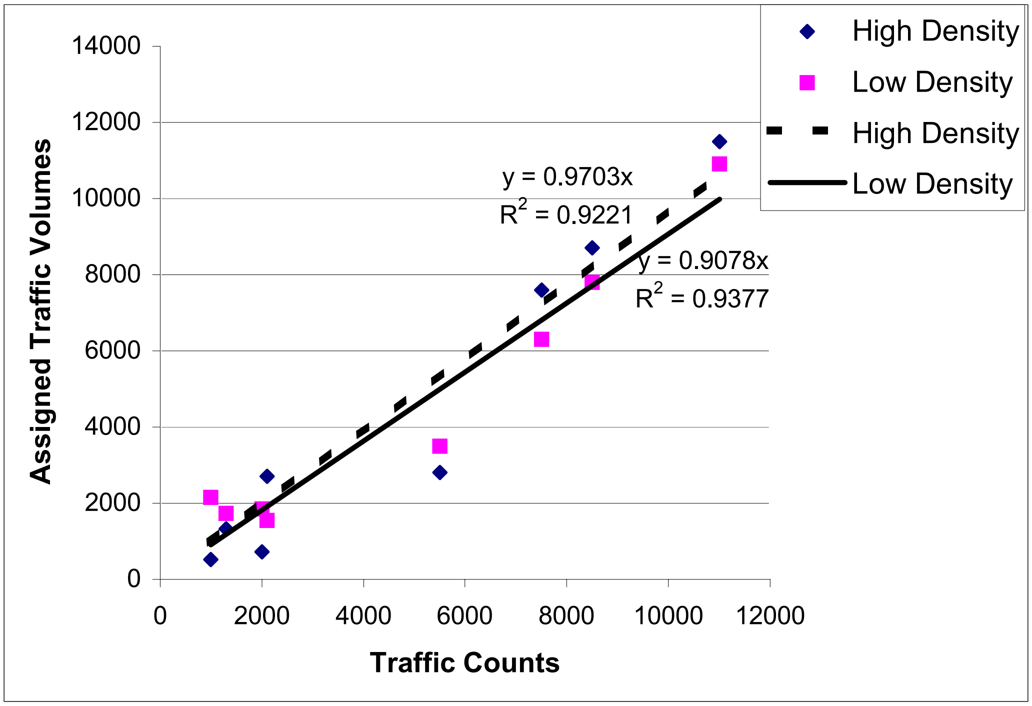



**Figure 6.4 Plot of Assigned Traffic Volumes vs. Traffic Counts on Streets on the Screenline and the Respective Regression Lines for Increased Trip Productions**

## Total Miles and Vehicle Miles of Travel

Table 6.5 presents the total length of streets classified according to functional street classification, for both levels of detail of TAZs.

**Table 6.5 Total Length of Streets According to Functional Classification**

| Link Type | Classification | Length (miles) | | |
|---|---|---|---|---|
| | | From KDOT(28) | High Density Level | Low Density Level |
| 1 | Major Arterial | 7.75 | 7.71 | 7.44 |
| 2 | Minor Arterial | 11.16 | 10.21 | 8.02 |
| 3 | Collector | 10.00 | 6.87 | 4.45 |

Table 6.6 presents the values of average daily vehicle miles of travel (ADVMT) within the study area as estimated from traffic volumes loaded on the streets by the model and is compared with the values obtained from KDOT (28). Also, the corresponding values obtained after increasing trip productions are shown.

**Table 6.6 Average Daily Vehicle Miles of Travel**

| Link Type | Functional Classification of Streets | Average Daily Vehicle Miles of Travel | | | | |
|---|---|---|---|---|---|---|
| | | Counts (28) | Low Density Level Production Factors | | High Density Level Production Factors | |
| | | | NCHRP (365) | Factored by 1.15 | NCHRP (365) | Factored by 1.13 |
| 1 | Major Arterial | 47,012 | 40,800 | 42,100 | 41,250 | 44,900 |
| 2 | Minor Arterial | 45,189 | 24,700 | 26,900 | 28,950 | 31,000 |
| 3 | Collector Road | 27,302 | 2,975 | 3,385 | 6,100 | 6,800 |

For those links with traffic counts Table 6.7 and 6.8 present the values of average daily vehicle miles of travel for streets of different functional classification estimated from traffic counts and compares them with the values estimated from traffic volumes loaded by the travel demand model.

**Table 6.7 Average Daily Vehicle Miles of Travel For Links With Traffic Counts for Low Density Level of Zoning**

| Link Type | Functional Classification | Average Daily Vehicle Miles of Travel | | |
|---|---|---|---|---|
| | | Counts (28) | From Traffic Volume Assigned by Model | |
| | | | NCHRP (365) | Factored 1.15 |
| 1 | Major Arterial | 40,000 | 31,150 | 31,500 |
| 2 | Minor Arterial | 31,500 | 20,700 | 23,750 |
| 3 | Collector Road | 7,186 | 3,295 | 3,385 |

**Table 6.8 Average Daily Vehicle Miles of Travel For Links With Traffic Counts for High Density Level of Zoning**

| Link Type | Functional Classification | Average Daily Vehicle Miles of Travel | | |
|---|---|---|---|---|
| | | Counts (28) | From Traffic Volume Assigned by Model | |
| | | | NCHRP (365) | Factored 1.13 |
| 1 | Major Arterial | 40,000 | 30,000 | 32,500 |
| 2 | Minor Arterial | 31,484 | 25,350 | 27,900 |
| 3 | Collector Road | 8,693 | 6,100 | 5,500 |

## Regression Analysis

Regression analysis was performed to estimate the slope of the least square line with traffic counts on the links as the independent variable and the corresponding traffic volumes assigned by the model as the dependent variable. The intercept of the regression line was forced to pass through the origin in the analysis. The results of SAS regression analysis are shown in Tables 6.9 and 6.10. Figures 6.5 shows the plot of assigned traffic volumes vs. observed traffic counts and the regression line for the two levels of zoning.

**Table 6.9 Linear Regression Analysis for Low Density Level of Zoning**

Model: MODEL1
NOTE: No intercept in model. R-square is redefined.
Dependent Variable: OBS_VOL

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Value | Prob>F |
|---|---|---|---|---|---|
| Model | 1 | 1272189702.3 | 1272189702.3 | 551.125 | 0.0001 |
| Error | 84 | 193901332.87 | 2308349.2009 | | |
| U Total | 85 | 1466091035.2 | | | |

| | | | |
|---|---|---|---|
| Root MSE | 1519.32525 | **R-square** | **0.8677** |
| Dep Mean | 2932.89694 | **Adj R-sq** | **0.8662** |
| C.V. | 51.80289 | | |

**Parameter Estimates**

| Variable | DF | **Parameter Estimate** | Standard Error | T for H0: Parameter=0 | Prob > \|T\| |
|---|---|---|---|---|---|
| TC | 1 | **0.734084** | 0.03126946 | 23.476 | 0.0001 |

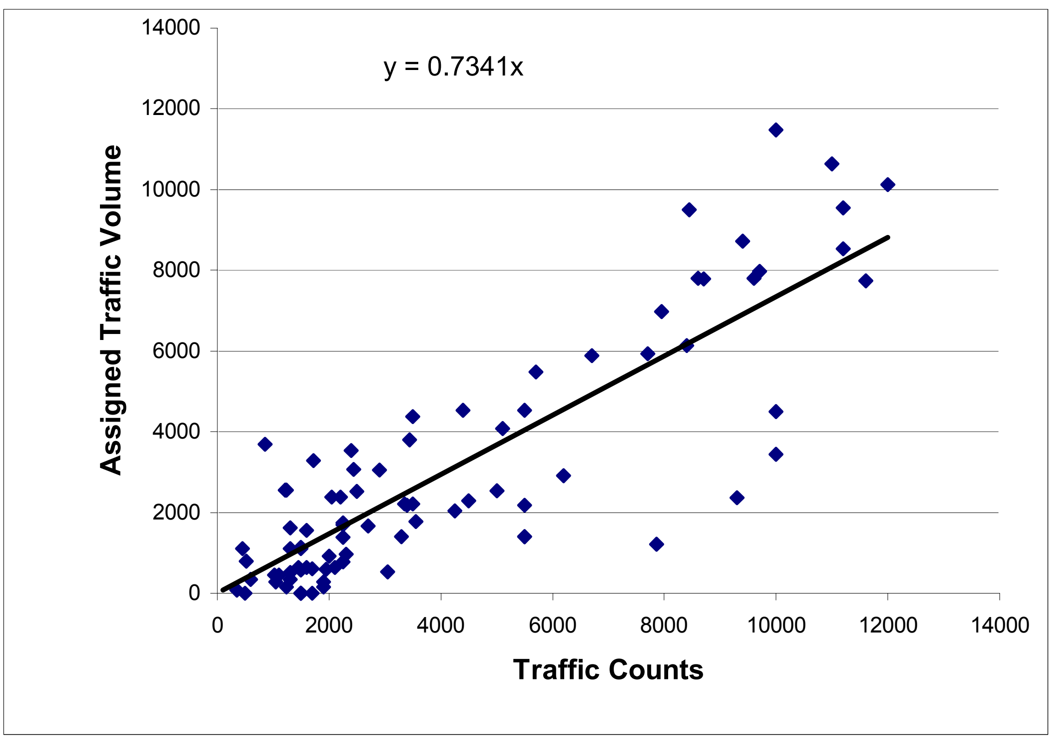



**Figure 6.5 Plot of Assigned Traffic Volume vs. Traffic Counts and Regression Line for Low Density Level of Zoning**

**Table 6.10 Linear Regression Analysis for High Density Level of Zoning**

Model: MODEL1
NOTE: No intercept in model. R-square is redefined.
Dependent Variable: OBS_VOL

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Value | Prob>F |
|---|---|---|---|---|---|
| Model | 1 | 1434458694.8 | 1434458694.8 | 813.746 | 0.0001 |
| Error | 105 | 185092266.23 | 1762783.4879 | | |
| U Total | 106 | 1619550961.1 | | | |

| | | | |
|---|---|---|---|
| Root MSE | 1327.69857 | **R-square** | **0.8857** |
| Dep Mean | 2848.83491 | **Adj R-sq** | **0.8846** |
| C.V. | 46.60497 | | |

**Parameter Estimates**

| Variable | DF | **Parameter Estimate** | Standard Error | T for H0: Parameter=0 | Prob > \|T\| |
|---|---|---|---|---|---|
| TC | 1 | **0.734007** | 0.02573093 | 28.526 | 0.0001 |

Table 6.5 below shows the plot of assigned traffic volumes vs. observed traffic counts and the regression line.

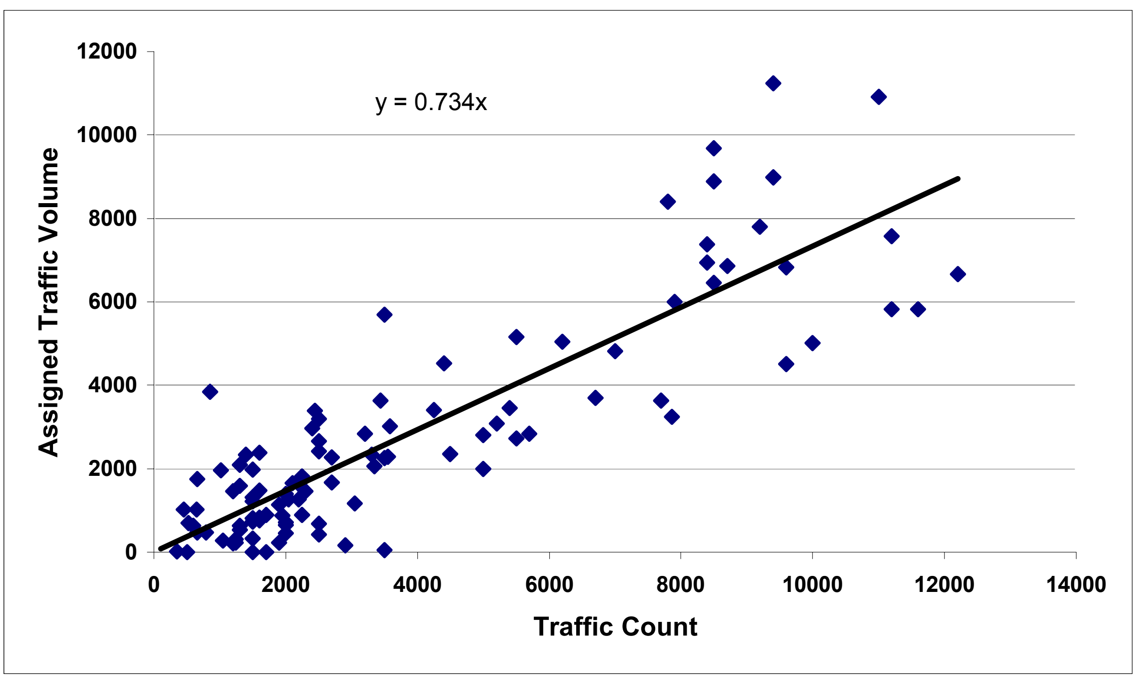



**Figure 6.6 Plot of Assigned Traffic Volume vs. Traffic Counts and Regression Line for High Density Level of Zoning**

## Proposed North Bypass

Figure 6.11 presents the traffic volumes assigned to the proposed north bypass on each section between intersection with other streets.

**Table 6.11 Comparison of Traffic Assignments on the North Bypass**

| Section | Assigned Traffic Volumes | |
|---|---|---|
| | Low Density Level | High Density Level |
| Old US 81 - Maxwell Street | 1,000 | 930 |
| Maxwell Street - Centennial Drive | 905 | 960 |
| Centennial Drive - I-135 | 1,670 | 1,015 |

# Chapter 7: Use of QRSII in Modeling Small Urban Area Travel

The intent of this research was to perform almost identical steps with both models, TransCAD and QRSII, to compare the staff time necessary to perform the same functions as well as the results. However, this soon proved to be unproductive because it became obvious that there was no value in making the same mistakes with both models. The research staff learned from the effort of the one that was ahead or run first at any given step. Two examples of the learning process were the need to eliminate some of the classified streets from the networks because of the zone size, and the tying of the zone centroids to the network to improve loading.

The objective was then revised to allow each model to be used with default parameters, where available, and supplement them with readily available published data. Trip generation data were used for TransCad and the default parameters were used with QRSII. Although the original source was the same, the models occasionally used different ranges to look up the appropriate function. The researcher did not try to reconcile the differences in these functions.

The zonal summaries of population and socioeconomic data were prepared using the GIS platform provided by TransCAD and Maptitude.

## Network Development

As mentioned in Chapter 2, the GNE version 6.0 was used for developing the networks for further modeling using QRSII. Recent versions of GNE allow a bitmap overlay or underlay of the street system and zone boundaries so that the assignment network can be easily built to scale. Although not required, every link of the network was given a unique name so that the network could be extracted into a text file that could be opened in a spreadsheet for ease of data entry of the network attributes. The network could then be updated with the desired network attributes such as speed, capacity and functional classification. The alternative would have been to enter every element of the attributes of the network interactively through GNE. In addition to the two basic levels of detail, three configurations were developed in QRSII for each level. They were:

- A network representing the present street system,
- A network with a North Bypass connecting to I-135 in an undeveloped corridor,
- A network with an internal CBD Bypass in a developed corridor.

Only the first two were develop for TransCAD. While the North Bypass is a part of the city's Comprehensive Plan, the CBD Bypass is purely a fictitious route, serving only to test the models developed in this research. Figure 7.1 shows the location of the CBD Bypass on the street network within the city.

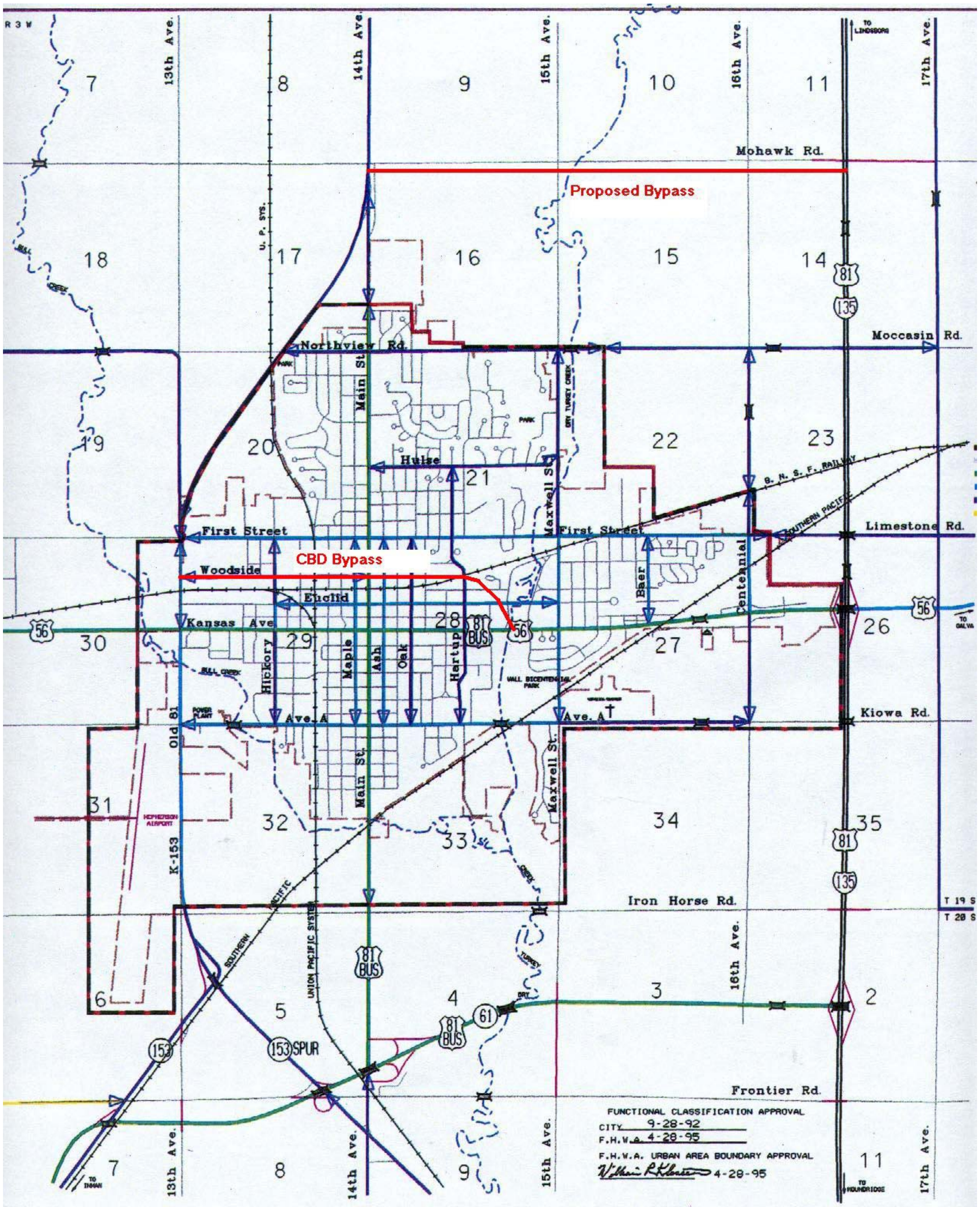



**Figure 7.1 Street Network with CBD Bypass**

## Results

Figures 7.2 and 7.3 show the bandwidth plots of the present network loaded with traffic volumes assigned by the models for the two levels of detail.

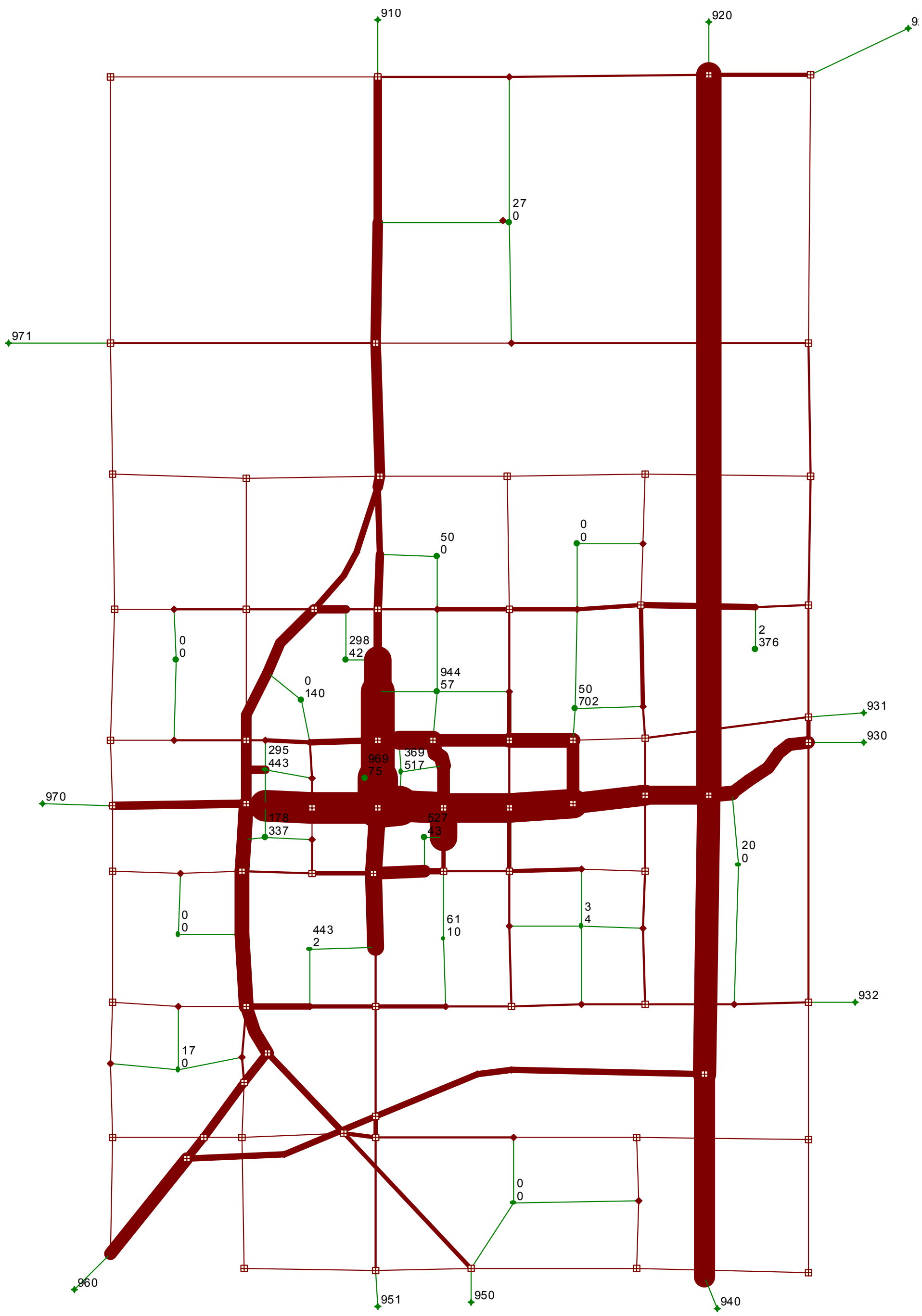



**Figure 7.2 Existing Network with Traffic Volumes for the Low Density Network**

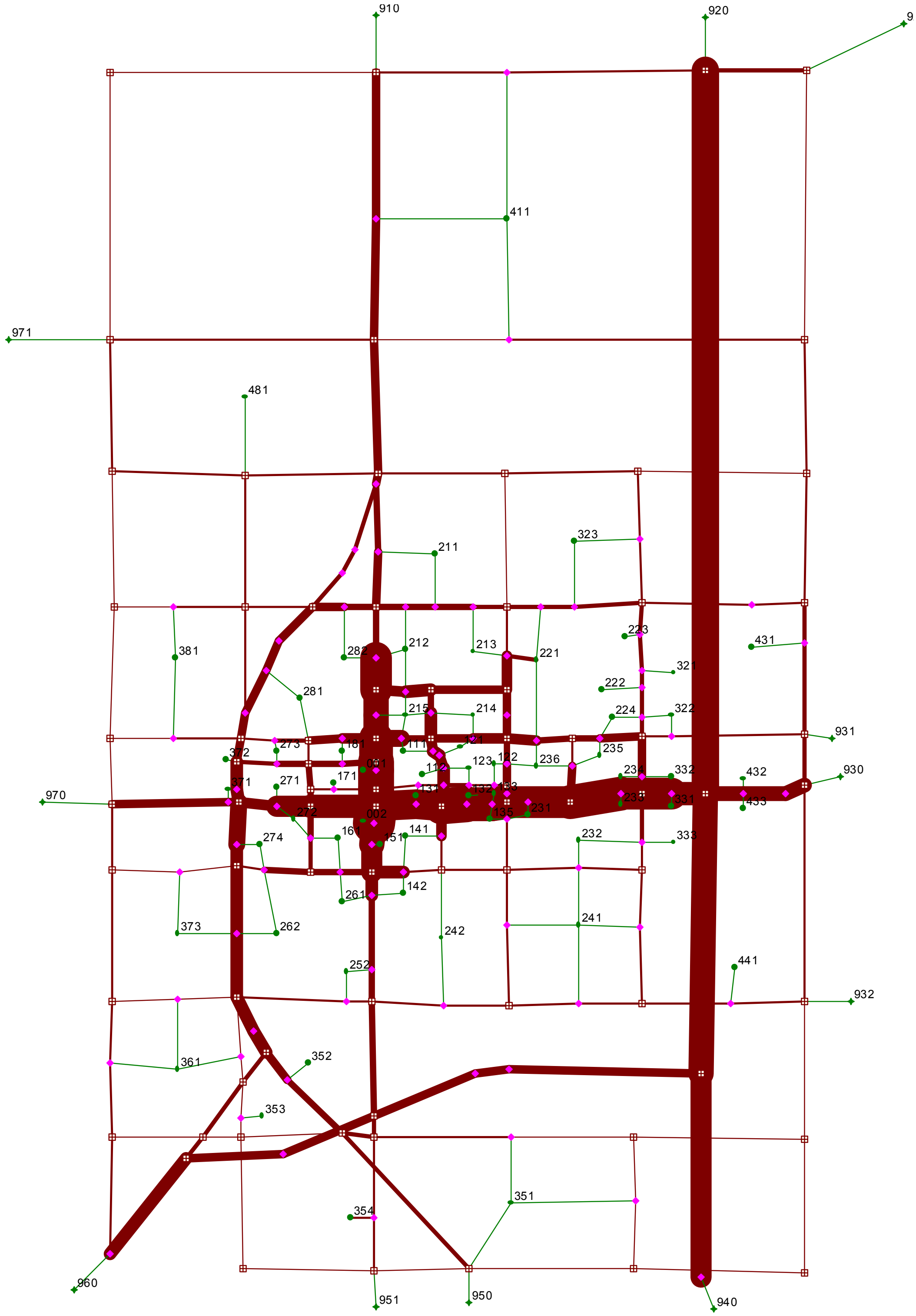



**Figure 7.3 Existing Street Network with Traffic Volumes for the High Density Network**

Figures 7.4and 7.5 show the bandwidth plot of the street network, with North Bypass included, loaded with assigned traffic volumes.

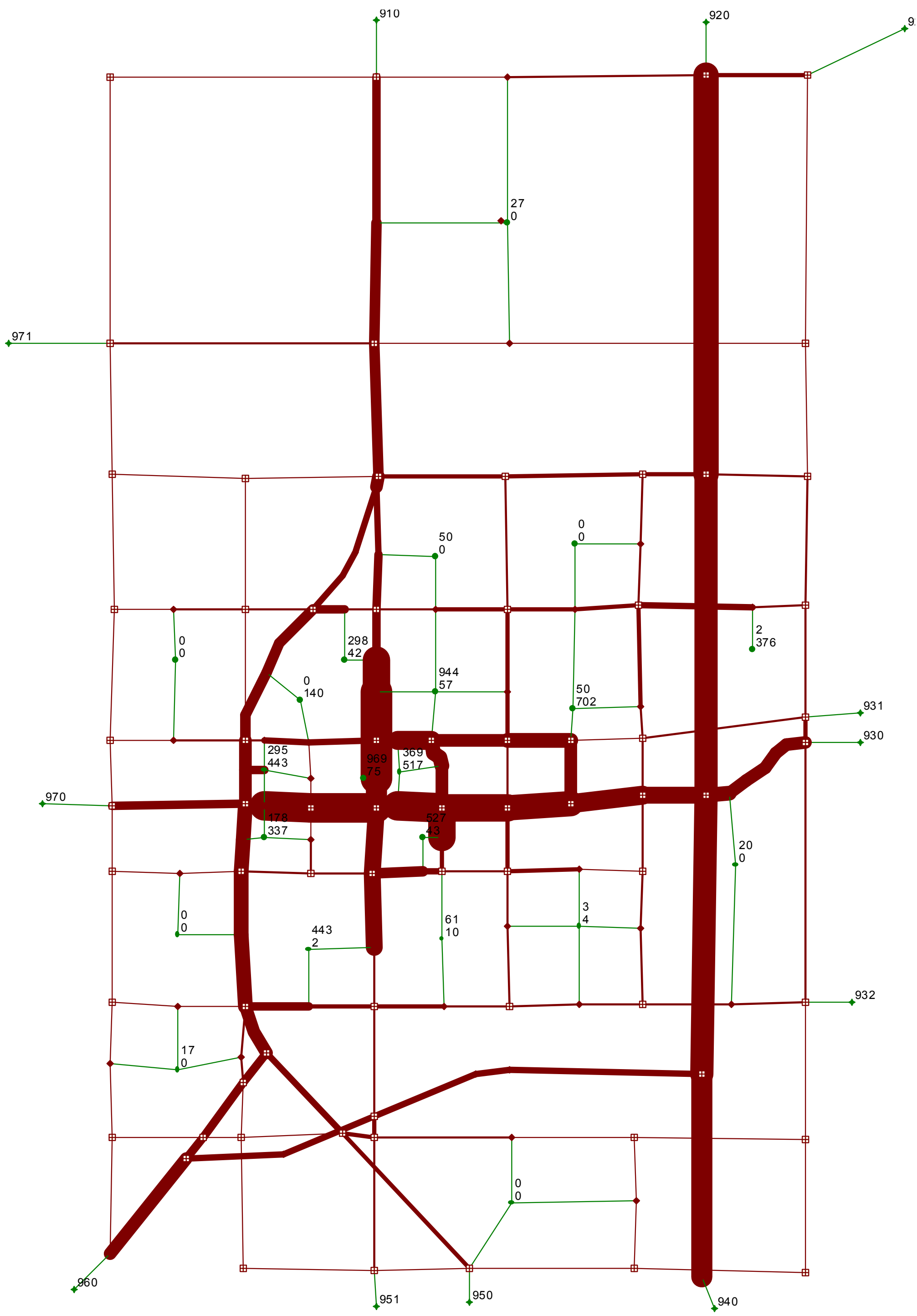


**Figure 7.4 Low Density Network with North Bypass Included**

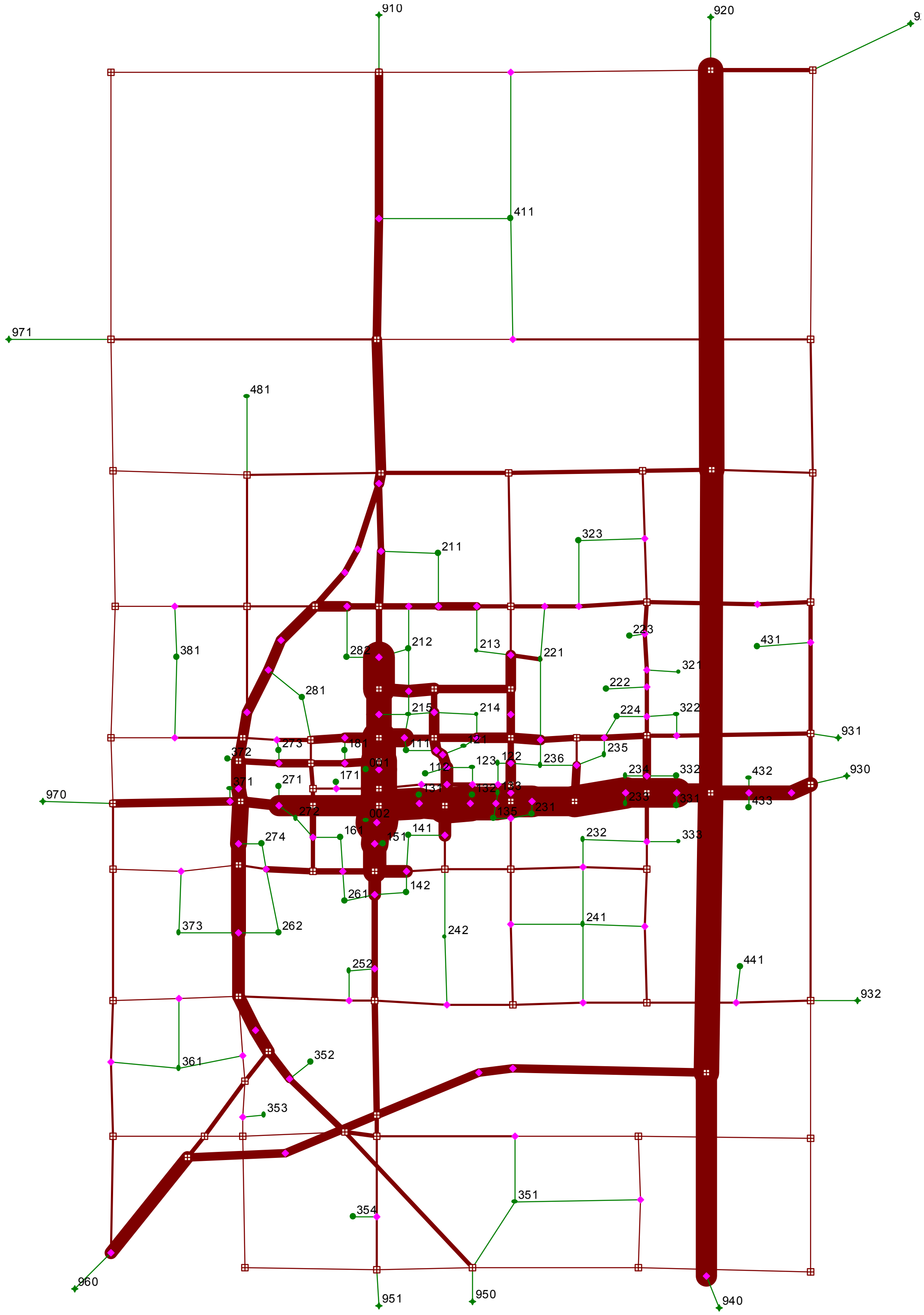


**Figure 7.5 High Density Network with North Bypass Included**

The assigned traffic on the North Bypass displayed insignificant differences between the two levels of detail. Table 7.1 shows the loaded traffic volumes on the North Bypass between intersections with other streets.

**Table 7.1 Comparison of Traffic Assigned to North Bypass For Low and High Levels**

| Section | Assigned Traffic Volumes by Model (vpd) | |
|---|---|---|
| | **Low Density** | **High Density** |
| Old US81 - Maxwell Street | 1194 | 1720 |
| Maxwell Street - Centennial Drive | 1710 | 1890 |
| Centennial Drive - I-135 | 915 | 1875 |

Figures 7.6 and 7.7 show the bandwidth plot of the street network, with CBD Bypass included, for both levels of detail.

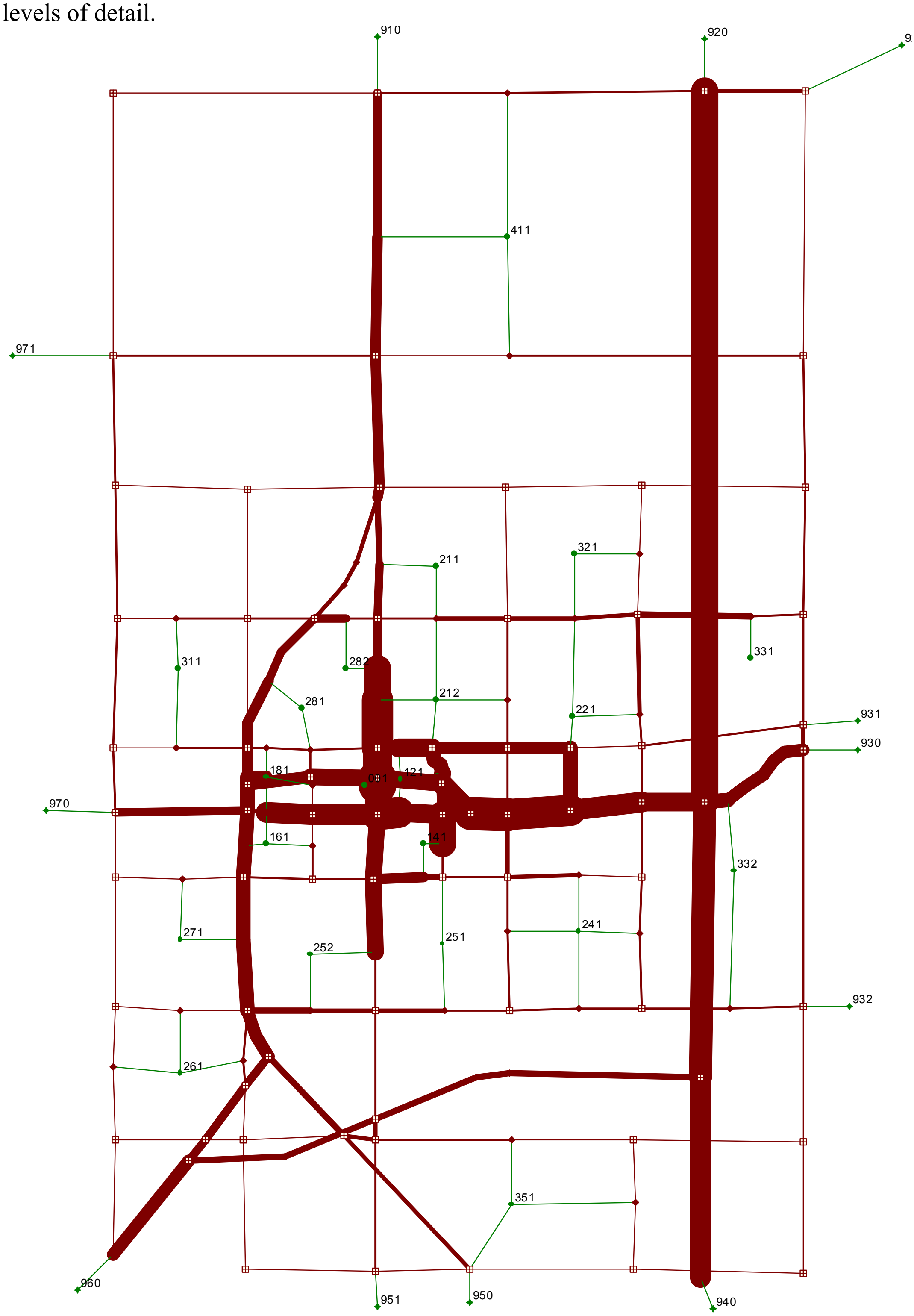



**Figure 7.6 Low Density Network with CDB Bypass Included**

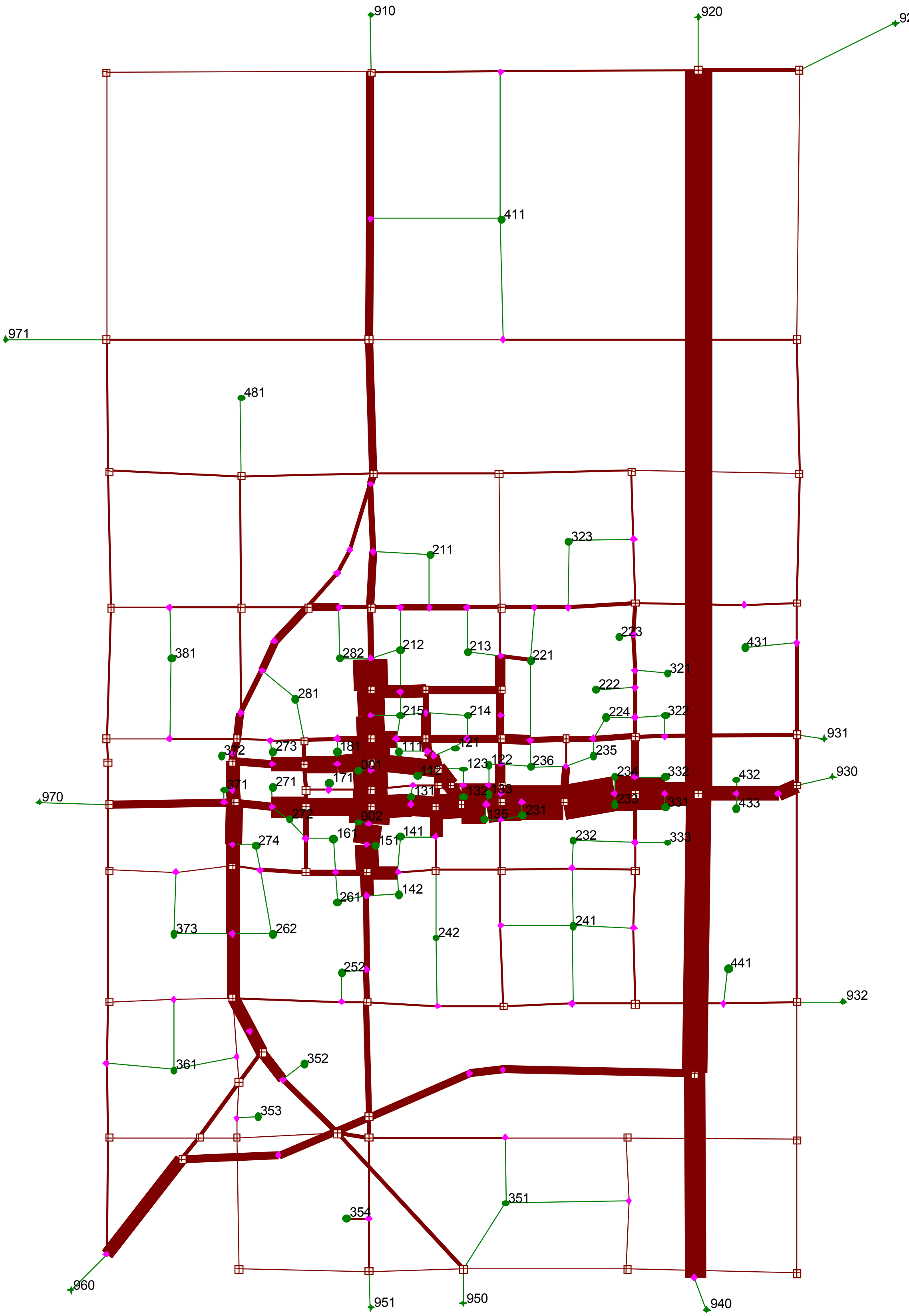



**Figure 7.7 High Density Network with CDB Bypass Included**

**Screenline Analysis:**

Table 7.2 presents the screenline analysis results obtained from the QRSII models. There are no loads on Maple, Ash, and Oak because they are not on either the low density zone network or the high density zone network. Also, it should be noted that the cells in the CBD Bypass row only include values for assignments that included the bypass. The sum of traffic volumes assigned across the screen line on the current and North Bypass on both the low and high-density networks are close to the count taken along the screen line. This would indicate that the default trip generation equations and the friction factors for the distribution model produced reasonable results. Although a specific analysis was not made for the two CDB Bypass assignments, one would expect that there would be a considerable number of trips crossing the screen line multiple times. This would explain their sum being greater than other assignments and the counts.

**Table 7.2 Screenline Analysis for the QRSII Models**

| | | ***Low Density Network*** | | | ***High Density Network*** | | |
|---|---|---|---|---|---|---|---|
| ***Location*** | **Traffic Count** | **Present Network** | **North Bypass** | **CBD Bypass** | **Present Network** | **North Bypass** | **CBD Bypass** |
| **12th Ave** | | 4 | 3 | 47 | 8 | 3 | 57 |
| **US81 Bypass** | 5500 | 4048 | 5959 | 6398 | 5266 | 6891 | 6585 |
| **Hickock** | 1000 | 26 | 9 | 1902 | 2052 | 1774 | 1407 |
| **Maple** | 4405 | | | | | | |
| **Main** | 8500 | 19360 | 14109 | 17606 | 16643 | 16504 | 17130 |
| **Ash** | 2885 | | | | | | |
| **Oak** | 2010 | | | | | | |
| **Hartup** | 2100 | 5720 | 6340 | 4229 | 4995 | 4958 | 2170 |
| **CBD Bypass** | | | | 9244 | | | 7824 |
| **Maxwell** | 1300 | 20 | 19 | 20 | 2424 | 2477 | 1501 |
| **First St (E-W)** | 7500 | 5016 | 6650 | 5826 | 2442 | 2552 | 2349 |
| **Centennial** | 2000 | 444 | 484 | 704 | 1757 | 1931 | 1982 |
| **I-135** | 9300 | 11949 | 10790 | 12085 | 12297 | 10980 | 12322 |
| **17th Ave** | 1600 | 142 | 109 | 141 | 1663 | 1845 | 1930 |
| | | | | | | | |
| **Total** | 48100 | 46729 | 44472 | 58202 | 49547 | 49915 | 55257 |

# Chapter 8: Discussion and Conclusions

## Discussion

1. There are three important questions to ask when beginning a small urban area study.

   - How much data are available?
   - How old is it?
   - What is the problem (or project) that needs to be addressed

   Usually, there is not a lot of data available for small urban areas. An external O-D is important because the external local and through traffic is a greater part of the traffic stream than it is in a large urbanized area. A small urban area is less likely to have a planning department that is equipped to provide support in data collection. One must look to secondary sources such as the Census and to private firms that sell data. This is the most likely source of employment data. Hopefully, the public works departments and the state transportation agency will have a good inventory of the streets and highways to use in coding the network. Aerial photos are invaluable in understanding the makeup of the urban area.

   The next question is to determine what will be needed to bring the data up-to-date. How much effort will be needed to get the data all on a common base will depend on how much change has occurred since the data were collected. It will require a great deal of good judgment to determine the soundness of the data and the best methods for updating, if that is necessary.

   More than anything else, the nature of the problem will determine the scope of the study. If the urban area is preparing a comprehensive plan with a transportation component, then a great deal more data and analysis will be required. This research has shown that very little internal analysis is necessary to study the feasibility of a bypass. However, a bypass study will require much more complete and up-to-date data about through and local travel that would be obtained from external O-D surveys or from area-wide transportation models.

2. Transportation Planning Professionals are fortunate to have so much data available at the block level through the Bureau of the Census. However, since this research is being done in a census year, it points out the problem with using Census data. The 1990 Census data are ten years old and the new data is not expected to be available for several years. If an area is experiencing growth and that growth is what needs to be addressed, then alternative sources of data may be required. Earlier work done by one of the authors (30) showed that one could successfully use dwelling units to estimate productions and parking stalls to estimate attractions. Sufficient traffic counts have to be available to adequately calibrate the models.

3. It was discovered during the assignment of employment to blocks that many of the blocks in the “Streets 97” file did not contain address ranges. This caused the TransCad and Maptitude to assign the location to the midpoint of the endpoints of the named street. This may be a problem that was unique to McPherson, but it may be common to small cities that do not have the planning staff that has the capability to work with the Bureau of the Census to adequately review

the Tiger file data. One should select the blocks with and without address range information and plot them in different colors to visually check for missing data

4. One should be very careful in updating old external OD data to the study year. For example, if two opposite stations having a large movement between them are growing, it does not mean that through movement between them is growing. Both stations may be experiencing large growth because of commuting local traffic because of development adjacent to the urban area. Applying a growth factor, such as Fratar, to the station-to-station trips will produce erroneous results. The through traffic growth is completely independent to that of the urban area. It is advisable to examine the corridor growth of the route some distance from the urban area to determine the actual growth of through trips.

5. When preparing models in any size of area, the zone size and network should be compatible. Large zones will not adequately load a fine network. Large zones will result in fewer trips on the network because there will be more intra-zonal trips that never get assigned. However, with a sparse network, actual streets parallel to the coded links are carrying a larger portion of the actual travel in the urban area. The coded link is actually representing a corridor and will be considerably overloaded on the assignment. When reviewing or comparing assignments, this condition must be recognized.

6. When comparing vehicle-miles from an assignment to the actual travel within the city or urban area, the same problem can occur as discussed above. For a scarce network, a considerable portion of the travel actually occurs on non-network links. In order to match vehicle-miles, either the network will be overloaded or there will be a shortfall in total travel on the network.

7. TransCad contains a routine that produces an OD trip matrix in an iterative fashion by making adjustments to an initial trip table so that the assigned traffic matches the counts on those respective links. This appears to be a breakthrough in updating out-of-date urban travel models. It is possible to start with any matrix, including all "1's". However, "garbage in produces garbage out". An initial trip table of all "1's" matched the traffic counts, but produce a totally useless trip table. If one starts with a well-calibrated model and updates it to a new base year using an adequate number of traffic counts, it appears that the results may be satisfactory. More testing is required to verify this assumption.

8. It appears that the published trip generation factors underestimate trip production in small urban areas. For one thing, there are likely to be many "home-for-lunch" trips that mirror the home-work trips. Theoretically, these are non-home-based trips but they are produced and attracted by the same land use and urban activities that generate the home-work trips. To reconcile for this difference, the home-work trip productions may need to have a larger factor. A second problem that may occur is that of "auto-occupancy". Most published trip generation emphasize person-trips rather that vehicle trips. They assume that a modal-split model will be applied to the person-trips to determine that portion that will be auto-drivers (i.e., vehicles trips). However, in small urban areas, person-trips almost equate to vehicle-trips. Usually the use of the vehicle-trip rates in published material underestimates small area trip production because the assumed auto-occupancy rates are higher than what actually occurs.

## Conclusions

- Using short-cut procedures for small urban areas afford an effective and efficient method for supplying location and design level traffic estimates. The most important factor to determine the detail necessary is the location of the project under study. If it is located close to the center of the area and interacts with numerous existing streets, then the model needs to be very detailed. If the project is outside the present developed area, very little detail is necessary for the majority of the urban area.

- If the project under study is a bypass, then the external-local and through trips are the most important elements of the modes. Use of old external OD data to obtain current trips must be done very carefully. These trips cannot be properly factored using Fratar or any station growth factor model unless the growth in both the local trips and the through trips are the same. This is unlikely to be the case.

- The use of GIS is a very useful tool to summarize employment and population data to the zoning system being used, without regard to whether the zoning is sparse or very detailed. Beyond that, GIS was of little benefit. Using QRSII's new overlay feature was just as convenient in developing the network as was using the US Streets data with TransCad.

- TransCad is a very expensive piece of software and is difficult to learn how to use efficiently. It produces many files for which one must keep record. One user commented that it was almost easier to reformat the hard drive than to attempt to delete the appropriate files when a project is completed. One feels that they are more in control using QRSII, albeit, it does not have many of the features that TransCad has. However, in this project, TransCad was not given a fair test since the researchers entered the project with more experience with QRSII.

- A model to simulate the movement of traffic in a small urban area can be developed by almost anyone with computer skills. However, the characteristics of each area are different and the successful calibration on the model requires considerable experience in urban transportation planning. An inexperienced person can fail to detect when problems have occurred and the procedures have to be modified to obtain a reliable model. The drawback with QRSII is that it is too easy to run using default parameters. A person is tempted to skip some of the calibration steps if time is critical. This can also be a great benefit, as well. Since TransCad is more difficult to use, one would expect the user to be more familiar with the urban transportation planning process just to make it run.

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# <u>Appendix 1</u>

***Socioeconomic Data for Census Tracts Within Study Area***

(no URL reload available)

**1990 US Census Data**
Database: **C90STF3A**
Summary Level: **State--County--Census Tract**

***BNA 9881:*** ***FIPS.STATE=20, FIPS.COUNTY90=113, FIPS.TRACT90=9881***

**MEDIAN HOUSEHOLD INCOME IN 1989**
*Universe: Households*
Median household income in 1989.......................................**28448**
**HOUSING UNITS**
*Universe: Housing units*
Total.................................................................**1087**
**PERCENT OF HOUSING UNITS IN SAMPLE**
*Universe: Housing units*
Total.................................................................**34.4**
**OCCUPANCY STATUS**
*Universe: Housing units*
Occupied...............................................................**998**
Vacant..................................................................**89**
**TENURE BY VEHICLES AVAILABLE**
*Universe: Occupied housing units*
Owner occupied:
None....................................................................**24**
1......................................................................**136**
2......................................................................**347**
3......................................................................**192**
4.......................................................................**81**
5 or more...............................................................**47**
Renter occupied:
None....................................................................**11**
1.......................................................................**61**
2.......................................................................**73**
3.......................................................................**11**
4........................................................................**6**
5 or more................................................................**9**
**VEHICLES AVAILABLE**
*Universe: Occupied housing units with householder of Hispanic origin*
None.....................................................................**0**
1 or more................................................................**5**

***BNA 9882:*** ***FIPS.STATE=20, FIPS.COUNTY90=113, FIPS.TRACT90=9882***

**MEDIAN HOUSEHOLD INCOME IN 1989**
*Universe: Households*
Median household income in 1989.......................................**21030**
**HOUSING UNITS**
*Universe: Housing units*
Total.................................................................**1248**
**PERCENT OF HOUSING UNITS IN SAMPLE**
*Universe: Housing units*
Total.................................................................**12.0**

**OCCUPANCY STATUS**
*Universe: Housing units*
Occupied.........................................................1136
Vacant.........................................................112
**TENURE BY VEHICLES AVAILABLE**
*Universe: Occupied housing units*
Owner occupied:
None.........................................................47
1.........................................................308
2.........................................................267
3.........................................................91
4.........................................................45
5 or more.........................................................0
Renter occupied:
None.........................................................93
1.........................................................196
2.........................................................79
3.........................................................0
4.........................................................10
5 or more.........................................................0
**VEHICLES AVAILABLE**
*Universe: Occupied housing units with householder of Hispanic origin*
None.........................................................0
1 or more.........................................................0

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***BNA 9883:*** ***FIPS.STATE=20, FIPS.COUNTY90=113, FIPS.TRACT90=9883***
**MEDIAN HOUSEHOLD INCOME IN 1989**
*Universe: Households*
Median household income in 1989.........................................29015
**HOUSING UNITS**
*Universe: Housing units*
Total.........................................................1125
**PERCENT OF HOUSING UNITS IN SAMPLE**
*Universe: Housing units*
Total.........................................................24.6
**OCCUPANCY STATUS**
*Universe: Housing units*
Occupied.........................................................1031
Vacant.........................................................94
**TENURE BY VEHICLES AVAILABLE**
*Universe: Occupied housing units*
Owner occupied:
None.........................................................24
1.........................................................129
2.........................................................335
3.........................................................262
4.........................................................86
5 or more.........................................................19
Renter occupied:
None.........................................................21
1.........................................................78
2.........................................................52
3.........................................................25
4.........................................................0
5 or more.........................................................0

**VEHICLES AVAILABLE**
*Universe: Occupied housing units with householder of Hispanic origin*
None....................................................................**2**
1 or more...............................................................**0**

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## *BNA 9884: FIPS.STATE=20, FIPS.COUNTY90=113, FIPS.TRACT90=9884*

**MEDIAN HOUSEHOLD INCOME IN 1989**
*Universe: Households*
Median household income in 1989.........................................**33333**
**HOUSING UNITS**
*Universe: Housing units*
Total...................................................................**2107**
**PERCENT OF HOUSING UNITS IN SAMPLE**
*Universe: Housing units*
Total...................................................................**16.0**
**OCCUPANCY STATUS**
*Universe: Housing units*
Occupied................................................................**2029**
Vacant..................................................................**78**
**TENURE BY VEHICLES AVAILABLE**
*Universe: Occupied housing units*
Owner occupied:
  None..................................................................**33**
  1.....................................................................**315**
  2.....................................................................**813**
  3.....................................................................**274**
  4.....................................................................**22**
  5 or more.............................................................**22**
Renter occupied:
  None..................................................................**93**
  1.....................................................................**297**
  2.....................................................................**138**
  3.....................................................................**13**
  4.....................................................................**9**
  5 or more.............................................................**0**
**VEHICLES AVAILABLE**
*Universe: Occupied housing units with householder of Hispanic origin*
None....................................................................**4**
1 or more...............................................................**6**

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## *BNA 9885: FIPS.STATE=20, FIPS.COUNTY90=113, FIPS.TRACT90=9885*

**MEDIAN HOUSEHOLD INCOME IN 1989**
*Universe: Households*
Median household income in 1989.........................................**23802**
**HOUSING UNITS**
*Universe: Housing units*
Total...................................................................**805**
**PERCENT OF HOUSING UNITS IN SAMPLE**
*Universe: Housing units*
Total...................................................................**15.2**
**OCCUPANCY STATUS**
*Universe: Housing units*
Occupied................................................................**728**
Vacant..................................................................**77**

**TENURE BY VEHICLES AVAILABLE**
*Universe: Occupied housing units*
Owner occupied:
None....................35
1....................80
2....................253
3....................72
4....................8
5 or more....................14
Renter occupied:
None....................25
1....................141
2....................73
3....................20
4....................7
5 or more....................0
**VEHICLES AVAILABLE**
*Universe: Occupied housing units with householder of Hispanic origin*
None....................0
1 or more....................0

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***BNA 9886: FIPS.STATE=20, FIPS.COUNTY90=113, FIPS.TRACT90=9886***
**MEDIAN HOUSEHOLD INCOME IN 1989**
*Universe: Households*
Median household income in 1989....................26430
**HOUSING UNITS**
*Universe: Housing units*
Total....................2430
**PERCENT OF HOUSING UNITS IN SAMPLE**
*Universe: Housing units*
Total....................12.3
**OCCUPANCY STATUS**
*Universe: Housing units*
Occupied....................2279
Vacant....................151
**TENURE BY VEHICLES AVAILABLE**
*Universe: Occupied housing units*
Owner occupied:
None....................26
1....................398
2....................829
3....................230
4....................53
5 or more....................21
Renter occupied:
None....................78
1....................363
2....................234
3....................47
4....................0
5 or more....................0
**VEHICLES AVAILABLE**
*Universe: Occupied housing units with householder of Hispanic origin*
None....................0
1 or more....................46

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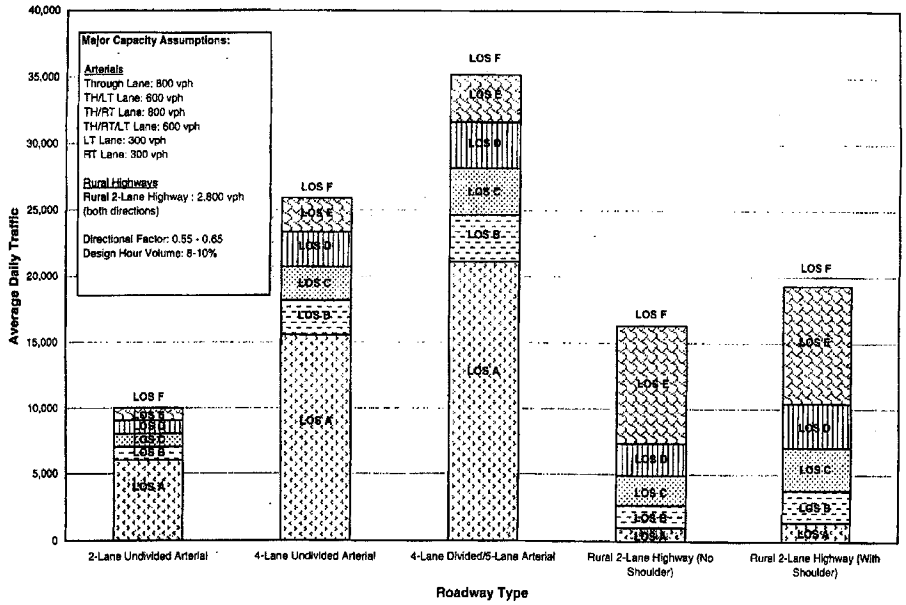
### *BNA 9887: FIPS.STATE=20, FIPS.COUNTY90=113, FIPS.TRACT90=9887*

**MEDIAN HOUSEHOLD INCOME IN 1989**
*Universe: Households*
Median household income in 1989.......................................**26511**
**HOUSING UNITS**
*Universe: Housing units*
Total.................................................................**2139**
**PERCENT OF HOUSING UNITS IN SAMPLE**
*Universe: Housing units*
Total.................................................................**33.2**
**OCCUPANCY STATUS**
*Universe: Housing units*
Occupied..............................................................**2029**
Vacant................................................................**110**
**TENURE BY VEHICLES AVAILABLE**
*Universe: Occupied housing units*
Owner occupied:
None..................................................................**38**
1.....................................................................**329**
2.....................................................................**678**
3.....................................................................**320**
4.....................................................................**135**
5 or more.............................................................**45**
Renter occupied:
None..................................................................**34**
1.....................................................................**160**
2.....................................................................**230**
3.....................................................................**35**
4.....................................................................**25**
5 or more.............................................................**0**
**VEHICLES AVAILABLE**
*Universe: Occupied housing units with householder of Hispanic origin*
None..................................................................**2**
1 or more.............................................................**12**

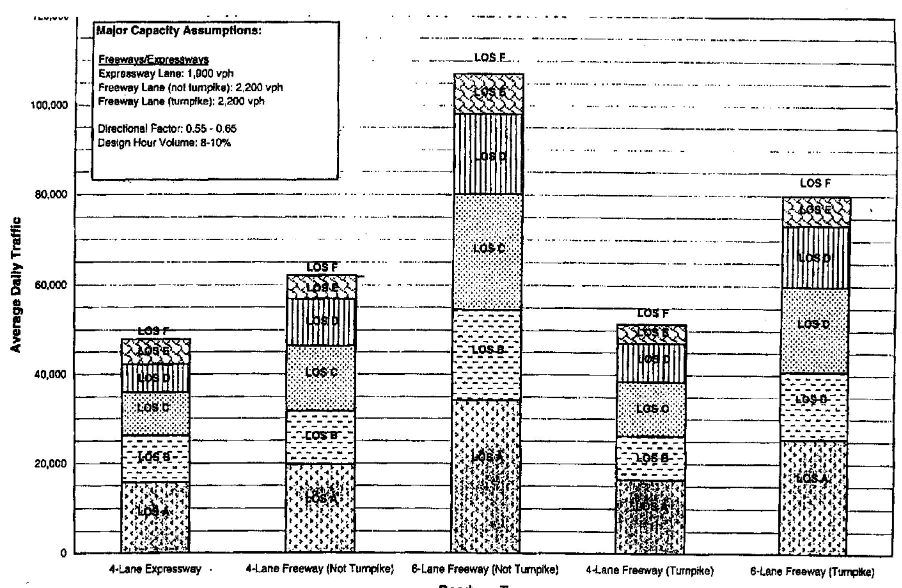
# Appendix 2

## *Roadway Capacities by Type of Facility*




NOTE: Roadway capacities for each roadway type were adjusted in some cases to account for heavy commercial vehicles, rolling terrain, no passing zones, and narrow lane/shoulder widths.

SOURCE: 1998 Highway Capacity Manual, and NCHRP




NOTE: Roadway capacities for each roadway type were adjusted in some cases to account for heavy commercial vehicles, rolling terrain, no passing zones, and narrow lane/shoulder widths.

SOURCE: 1998 Highway Capacity Manual, and NCHRP

# Appendix 3

***Vehicle-Miles Travel Data for McPherson***

| CITY CONNECTING | | NON-STATE | | NON-STATE | | NON-STATE | | NON-STATE | | TOTAL | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LINKS & TURNPIKE | | OPAU | OPAU | MIAU | MIAU | COLL | COLL | LOCU | LOCU | | |
| Miles | DVMT | Miles | DVMT | Miles | DVMT | Miles | DVMT | Miles | DVMT | MILES | DVMT |
| | | | | | | | | | | | |
| 4.988 | 35908 | 1.570 | 10310 | 8.570 | 28673 | 7.185 | 11840 | 51.417 | 26849 | 73.730 | 113580 |
| 4.988 | 35788 | | | 17.000 | 44685 | | | 48.882 | 17860 | 70.870 | 98333 |