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16. Abstract

Travel estimates from models and manuals developed from trip attraction rates having high variances due to few survey observations can reduce confidence and accuracy in estimates. This project compiled and analyzed data from more than a decade of work place and special generator travel surveys in Texas to develop (1) a generic set of trip attraction rates for different metropolitan planning organization (MPO) size categories in Texas, and (2) a Texas trip generation manual similar to the national Institute of Transportation Engineers' (ITE's) *Trip Generation Manual*, but based on local Texas data. The study results revealed that the Texas trip generation rates were generally lower than comparable rates in the ITE manual.

The research team reviewed and assessed Texas Department of Transportation current work place survey methods and design. The researchers then made recommendations on changes that would enable ITE-type trip generation data to be collected, in addition to the data collected as part of this survey, to develop trip attraction rates for modeling. The study also used the master database of trip attraction data from Texas work place surveys to develop disaggregate trip attraction rates for modeling using numerous explanatory variables. Here, the data were grouped into 14 employment categories, and linear regression models were (1) developed for non-commercial and commercial trips, and (2) analyzed for various trip purposes and mode combinations. This analysis revealed the following significant indicators of attraction rates: parking availability, MPO area size, traffic analysis zone area type, employment density, and establishment type. These are factors that should be used in future studies. The disaggregate attraction rates could be used as a benchmark or reference for calibrating certain aspects of activity-based models.

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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

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- Brian S. Bochner, TTI, Senior Research Engineer.
- Chris Simek, TTI, Assistant Research Scientist.
- Zeina Wafa, Graduate Research Assistant, CTR.

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1. INTRODUCTION

Travel surveys are needed to support the development, calibration, and validation of a travel demand model in the transportation planning process. State departments of transportation (DOTs) and metropolitan planning organizations (MPOs) across the country routinely conduct travel surveys to ensure that local travel and trip-making rates and characteristics are included in their model development and/or updates. To this end, the Texas Department of Transportation (TxDOT) has one of the most robust travel survey and data collection programs in the country in support of travel demand modeling and transportation planning in the state of Texas. The program includes traditional surveys and new and emerging data collection efforts to collect data on various components of travel and trip making that are needed as input to models or that aid in transportation policy and decision making. TxDOT's program includes the following key survey and data collection efforts:

- **External Data Collection.** This effort utilizes a combination of new methods and technologies, such as Bluetooth, cellular, and global positioning system (GPS) data, to develop estimates of the amount of vehicles that travel into, out of, and through a study area. It also provides estimates on the proportions of residents versus non-residents and commercial versus non-commercial vehicles that make up these movements.
- **Commercial Vehicle Surveys.** This survey collects data that are used to develop estimates on commercial vehicle trip length frequency distribution and the total amount of commercial vehicle travel in a study area.
- **Household Surveys.** This survey samples residents in a study area to develop trip production rates, trip length frequency distributions of resident travel, and an estimate of the total internal travel made by residents within the study area.
- **Work Place Surveys.** This instrument surveys a sampling of work place establishments in a study area to develop trip attraction rates based on the destination end of travel. It also provides an estimate of total non-resident travel in the study area, as well as any commercial vehicle trip rates.

FOCUS ON WORK PLACE SURVEYS AND DATA

This study focuses on the work place survey and the types and uses of data derived from the survey. The primary purpose of the work place survey is to estimate and understand the trip attraction characteristics of basic, retail, service, and education establishments. To accomplish this, the survey collects data needed to develop trip attraction rates, typically by employment type specific to the area being surveyed, for use in the trip generation step of travel demand modeling. The survey collects information on the amount of travel that is attracted by work places (or establishments) on a daily basis within a designated study area. In addition to trip attraction data, the survey can also be used to collect information on non-resident travel within a survey area. The survey data, along with the model, assist state DOTs, MPOs, and MPO-member entities in transportation planning and the development of local and regional transportation improvement programs (TIPs).

While the household survey collects information on the production side of trip making, work place surveys collect data on trip attractions at the destination end of trip making. As such, work place surveys collect information on the amount and characteristics of travel to and from

non-residential establishments, and unlike household surveys, they collect information on travel made by persons who do not live in the study area, as well as data on commercial vehicle trip making at work place sites.

For more than a decade, TxDOT has conducted work place travel surveys as part of its statewide travel survey program. As part of this program, Texas's 25 MPOs are consolidated into 14 travel survey regions, shown in Figure 1. TxDOT attempts to conduct surveys in each region on a recurring basis about every 10 years to support modeling for the state's 25 MPOs. The Texas A&M Transportation Institute (TTI) assisted TxDOT with the development of this program and has provided technical and research support for the program since its inception.

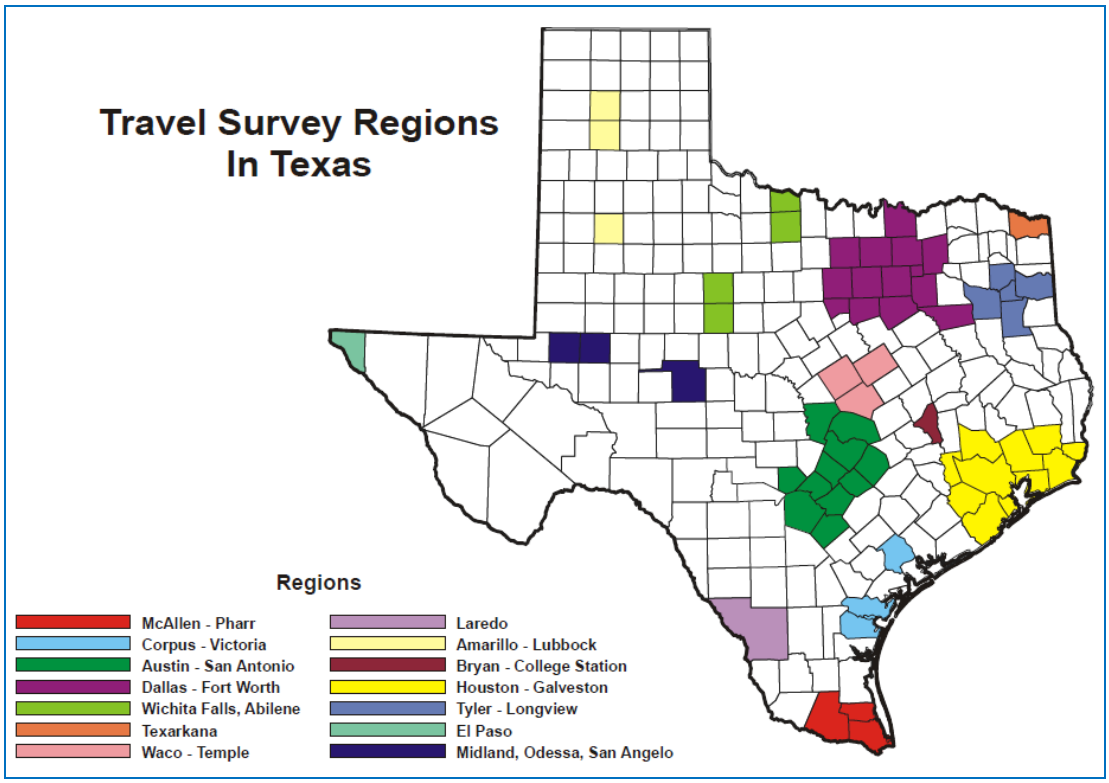

Figure 1. Travel Survey Regions in Texas.

From 1984 to 2014, 34 work place surveys were conducted in the state of Texas. While a few of these were conducted by MPOs, the rest were conducted by TxDOT with assistance from TTI.

PROJECT PURPOSE

Trip attraction rates used in travel demand models and Institute of Transportation Engineers (ITE) trip generation rates used in traffic impact analyses generally have high variances, which, in turn, can reduce confidence and accuracy in estimates developed using these rates. The high variability in trip attraction rates is often caused by an insufficient number of surveys or studies used in developing the rate(s). Developing trip attraction/generation rates for models or site-level analyses can be difficult since the surveys and studies needed to derive these rates can be expensive. In light of this, the purpose of this study was to compile and analyze data from more than a decade of work place and special generator travel surveys in Texas to:

- Focus on "trip attractions" in lieu of "trip productions" and determine if, by combining work place data from many areas and increasing the sample size, the variability in trip attraction rates could be reduced and thereby improve trip rates for modeling and site analyses for land development.
- Aggregate work place survey data from around the state and analyze it to determine if a generic set of attraction rates could be developed for different MPO size categories.
- Utilize work place survey data to develop a Texas trip generation rate manual and then compare these rates to rates for the same land use codes (LUCs) in the national ITE *Trip Generation Manual*.
- Utilize the work place survey data to examine how trip attraction data can be used to benefit advanced models, such as tour- and activity-based models, in lieu of traditional four-step trip-based models.

Another purpose of the study was to review TxDOT's current work place survey methods and design to determine if any changes needed to be made for improvement. This effort also included identifying what changes could be made to the work place survey such that it could collect data to develop ITE-type trip generation rates for site-level analyses, in addition to collecting data to develop trip attraction rates for modeling.

IMPORTANCE OF TRIP ATTRACTIONS

Trip generation, the first step in the travel demand modeling process, focuses on developing trip productions and trip attractions. Obtaining accurate trip productions (the home-based end) and trip attractions (the work place or special generator end) is critical to ensure that demand model outputs produce reliable and useful results. Quotes from multiple researchers reiterate the importance of this concept. As stated by Stopher and Greaves, "It is axiomatic that a model can never be better than the data from which it is estimated" (*1*, p. 367). According to research done by Zhao and Kockelman, "Mispredictions at early stages of the multi-stage model (e.g., trip generation) appear to be amplified across later stages" (*2*, p. 162). Likewise, Kikuchi et al. stated, "It is critical that [trip generation] produce an accurate value as these values form the basis for the subsequent steps and the errors in this step can propagate in the entire estimation process" (*3*). Thus, efforts made to improve the trip rates used in the trip generation process will be apparent in the accuracy of subsequent stages and the final output of the travel demand modeling process. Indeed, substantial effort has been invested in improving the trip generation model and resulting estimates, though much of the earlier efforts focused exclusively on trip productions rather than trip attractions (*4*, *5*).

Trip attraction rates vary by employment category and area type. However, small sample sizes often lead to illogical patterns in how the different area type trip attraction rates vary and compare to each other. Using a larger data set in developing trip attraction rates may help to stabilize the data and remove inconsistencies in how trip attraction rates across area types compare relative to one another. Use of sufficiently large data sets that produce trip attraction rates that better mirror reality would provide insight into what to expect with regard to variability across area types. Additionally, future research could address the following statement given in research performed by Pearson and Dresser: "One concern is the number of area types used and the grouping of employment types" (*6*, p. 91). Another measure that could be used to assess trip attraction rate improvements is the scaling factor used in adjusting trip attraction rates to be

consistent with trip production rates. A reduction in the disparity seen in trip productions and trip attractions would contribute to increased confidence in the trip generation step of the travel demand modeling process.

Trip Attraction Rates vs. Trip Production Rates

Generally, trip production rates are assumed to be more accurate and less variable than trip attraction rates (*6*)—largely due to limited trip attraction rate data that are reliant on expensive work place and special generator surveys. Consequently, greater confidence is placed in production rates than attraction rates, and thus the practice at TxDOT (as in most urban areas throughout the United States) is to scale resulting trip attractions by trip purpose to trip productions prior to the trip distribution step. Though seen as more reliable, one approach to decreasing variability in trip generation data is to work to improve the more commonly used trip production rates. In this vein, research performed by Faghri and Aneja used artificial neural network (ANN) backpropogation techniques in an attempt to create artificial data that could be used to minimize the cost associated with an increased sample size (which contributes to decreased variability) (*7*). Compared to regression analysis techniques, the ANN method produced more accurate results but also required a longer computation time (*7*). A contrasting approach that may be used to improve the reliability of the data used in the trip generation step of the travel demand model is to improve trip attraction rates (the focus of this study). The fact that trip attraction rates generally have greater variability than trip production rates may be overcome if a sufficiently large and accurate set of data related to work place and special generators were available for little or no additional cost to governmental agencies.

It may be argued that since trip attraction rates are ultimately scaled to the trip production rates, the quality and reliability of trip attraction rates are irrelevant. While this statement may be true at the regional level, trip attraction rates most assuredly matter by area type—which is especially important when the objective is to validate the model based on area type. Trip attraction rate improvements at the area type level will subsequently lead to improvements at the zonal level.

Further Discussion of Related Research

One of the paramount early special generator studies was performed by the Transportation Planning Division of the Texas State Department of Highways and Public Transportation (*8*). The scope of this work included "travel data from 318 individual generators, classified by urban area, relative density, and generator type (including residential, commercial, industrial and others)" (*8*, p. 1). The sites selected for inclusion in this analysis represent a wide range of generator types and were selected based on data collection feasibility and their anticipated contribution to achieving the study's objectives. The objectives of this research were threefold, and included the following:

- "Reconcile trip production and attraction rates to reflect current travel characteristics in each urban area for 1975 planning reviews.
- Estimate travel volumes generated by a specific land use and the resulting impact upon nearby existing or planned facilities.
- Quantify the trips generated by unique (one of a kind) traffic generators" (*8*, p. 3).

One hundred of the 318 special generators were residential. The definitions provided for delineating between urban, suburban, rural, and resort were vague and could be better defined in future studies. For each group of special generators, "Travel variables associated with each type of generator were examined for their quantitative impact upon trip generation" (*8*, p. 5). The commercial business category was associated with a high degree of trip rate variability, even within those businesses that were thought to be similar based on size and type. Likewise, a high degree of variability was found within industrial categories. As stated in the report, "This suggests that general knowledge of industrial type is of limited value in computing industrial trip generation unless more site-specific information is available" (*8*, p. 84). However, employment was found to be the most useful variable in forecasting industrial trip rate. In terms of the airport special generator analysis, it was found that airport trip generation was most closely correlated with deplaning passengers per day.

One of the key research efforts in the area of work place surveys was performed by Barton-Aschman Associates Inc. and submitted to the North Central Texas Council of Governments (NCTCOG) (*9*). The motivation for the study was the ability to better calibrate trip attraction rates and gather data on work place and special generators that would aid in the update and improvement of travel demand models for NCTCOG. Although travel surveys had been performed in previous decades, it was desirable to obtain more updated data for the area's travel demand models. Both work place and special generator surveys were included in the analysis. The establishments included in the survey were obtained from a combination of the 1977 NCTCOG socioeconomic file and the 1984 Dun and Bradstreet file of establishments. Three different area types were used in the survey analysis, namely central business districts (CBDs) and other business districts, urban residential, and suburban residential and rural. According to the report, "This was done because the rate of non-work trips per employee was expected to vary significantly among these three categories" (*9*, p. 6). Area type is related to "employment density and the population density of a zone" (*9*, p. B-2). Establishments deemed to have unique properties that would impact their trip attraction rates were analyzed separately from the work place survey, in the form of special generator surveys.

More recent work was performed by the Transportation Research Center at the University of Florida (*10*). The objectives of this research effort were to "analyze qualitatively trip generation characteristics of special generators" (*10*, p. viii) and "examine the advantages and disadvantages of two modeling methods for performing traffic impact analyses for proposed developments" (*10*, p. viii). The two modeling methods discussed were the link distribution percentage method and the special generator approach. The authors indicated that "these two methods produced pretty consistent estimates of traffic impacts caused by different hypothetical scenarios" (*10*, p. 70). However, the link distribution percentage method is a simpler method to use. The authors cautioned, "Special generator[s] may be a 'necessary evil' in the four-step demand modeling process. It is not a practice that modelers should be encouraged to adopt, because the presence of special generators may affect the transferability and generality of the model. Instead, more efforts could be made to refine the module of trip generation" (*10*, p. 18).

The Texas A&M Transportation Institute has published multiple reports relaying information on travel survey methodologies, travel survey design, data collection procedures, and an analysis of travel surveys performed in Texas (*6*, *11*, *12*). More specifically, the report entitled *Evaluation of Urban Travel Survey Methodologies* analyzed the methodologies used for travel surveys

performed in Texas in 1990 and 1991 (*6*). Travel surveys performed in 1990 and 1991 for five locations (San Antonio, Tyler, Amarillo, Brownsville, and Sherman-Denison) were designed to reflect improvements over the earlier travel surveys that were performed in Dallas–Fort Worth, Houston, and Texarkana. The report entitled *Urban Travel Demand Modeling Data* had two main objectives: "The first is an overview of the methods used to develop the travel demand models (specifically the trip generation models), and was accomplished relative to the urban travel surveys that have been conducted in Texas. The second aspect is the development and projection of the input data for the trip generation phase of travel demand modeling" (*11*, p. xiii). As part of this effort, travel surveys performed in Texas from 1984 to 1991, as well as the methodologies used by transportation agencies across the country, were analyzed. An even more comprehensive approach was performed by Pearson, Gamble, and Salami of TTI (*12*) and can be considered the principal result of the 1990 and 1991 Texas travel surveys analysis. Within the report, graphs and recommended trip attraction rates are included.

A comprehensive trip generation rate study was performed for Montgomery County, Maryland—with data collected in 1986 and 1987 (*13*). The work was done by Douglas & Douglas Inc. and given to the Maryland-National Capital Park & Planning Commission to aid in the planning process. The objective was to compare the trip rates obtained based on travel surveys performed specific to Montgomery County to those available from the ITE *Trip Generation Manual* based on national data. Included in the analysis were 162 sites, with commercial office buildings, residential sites, shopping centers, and fast food restaurants analyzed. Not only were the data used in this analysis specific to Montgomery County, but the sample contained more data points. The resulting trip generation equations developed are described by the statement, "While we may have pursued a prudent and somewhat conservative course, the results are not uniformly more conservative than using the nationwide ITE rates. Indeed, in many of the land use categories, the rates derived from Montgomery County data result in lower estimates of traffic" (*13*, p. 8-30).

Additionally, a trip generation study specific to hotels, fast food restaurants, and service stations was performed by the National Capital Region Transportation Planning Board Metropolitan Washington Council of Governments for the District of Columbia Department of Public Works. Data for the study were collected in 1989 and consisted of data from "two hotels, four fast food restaurants and four service stations" (*14*, p. ii). The San Diego Association of Governments and the California Department of Transportation, District 11 developed a report in 1990 that estimated the trip rates of various land use types based on data collected in the San Diego area. Each site for which data were collected was grouped into a land use category—allowing for easy comparisons of trip rates for similar sites.

There are a number of methodologies that may be used to estimate trip attraction rates. Research performed by Kikuchi et al. analyzed both a microscopic and a macroscopic approach to developing trip attraction rates for shopping centers in Delaware (*3*). The microscopic approach worked to develop trip attraction rates based on weighted values assigned to each business within the shopping center—accounting for trip chaining effects in the process. In contrast, the macroscopic approach used data such as the square footage and adjacent parking spaces to develop a regression used to estimate the number of trip attractions related to each business.

Research performed by Ben-Edigbe and Rahman considered the impacts of using trip attraction rates (tied to the school end of the trip) as opposed to using more traditional trip production rates

(tied to the home end of the trip) for trip generation (*15*). This approach was considered because of suspected inaccuracies in parents reporting personal information when gathering information at the home end of the trip. The authors found their trip attraction methodology to be both efficient and effective in collecting trip generation data.

Purvis et al. considered the relationship between duration to work and the number of discretionary trips (*16*). A sensitivity analysis considered the effect on the model outputs of using different trip durations for home-based work (HBW) trips. As the work trip duration decreased, the percentage of home-based shopping and home-based recreational trips increased. More specifically, "Sensitivity analyses indicate that a 10 percent decrease in average work trip duration would yield a 1.2 percent increase in home-based shop trips and a 0.9 percent increase in home-based social/recreation trips for all means of transportation" (*16*, p. 44). The results of this analysis were incorporated into trip generation models as improvements to travel demand modeling for the San Francisco area.

Krishnamurthy and Kockelman performed research investigating how uncertainty propagates through various stages of modeling (*17*). Data from the Austin, Texas, area were used. Based on results of their analysis using Monte Carlo simulation techniques, the authors included trip attraction rates among the factors linked most to output variations. This finding further strengthens the need to develop more accurate trip attraction rates for use in travel demand modeling.

Research performed by Miller et al. analyzed the effects of borrowing residential trip generation rates (*18*). Four different methods of calculating trip generation rates were employed in calculating the trip generation rates associated with nine neighborhoods. Rates calculated using the first three methods (ground counts, household surveys, and national trip generation rates) were not found to be significantly different. However, the authors cautioned, "While statistical differences are a useful indicator, they will not always indicate whether or not there is a practical difference" (*18*, p. 111). Performing a sensitivity analysis may be prudent as a check to ensure that the trip rates used seem reasonable. Although borrowing trip rates from another area may be possible, using trip rates specific to an area is an obvious preferred choice. (See 2012 National Cooperative Highway Research Program [NCHRP] report [*19*] that was co-authored by Bhat and provides a comprehensive review of transferability studies and trip generation rates.) Thus, using the work place and special generator data obtained for Texas would aid in developing travel demand models that better reflect the demands and needs of Texas.

RESEARCH WORK PLAN

The work plan for this research project was made up of nine tasks that were completed over a two-year period. TTI led the project, with the Center for Transportation Research (CTR) at the University of Texas providing support in key areas. The project's nine tasks were as follows:

1. Perform literature review and review of previous work.
2. Review and examine work place/special generator (WP/SG) survey design and methods.
3. Compile and analyze data to develop trip attraction rates for modeling.
4. Conduct analyses to develop trip generation rates for land development.
5. Evaluate models and potential explanatory variables.

6. Establish criteria for the Texas Trip Generation Manual.
7. Prepare a draft trip generation manual and user's guide.
8. Conduct a workshop to present manual and user's guide to TxDOT.
9. Prepare research and summary reports.

Tasks 1 through 6 made up the core effort of the work, while Tasks 7, 8, and 9 involved development of final reports, a draft Texas Trip Generation Manual, and a workshop with a PowerPoint presentation to demonstrate how to use the manual and the products of this research.

TxDOT's Project Monitoring Committee (PMC) was involved to provide strategic input and reviews at several points in the project. PMC input was provided at two project status meetings held in Austin and through review and comments of task memorandums that were submitted upon the completion of each task.

The results of the project have significant potential for application by TxDOT, MPOs, and local areas. Key implications and areas where findings from this research could be used include the following:

- A set of attraction rates for small and medium-sized Texas MPOs that could potentially be used for areas not having work place survey data.
- Changes in TxDOT's work place survey specifications due to recommended changes in survey methods and designs.
- Increased confidence and accuracy in results of travel demand models as a result of lower variances in attraction rates used.

ORGANIZATION OF REPORT

This chapter has provided an introduction to the project objectives and scope. The remainder of the report consists of seven additional chapters:

- Chapter 2 provides an overview of Texas work place surveys and how they are performed and designed.
- Chapter 3 details how ITE trip generation data are collected and provides a comparison of ITE data collection and TxDOT WP/SG procedures. Chapter 3 also provides suggestions on how the TxDOT WP/SG surveys should be modified to ensure that data obtain the same information that ITE collects as part of its trip generation analysis efforts.
- Chapter 4 outlines the steps that were taken in compiling the data set that was used in developing generic attraction rates for modeling.
- Chapter 5 details how the data set used in the development of trip generation rates for land development was compiled and provides some comparisons between Texas rates and ITE rates.
- Chapter 6 describes the criteria that were used in developing the Texas Trip Generation Manual, which largely follows the format of the ITE *Trip Generation Manual*, to allow for easy comparisons.

- Chapter 7 looks into disaggregate attraction models and explanatory variables that may be of interest in modeling and examines how trip attraction rates may be used in advanced travel demand models.
- Chapter 8 summarizes the report and provides the conclusions and recommendations resulting from this research project.

2. TEXAS WORK PLACE SURVEY DESIGNS AND METHODS

Research by TTI in the early 1970s demonstrated that it was cost prohibitive to survey enough households to accurately develop trip tables from household surveys for use in travel demand modeling. As a result of the research performed by TTI's Dr. Vergil Stover and Dr. Jim Benson, a need was identified for the development of attraction models to use in combination with production models in travel demand modeling. A summary of the work place travel surveys that have been performed, or are currently being performed, in Texas is provided in Table 1.

Table 1. Texas Work Place Travel Surveys by Year and Area.

Year	Area
1984	Dallas–Fort Worth
1989	Texarkana
1990	San Antonio
1990	Amarillo
1990	Brownsville
1991	Tyler
1991	Sherman-Denison
1993	Jefferson-Orange-Hardin Counties
1994	Dallas–Fort Worth (North Central Texas Council of Governments)
1994	El Paso
1995	Houston-Galveston Area Council (HGAC)
1996	Corpus Christi*
1997	Austin Area Travel Survey
2003	Laredo
2004–2006	Rio Grande Valley
2005–2006	San Antonio–Bexar County
2006–2007	Austin
2010	Killeen-Temple
2010	Amarillo
2010	Jefferson-Orange-Hardin Counties
2010	Lubbock
2010	Waco
2010–2011	Corpus Christi
2010–2011	El Paso
2010–2011	Victoria
2011	Abilene
2011	Houston-Galveston Area Council
2011	Wichita Falls
2011–2012	Sherman-Denison
2012	Dallas–Fort Worth
2013	Texarkana
2013	Bryan–College Station
2014	San Angelo
2014	Midland-Odessa

*No work place surveys performed—just special generator surveys.

In early research conducted by the Texas A&M Transportation Institute, attraction estimates were largely thought to be less accurate than production estimates. As a result, work place travel surveys were developed within Texas in the 1980s in an effort to develop better attraction models.[1]

The conference paper entitled *Work Place Surveys: A Hidden Gem?* provides a thorough overview of the work place survey methods currently being employed by TxDOT (*20*). It notes that work place travel survey benefits include the ability to capture elements of visitor and commercial travel, as well as capture shorter trips that often go unreported in household travel surveys. Ultimately, the goal of work place surveys (in Texas) is to estimate trip attraction rates based on employment type and area type. While the procedures and methods employed in work place travel surveys within Texas have largely remained constant, there are several changes and nuances worth mentioning. The following section provides a description of multiple aspects of work place travel survey design and how it has evolved over time.

KEY METHODS AND PRACTICES

There are several aspects to consider in the design, implementation, and use of travel survey data. The research team identified eight categories as important areas to consider within work place travel surveys:

- Sampling Methods and Sources.
- Sample Stratifications and Sizes.
- Sample Selection and Participation Rates.
- Work Place Employees and Visitors: Same Survey Instrument?
- Completion of Sample Stratification Cell Targets/Quotas.
- Data Collection and Survey Fielding Methods/Approaches.
- Data Checking, Analysis, and Expansion.
- How Work Place Survey Data Are Used in Trip and Tour-Based Models and Activity-Based Models.

The following subsections provide some background on Texas work place travel survey practices and how they have evolved over time.

Sampling Methods and Sources

Early travel surveys performed in Texas during the 1960s and early 1970s were large-scale origin-destination (O-D) surveys generated by conducting home interviews. While this approach provided reliable information, it was extremely time consuming and expensive. In the 1980s, Texas travel surveys shifted toward a smaller sample size to make surveys more manageable in terms of time and money (*6, 11*). As a result, the Dallas–Fort Worth (DFW) Work Place Survey performed in 1984 consisted of two contracts, one for sample design and one for performing the survey (*9*).

[1] Personal communication with David Pearson, 2013.

Current work place surveys in Texas include both full surveys and partial surveys. A full survey includes an establishment survey, intercept interview surveys, and work place person or vehicle counts; a partial survey differs from a full survey in that intercept interview surveys are not performed. This survey design is implemented as a more cost-effective measure in obtaining data from more establishments—to ultimately be used in creating attraction rates that will be more reflective of the study area's work place trips (*20*). The first form of partial surveys evolved in the process of performing the 1995 HGAC Work Place Survey in an effort to "meet the sampling goals of the survey" (*21*, p. 7). Since then, partial surveys have become a useful tool in obtaining a larger sample of data under a constrained budget, which ultimately leads to a better model. Interestingly, the 1996 Corpus Christi Special Generator Survey had three of the four special generator sites surveyed using partial surveys (*22*). However, subsequent special generator surveys utilized the full survey methodology for special generator sites.

Sample Stratifications and Sizes

Small to mid-sized areas generally have a total of 300 work places surveyed; a third to half of those surveys are full, with the remainder being partial. A similar approach is taken with larger urban areas; however, the total number of work places surveyed is more likely to be in the 400 surveys to 600 surveys range (*20*). Pearson and Dresser provided recommendations on the percentage of employees to include within the survey based on employment type and urban area population (*23*). As further explained in *Work Place Surveys: A Hidden Gem?*, most current sampling plans are generally simpler (only stratified by employment type) than the sampling plans that were common in the 1990s and early 2000s (stratified by employment type and area type) (*20*). Basic, service, and retail are fairly standard employment type categories. Further disaggregation to include education as its own category was first employed in the 2006–2007 Austin Area Work Place Travel Survey. This additional employment type disaggregation was an afterthought, implemented after the survey had been performed because modelers wanted this further disaggregated information. This is an example of how changes in survey design are largely brought about to better satisfy the needs of modelers. The sampling plan associated with large urban areas may include an even more complex stratification method, beyond basic, service, retail, and education. This was the case in the 2011 Houston-Galveston Area Work Place Survey, where the sample was stratified based on employment type, with more categories than is typical—including industrial, retail, medical, office, education, and government employment (*20*).

Some of the earlier Texas work place surveys (even up through the 2003 Laredo and the 2004–2006 Rio Grande Valley) determined employment type based on Standard Industrial Classification System (SIC) codes. More recent surveys used the North American Industrial Classification System (NAICS) codes to determine employment type. SIC codes can be up to four digits and are grouped by either demand or production, while NAICS codes can be up to six digits and are grouped by establishments that produce similar goods or services. Because national standards shifted toward the use of NAICS codes, SIC codes are rarely used anymore (*24*). The shift to NAICS codes within Texas travel surveys was largely a result of modelers' efforts to reclassify establishments by employment type in a manner that more accurately reflected their true function. For instance, post offices are defined as retail under the NAICS codes, which is considered a more accurate classification than under the SIC system.[1]

In terms of area type, the way that level of disaggregation for area type is defined has been consistent across Texas work place travel surveys; however, how area type is defined and used in different urban areas has not been consistent. Area type can be defined based on population and employment density (*25*). If area type is too disaggregated, it may result in having too small of a sample size, or no surveyed establishments, in some cells. This was the case in the Brownsville work place survey performed in the early 1990s. This scenario—along with different area classifications—may cause difficulty in comparing different urban areas (*25*). To remedy the issue of small or no samples within some stratification categories, the survey design was later changed to be performed in two phases. The results of the pilot survey performed in Phase 1 could be used to make adjustments to the sampling plan for the actual survey to be performed in Phase 2, thereby addressing sample design issues before they become an issue in the survey results. The following provides a brief summary of how the pretest/different survey phases have evolved in Texas:

- In the 1984 Dallas–Fort Worth Work Place Survey, a pretest of 30 firms was performed to check the questionnaire form and procedures. Nine firms actually completed the pretest survey, and based on these results, some of the questions' wording was altered to be clearer. It also was decided that just one endorsement letter should be included.
- In the early 1990s, a pilot test was done that included one establishment from each of the three employment types of basic, retail, and service. Based on the results, the questionnaires were altered.
- The 1993 Jefferson-Orange-Hardin Regional Transportation Study (JOHRTS) Work Place Survey included 33 pilot sites, which were eventually included within the actual survey data because no changes were made to the survey or methodology after performing the pretest (*26*).
- At the beginning of the 1994 El Paso Work Place Survey, the freestanding/non-freestanding (FS/NFS) status of an establishment was not a sample variable. However, near the end of the data collection process, an attempt was made to bolster the FS/NFS establishments in each cell so that they could better replicate the proportion of each found in the pre-survey that included 2.5 percent of businesses (*27*).
- The 2003 Laredo Work Place Survey consisted of a pre-survey where 5 percent of the businesses in Webb County were contacted and asked about the FS/NFS status of the business so that these establishments could be created based on employment type (*28*). This pretest methodology was also implemented in the 2005–2006 San Antonio–Bexar County Work Place Survey and the 2006–2007 Austin Area Work Place Survey, though the process was called Phase 1. This information obtained in Phase 1 helped in determining the sampling plan for the survey of establishments that took place in Phase 2—with different procedures followed for full and partial surveys (*29*).
- More recent surveys have done away with the two-phase approach; however, a pilot study is performed where five work places are surveyed to test the methodology that will later be used in the main survey. The pilot survey data are generally not used as part of the full survey sample.

Sample Selection and Participation Rates

In order to select the establishments to include within the sample, the list of establishments included within the sampling frame is stratified as desired. The source of the sampling frame may vary for each survey. The 1984 DFW Work Place Survey sampling frame was based on the NCTCOG socioeconomic file that was completed in 1977, updated in 1980, and was supplemented using the region's Dun & Bradstreet 1984 file of establishments (*9*). With more modern Texas travel surveys, the sampling frame is often defined by a list of establishments provided by the Texas Employment Commission. Another sampling frame that is mentioned specifically for the truck survey that was performed within the 1990 San Antonio Work Place Survey is the telephone directory. One business was selected per page until the goal of having 400 trucks agree to participate was met (*30*).

Throughout the past few decades, sampling methodologies employed in selecting establishments to participate in work place travel surveys have been selected based on quota sampling—wherein establishments are segregated into different groups depending on specified stratification criteria. The actual establishments to include in the survey are then selected using a "systematic random sampling technique" (*6*, p. 8). Essentially, establishments are disaggregated into basic, service, and retail employment types, and education establishments are manually separated from the list of service establishments. A random number generator is then used to develop a subsample from each employment type. The vendor is instructed to start recruiting businesses from the top of the list and continue until the cell quotas are roughly met. If an establishment refuses to participate, the next establishment on the list is contacted for recruitment.

As described for the 1990 San Antonio Work Place Survey, "Recruiting participants was accomplished by telephone contact, formal correspondence, and meetings with people having authority over the establishment being recruited" (*30*, p. 7). After the establishment agreed to participate, a follow-up meeting was scheduled so that the survey could be explained in greater detail, any questions related to the survey could be answered, and the survey date could be established (*30*). Current practice dictates that "for larger work places that agree to participate in the survey, a pre-survey site visit is scheduled to meet with the work place's management to ensure that they are comfortable with the survey approach and data collection plan" (*20*, p. 8).

A record is kept of all establishments for which an effort is made to recruit them in the survey, regardless of whether the establishment agrees to participate (*20*). Participation rates vary noticeably for each survey area. Some example participation rates are 23 percent for the 1993 JOHRTS Work Place Survey (*26*), 27 percent in the 2010 Killeen-Temple Urban Transportation Study (KTUTS) Work Place Survey (*31*), 32 percent in the 1994 El Paso Survey (*27*), and as high as a 73 percent response rate in the 2003 Laredo Work Place Survey (*28*).

Work Place Employees and Visitors: Same Survey Instrument?

In earlier years, employees and visitors were surveyed separately—with employees being given a 24-hour travel survey to complete and visitor trip information being gathered via intercept interviews performed at the establishment. However, as of the 2010 Texas work place surveys, employees and visitors are now surveyed together. This change was implemented to simplify the survey design in an effort to reduce costs and obtain more reasonable bids. Surveying employees

and visitors using the same survey instrument eliminates the need to develop two distinct surveys and ensures that employees are not inadvertently included within the intercept interviews intended for visitors.

Although this switch to having the same survey for both employees and visitors may save on costs and make administrating the survey logistically easier, it may create other problems. For instance, the results could be biased if disproportionate levels of those surveyed are either employees or visitors. When employees and visitors were surveyed separately, it was easier to ensure that HBW trips were captured—which is very important from a modeling standpoint. It may be necessary to modify the survey procedure to ensure that a certain percentage of employees versus visitors is obtained.[1]

TxDOT's Work Place Survey Method and Instruments

Over the years, TxDOT and TTI have refined methods of work place data collection in order to collect necessary data in an efficient and cost-effective manner. Data collection generally follows three paths.

Establishment Survey

This survey determines whether the work place is freestanding (e.g., points of vehicle access and parking are clearly established and are designed to serve that work place only), or non-freestanding (e.g., vehicle access points and parking are designed to serve more than one establishment). Data on total employment, number of employees at work during the travel survey day, amount of parking, number of daily deliveries, hours of operation, and other general information are collected with this survey. The establishment survey is generally conducted in two parts:

- **Form G**, which is the initial recruitment data for a large sample pool. Recruitment at this time focuses on whether an establishment wishes to:
  - Fully participate (i.e., full surveys).
  - Partially participate (i.e., partial surveys).
  - Refuse to participate.
  - Refuse to answer.

  Data for this form are collected over the telephone and include location and contact information, estimated total employment, estimated average workers and visitors on a typical day, hours of operation and deliveries, and number of vehicles owned.
- **Form A**, which is an updated and augmented version of **Form G**. For full surveys, Form A includes data from the date for which intercept surveys were conducted. These data include person or vehicle counts, total employees at work, the establishment type (freestanding or non-freestanding), and the NAICS code. Similar data are collected for partial surveys except that no intercept surveys are conducted at the site. The vehicle counts collected for Form A involve counting all vehicles (non-commercial and commercial) entering and exiting the surveyed establishments during their normal operating hours using accumulative count recorders (ACRs) or video cameras. For those sites not suitable for vehicle counts, manual counts of persons and/or vehicles are conducted. The counts are performed at each entrance and exit beginning a minimum of

one hour prior to the location's normal operating hours and ending no later than one hour after normal operating hours.

Intercept Interview Survey

This survey involves an intercept interview of persons as they enter and/or exit the establishments. All survey participants are randomly selected and include both employees and non-employees.

Intercept surveys are separated into two forms:

- **Form B**, which includes intercept surveys of employees and visitors at freestanding establishments.
- **Form C**, which includes intercept surveys of employees and visitors at non-freestanding establishments.

Forms B and C collect similar data from participants. These data include home/residence location, location immediately prior to arriving at the establishment (origin), travel location after leaving the establishment (destination), purpose of the trip to the establishment (trip purpose), and mode of travel. Additional data are then imputed from the responses and include geocoding of residence, origin, and destination locations and determining residency status (do they reside in the study area or not?).

The principal difference between the forms is that for non-freestanding sites, participants are asked if this is the first establishment they visited at the site and how many more they intend to visit.

Form B intercept surveys are collected at special generator sites such as airports and colleges. However, special generators may have different mode and trip purpose variables. Accordingly, there are several variants to Form B, including the following:

- **Form B**—Standard Special Generator.
- **Form B**—Airports.
- **Form B**—Universities/Colleges.

Commercial Interview Survey

This survey involves drivers of commercial vehicles arriving at/departing from the establishment. Data for commercial vehicles are collected using **Form D**. Data collected include origin, destination, cargo being transported, and cargo weight.

TxDOT's Previous Work Place Survey Methodology

The work place survey data collected for the Austin, San Antonio, Laredo, and Rio Grande Valley surveys differed somewhat from the current format. The difference in how data for these areas were collected in relation to current practice is provided below.

- **Form A** establishment data were a combination of Forms A and G from the current survey standards.
- **Form B** was separated into two parts, **Form B1** and **Form B2**. Unlike Form B in the current instruments, Form B was a travel diary of the employee. It was completed by employees of the work place for a one-day period on the day that counts were collected at the establishment.
  - **Form B1** included personal information such as home location, type of vehicle owned, and household income and size.
  - **Form B2** contained data similar to Forms B and C in the current standards; however, rather than just containing the trips to and from the establishment, it included successive trips prior to arriving at and departing from the establishment.
- **Form C** was similar to Form B in the current instruments but was for freestanding work place visitors only.
- **Form D** was similar to Form C in the current instruments but was for non-freestanding work place visitors only.

Sample Stratification and Cell Targets/Quotas

The cell target quotas for a given employment type, area type, or employment size are just that—a target. Generally, the actual number of establishments surveyed within each stratified cell falls approximately close to the target value, though the quotas may not match exactly. In some instances, the original quotas are not met. For instance, during the 2006–2007 Austin Work Place Survey, there were some problems encountered by the vendor regarding the amount of funding that was allocated for the survey. As a result, the survey was terminated and the number of sites surveyed was less than had been scheduled in the original sampling plan (*32*).

In the 1993 JOHRTS Work Place Survey, the initial quota of surveying a minimum of 150 work places with 10 establishments per sample stratification was revised to 196 "by substituting the average number of employees per work place by sample category instead of the region wide average in the calculations. It was felt that the 10 site quota was not a representative sample" (*26*, p. 2). The JOHRTS Work Place Survey report goes on to say that "an area was considered deficient if less than five establishments were selected to be surveyed. If an area was deficient, establishments were manually selected until a minimum of seven sites were chosen for each cross-classification" (*26*, p. 4).

Within the 1994 El Paso Work Place Survey, a minimum of 10 establishments and a maximum of 27 establishments were established for each sample cell (*27*). Additionally, a series of extenuating circumstances led to the initial sample quotas being adjusted after field work had begun. Among the difficulties were "establishments in El Paso were wary of the legitimacy of the survey and recruiting took extra call-backs and personal visits, the Mayor withdrew the letter of support used in the employer package because of questions regarding the confidentiality of the data, and higher than expected drop-out rates were encountered after initial agreement to participate" (*27*, p. 7). This reinforces the importance of reaching out to the public to inform them of the importance of the survey and of its legitimacy.

Data Collection and Survey Fielding Methods/Approaches

The procedures followed during the data collection process differ depending on the type of survey being performed (i.e., partial or full), the size of the establishment, whether the establishment is FS/NFS, and the layout of the site (i.e., number and location of establishment access points, establishment building entrances).

Once an establishment has agreed to participate in the survey, the next step related to data collection is performing an establishment survey. This can be performed on the phone with the owner or manager of the establishment, enabling surveyors to obtain information on the number of employees, number of employees at work on the survey day, hours of operation, available parking, and other general information that may be useful in collecting and analyzing the establishment's trip attraction data. Another key piece of information that is collected through the establishment survey is the FS or NFS status of the establishment (*31*). For some surveys, the FS/NFS status is verified for a subsample of the establishments to be surveyed by performing a site visit (*28*, *33*). NFS sites are treated slightly different than FS establishments during the survey process, as described by Pearson and Dresser. Though similar in most respects, an NFS establishment also requires "a survey of the activity center where the work place is located" (*23*, p. 20).

Within the 1994 El Paso Work Place Survey, the FS/NFS status of an establishment was not considered as a sample variable. However, near the end of data collection, an attempt was made to bolster the FS/NFS sites in each cell to replicate TxDOT's pre-survey goal of a 2.5 percent sample of businesses (*27*). As part of this effort, NFS procedures included the "use [of] total attraction rates computed from the FS work place surveys to the number of employees at work in each work place in each industry type to develop the relative attractiveness for each work place by trip purpose. Since FS rates were not available for El Paso, the rates from the 1993 JOHRTS (Beaumont–Port Arthur) survey were used" (*27*, p. 11). Additionally, the assumption that CBD establishments were FS was made to make intercept interviews easier to perform (*27*). Field surveyors also generally visited the site prior to the survey day to get a better sense of the site layout, to determine how many surveyors would be needed and where they should be located, and to assess what methods would be needed to collect vehicle or person counts (*25*). Means used to perform counts ranged from video camera, ACRs, tube counters, and manual counts.

In the 1984 DFW Work Place Survey, no intercept interviews were performed. Rather, field staff distributed a questionnaire to all non-employees entering the establishment. A separate questionnaire was distributed to employees. The number of employee questionnaires to distribute was determined based on the employment size of the establishment. All employees were given a questionnaire if there were fewer than 100 employees, 100 questionnaires plus one more for every two additional employees were distributed at establishments with 100 to 500 employees, and a total of 300 employee questionnaires were distributed at establishments with more than 500 employees (*20*).

Interestingly, a report detailing the 1993 JOHRTS Work Place Survey discusses the method of performing the intercept interview survey by stating, "The interviewers generally interviewed everyone approaching their station. If a business was busy, interviewers surveyed as many visitors as possible" (*26*, p. 8). However, current special generator surveys include more specific

specifications that the lesser of 10 percent of the actual number of employees and visitors or 500 surveys must be performed (*34*).

As of 2011, it became a requirement that intercept interviews be performed using computer-assisted personal interview technology—thereby minimizing errors and increasing the legitimacy of the survey (*20*). Prior to this, a pen and paper approach was largely implemented.

All field surveyors and interviewers are trained and provided a manual about how to perform their duties. As part of the 1994 El Paso Work Place Survey, Barton-Aschman staff sent stealth visitors to check if interviewers were doing their job well (*27*).

Some component of a truck or commercial vehicle survey has been included in the Texas work place surveys throughout their nearly three-decade history.[1] However, the first time surveyors asked about vehicles owned or leased by an establishment and used for business purposes was in the Rio Grande Valley 2004–2006 Work Place Survey. The Austin and San Antonio work place travel surveys in 2006–2007 included the use of GPS as an option in collecting a portion of this information (*35*).

Counts are done for 24 hours in instances where the establishment is always open, beginning at 6:00 a.m. the day of the survey. However, if the establishment is not always open, counts are required to begin a least one hour prior to the start of business hours and end no sooner than one hour after the close of business hours (*20*).

Data Checking, Analysis, and Expansion

Data checks are generally performed during various stages of the survey. In selecting which establishments to include within the sampling frame, establishments that are known to be out of business are removed from the list of potential establishments to include in the survey. Additionally, a check is made to ensure the same establishment is not listed twice. In the 1984 DFW Work Place Survey, survey data were collected in paper form via separate questionnaires for visitors and employees. Thus, it was necessary to log, edit, code, keypunch, and geocode the data. Editing and contingency checks were performed (*9*). For the 1990 San Antonio Work Place Survey, the questionnaires were checked for logic; however, "Editors were instructed not to 'fix' the data unless it was obvious what the employee had intended to record" (*30*, p. 11). After this initial check for logic, trip logic and time logic were checked by a computer program (*30*). The 1993 JOHRTS Work Place Survey mentions that the data were edited and that origin-destination data were geocoded (*26*). The 1994 El Paso Work Place Survey report specifically indicates that tubes used for counting vehicles entering and exiting NFS sites could be verified and calibrated if needed (*27*). As part of the 2003 Laredo Work Place Survey, "TxDOT randomly selected 10 percent of the work places surveyed by Nustats DataSource to field verify their FS versus NFS status" (*28*, p. 5).

A report documenting the work place surveys performed in the early 1990s highlighted that some of the data obtained were not usable; however, for some missing data, the assumptions made in analyzing the data may have impacted the results (*25*). In terms of data expansion, "The trips were expanded by trip purpose for person and auto driver trips individually" (*25*, p. 119). Pearson and Dresser described the recommended practice for expansion at the time of their 1992

report, stating, “In lieu of averaging the attraction rates over all of the work places surveyed (by employment type and area type), it is recommended that the total attractions and total employment (by trip purpose) be summed by area type and type of employment for the work places surveyed” (*23*, p. 29–30).

There is some debate about whether to adjust the attraction rates obtained through the work place survey to the production rates obtained through the household survey, or vice versa. Generally, the number of total attractions is larger than the total productions. Modelers often argue in favor of adjusting attraction rates to better match production rates due to the larger sample size that is often associated with household surveys. However, household surveys may be associated with a large number of unreported trips because of proxy response or no reporting of some trips. Work place surveys, on the other hand, contain counts that may make their associated estimates more reliable.[1]

With current Texas work place travel surveys, the trip attraction rates estimated from the work place survey are calibrated against the trip production rates obtained from the household survey; likewise, the commercial vehicle trip rates are calibrated against the trip rates obtained from the commercial vehicle data. This calibration step is critical as a means of checking the validity of the rates obtained through travel surveys before they are used in the modeling process (*20*).

Hard et al. further explained the steps currently taken to expand data, stating that:

> Using surveys completed by employees at the site, employee data are expanded first to estimate the total employee trips by purpose for the site. The trips are subtracted from the total person count for the site to estimate the visitor trips. The visitor survey data are used to establish the proportion of visitor trips by purpose and these percentages are applied to the total estimated visitor trips to estimate the visitor trips by trip purpose. The number of external trips and trips made by individuals that did not live in the study area are also compiled and expanded with the number of trips by trip purpose (*20*, p. 9–10).

Ultimately, “Data from surveyed work place sites are processed and expanded separately for visitors and employees. Trip data derived from the survey are analyzed to develop trip attraction rates by trip purpose” (*20*, p. 12).

STRENGTHS AND WEAKNESSES OF TEXAS WORK PLACE SURVEYS

The previous descriptions about the Texas work place surveys show that current survey practices have both strengths and weaknesses, some of which are highlighted below.

Strengths

TxDOT’s Travel Survey Program provides a consistent source of updated data for Texas MPOs that can be used in travel demand modeling and in developing more advanced travel demand models, such as tour-based or activity-based models. This type of system is beneficial to Texas MPOs in that it provides data to more effectively plan for the transportation needs of Texas communities. It also provides a good program model for other states that are considering implementing a travel survey program.

Another strength of the work place survey is its capture of non-resident travel. Formerly, non-resident travel was captured in both the work place and external surveys. Understandably, the percentage of non-resident travel will vary greatly with the MPO area being considered. With the recent discontinuance of external surveys because of safety concerns and political pressures, it is even more critical that this information be collected through the work place survey. Given some significant differences between external travel values obtained from work place and external surveys in the past, it will be important to consider the cause of these differences and adjust survey wording and survey instruments accordingly.

Weaknesses

One of the weaknesses of the current TxDOT Travel Survey Program is the lack of comparability with ITE trip generation rates. TxDOT does not collect information on as many independent variables as ITE does. Data from work place surveys are collected for a different purpose than ITE trip generation rates. However, in some cases the work place survey data may be comparable to ITE data. Another weakness of the current approach is the relatively small sample size. Typically, it is desirable to have 30 observations within each subsample from a statistical standpoint. However, this can become difficult when employment and area are stratified. Cost can be a limiting factor in obtaining more establishments within each desired cell.

Likewise, an inconsistency between how MPOs apply area types is a weakness that should be addressed. Typically, "The assumption is made that the process for defining the area type for zones is non-regimented and may be based strictly on professional judgment" (*23*, p. 5). Given this assumption, it is unclear where the split between different area types should be from the attraction standpoint. There has not been much research about the point where attraction rates actually change for the urban, suburban, and CBD fringe areas. More research is necessary in this field to aid in smoothing attraction rates across area types.

Recommendations for Improvements

One recommendation that may lead to cost savings within the Texas Travel Survey Program would be to incorporate the commercial vehicle survey into the work place survey. There is a great deal of overlap in the data collected in the commercial vehicle survey and the commercial vehicle or truck component of the work place survey. One thing that may complicate the incorporation process may be that some work places do not have commercial vehicles.

It is recommended that a training day be organized to instruct vendors of critical practices to implement in performing surveys to ensure the highest quality survey results are obtained. One area that should be addressed within the vendor training is how to handle employees who might leave the establishment and come back later in the day—should they be surveyed twice? The nature of the activity that the employee is engaging in will largely dictate how this issue is addressed (i.e., leaving the premise and returning after making a trip versus walking outside for a cigarette break). Three possible ways to deal with these types of trips are described within Chapter 18 of the *Travel Survey Manual* maintained by the Transportation Research Board (TRB) Travel Survey Methods committee (*36*):

- Determine during the employer interview if the establishment provides an internal smoking area and if all smokers use it. If the answers to both are yes, then the smoking trips will never be observed and, therefore, never counted.
- Conduct the cordon count outside of where employees are likely to take their breaks, in which case the smoking trips will not be counted.
- Specifically ask employees on the employee questionnaire the number of times they left the building for incidental trips such as smoking.

It may be beneficial to consider how technology can be incorporated into future work place travel surveys performed in Texas. It may be possible to develop a web-based survey for the employee questionnaire portion of data collection. However, it may be difficult to implement this type of survey at work place establishments where employees do not have ready access to a computer.

It is also recommended that the lack of field checking be addressed. This would help with quality control issues and help to standardize the practice of data collection between establishments and between MPO areas.

3. WORK PLACE SURVEY DATA AND ITE TRIP GENERATION RATES

In the transportation planning process, trip generation data are used to develop an estimate of the total demand for travel to or from a specified geographic area. The types of trip generation data required for planning activities are defined by the geographic area in which they are expected to be applied, as follows:

- For site-level planning applications, such as the development of a traffic impact study or traffic impact assessment (TIA), estimates of the demand for travel to/from an individual site (land parcel or development) are required. These data are used to project site-level traffic demands for a proposed land development and to recommend short-term improvements to account for the impact of new traffic on adjacent infrastructure. Site-level trip generation data are typically derived from traffic counts obtained at existing sites similar in nature to the proposed site.
- For urban- and regional-level planning applications, such as inputs to the traditional four-step urban transportation planning model, travel demand (productions and attractions) is estimated at the level of a traffic analysis zone (TAZ), which is usually larger than an individual land parcel. These data are used to estimate inter-zonal travel demand for the purposes of programming recommended infrastructure improvements for mid- and long-term transportation plans developed by MPOs. These trip generation data are typically derived from household, work place, or special generator surveys.

The primary source of site-level trip generation data is a database maintained by the Institute of Transportation Engineers and published in the *Trip Generation Manual*, a three-volume report currently in its ninth edition (*37*). ITE maintains a database of site-level trip generation data for 172 unique land uses with data from more than 5,500 studies. While there are some similarities between the two types of trip generation data, there are important distinctions between the data collected for the ITE *Trip Generation Manual* and the data collected as part of a work place or special generator travel survey. This section describes the procedures for collecting trip generation data for inclusion in the ITE trip generation database and compares these procedures to the data collection procedures for Texas work place and special generator surveys. Also included in this section is a set of recommendations on how the Texas work place and special generator survey procedures could be modified to allow for greater compatibility with the needs of the ITE trip generation database.

ITE TRIP GENERATION DATA COLLECTION PROCEDURES

Recommended procedures for collecting trip generation data for inclusion in the ITE trip generation database (and future updates to the *Trip Generation Manual*) are described in the ITE *Trip Generation Handbook,* a companion report to the *Trip Generation Manual*. It is published by ITE and is currently in its second edition (*38*). The *Trip Generation Handbook* also describes procedures for collecting other types of site-level traffic data that are important for the development of TIAs (notably, pass-by trip data and internal trip capture data). As of the ninth edition of the *Trip Generation Manual*, the *Trip Generation Handbook* is also bundled within the *Trip Generation Manual User's Guide*, which is included as Volume 1 of the three-volume set. The handbook is also available as a stand-alone publication. All references in this section to ITE recommended practices or procedures refer to the *Trip Generation Handbook*.

Chapter 4 of the *Trip Generation Handbook*, "Conducting a Trip Generation Study," outlines the procedures for conducting a site-level trip generation study to collect data for inclusion in the ITE trip generation database. The following specific topics are covered:

- Selecting land use/site for the study.
- Selecting a time period for the study.
- Selecting/documenting the independent variables associated with the site.
- Conducting the field data collection.

Selecting Land Use/Site for Study

ITE trip generation data are classified by the land use characteristics of the individual site being studied. The current *Trip Generation Manual* contains trip generation data for 172 different land use types, which ITE terms "land use codes." The manual contains descriptions of the characteristics and features of each LUC. For the purposes of selecting a site for a trip generation study, these descriptions should be compared to the characteristics of the site(s) proposed for the study. Maintaining as much consistency as possible between the characteristics outlined in the ITE LUC description and the characteristics of the site is critical to ensure that the data can be included among the other observations in that LUC. A site should not contain land uses of more than one type of LUC unless a multi-use development data collection is proposed. In addition to satisfying the definition of the ITE land use code, ITE provides the following recommendations in terms of criteria for selecting a site for a trip generation study (*37*, p. 17):

- Occupancy should be reasonably full (i.e., at least 85 percent) for land uses where portion(s) of the site may be constructed but not occupied.
- Development should be mature (i.e., at least two years old) and located in a relatively mature area that demonstrates reasonable economic success.
- Necessary data, traffic data as well as the site characteristics, can be obtained readily and accurately.
- Driveways and other paths used to access the site should be easily defined and not include any cut-through or non-site traffic.
- Site should have minimal to no on-site or adjacent roadway construction.
- Site must be typical of sites in the area with no unusual activities underway.
- Permission should be obtained from the site owner/manager.

The above suggestions reflect an ideal site for a trip generation study that will provide adequate data that are both usable for current needs and transferable for future ITE use.

Selecting Time Period for Study

Site-level planning applications, such as TIAs, are generally concerned with the volume of traffic generated by a proposed site development activity over the course of a peak hour of traffic demand consisting of one or more 60-minute periods throughout an average day. The focus on peak hours of traffic demand corresponds to the analysis approach used for the design of traffic control and other capacity analyses at roadway intersections. The ITE data reflect this approach, and studies typically request and report data for the following time periods of an average day:

- **AM and PM Peak Hour of Adjacent Street Traffic**: Highest hour of traffic demand at a site, between 7:00 a.m. and 9:00 a.m. and between 4:00 p.m. and 6:00 p.m. Corresponds approximately to the typical morning and afternoon rush hour periods.
- **AM and PM Peak Hour of the Generator**: Highest hour of traffic demand at a site during any AM and PM period, not necessarily corresponding to the peak hour of traffic on the street adjacent to the site.
- **Daily**: 24-hour total vehicle count.

Trip generation data for these time periods are reported by ITE for traffic on an average weekday and, in some cases, a typical weekend day. The weekend data tend to be peak hour of generator or daily rates since peak hour of adjacent street traffic is not a concern on weekends. Some land uses will focus on other analysis days, such as Fridays for cinemas and Sundays for churches.

Selecting Independent Variables for ITE Trip Generation

The ITE trip generation data are reported in terms of a trip generation rate per unit of development associated with the site. Development units for a particular LUC are selected based on what characteristics of the site are expected to influence the amount of trips that are generated by the site. In deciding which independent variable to relate to trip generation rates, it is important to select a variable that appears to be a cause for the variation in trip ends generated by a land use (*37*, p. 3). Typical independent variables used to estimate trip generation include:

- Size of building(s) on the site.
- Size of the site/parcel.
- Number of employees at the site.

Other independent variables that have been identified as being influential in the amount of traffic generated by a particular land use include the following:

- Number of students (schools, colleges, universities).
- Number of seats and/or movie screens (cinemas).
- Number of fueling positions (gas stations, convenience stores with gas pumps).
- Number of drive-in lanes (banks).
- Number of rooms (hotels, motels, resorts).
- Number of beds (hospitals, nursing homes).
- Number of flights per day (airports).

ITE also recommends that the underlying independent variable data corresponding to a trip generation study be collected through direct observation or provided by the site owner/manager, rather than derived from secondary sources (*37*, p. 18). Collection of independent variable data should clearly state the independent variable data in terms of overall site characteristics as well as characteristics specific to the site at the time of the study (e.g., the total number of rooms in a hotel and the number of occupied rooms on the day of the study should be documented). Care should be taken by the analyst to document all independent variable data with clear field notes to allow for additional analysis or further interpretation if needed after the study is complete.

Conducting the Trip Generation Study

In terms of the actual day(s) for collecting trip generation data, the ITE recommended practice is to observe site-generated traffic on an average day for a minimum of 24 hours. At a minimum, automatic traffic recorder counts should be obtained through a full 24-hour period, although longer counts of 48 hours to as long as a week provide greater insight into the temporal patterns of site-generated traffic. Manual counts utilizing field data collection personnel observing site-generated traffic may be used to supplement automatic counts and to provide a check against the automatic count data. For special land uses, data collection on Fridays, Saturdays, or Sundays may be necessary. The selection of an average day is left to the discretion of the analyst; ITE recommends avoiding holidays, construction periods, bad weather, or other unusual activities. For instance, trip generation counts should not be made during the summer months in college towns or at retail sites during heavy shopping periods.

ITE provides the following guidelines for conducting a trip generation study:

- Traffic volumes should be counted on a directional basis (i.e., separate counts of entering and exiting trips) by 15-minute periods. Automatic traffic count recorders or manual counts by field data collection personnel may be used for these counts.
- Manual counts may be needed to validate the data from an automatic traffic count recorder. Manual counts may also be used to identify vehicle occupancy.
- If possible, trucks should be counted as a subset of the vehicle trip generation. Manual counts during peak periods should tabulate trucks separately.
- If possible, hourly traffic volume on the streets adjacent to the site should be obtained and reported along with the trip generation data.

ITE provides standardized forms for reporting the results of trip generation studies for inclusion in the ITE trip generation database. These forms, found in the *Trip Generation Manual* and *Trip Generation Handbook*, should be reviewed prior to starting a trip generation study to ensure that all requisite data elements are obtained.

COMPARISON OF ITE DATA COLLECTION AND WP/SG TRAVEL SURVEY PROCEDURES

This section provides a discussion of the similarities and differences between the ITE recommended procedures for collection of trip generation data and the Texas procedures for work place/special generator travel surveys. The issues discussed in this section reflect the different uses of each type of trip generation data within the transportation planning process. Nevertheless, some similarities exist.

Site Selection

The selection of a study site for an ITE trip generation data collection project is based on the adequacy of available sites in terms of (1) compatibility of the site with an ITE LUC, and (2) suitability of the site in terms of the data collection requirements (e.g., isolated driveways with no cut-through traffic). Establishments for the work place and special generator surveys are randomly selected from a list of establishments in the study region by NAICS classification

provided by the Texas Workforce Commission. For both types of studies, some sites that otherwise meet the criteria for inclusion may be rejected due to physical constraints such as issues counting driveways or the refusal of the site management to participate in the study.

Land Use Classification

As mentioned before, ITE has established a system of classification for site-level trip generation data consisting of 172 unique land use codes. In TxDOT practice, the NAICS classification system is used in the work place and special generator travel surveys to classify establishments by employment type (basic, retail, service, or education, among others) and subsequently to calculate trip attraction rates by trip purpose based on these employment types. The use of specific land use codes for ITE trip generation and employment type categories for travel surveys reflects the analysis needs for each study type (i.e., site-level data for trip generation versus data that are more amenable to long-term forecasting for work place surveys).

Type of Data Collected

The primary data collected for an ITE trip generation study are a 24-hour count of vehicle trips or person trips entering and exiting an individual site. The primary data collected for work place/special generator travel surveys in Texas are the surveys of employees and visitors to selected establishments. In addition to the travel surveys, cordon-line counts at work places and special generators are also obtained for these establishments. Vehicle trip counts are collected at freestanding work places and special generators, while person trip counts are collected at non-freestanding work places. Historically, ITE data have been collected in the form of vehicle trips. However, there is a shift toward collecting both vehicle trip and person trip data.

Time Period of Analysis

ITE trip generation data are primarily used for peak hour analyses of the impact of new site-level development on adjacent infrastructure. While ITE recommends collecting trip generation data for an entire 24-hour period, the total 24-hour volume is rarely used in TIAs. Texas work place and special generator surveys provide data on average weekday travel—with no time-of-day disaggregation reported and no consideration given to weekend trips.

Independent Variables

ITE trip generation analysis utilizes a wide variety of independent variables, depending upon the land use considered. In Texas work place surveys, number of employees and number of employees at work on the survey day are generally the only independent variables that are reported—largely because the data are intended to be used in travel demand models. For special generator surveys, additional data (e.g., the number of students for a college or university or square footage for a regional mall) that are more aligned with the independent variable data needs for ITE are collected.

Geographic Scope of Trip Generation Rates

The ITE trip generation database contains data for 172 unique land use codes specifically defined in the *Trip Generation Manual*. The raw data from each site are added to the database as an

individual site with no stratification or weighting applied to the data. In Texas, the trip attraction rates derived from work place and special generator travel surveys are aggregated by area type reflecting CBD, urban, suburban, and rural areas.

Calculation of Trip Generation Rates

The ITE trip generation database contains data for 172 unique land use codes specifically defined in the *Trip Generation Manual*. The raw data from each site are added to the database, and the trip generation rates as a function of one or more independent variable(s) are calculated. The trip attraction rates for Texas work place and special generator surveys are calculated by aggregating each surveyed establishment by area type, employment type, and trip purpose. These differences are most reflective of the different purposes of the two types of trip generation data.

Trip Rate Disaggregation

The trip attraction rates developed for work places and special generators are disaggregated by area type, employment type, and trip purpose. Additional disaggregation may be feasible, such as separating resident and non-resident travel. Except for separating entering/exiting trips, the ITE trip generation data do not reflect any additional disaggregation of trips or site characteristics. Some sites will have truck trip generation collected separately if a large percentage of trucks is expected. There are some mechanisms in place to collect area type data for the ITE database; however, these data are not reported in the *Trip Generation Manual*.

MODIFICATIONS TO WP SURVEY TO COLLECT ITE DATA

The procedures for ITE trip generation studies and the Texas procedures for work place and special generator travel surveys are defined to ensure that the data collection is valid and usable for specific transportation planning applications. However, there are some adjustments that could be made to the Texas procedures for work place and special generator travel surveys that could allow for greater flexibility in terms of using the data collected for ITE trip generation (i.e., site planning) applications. To this end, the following modifications are recommended.

Recommendation 1

The ITE LUC classification system provides greater detail than the NAICS classification system in terms of characterizing the subject land use. In order to utilize the data obtained in work place and special generator surveys for site planning purposes, the ITE LUC for each establishment is needed. Therefore, it is recommended that the ITE LUC for each establishment with a full or partial survey be estimated and reported on the Work Place General Survey Form G and Form A, as appropriate.

Recommendation 2

Trip generation data for site planning typically utilize a greater number of independent variables than trip generation data for travel demand modeling. In order to utilize the data obtained in work place and special generator surveys for site planning purposes, more independent variable data are required from each establishment. Therefore, it is recommended that the initial data

collection for work place and special generator travel surveys include, at a minimum, the following additional independent variable data:

- Size of building(s) at the site (square footage).
- Size of the site (acres).
- Number of parking spaces available at the site.
- Number of servicing positions at the site (e.g., bank teller lanes or fuel pumps).

Additional independent variable data may be needed, and the final recommendations for this project will reflect these needs, as well as an estimate of the time requirements and potential data sources for independent variable data. The Work Place General Survey Form A should be modified to provide a location to document the additional data.

Recommendation 3

The data collection procedures for freestanding work places and special generators include a count of all vehicle trips generated by the establishment during the survey day. These counts are consistent with the type of counts required by ITE for its trip generation studies. However, the current specifications for Texas work place and special generator surveys do not require these counts to be disaggregated by (1) 15-minute periods, and (2) entering and exiting trips. In order to utilize the data obtained in work place and special generator surveys for site planning purposes, it is recommended that the specifications be updated to require greater disaggregation for the vehicle trip counts at surveyed establishments.

4. COMPILATION AND ANALYSIS OF WORK PLACE DATA AND DEVELOPMENT OF GENERIC ATTRACTION RATES

This chapter documents the research and analysis undertaken to build a master data file of work place, employee, and visitor surveys compiled from surveys of work places and special generators conducted in Texas. It also details the methods and procedures used to analyze these data for the development of standardized trip attraction rates. Accordingly, this chapter discusses:

- The development of a comprehensive database of work place surveys and special generators.
- The development and review of area types and density criteria for use in developing attraction rates by area type and density categories.
- The development and review of NAICS employment types used in developing attraction rates.
- Standardization of attraction rates for possible use in Texas travel demand models.
- Variation in attraction rates.

From 1984 to 2012, 32 work place surveys were conducted in the state of Texas. While a few of these were conducted by MPOs, the remaining surveys were conducted by TxDOT with assistance from TTI. The development of a master database of these surveys focused on those conducted from 2003 to 2012 (for the research described in Chapters 3 and 4). While the intention of this development process sought to include all surveys within this time frame, not all are included at this time. Principally, this is due to the excluded surveys not being in final form during the development stages. However, the database structure is developed to allow for those surveys not included and future surveys to be added at the appropriate time.

Table 2 lists the 15 study areas where surveys were conducted and their status for inclusion, and those that are not included. Figure 2 illustrates all Texas MPOs and those study areas included in the database. The terminology "study area/MPO" was used in this project rather than just MPO. Typically, the study area is the boundary of the MPO's travel demand model, which may be larger than the boundaries of the MPO. Additionally, a combined regional travel demand model represents the Brownsville, Hidalgo, and Harlingen–San Benito MPOs. This region is referred to as the Rio Grande Valley.

Table 2. MPO Areas Included in Texas Work Place Survey Master Database.

Year	Study Area/MPO	MPO Name(s)	Included in Master Database	Short Name in Database
2003	Laredo	LUTS	Yes	LAR
2004–2006	Rio Grande Valley	Brownsville, Hidalgo, Harlingen–San Benito MPOs	Yes	LRGV
2005–2006	San Antonio	SABCMPO	Yes	SA
2006–2007	Austin	CAMPO	Yes	AUS
2010	Killen-Temple	KTMPO	Yes	KT
2010	Amarillo	Amarillo MPO	Yes	AML
2010	Beaumont	SETRPC/JOHRTS	Yes	BMT
2010	Lubbock	LMPO	Yes	LUB
2010	Waco	Waco MPO	Yes	WAC
2010–2011	Corpus Christi	Corpus Christi MPO	Yes	CC
2010–2011	El Paso	El Paso MPO	Yes	EP
2010–2011	Victoria	Victoria MPO	No	-
2011	Abilene	Abilene MPO	Yes	ABL
2011	Houston-Galveston	H-GAC	Yes	HG
2011	Wichita Falls	Wichita Falls MPO	Yes	WF
2011–2012	Sherman-Denison	Sherman-Denison MPO	Yes	SD
2012	Texarkana	Texarkana MPO	No	-
2012	Dallas–Fort Worth	NCTCOG	No	-
2012	Bryan–College Station	BCSMPO	No	-

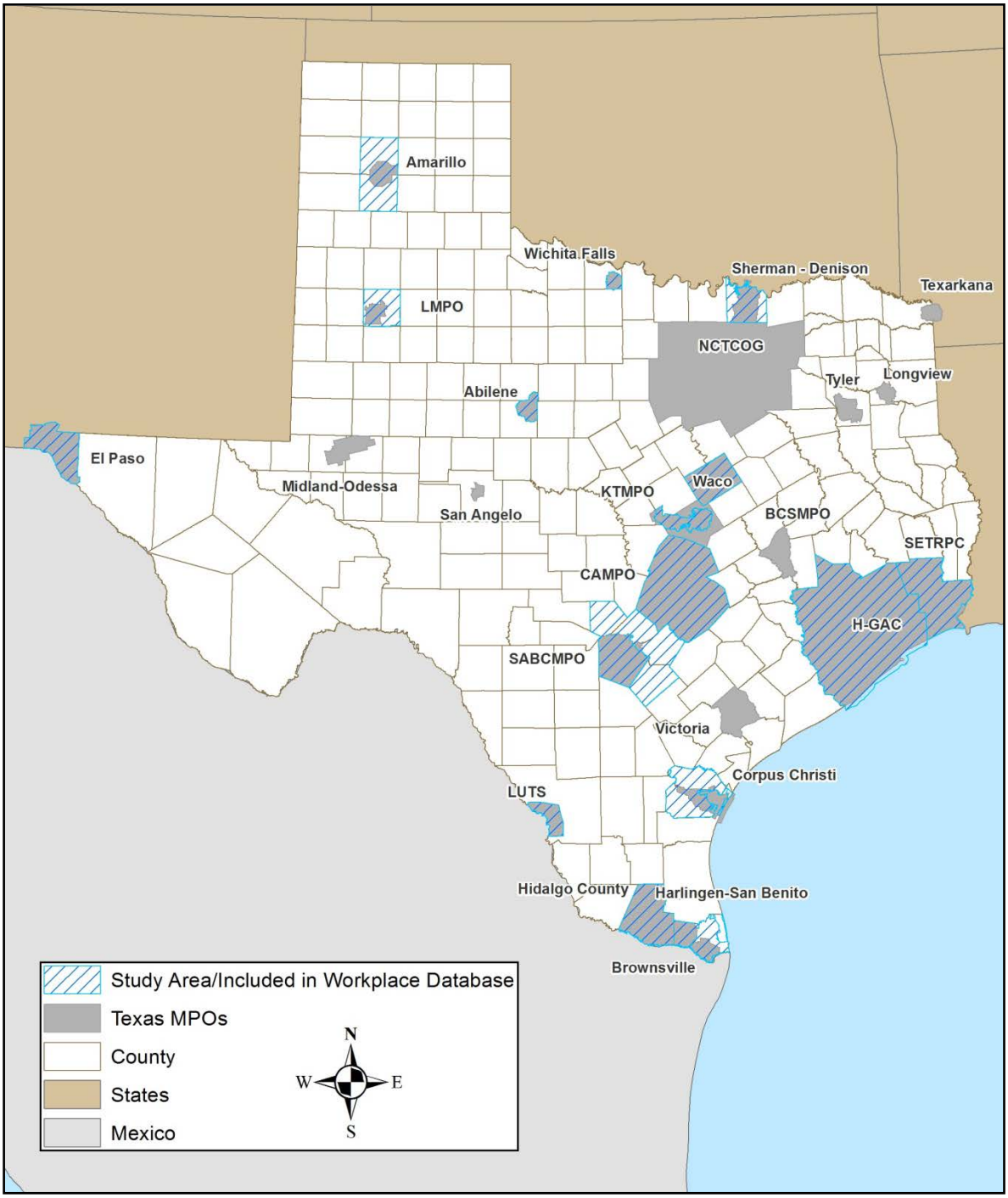

Figure 2. Work Place Survey Study Areas and Texas MPOs.

MASTER DATABASE ASSEMBLY—FORMATS AND VARIABLES

For every work place survey effort, data formats and variables are essentially study area specific. Over time, different research questions have been introduced and removed. Additionally, survey standards prior to 2013 relied on American Standard Code for Information Interchange (ASCII) standards. These standards are used to dictate characters and types on text files used by computing programs. Data files from data collection firms, per standards, were delivered to TxDOT in text file formats that could be easily input into quality control programs developed by TxDOT and TTI. To analyze data in text file format, the researcher must know the variables that are contained in the file, as they often lack field headers, and the position of the variable in the file (e.g., if it begins at 1 character into the file or 50 characters into the file) and the length of the field (e.g., 50 characters in length).

While these protocols are sufficient for the analysis of surveys for a single study area, they pose a challenge for an analysis using all of the data from multiple study areas. Accordingly, the research team inspected each of the 15 work place surveys and developed a common variable structure. In most cases, this common structure necessitated that each variable from the surveys be parsed from its text file, inspected, and aligned with common data from other surveys. After a common data structure was developed, each variable and its accompanying data codes were also combined into a common set.

MASTER DATABASE ASSEMBLY—ESTABLISHMENTS

Methodology

To maximize completeness of the establishment data and streamline analysis thereof, Forms A and G were combined. The research team found much of the data and associated codes for the establishments to be consistent between surveys. Some establishment information was excluded from the final database preparation due to its being inconsistent between surveys or not applicable to the task. These data include:

- Survey area type (this is replaced by area types defined by density ranges based on regional model demographics).
- Establishment employment sector.
- Establishment recruitment data, such as call disposition and number of attempts.

To provide greater flexibility in analysis, the surveyed establishments were augmented with information based on geographic information system (GIS) imputation, along with the addition of unique identifications (IDs) and selection flags. This information includes:

- Establishment ID based on the combination of the original survey ID, the study area, and the year of the survey.
- MPO.
- Establishment county.
- Establishment regional model zone (Note: this was tested against the model zone included in the survey).

- Establishment state area model zone.
- Establishment full or partial survey flag.

Missing Data

Throughout the work place surveys, missing data or data outside of the study area were either assigned a code or left blank. To create an easily recognizable flag (or warning), missing data were assigned a generic code of 99999.

Establishment Types

During initial data collection, work places were asked whether or not they wished to participate. At this time, they were given the option to decline participation, fully participate, or partially participate. Those that wished to fully participate had employees and visitors surveyed, provided detailed data of the establishment, and had vehicle or person counts performed at the site on the day of the survey. Those that wished to partially participate provided some data about the establishment and had either vehicle or person counts performed at the site.

Additionally, researchers identified establishment special generators and added a group flag. Special generators included in the database are listed in Table 3 with their assigned group.

Table 3. Work Place Survey Special Generators.

Special Generator Site ID	Special Generator Name	Special Generator Study Area/ MPO	Special Generator Type
ABL_8001_2011	Dyess AFB	ABL	SPG_Military
ABL_8002_2011	Abilene Christian University	ABL	SPG_University
ABL_8003_2011	Hendrick Health Center	ABL	SPG_Hospital
ABL_8004_2011	Abilene Mall	ABL	SPG_Mall
AML_10000_2009	Amarillo Airport	AML	SPG_Air
BMT_7000_2011	Southeast Texas Regional Airport	BMT	SPG_Air
BMT_7001_2011	Hardin Port of Beaumont	BMT	SPG_Port
BMT_7002_2011	Hardin Memorial Hospital	BMT	SPG_Hospital
BMT_7003_2011	Hardin Parkdale Mall	BMT	SPG_Mall
CC_15001_2010	International Airport	CC	SPG_Air
CC_15002_2010	Spohn Hospital South	CC	SPG_Hospital
CC_15003_2010	Del Mar College	CC	SPG_University
CC_15004_2010	Aquarium	CC	SPG_Other
CC_15005_2010	Spohn Memorial Hospital	CC	SPG_Hospital
CC_15006_2010	Lexington	CC	SPG_Other
EP_3_2010	Cielo Vista Mall	EP	SPG_Mall
EP_4_2010	University Texas El Paso	EP	SPG_University
EP_5_2010	Fort Bliss	EP	SPG_Military
HG_85002_2010	Port of Freeport	HG	SPG_Port

Table 3. Work Place Survey Special Generators (Continued).

Special Generator Site ID	Special Generator Name	Special Generator Study Area/ MPO	Special Generator Type
HG_85003_2010	Hobby Airport	HG	SPG_Air
HG_85004_2010	University of Houston	HG	SPG_University
HG_85005_2010	George Bush Intercontinental Airport	HG	SPG_Air
KT_10_2010	Fort Hood/Killeen Regional Airport	KT	SPG_Air
KT_11_2010	Killeen Mall KTUTS	KT	SPG_Mall
KT_12_2010	Metroplex Hospital KTUTS	KT	SPG_Hospital
KT_7_2010	Mary Hardin Baylor University	KT	SPG_University
KT_8_2010	Central Texas College Main Campus	KT	SPG_University
KT_9_2010	Temple Junior College	KT	SPG_University
LUB_20000_2009	Lubbock Airport	LUB	SPG_Air
LUB_30000_2009	Texas Tech University	LUB	SPG_University
SD_301_2011	Grayson County College	SD	SPG_University
SD_302_2011	Texoma Medical Center	SD	SPG_Hospital
SD_303_2011	Texas Health Presbyterian–WNJ	SD	SPG_Hospital
SD_304_2011	Austin College	SD	SPG_University
SD_305_2011	Sherman Town Center	SD	SPG_Mall
WAC_1_2010	Baylor University	WAC	SPG_University
WF_6000_2011	Midwestern State University	WF	SPG_University
WF_7000_2011	Sikes Senter Mall	WF	SPG_Mall
WF_8000_2011	United Regional Health Center	WF	SPG_Hospital

Establishment Employment Types

Each establishment in the survey was assigned an employment type. Employment types were aggregations of many types of work places into condensed common types. Traditionally, these types include basic, service, retail, and education, with each representing different trip generation intensities and trip-making behavior. The assignment of these types is conducted using NAICS codes. In the case of the Laredo and Rio Grande Valley surveys, this conversion was accomplished using the standard coding system prior to NAICS, the Standard Industrial Classification System codes. Over the years, however, the assignment process has been refined. Additionally, some study areas have had divergent employment type categories from other areas. To ensure that all establishments across all employment types were defined by a common coding system, each employment was reassigned based on Table 4.

Table 4. NAICS Groupings by Employment Type.

Employment Type	NAICS Code	Industry Group
Basic	11	Agriculture, Forestry, Fishing and Hunting
	21	Mining, Quarrying, and Oil and Gas Extraction
	22	Utilities
	23	Construction
	31–33	Manufacturing
	42	Wholesale Trade
	48–49	Transportation and Warehousing (except 491)
	5111	Newspaper Publishers/Book Publishers/Directory Publishers
	5112	Software Publishers
	512	Motion Picture and Sound Recording (except 51213)
	5151	Radio and TV Broadcasting
	5152	TW Cable
	5173	Telecommunications Resellers
	5174	Satellite Network
	5175	Cable and Other Program Distribution
Retail	44–45	Retail
	51213	Motion Picture Theaters
	71	Arts, Entertainment, and Recreation
	722	Food Service and Drinking Places
	491	Post Offices
Service	516–5172	Internet Publishing and Telecommunications
	5179	Other Telecommunications
	518–519	Internet Service Providers and New Syndicates
	52	Finance and Insurance
	53	Real Estate and Rental and Leasing
	54	Professional, Scientific, and Technical Services
	55–56	Company Management and Administrative Support
	6114–6116	Business, Technical Trade, and Other Schools
	6117	Educational Support Services
	62	Health Care and Social Assistance (including hospitals)
	721	Accommodations (hotels)
	81	Other Service, Repair, and Maintenance
	92	Public Administration (including Justice, Public Order, and Safety)
	9999	Unknown
Education	6111	Elementary and Secondary Schools
	6112–6113	Jr. Colleges, Colleges, Universities, and Professional Schools

*Laredo and the Lower Rio Grande Valley were converted from SIC to NAICS prior to assignment.

Work Place Survey Establishment Database Results

The final establishment database includes 5,147 work places surveyed over a 13-year period. Table 5 lists the total work places included in the master database by partial and full. The results of the employment type assignment are provided in Table 6. The geographic dispersion of all establishments surveyed is displayed in Figure 3.

Table 5. Work Place Surveys in Database.

Study Area/MPO	Full Survey Work Place	Partial Survey Work Place	Total Establishments
Abilene	229	175	404
Amarillo	119	186	305
Capital Area (Austin)	80	129	209
Corpus Christi	118	187	305
El Paso	215	215	430
Houston-Galveston Area Council	303	301	604
Jefferson-Orange-Hardin Counties	223	282	505
Killeen-Temple	96	165	261
Laredo	101	222	323
Lubbock	114	197	311
Rio Grande Valley	101	201	302
San Antonio	41	125	166
Sherman-Denison	155	150	305
Waco	104	202	306
Wichita Falls	206	198	404
Total	**2,205**	**2,935**	**5,140**

Table 6. Work Place Survey Establishments by MPO and Employment Type.

Study Area/MPO	Basic	Service	Retail	Education	Special Generator	Total Establishments
Abilene	60	152	142	46	4	404
Amarillo	55	100	100	49	1	305
Austin	50	84	58	17	-	209
Beaumont	50	99	101	51	4	305
Corpus Christi	68	155	138	63	6	430
El Paso	92	211	211	87	3	604
Houston-Galveston	60	244	102	95	4	505
Killeen-Temple	35	94	79	47	6	261
Laredo	83	98	142	-	-	323
Lubbock	54	97	104	54	2	311
Rio Grande Valley	35	130	130	7	-	302
San Antonio	65	59	18	24	-	166
Sherman-Denison	50	119	101	30	5	305
Waco	51	105	103	46	1	306
Wichita Falls	57	147	144	53	3	404
Total	**865**	**1,894**	**1,673**	**669**	**39**	**5,140**

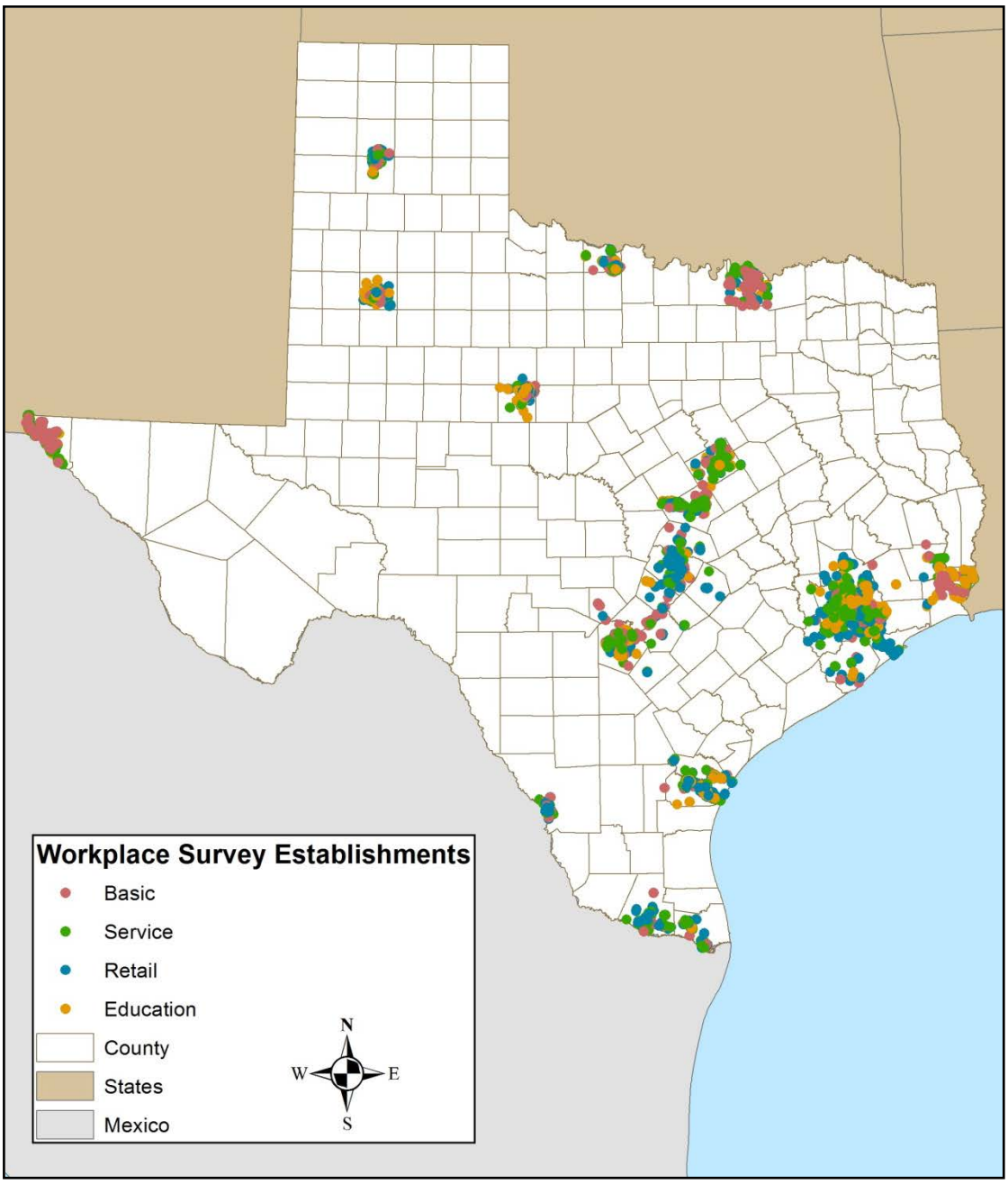

Figure 3. Texas Work Place Survey Establishments, 2003–2012.

MASTER DATABASE ASSEMBLY—INTERCEPT SURVEYS

Methodology

The compilation of the intercept surveys for the master work place survey database was accomplished by combining Forms B and C along with the Special Generator Form B. To ensure the integrity of the data, each survey effort underwent detailed review of underlying assumptions and accompanying data codes. The result of this review indicated that major components of the intercept surveys would need to be recoded so that they would coalesce.

Work Place Intercept Surveys—Austin, San Antonio, Laredo, and the Lower Rio Grande Valley

Employee surveys for Austin, San Antonio, Laredo, and the Rio Grande Valley represented a special case. The employee surveys for these study areas were divided into two forms, one representing demographic/residency data and the other representing multiple trips. For all other study areas, employees of an establishment were interviewed in a similar fashion to visitors. To compensate, the researchers combined Forms B1 and B2 to form a survey record similar to the visitor survey record. This process assumed that:

- The origin immediately prior to the employee's work place was the *origin*.
- The destination immediately following the employee's work place was the *destination*.

Work Place Intercept Surveys—IDs

Each survey in the data set was assigned two IDs—a unique ID (cid) for the survey and an establishment ID (e_id_t). The unique ID was assigned at the original survey level prior to the assembly of the database. This ID allows for a way to tie back any given survey to its original set prior to any editing. The establishment ID allows the survey to be joined to its corresponding establishment during analysis.

Missing Data

Throughout the work place surveys, missing data or data outside of the study area were either assigned a code or left blank. To create an easily recognizable flag (or warning), missing data were assigned a generic code of 99999.

Work Place Intercept Surveys—Data Recoding

The bulk of the effort to develop the master database was spent on sorting, processing, and recoding variables from individual surveys. This procedure was necessary so that the variables from all of the intercept surveys would be common and analysis would thus be consistent.

County of Origin, Destination, and Residence

A major component of this effort was identifying the origin, destination, and residence counties for every intercept survey. The reason for this effort is that each survey effort was considered unique. Accordingly, origin and destination county codes used for each effort were assigned codes 1, 2, 3…, which then corresponded to a county in the region. For example, the Houston-Galveston survey used code 1 for Brazoria County, while the Corpus Christi survey used 1 for Nueces County. When combined into one data set, these codes would be in conflict. To compensate, a look-up table was developed that converted all of the codes from each survey into Federal Information Processing Standard (FIPS) codes. The FIPS code is standard code maintained by the National Institute of Standards and Technology. Although FIPS has a granularity down to the geographic census block level, the important set here is the state and county level. The FIPS code for Texas is 48, and the county code begins with 001 for Anderson County and proceeds at odd-numbered intervals to 507 for Zavala County.

In addition to this conversion process, it was found that many of the county codes were missing, not assigned, or not assigned because they were out of the regional model area. To compensate for this, the research team geographically processed, using GIS technology, the known coordinates of the surveyed persons' residence, origin, and destination to obtain the associated county of the coordinate. Additionally, when no coordinate data were present, the location textual address was inspected to see if its county or state could be discerned.

The final part of this task was the assignment of the final FIPS code for each residence, origin, and destination. In some cases researchers noticed that the county they obtained using GIS did not match the stated response county. In these cases, and to not deviate from past analysis efforts, it was always assumed that the stated response was correct. Finally, residences, origins, and destinations outside of Texas were coded to the state FIPS if in the United States, "MX" if Mexico, "OT" if other country not Mexico, and "NA" if absolutely not known.

Residence counties were similarly processed. However, the survey data do not provide residence county explicitly but rather the "name of city, county, or country where the person lives." Accordingly, a look-up table was developed that converted the residence data to FIPS codes for state and county. Furthermore, the survey data do not provide the county in which the home of the person being surveyed is located. To compensate, the home county was developed with GIS techniques using the home coordinates. Using both pieces of data, a final residence county FIPS code was imputed.

Residence Codes

Recoding of the residence county codes and imputation of missing data necessitated that the residence code for each survey be revisited. The residence code in the survey data is the indicator of whether or not the person being surveyed is a resident of the study area. As previously noted, typically the study area is the boundary of the MPO's travel demand model, which may be larger than the boundaries of the MPO. This indicator has an important impact on the eventual calculation of trip attraction rates. To check the residency codes, the counties contained by each survey study area were input into a look-up table. However not all study areas were entirely contiguous with the counties in which they reside. Furthermore, some work place survey efforts captured work places not contained in the study area. This was the case for Wichita Falls and Abilene, which surveyed 57 and 33 work places outside of the study area, respectively. Table 7 lists the county-based assignment of residency codes by study area.

Table 7. Study Area/MPO to Residence County Assignments.

Study Area/MPO	FIPS	County
Abilene	48253	Jones
	48441	Taylor
Amarillo	48375	Potter
	48381	Randall
Austin	48021	Bastrop
	48055	Caldwell
	48209	Hays
	48453	Travis
	48491	Williamson
Beaumont	48199	Hardin
	48245	Jefferson
	48361	Orange
Corpus Christi	48355	Nueces
	48409	San Patricio
El Paso	48141	El Paso
Houston-Galveston	48039	Brazoria
	48071	Chambers
	48157	Fort Bend
	48167	Galveston
	48201	Harris
	48291	Liberty
	48339	Montgomery
	48473	Waller
Killeen-Temple	NA	Used Original Residence Codes
Laredo	48479	Webb
Rio Grande Valley	48061	Cameron
	48215	Hidalgo
Lubbock	48303	Lubbock
San Antonio	48029	Bexar
	48091	Comal
	48187	Guadalupe
	48259	Kendall
	48493	Wilson
Sherman-Denison	48181	Grayson
Waco	48309	McLennan
Wichita Falls	48485	Wichita

Trip Purposes

Each person surveyed is asked to provide the purpose of their trip to the establishment. Generally, the person being surveyed is given a choice from a list of trip purposes. Examples include a work-related trip, a school-related trip, etc. There are 13 possible trip purposes utilized in the TxDOT work place survey program. For each survey, trip purposes are assigned a numeric code.

Due to the differing needs of the modeling program, these codes, including trip purpose type, are not consistent throughout all work place surveys. The research team found 68 different combinations of trip purpose codes when all the trip purposes and codes from each survey effort were grouped together in one set. Accordingly, the researchers sought to normalize all the trip purposes into a common coding scheme. This was accomplished by using a look-up table of trip purposes for each study area and assigning each purpose to a common code. Additionally, while these trip purposes could allow for greater stratification of trip purpose for use in transportation demand modeling, they are generally utilized to decide if the trip purpose is work related or not work related. Table 8 lists the normalized trip purposes, purpose codes, and whether or not the purpose is work related.

Table 8. Normalized Trip Purpose Codes.

Normalized Purpose Code	Normalized Purpose Definition	Trip Purpose Flag	Flag Definition
1	Return Home	2	Not Work Related
2	Work Related	1	Work Related
3	School Related	2	Not Work Related
4	Social/Recreational/Visit	2	Not Work Related
5	Shop	2	Not Work Related
6	Eat Out	2	Not Work Related
7	Personal Business	2	Not Work Related
8	Pickup/Drop-Off Passenger	2	Not Work Related
9	Change Travel Mode	2	Not Work Related
10	Delivery—Pickup/Drop-Off	2	Not Work Related
11	Other	2	Not Work Related
12	Go to Work	1	Work Related
99	No Response	99	Not Work Related

In addition to normalizing the trip purpose codes, the purpose "Other" was extracted from the surveys. The purposes listed as "Other" were reviewed to ascertain if, in fact, they could be assigned to one of the normalized codes. About 566 trip purposes were recovered this way.

Arrival and Departure Modes

Similar to the trip purposes, mode codes, including the number of possible modes, are not consistent throughout all the work place surveys. The research team found 70 different combinations of modes and codes when all of the survey efforts were grouped in one set. Accordingly, the research team sought to normalize all the travel modes into a common coding scheme. This was accomplished by using a look-up table of travel modes for each study area and assigning each purpose to a common code. Table 9 lists the normalized travel modes.

Table 9. Normalized Travel Mode Codes.

New Travel Mode Code	Definition
1	Driver (car/truck/van)
2	Passenger (car/truck/van)
3	Walk
4	Bicycle
5	Bus/Public Transportation
6	School Bus
7	Taxi/Limo
8	Commercial Cargo Transport Vehicle
9	Motorcycle
10	Other
11	Airplane
12	Hotel/Motel Shuttle Bus/Van
13	Other Parking Shuttle
99999	No Response
99999	Unknown

Work Place Survey Intercept Database Results

The final intercept survey database includes 83,750 surveys collected over an 11-year period. Table 10 and Table 11 provide breakouts of this total by employees/visitors surveyed and by employment type, respectively. Figure 4 illustrates the geographic dispersion of the origin, destination, and intercept point of the surveys.

Table 10. Total Intercept Surveys in Database by Employee/Visitor.

Study Area/MPO	Employees	Visitors	Total Surveys
Abilene	4,102	6,425	10,527
Amarillo	2,154	2,956	5,110
Austin	805	2,325	3,130
Beaumont	1,340	2,247	3,587
Corpus Christi	1,193	2,627	3,820
El Paso	3,552	7,893	11,445
Houston-Galveston	2,827	4,867	7,694
Killeen-Temple	1,695	4,385	6,080
Laredo	325	2,792	3,117
Lubbock	1,534	2,735	4,269
Rio Grande Valley	269	2,650	2,919
San Antonio	328	502	830
Sherman-Denison	1,555	3,858	5,413
Waco	1,159	2,657	3,816
Wichita Falls	3,576	8,417	11,993
Total	**26,414**	**57,336**	**83,750**

Table 11. Total Intercept Surveys in Database by Employment Type.

Study Area/MPO	Basic	Service	Retail	Education	Special Generators	Total
Abilene	593	1,369	3,095	2,073	3,397	10,527
Amarillo	708	934	2,167	1,131	170	5,110
Austin	387	1,079	1,559	105	-	3,130
Beaumont	201	324	1,070	462	1,530	3,587
Corpus Christi	254	737	1,200	474	1,155	3,820
El Paso	707	1,640	5,036	1,782	2,280	11,445
Houston-Galveston	226	1,478	1,867	1,185	2,938	7,694
Killeen-Temple	294	478	1,840	800	2,668	6,080
Laredo	323	462	2,332	-	-	3,117
Lubbock	213	453	1,692	1,055	856	4,269
Rio Grande Valley	276	597	1,980	66	-	2,919
San Antonio	308	297	206	19	-	830
Sherman-Denison	176	757	2,108	312	2,060	5,413
Waco	299	696	1,933	645	243	3,816
Wichita Falls	593	1,599	4,474	2,363	2,964	11,993
Total	**5,558**	**12,900**	**32,559**	**12,472**	**20,261**	**83,750**

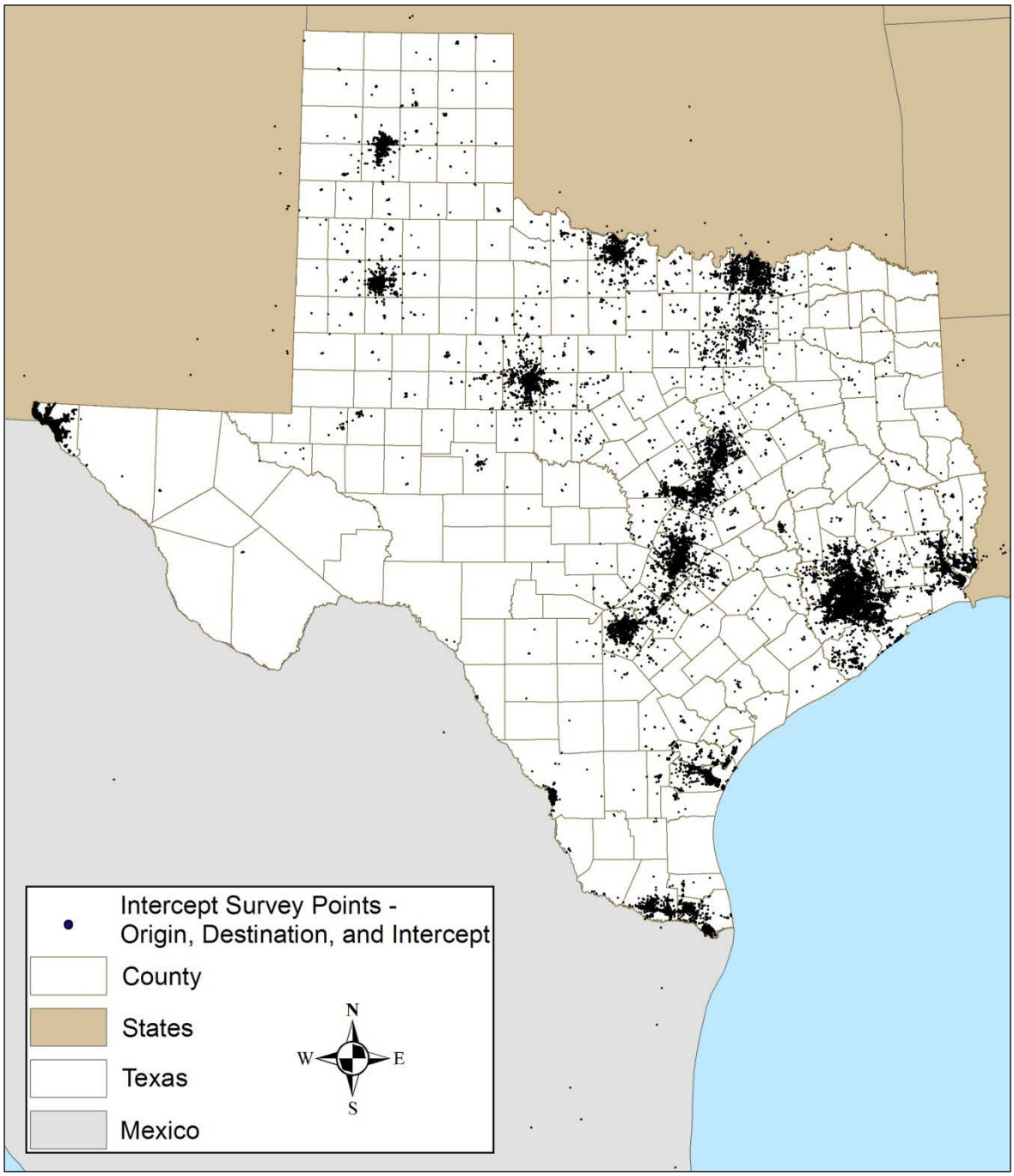

Figure 4. Texas Work Place Intercept Surveys 2003–2012.

DEVELOPMENT OF ESTABLISHMENT STUDY GROUPINGS AND MODEL AREA TYPES

The research team developed unified study area groupings and population/employment density categories (area types) in order to (1) assess the variability of trip attraction rates for a given study area and between study areas, (2) create a larger sample pool, and (3) test/develop generic trip attraction rates. The development of a robust data set based on these groupings has been a long-term goal of researchers (*25*).

Establishment Study Area Types

The work place survey efforts included in the database represent data from regions of varying population size and economic activity. Table 12 provides each study area's 2010 US Census population and geographic area in square miles.

Table 12. Study Area/MPO 2010 Population and Area.

Study Area/MPO	Area (Square Miles)	2010 Population
Abilene	266	125,229
Amarillo	348	216,490
Austin	2,840	1,603,952
Corpus Christi	538	328,116
El Paso	1,240	853,190
Houston-Galveston	8,466	5,892,002
Killeen-Temple	555	348,556
Laredo	421	243,978
Lubbock	193	245,161
San Antonio	1,287	1,763,463
Sherman-Denison	320	86,830
Beaumont	2,229	388,746
Waco	1,061	234,906
Wichita Falls	153	108,311
Rio Grande Valley (Brownsville, Hidalgo, Harlingen–San Benito MPOs)	1,615	1,152,101

Source: (*39*)

For the initial stages of this study, the research team grouped each of these areas into four categories based on total population. To maximize comparability with historic research and generic trip attraction rates, these four groupings are based on those presented in NCHRP Report 365, "Travel Demand Estimation Techniques for Urban Planning."

These categories and associated study area/MPOs include:

- Urban Area Population 50,000–199,999, herein termed Small:
  - Abilene.
  - Sherman-Denison.
  - Wichita Falls.
- Urban Area Population 200,000–499,999, herein termed Medium:
  - Beaumont.
  - Killeen-Temple.
  - Corpus Christi.
  - Lubbock.

    - Laredo.
    - Waco.
    - Amarillo.
- Urban Area Population 500,000–1,199,999, herein termed Large:
    - Rio Grande Valley.
    - El Paso.
- Urban Area Population 1,200,000, herein termed Metropolis:
    - Houston-Galveston.
    - San Antonio.
    - Austin.

Establishment Area Types

Previous research tasks (see Chapter 1 and Chapter 2) have documented the purpose and use of *area types* in Texas travel demand models and similar models elsewhere. As noted in Chapter 2, area type can be defined based on population and employment density (*25*). However, how area type is defined and used in different urban areas has not been consistent. Typically, area types are defined by travel demand model developers to be used in the models and supplied to survey researchers for production/attraction rate development. Area types and general density breaks include:

- Central Business District—typically a historical boundary but can also be 50 persons/employees per acre and greater.
- CBD Fringe—greater than 15 persons/employees per acre but less than 50.
- Urban—greater than 10 persons/employees per acre but less than or equal to 15.
- Suburban—greater than 1 person/employee per acre but less than or equal to 10.
- Rural—less than or equal to 1 person/employee per acre.

For a number of reasons, area types may be defined on other criteria besides employment/population densities, or be based on different density breaks. These include:

- The need to keep model roadway link speeds consistent.
- Local characteristics.
- Central business districts being based on historical boundaries rather than employment/population densities.

To maintain a consistent definition of area types, the research team obtained all available demographic and traffic analysis zone data from TxDOT for the applicable year of the survey. Demographic data for Killeen-Temple, Laredo, and Waco were not available. To compensate for the lack of demographic data in these areas, the research team utilized demographic data from the SAM v2 model.

In addition, demographic data from SAM v2 were used to establish area types of establishments not in a study area (e.g., Wichita Falls and Abilene). It is recognized that the SAM v2 data are much coarser than those contained in the models for individual study areas and that SAM v2 data differ from the base year of these models. Accordingly, it is recommended that when demographic data are available, the analysis be updated.

The methodology and definition used in the development of establishment area type are provided below.

Density Factors Method A—Individual TAZs

Method A population and employment density factors necessary to develop area types can be calculated using the following procedures (terms are in brackets).

1. Calculate the total population [TP] and the total employment [TE] for all TAZs.
2. Calculate a normalization factor [NF] by dividing TP/TE. The normalization factor is computed because employment for a given region is typically less than the population. The normalization factor is used to bring the employment into a 1-to-1 relationship with the population. Otherwise, population centers may look denser than employment centers.
3. Calculate the density factor [DF] using the population of a zone [p], the employment of a zone [e], the normalization factor [NF], and the acres of the zone [A]. The calculation then is $(p+(e\times NF))/A=DF$.

In reality, this method often leaves gaps, or areas within highly dense areas that appear less dense, between similar areas. This can occur when a TAZ contains a large park or other type of undeveloped parcel. To compensate for this, the research team used a methodology recommended by the TxDOT and TTI travel demand model research team. This method is presented as follows.

Density Factors Method B—Individual + Surrounding TAZs

Method B population and employment density factors necessary to develop area types can be calculated using the following procedure (terms are in brackets).

1. Calculate the total population [TP] and the total employment [TE] for all TAZs.
2. Calculate a normalization factor [NF] by dividing TP/TE. The normalization factor is computed because employment for a given region is typically less than the population. The normalization factor is used to bring the employment into a 1-to-1 relationship with the population. Otherwise, population centers may look denser than employment centers.
3. Calculate the composite density factor [CDF] using the population of a zone + the population of all surrounding zones [ps], the employment of a zone + the employment of all surrounding zones [es], the normalization factor [NF], and the acres of the zone + the acres of all surrounding zones [AS]. The calculation then is $(ps+(es\times NF))/AS=CDF$.

Using the methodologies presented, each establishment in the work place survey database was assigned a density factor based on the assigned TAZ and study area. Table 13 describes the number of establishments in each area type by study area/MPO. Figure 5 illustrates population employment densities throughout Texas.

Table 13. Study Area/MPO Establishments by Density Category.

Study Area/MPO	Total Establishments by Density Category						Total
	≥0,<1	≥1,<10	≥10,<15	≥15,<50	≥50	SPG	
Abilene	60	229	72	39	-	4	404
Amarillo	32	145	86	34	7	1	305
Austin	28	78	23	67	13	-	209
Beaumont	71	168	25	37	-	4	305
Corpus Christi	56	172	82	109	5	6	430
El Paso	28	214	148	190	21	3	604
Houston-Galveston	58	220	82	126	15	4	505
Killeen-Temple	74	181	-	-	-	6	261
Laredo	118	4	35	166	-	-	323
Lubbock	36	125	98	50	-	2	311
Rio Grande Valley	11	116	65	110	-	-	302
San Antonio	12	55	48	46	5	-	166
Sherman-Denison	119	143	32	6	-	5	305
Waco	82	159	47	17	-	1	306
Wichita Falls	82	312	4	3	-	3	404
Total	**867**	**2,321**	**847**	**1,000**	**66**	**39**	**5,140**

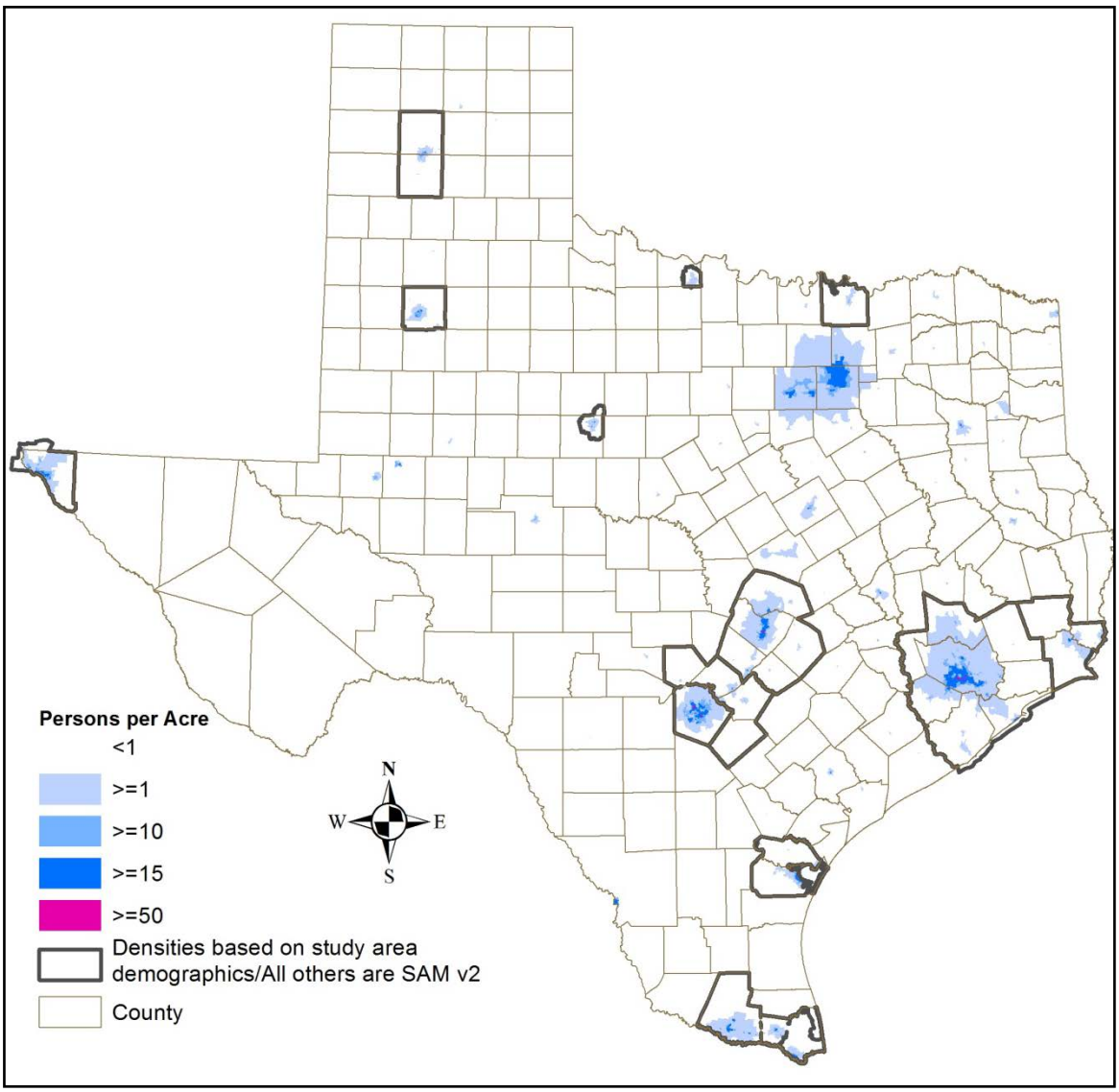

Figure 5. Texas Population/Employment Density Distribution.

DEVELOPMENT OF TRIP PURPOSES FOR ATTRACTION RATES AND ATTRIBUTION OF TRIP LENGTHS/TIMES

Translating trip purposes consistent with travel demand models from those obtained from a survey is a relatively straightforward process. However, due to the varying needs of different study areas/MPOs, trip purposes used to model travel behavior vary. To develop and assess generalized rates, the research team defined trip purposes based on data needs for a generic travel demand model.

In addition to the development of travel demand model trip purposes, the research team also attributed trip lengths and trip times to each survey. The attribution of this information was not a specific focus of the research. However, since the majority of the work necessary to obtain this information was being conducted, the researchers felt that it would be prudent to collect this information.

Travel Demand Model Trip Purposes for Attraction Rates

The surveyed trip purposes were classified according to the following trip categories and were distinguished between those made by residents and non-residents of each study area/MPO.

- **Home-based work (HBW)**—when the purpose was work related, the origin or destination was the home, and the origin or destination was located within the study area.
- **Home-based non-work (HBNW)**—when the purpose was not work related, the origin or destination was the home, and the origin or destination was located within the study area.
- **Non–home-based destination (NHB-D)**—when the origin was not the home, the destination was the establishment being surveyed, and the origin was located within the study area.
- **Non–home-based origin (NHB-O)**—when the reported destination when leaving the establishment being surveyed was not the home, and the destination was located within the study area.
- **External trip origin (EXT-O)**—when the origin was outside the study area.
- **External trip destination (EXT-D)**—when the destination was outside the study area when leaving the establishment.

For each trip purpose, travel demand model trip attraction rates are derived. Attraction rates are model inputs that represent total daily travel to and from a geographic area (i.e., TAZ) as represented by total employment by employment type. Table 14 shows the distribution of resident and non-resident trips at the surveyed establishments by trip purpose for auto-driver trips. Table 15 shows the distribution of resident and non-resident trips at the surveyed establishments by trip purpose for person trips.

Table 14. Total Unexpanded Auto-Driver Trips by Purpose, by Resident/Visitor.

Study Area/MPO	HBW	HBNW	NHB_D	NHB_O	EXT_O	EXT_D	Total
Resident Auto-Driver Unexpanded Trips*							
Abilene	3,579	3,914	1,899	2,290	47	75	11,804
Amarillo	3,110	2,818	1,210	1,428	77	73	8,716
Austin	1,170	2,231	714	972	37	25	5,149
Beaumont	1,103	1,808	271	394	3	3	3,582
Corpus Christi	1,114	1,834	670	844	7	17	4,486
El Paso	4,063	7,629	1,084	2,156	7	19	14,958
Houston-Galveston	3,049	3,976	532	839	6	8	8,410
Killeen-Temple	1,799	3,234	280	595	6	14	5,928
Laredo	458	6	608	760	1,269	1,136	4,237
Lubbock	1,980	1,845	765	1,004	11	26	5,631
Rio Grande Valley	471	3,010	490	665	3	17	4,656
San Antonio	576	563	123	156	8	12	1,438
Sherman-Dennison	1,325	3,145	501	728	308	314	6,321
Waco	1,663	3,429	505	732	7	16	6,352
Wichita Falls	3,549	6,920	1,825	2,186	51	74	14,605
Total Resident	**29,009**	**46,362**	**11,477**	**15,749**	**1,847**	**1,829**	**106,273**
Non-Resident Auto-Driver Unexpanded Trips*							
Abilene	2	15	182	248	416	339	1,202
Amarillo	-	-	60	80	228	208	576
Austin	8	-	33	79	103	49	272
Beaumont	1	-	12	15	56	54	138
Corpus Christi	2	4	39	53	81	71	250
El Paso	-	-	55	114	274	215	658
Houston-Galveston	7	1	10	19	49	40	126
Killeen-Temple	2	-	42	74	262	230	610
Laredo	-	-	138	181	338	295	952
Lubbock	-	3	69	101	157	126	456
Rio Grande Valley	5	7	45	60	97	86	300
San Antonio	13	-	2	12	31	8	66
Sherman-Dennison	2	4	-	-	2	2	10
Waco	-	7	50	47	213	215	532
Wichita Falls	-	2	169	194	491	466	1,322
Total Non-Resident	**42**	**43**	**906**	**1,277**	**2,798**	**2,404**	**7,470**
Grand Total	**29,051**	**46,405**	**12,383**	**17,026**	**4,645**	**4,233**	**113,743**

*Excludes trips to special generators, excluded establishments, and non-freestanding establishments that are not the first store visited.

Table 15. Total Unexpanded Person Trips by Purpose, by Resident/Visitor.

Study Area/MPO	HBW	HBNW	NHB_D	NHB_O	EXT_O	EXT_D	Total
Resident Person Unexpanded Trips*							
Abilene	3,820	4,236	2,077	2,476	49	80	12,738
Amarillo	3,249	3,001	1,285	1,499	79	81	9,194
Austin	1,276	2,400	786	1,067	41	28	5,598
Beaumont	1,162	1,991	309	434	3	4	3,903
Corpus Christi	1,236	2,029	738	925	7	17	4,952
El Paso	4,372	8,763	1,283	2,426	9	19	16,872
Houston-Galveston	3,266	4,509	585	913	6	11	9,290
Killeen-Temple	1,874	3,354	292	614	6	14	6,154
Laredo	476	7	662	811	1,394	1,262	4,612
Lubbock	2,112	2,054	844	1,104	12	26	6,152
Rio Grande Valley	511	3,516	565	766	3	17	5,378
San Antonio	645	612	132	167	8	12	1,576
Sherman-Dennison	1,361	3,305	536	772	332	332	6,638
Waco	1,705	3,532	529	760	7	17	6,550
Wichita Falls	3,839	7,871	2,067	2,458	65	86	16,386
Total Resident	**30,904**	**51,180**	**12,690**	**17,192**	**2,021**	**2,006**	**115,993**
Non-Resident Person Unexpanded Trips*							
Abilene	3	17	206	282	480	390	1,378
Amarillo	-	-	64	87	256	233	640
Austin	10	1	55	113	134	67	380
Beaumont	1	-	15	15	62	63	156
Corpus Christi	2	4	46	64	95	81	292
El Paso	-	1	83	197	433	320	1,034
Houston-Galveston	7	1	16	24	56	48	152
Killeen-Temple	2	-	47	79	269	237	634
Laredo	-	-	161	231	418	348	1,158
Lubbock	-	3	94	126	173	142	538
Rio Grande Valley	5	9	63	80	118	107	382
San Antonio	13	-	2	12	32	9	68
Sherman-Dennison	2	4	-	-	2	2	10
Waco	-	7	53	51	218	221	550
Wichita Falls	-	2	205	243	562	524	1,536
Total Non-Resident	**45**	**49**	**1,110**	**1,604**	**3,308**	**2,792**	**8,908**
Grand Total	**30,949**	**51,229**	**13,800**	**18,796**	**5,329**	**4,798**	**124,901**

*Excludes special generator, excluded establishments, and non-freestanding establishments that are not the first store visited.

Trip Length and Trip Times

The research team attributed trip lengths and trip times to each survey in the master work place survey database. These trip lengths and time are for the following trip segments:

- Home to origin if home was not the trip origin.
- Origin to establishment.
- Establishment to destination.

The attribution of this information utilized the "skims" from the travel demand models for each study area/MPO. Skims represent the shortest roadway network path in length and time between every origin/destination TAZ pair. Similarly, the research team also attributed this information using skims from SAM v2.

DATA EXPANSION, ATTRACTION RATES, AND VARIABILITY

The development of attraction rates and investigation of variability utilized most of the establishments and surveys in the master work place survey database. The research team developed disaggregate attraction rates based on individual establishments and developed aggregate attraction rates based on the grouping of establishments. The aggregate rates are based on the categories described in this chapter. The following sections describe the expansion of the survey data and investigation of attraction rates. It should be noted that special generators may require specialized treatment not contemplated within the scope of this research; thus, while they are included in the master database and were included in data expansion, the discussion of attraction rates will exclude these establishments.

The full survey trip data were aggregated by site and then linked with the employment and count data collected from the establishment survey. The person and vehicle counts at each site were used to expand the survey trip data. The total trips were counted separately for employees and visitors at freestanding and non-freestanding establishments, and distinguished between residents and non-residents of each study area/MPO. The total trips were classified by purpose, both from the origin to the work place and from the work place to the next destination, and summed as person and motorized trips for each category of trip purpose.

The survey employee trips were expanded first to estimate the total employee person trips and employee motorized trips by purpose. The process involved dividing the survey employee trips for each category of purpose by the number of employee surveys and then multiplying this number by the total number of employees reported to be at work during the survey day. The expanded employee person/motorized trips were subtracted from the total person/vehicle count at the site to yield the total visitor person/motorized trips to the site.

The survey visitor person/motorized trips were used to establish the proportion of visitor trips for each category of trip purpose. These percentages were applied to the total estimated visitor trips to yield the visitor person/motorized trips by purpose. The average visitor vehicle occupancy rates were based on the auto-driver mode of travel and were calculated for each trip purpose. These occupancy rates were used to convert the expanded visitor person trips to motorized trips, or visitor motorized trips to person trips, depending on whether a vehicle count or a person count was conducted at the site.

After the data were expanded for each site, the results were aggregated by employment type and area type. These results were then used to estimate the number of employee and visitor trips by purpose and employment type at the partial survey sites. The person and vehicle counts at each partial survey site were used to expand the trip estimates.

The final trips were then categorized into the appropriate travel demand model rate category as follows:

- **HBW**—Resident home-based work trips.
- **HBNW**—Resident home-based non-work trips.
- **NHB**—Sum of resident non–home-based destination trips and resident non–home-based origin trips.
- **EXT**—Sum of resident external destination trips and resident external origin trips.
- **NON-RES**—Sum of all non-resident trips regardless of the trip purpose.

Table 16 and Table 17 summarize the results of trip expansion.

Table 16. Total Unexpanded and Expanded Auto-Driver Trips by Purpose.

Study Area/MPO	HBW	HBNW	NHB	EXT	NON-RES	Total
	Unexpanded Auto-Driver Trips*					
Abilene	3,579	3,914	4,189	122	1,202	13,006
Amarillo	3,110	2,818	2,638	150	576	9,292
Austin	1,170	2,231	1,686	62	272	5,421
Beaumont	1,103	1,808	665	6	138	3,720
Corpus Christi	1,114	1,834	1,514	24	250	4,736
El Paso	4,063	7,629	3,240	26	658	15,616
Houston-Galveston	3,049	3,976	1,371	14	126	8,536
Killeen-Temple	1,799	3,234	875	20	610	6,538
Laredo	458	6	1,368	2,405	952	5,189
Lubbock	1,980	1,845	1,769	37	456	6,087
Rio Grande Valley	471	3,010	1,155	20	300	4,956
San Antonio	576	563	279	20	66	1,504
Sherman-Dennison	1,325	3,145	1,229	622	10	6,331
Waco	1,663	3,429	1,237	23	532	6,884
Wichita Falls	3,549	6,920	4,011	125	1,322	15,927
Total	**29,009**	**46,362**	**27,226**	**3,676**	**7,470**	**113,743**
	Expanded Auto-Driver Trips*					
Abilene	12,802	49,710	37,931	1,198	8,425	110,066
Amarillo	18,046	74,534	40,951	7,587	11,772	152,890
Austin	46,945	87,127	54,386	2,198	9,608	200,264
Beaumont	8,868	15,295	7,524	1,409	2,335	35,431
Corpus Christi	12,876	41,883	31,968	6,285	8,716	101,728
El Paso	29,843	207,153	65,203	495	14,610	317,304
Houston-Galveston	27,122	105,054	23,554	836	2,266	158,832
Killeen-Temple	25,343	79,179	30,783	4,895	13,814	154,014
Laredo	7,634	15,684	29,688	32,768	20,287	106,061
Lubbock	16,198	67,367	39,384	6,668	14,450	144,067
Rio Grande Valley	12,656	121,769	38,806	561	10,387	184,179
San Antonio	32,523	103,686	34,335	2,058	6,123	178,725
Sherman-Dennison	6,745	41,621	19,524	4,312	2,926	75,128
Waco	18,546	102,180	39,726	9,531	15,097	185,080
Wichita Falls	13,496	70,070	40,064	2,484	9,997	136,111
Total	**289,643**	**1,182,312**	**533,827**	**83,285**	**150,813**	**2,239,880**

*Excludes special generator, excluded establishments, and non-freestanding establishments that were not the first store visited trips.

Table 17. Total Unexpanded and Expanded Person Trips by Purpose.

Study Area/MPO	HBW	HBNW	NHB	EXT	NON-RES	Total
	Unexpanded Person Trips*					
Abilene	3,820	4,236	4,553	129	1,378	14,116
Amarillo	3,249	3,001	2,784	160	640	9,834
Austin	1,276	2,400	1,853	69	380	5,978
Beaumont	1,162	1,991	743	7	156	4,059
Corpus Christi	1,236	2,029	1,663	24	292	5,244
El Paso	4,372	8,763	3,709	28	1,034	17,906
Houston-Galveston	3,266	4,509	1,498	17	152	9,442
Killeen-Temple	1,874	3,354	906	20	634	6,788
Laredo	476	7	1,473	2,656	1,158	5,770
Lubbock	2,112	2,054	1,948	38	538	6,690
Rio Grande Valley	511	3,516	1,331	20	382	5,760
San Antonio	645	612	299	20	68	1,644
Sherman-Dennison	1,361	3,305	1,308	664	10	6,648
Waco	1,705	3,532	1,289	24	550	7,100
Wichita Falls	3,839	7,871	4,525	151	1,536	17,922
Total	**30,904**	**51,180**	**29,882**	**4,027**	**8,908**	**124,901**
	Expanded Person Trips*					
Abilene	13,390	81,877	54,913	1,596	12,798	164,574
Amarillo	19,412	119,525	59,313	16,726	19,227	234,203
Austin	50,628	123,555	65,411	2,596	13,505	255,695
Beaumont	9,248	23,237	10,160	3,040	3,557	49,242
Corpus Christi	13,499	62,740	43,574	12,487	14,020	146,320
El Paso	31,474	359,368	103,732	537	24,807	519,918
Houston-Galveston	27,812	157,445	34,580	950	2,819	223,606
Killeen-Temple	27,300	128,411	43,671	9,922	20,690	229,994
Laredo	7,759	18,734	43,906	59,870	35,212	165,481
Lubbock	17,042	101,914	56,662	14,952	23,703	214,273
Rio Grande Valley	13,630	208,240	60,627	574	17,279	300,350
San Antonio	34,997	151,770	44,622	2,152	7,491	241,032
Sherman-Dennison	6,860	61,991	26,721	5,889	4,775	106,236
Waco	19,274	157,154	57,808	20,010	24,242	278,488
Wichita Falls	14,153	109,507	56,746	3,527	14,621	198,554
Total	**306,478**	**1,865,468**	**762,446**	**154,828**	**238,746**	**3,327,966**

*Excludes special generator, excluded establishments, and non-freestanding establishments that were not the first store visited trips.

Base Attraction Rates and Variability

Base attraction rates are obtained using the total expanded trips by category and total employment. Base attraction rates are distinguished from final attraction rates for modeling in two ways:

- **Trip Balancing**—During the development of attraction rates, regional estimates of trip productions are obtained. These estimates are based on household travel surveys and represent the total trips produced by all households in the region on a typical day. Additionally, the base attraction rates are applied to regional employment data utilized in the travel demand model. Utilizing the summation of productions and attractions, attraction rates are adjusted by balancing attractions to productions, which tends to reduce the base attraction rate.
- **Rate Smoothing**—After trips are balanced, they are reviewed to consider if they are harmonious between trip purpose categories. The results of this process are attraction rates that do not go up or down wildly, resulting in smoother trip summaries.

Base Attraction Rate Derivation

For the purposes of this research, rates were developed as follows:

- ET = Expanded Trips.
- EMP = Total Establishment Employment.
- HBW Trip Rate = ET[HBW]/EMP.
- HBNW Trip Rate = ET[HBNW]/EMP.
- NHB Trip Rate = ((ET[NHB-O]/EMP)+(ET[NHB-O]/EMP))/2.
- NON-RES Trip Rate = (ET[NON-RES])/2)/EMP.

External trips are excluded from this process, as they are estimated by other means.

Base Attraction Rates

The tables (Table 18 through Table 25) and figures (Figure 6 through Figure 13) in the next sections present the base attraction rates and each category's rate distance (or variability) from the average rate.

WORK PLACE ATTRACTION RATES—PERSON TRIPS

Table 18. Person Trip Attraction Rates—Basic Establishments.

Group/Group Density Break	Count of Sites	Total EMP	Raw Trips	Total Expanded Trips for Rates	HBW Rate	HBNW	NHB	NON-RES	HBW Attraction Rate	HBNW Attraction Rate	NHB Attraction Rate	NON-RES Attraction Rate
All Basic	**839**	**37,129**	**10,720**	**173,357**	**57,914**	**50,770**	**47,142**	**17,531**	**1.56**	**1.37**	**0.63**	**0.24**
Metropolis	172	22,838	1,806	97,840	36,680	29,958	25,885	5,317	1.61	1.31	0.57	0.12
Metropolis, ≥50	6	1,216	124	4,923	2,755	841	1,003	324	2.27	0.69	0.41	0.13
Metropolis, ≥15,<50	50	7,451	414	21,785	9,115	2,392	9,280	998	1.22	0.32	0.62	0.07
Metropolis, ≥10,<15	37	4,652	348	13,954	5,793	3,166	4,485	510	1.25	0.68	0.48	0.05
Metropolis, ≥1,<10	61	9,022	783	54,773	18,310	22,283	10,765	3,415	2.03	2.47	0.60	0.19
Metropolis, ≥0,<1	18	497	137	2,405	707	1,276	352	70	1.42	2.57	0.35	0.07
Large	126	3,176	1,910	20,866	4,658	9,462	4,700	2,046	1.47	2.98	0.74	0.32
Large, ≥50	3	11	18	94	16	27	39	12	1.45	2.45	1.77	0.55
Large, ≥15,<50	51	882	647	7,352	1,259	2,485	2,260	1,348	1.43	2.82	1.28	0.76
Large, ≥10,<15	21	695	286	2,866	840	1,341	606	79	1.21	1.93	0.44	0.06
Large, ≥1,<10	44	1,007	851	8,451	1,421	4,769	1,654	607	1.41	4.74	0.82	0.30
Large, ≥0,<1	7	581	108	2,103	1,122	840	141	-	1.93	1.45	0.12	-
Medium	379	8,420	4,341	40,053	12,362	6,991	12,210	8,490	1.47	0.83	0.73	0.50
Medium, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Medium, ≥15,<50	56	886	604	6,942	1,055	389	1,996	3,502	1.19	0.44	1.13	1.98
Medium, ≥10,<15	36	554	464	4,181	1,013	840	1,835	493	1.83	1.52	1.66	0.44
Medium, ≥1,<10	183	4,716	2,312	18,172	7,095	4,153	4,885	2,039	1.50	0.88	0.52	0.22
Medium, ≥0,<1	104	2,264	961	10,758	3,199	1,609	3,494	2,456	1.41	0.71	0.77	0.54
Small	162	2,695	2,663	14,598	4,214	4,359	4,347	1,678	1.56	1.62	0.81	0.31
Small, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Small, ≥15,<50	12	344	225	1,676	404	578	582	112	1.17	1.68	0.85	0.16
Small, ≥10,<15	9	103	53	713	107	170	170	266	1.04	1.65	0.83	1.29
Small, ≥1,<10	80	1,356	1,404	7,748	2,268	1,824	2,805	851	1.67	1.35	1.03	0.31
Small, ≥0,<1	61	892	981	4,461	1,435	1,787	790	449	1.61	2.00	0.44	0.25

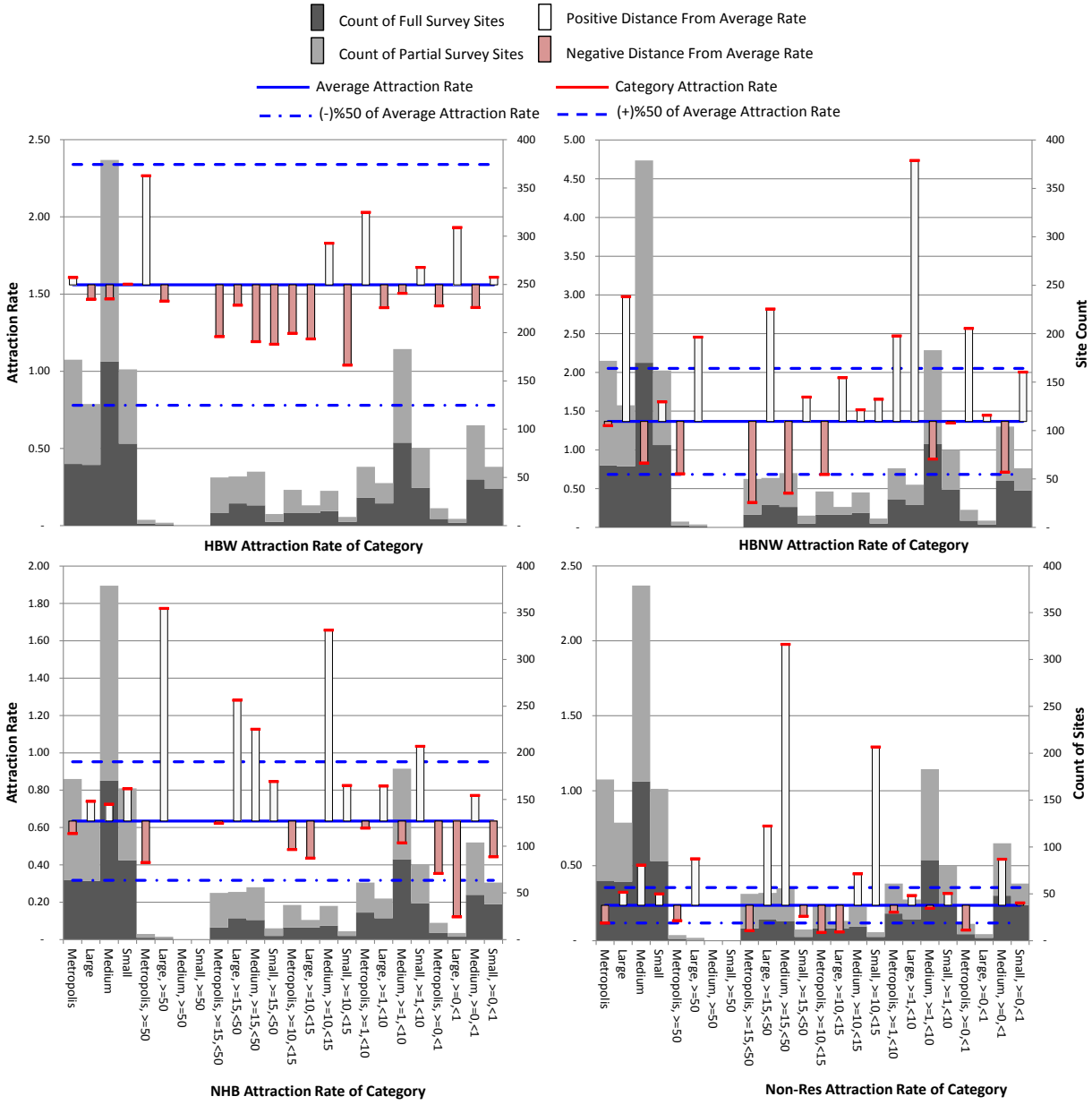

Figure 6. Person Trip Attraction Rates and Distributions—Basic Establishments.

Table 19. Person Trip Attraction Rates—Service Establishments.

Group/Group Density Break	Count of Sites	Total EMP	Raw Trips	Total Expanded Trips for Rates	HBW Rate	HBNW	NHB	NON-RES	HBW Attraction Rate	HBNW Attraction Rate	NHB Attraction Rate	NON-RES Attraction Rate
All Service	**1,870**	**56,795**	**24,958**	**454,014**	**89,927**	**204,449**	**123,255**	**36,383**	**1.58**	**3.60**	**1.09**	**0.32**
Metropolis	384	20,045	5,630	130,309	41,126	47,515	32,082	9,586	2.05	2.37	0.80	0.24
Metropolis, ≥50	20	4,593	472	25,451	10,372	5,919	7,704	1,456	2.26	1.29	0.84	0.16
Metropolis, ≥15,<50	105	7,689	1,746	41,620	15,236	9,593	10,556	6,235	1.98	1.25	0.69	0.41
Metropolis, ≥10,<15	53	1,485	436	12,774	4,112	5,618	2,982	62	2.77	3.78	1.00	0.02
Metropolis, ≥1,<10	156	5,368	2,300	42,363	10,390	20,896	9,466	1,611	1.94	3.89	0.88	0.15
Metropolis, ≥0,<1	50	910	676	8,101	1,016	5,489	1,374	222	1.12	6.03	0.75	0.12
Large	339	10,333	4,401	93,027	12,502	53,708	21,065	5,752	1.21	5.20	1.02	0.28
Large, ≥50	12	2,170	211	4,325	2,412	687	1,062	164	1.11	0.32	0.24	0.04
Large, ≥15,<50	137	4,309	1,894	51,620	5,297	31,108	10,688	4,527	1.23	7.22	1.24	0.53
Large, ≥10,<15	72	1,534	523	13,066	1,283	7,325	4,140	318	0.84	4.78	1.35	0.10
Large, ≥1,<10	111	2,255	1,729	21,193	3,058	12,471	4,921	743	1.36	5.53	1.09	0.16
Large, ≥0,<1	7	65	44	2,823	452	2,117	254	-	6.95	32.57	1.95	-
Medium	735	20,498	7,664	169,508	28,088	75,525	52,443	13,452	1.37	3.68	1.28	0.33
Medium, ≥50	8	565	470	2,912	908	843	1,002	159	1.61	1.49	0.89	0.14
Medium, ≥15,<50	146	2,145	1,484	19,768	2,550	6,811	7,287	3,120	1.19	3.18	1.70	0.73
Medium, ≥10,<15	144	3,094	1,239	28,193	3,909	11,933	8,587	3,764	1.26	3.86	1.39	0.61
Medium, ≥1,<10	306	13,276	3,375	99,148	18,863	50,999	24,026	5,260	1.42	3.84	0.90	0.20
Medium, ≥0,<1	131	1,418	1,096	19,487	1,858	4,939	11,541	1,149	1.31	3.48	4.07	0.41
Small	412	5,919	7,263	61,170	8,211	27,701	17,665	7,593	1.39	4.68	1.49	0.64
Small, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Small, ≥15,<50	26	327	426	3,342	373	1,633	1,241	95	1.14	4.99	1.90	0.15
Small, ≥10,<15	54	705	1,048	8,414	814	4,986	1,605	1,009	1.15	7.07	1.14	0.72
Small, ≥1,<10	262	4,023	4,677	42,661	5,733	17,433	13,308	6,187	1.43	4.33	1.65	0.77
Small, ≥0,<1	70	864	1,112	6,753	1,291	3,649	1,511	302	1.49	4.22	0.87	0.17

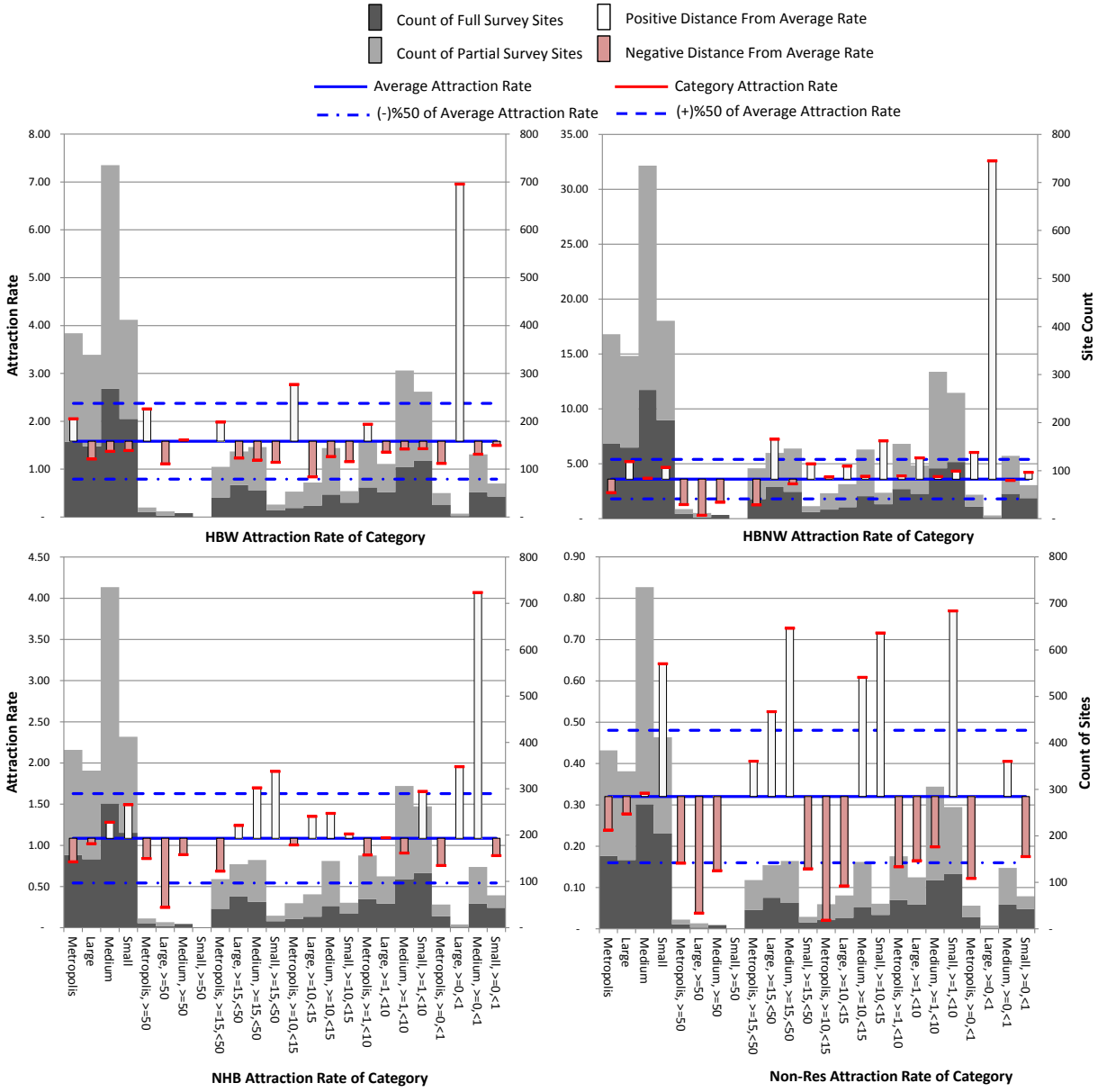

Figure 7. Person Trip Attraction Rates and Distributions—Service Establishments.

Table 20. Person Trip Attraction Rates—Retail Establishments.

Group/Group Density Break	Count of Sites	Total EMP	Raw Trips	Total Expanded Trips for Rates	HBW Rate	HBNW	NHB	NON-RES	HBW Attraction Rate	HBNW Attraction Rate	NHB Attraction Rate	NON-RES Attraction Rate
All Retail	**1,668**	**38,623**	**60,444**	**1,397,690**	**50,075**	**834,043**	**365,837**	**147,735**	**1.30**	**21.59**	**4.74**	**1.91**
Metropolis	176	6,834	6,910	213,163	9,404	144,641	51,805	7,313	1.38	21.16	3.79	0.54
Metropolis, ≥50	6	47	66	757	60	301	227	169	1.28	6.40	2.41	1.80
Metropolis, ≥15,<50	62	2,837	2,892	81,572	4,105	52,475	20,356	4,636	1.45	18.50	3.59	0.82
Metropolis, ≥10,<15	31	1,178	742	41,065	1,405	30,261	9,177	222	1.19	25.69	3.90	0.09
Metropolis, ≥1,<10	65	2,517	2,619	77,045	3,345	51,848	19,757	2,095	1.33	20.60	3.92	0.42
Metropolis, ≥0,<1	12	255	591	12,724	489	9,756	2,288	191	1.92	38.26	4.49	0.37
Large	341	8,580	13,612	464,259	13,159	327,038	92,393	31,669	1.53	38.12	5.38	1.85
Large, ≥50	6	100	401	2,900	148	1,054	1,278	420	1.48	10.54	6.39	2.10
Large, ≥15,<50	104	2,598	3,033	130,812	3,968	88,393	22,239	16,212	1.53	34.02	4.28	3.12
Large, ≥10,<15	92	1,802	4,189	102,379	2,425	66,185	27,680	6,089	1.35	36.73	7.68	1.69
Large, ≥1,<10	122	3,821	5,551	211,693	6,379	159,529	39,935	5,850	1.67	41.75	5.23	0.77
Large, ≥0,<1	17	259	438	16,475	239	11,877	1,261	3,098	0.92	45.86	2.43	5.98
Medium	764	17,004	21,495	523,558	20,226	255,625	158,768	88,939	1.19	15.03	4.67	2.62
Medium, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Medium, ≥15,<50	189	4,004	4,613	101,051	4,855	22,735	40,604	32,857	1.21	5.68	5.07	4.10
Medium, ≥10,<15	143	2,489	3,317	73,380	2,784	36,420	25,906	8,270	1.12	14.63	5.20	1.66
Medium, ≥1,<10	301	8,491	11,333	280,339	10,452	172,032	72,898	24,957	1.23	20.26	4.29	1.47
Medium, ≥0,<1	131	2,020	2,232	68,788	2,135	24,438	19,360	22,855	1.06	12.10	4.79	5.66
Small	387	6,205	18,427	196,710	7,286	106,739	62,871	19,814	1.17	17.20	5.07	1.60
Small, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Small, ≥15,<50	7	43	298	1,355	66	332	922	35	1.53	7.72	10.72	0.41
Small, ≥10,<15	42	382	861	12,655	467	6,672	4,423	1,093	1.22	17.47	5.79	1.43
Small, ≥1,<10	261	4,580	12,914	147,455	5,153	78,006	49,817	14,479	1.13	17.03	5.44	1.58
Small, ≥0,<1	77	1,200	4,354	35,245	1,600	21,729	7,709	4,207	1.33	18.11	3.21	1.75

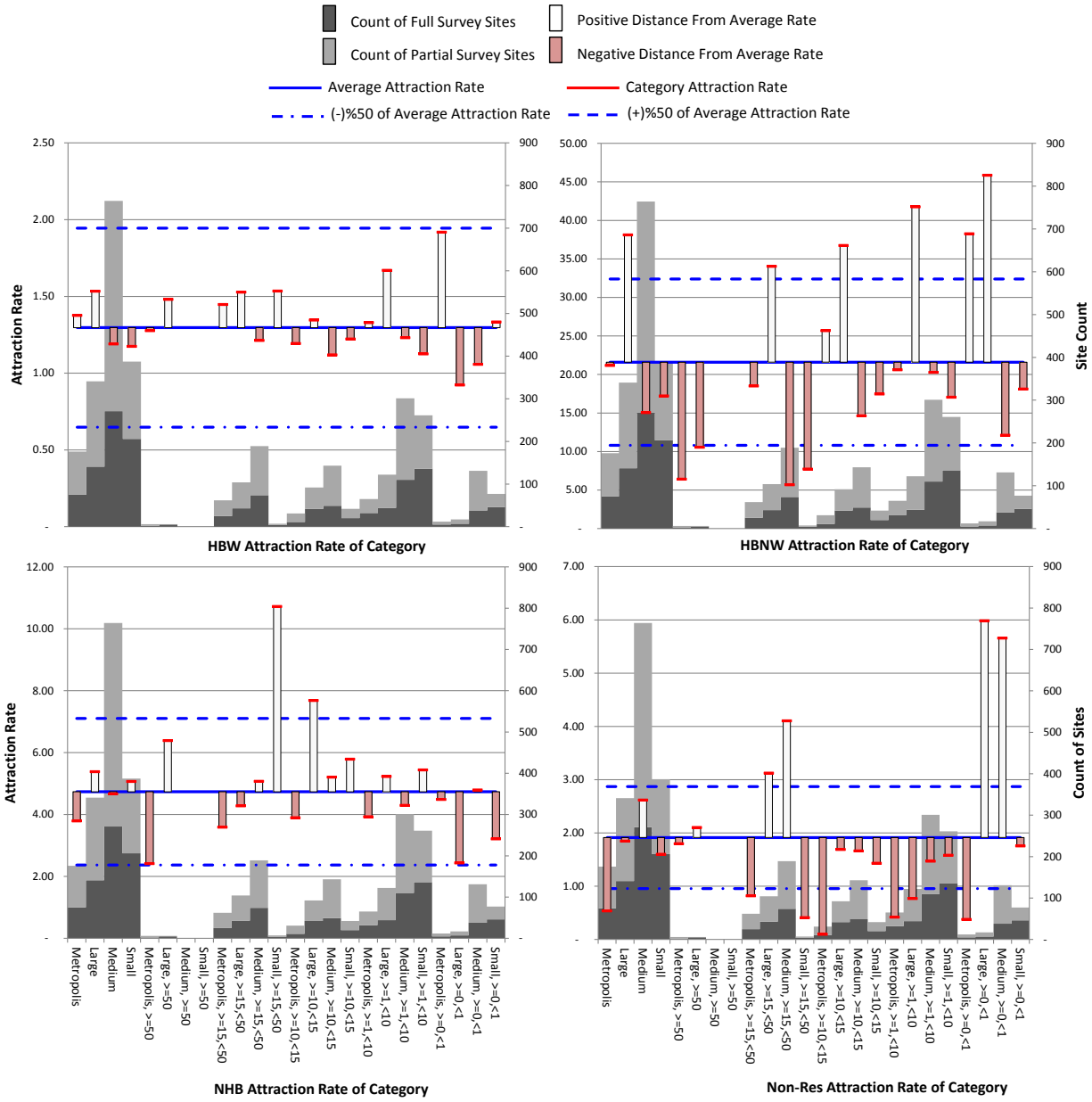

Figure 8. Person Trip Attraction Rates and Distributions—Retail Establishments.

Table 21. Person Trip Attraction Rates—Educational Establishments.

Group/Group Density Break	Count of Sites	Total EMP	Raw Trips	Total Expanded Trips for Rates	HBW Rate	HBNW	NHB	NON-RES	HBW Attraction Rate	HBNW Attraction Rate	NHB Attraction Rate	NON-RES Attraction Rate
All Education	**658**	**49,958**	**24,752**	**1,148,077**	**108,562**	**776,206**	**226,212**	**37,097**	**2.17**	**15.54**	**2.26**	**0.37**
Metropolis	135	12,862	2,612	273,323	26,227	210,656	34,841	1,599	2.04	16.38	1.35	0.06
Metropolis, ≥50	1	15	16	80	25	45	10	-	1.67	3.00	0.33	-
Metropolis, ≥15,<50	21	1,931	507	33,569	4,567	23,452	5,066	484	2.37	12.15	1.31	0.13
Metropolis, ≥10,<15	31	3,302	526	68,090	6,738	50,394	10,916	42	2.04	15.26	1.65	0.01
Metropolis, ≥1,<10	66	6,245	987	143,722	12,401	116,165	14,256	900	1.99	18.60	1.14	0.07
Metropolis, ≥0,<1	16	1,369	576	27,862	2,496	20,600	4,593	173	1.82	15.05	1.68	0.06
Large	94	8,964	3,695	241,005	14,785	177,400	46,201	2,619	1.65	19.79	2.58	0.15
Large, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Large, ≥15,<50	7	448	335	13,208	561	9,760	2,037	850	1.25	21.79	2.27	0.95
Large, ≥10,<15	28	4,098	1,216	100,730	6,935	72,746	20,508	541	1.69	17.75	2.50	0.07
Large, ≥1,<10	51	3,717	2,084	106,623	6,520	81,901	17,316	886	1.75	22.03	2.33	0.12
Large, ≥0,<1	8	701	60	20,444	769	12,993	6,340	342	1.10	18.53	4.52	0.24
Medium	300	20,938	9,056	447,875	52,858	273,574	91,673	29,770	2.52	13.07	2.19	0.71
Medium, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Medium, ≥15,<50	19	1,456	290	13,820	1,282	8,851	3,667	20	0.88	6.08	1.26	0.01
Medium, ≥10,<15	49	3,026	1,372	84,177	5,534	52,213	25,138	1,292	1.83	17.25	4.15	0.21
Medium, ≥1,<10	139	10,432	4,334	229,838	28,165	141,500	48,887	11,286	2.70	13.56	2.34	0.54
Medium, ≥0,<1	93	6,024	3,060	120,040	17,877	71,010	13,981	17,172	2.97	11.79	1.16	1.43
Small	129	7,194	9,389	185,874	14,692	114,576	53,497	3,109	2.04	15.93	3.72	0.22
Small, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Small, ≥15,<50	2	187	410	1,958	286	846	784	42	1.53	4.52	2.10	0.11
Small, ≥10,<15	3	152	252	3,584	241	2,618	720	5	1.59	17.22	2.37	0.02
Small, ≥1,<10	75	4,890	5,858	138,327	10,496	86,469	39,962	1,400	2.15	17.68	4.09	0.14
Small, ≥0,<1	49	1,965	2,869	42,005	3,669	24,643	12,031	1,662	1.87	12.54	3.06	0.42

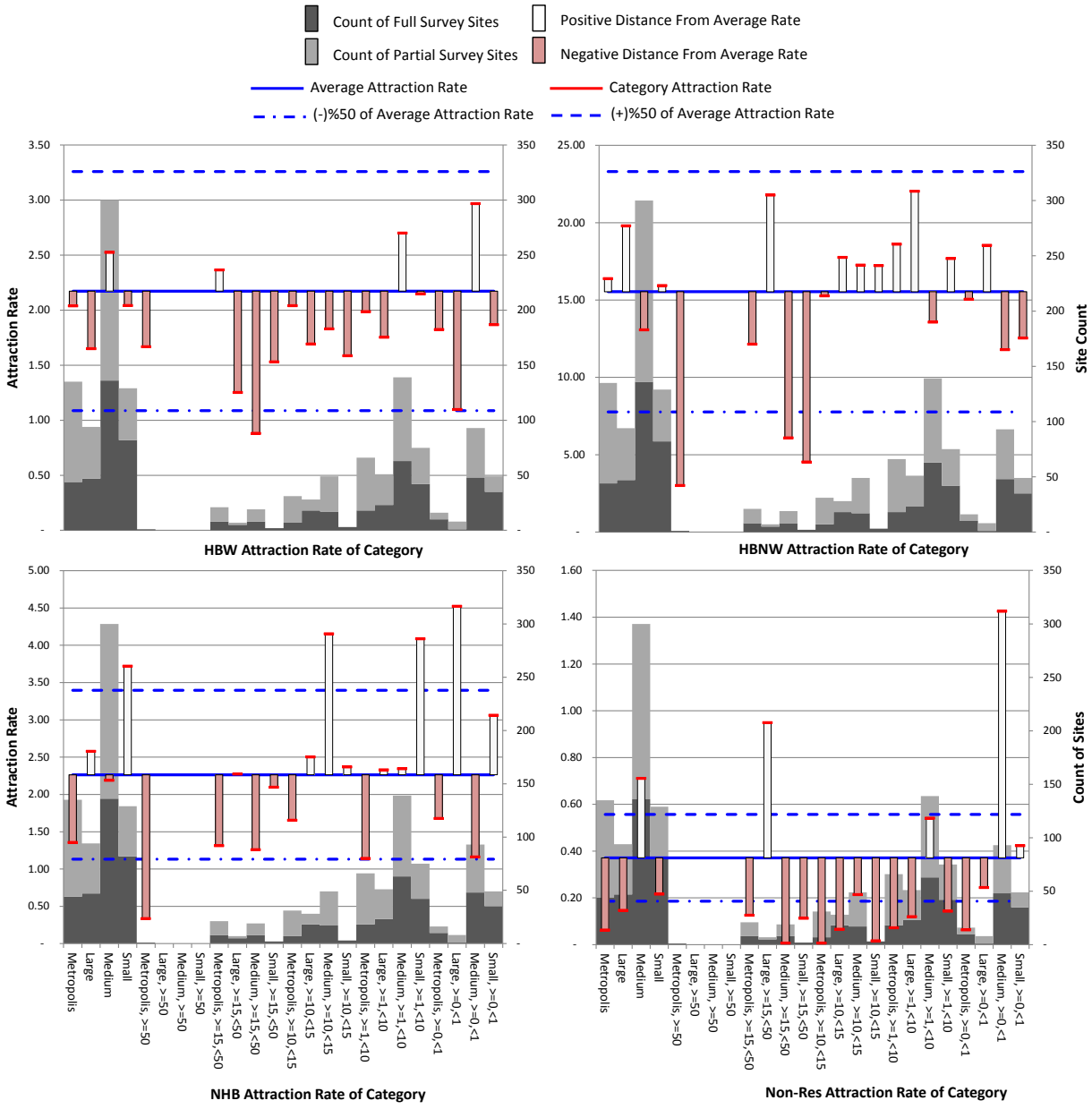

Figure 9. Person Trip Attraction Rates and Distributions—Education Establishments.

WORK PLACE ATTRACTION RATES—AUTO TRIPS

Table 22. Auto Trip Attraction Rates—Basic Establishments.

Group/Group Density Break	Count of Sites	Total EMP	Raw Trips	Total Expanded Trips for Rates	HBW Rate	HBNW	NHB	NON-RES	HBW Attraction Rate	HBNW Attraction Rate	NHB Attraction Rate	NON-RES Attraction Rate
All Basic	**839**	**37,129**	**9,892**	**150,412**	**54,991**	**38,649**	**42,560**	**14,212**	**1.48**	**1.04**	**0.57**	**0.19**
Metropolis	172	22,838	1,660	87,427	34,559	23,147	24,275	5,446	1.51	1.01	0.53	0.12
Metropolis, ≥50	6	1,216	86	4,273	2,529	521	912	311	2.08	0.43	0.38	0.13
Metropolis, ≥15,<50	50	7,451	376	19,824	8,357	1,748	8,999	720	1.12	0.23	0.60	0.05
Metropolis, ≥10,<15	37	4,652	336	12,394	5,701	2,334	3,835	524	1.23	0.50	0.41	0.06
Metropolis, ≥1,<10	61	9,022	733	48,887	17,296	17,487	10,287	3,817	1.92	1.94	0.57	0.21
Metropolis, ≥0,<1	18	497	129	2,049	676	1,057	242	74	1.36	2.13	0.24	0.07
Large	126	3,176	1,737	16,339	4,438	6,795	3,723	1,383	1.40	2.14	0.59	0.22
Large, ≥50	3	11	14	82	17	25	31	9	1.55	2.27	1.41	0.41
Large, ≥15,<50	51	882	564	6,100	1,178	2,041	1,971	910	1.34	2.31	1.12	0.52
Large, ≥10,<15	21	695	258	2,349	731	965	577	76	1.05	1.39	0.42	0.05
Large, ≥1,<10	44	1,007	793	6,120	1,390	3,295	1,047	388	1.38	3.27	0.52	0.19
Large, ≥0,<1	7	581	108	1,688	1,122	469	97	-	1.93	0.81	0.08	-
Medium	379	8,420	4,052	34,175	11,958	5,132	10,918	6,167	1.42	0.61	0.65	0.37
Medium, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Medium, ≥15,<50	56	886	563	5,322	1,055	308	1,711	2,248	1.19	0.35	0.97	1.27
Medium, ≥10,<15	36	554	415	3,436	992	627	1,477	340	1.79	1.13	1.33	0.31
Medium, ≥1,<10	183	4,716	2,153	15,936	6,806	2,838	4,436	1,856	1.44	0.60	0.47	0.20
Medium, ≥0,<1	104	2,264	921	9,481	3,105	1,359	3,294	1,723	1.37	0.60	0.73	0.38
Small	162	2,695	2,443	12,471	4,036	3,575	3,644	1,216	1.50	1.33	0.68	0.23
Small, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Small, ≥15,<50	12	344	203	1,313	385	437	408	83	1.12	1.27	0.59	0.12
Small, ≥10,<15	9	103	44	596	109	167	174	146	1.06	1.62	0.84	0.71
Small, ≥1,<10	80	1,356	1,291	6,690	2,140	1,457	2,446	647	1.58	1.07	0.90	0.24
Small, ≥0,<1	61	892	905	3,872	1,402	1,514	616	340	1.57	1.70	0.35	0.19

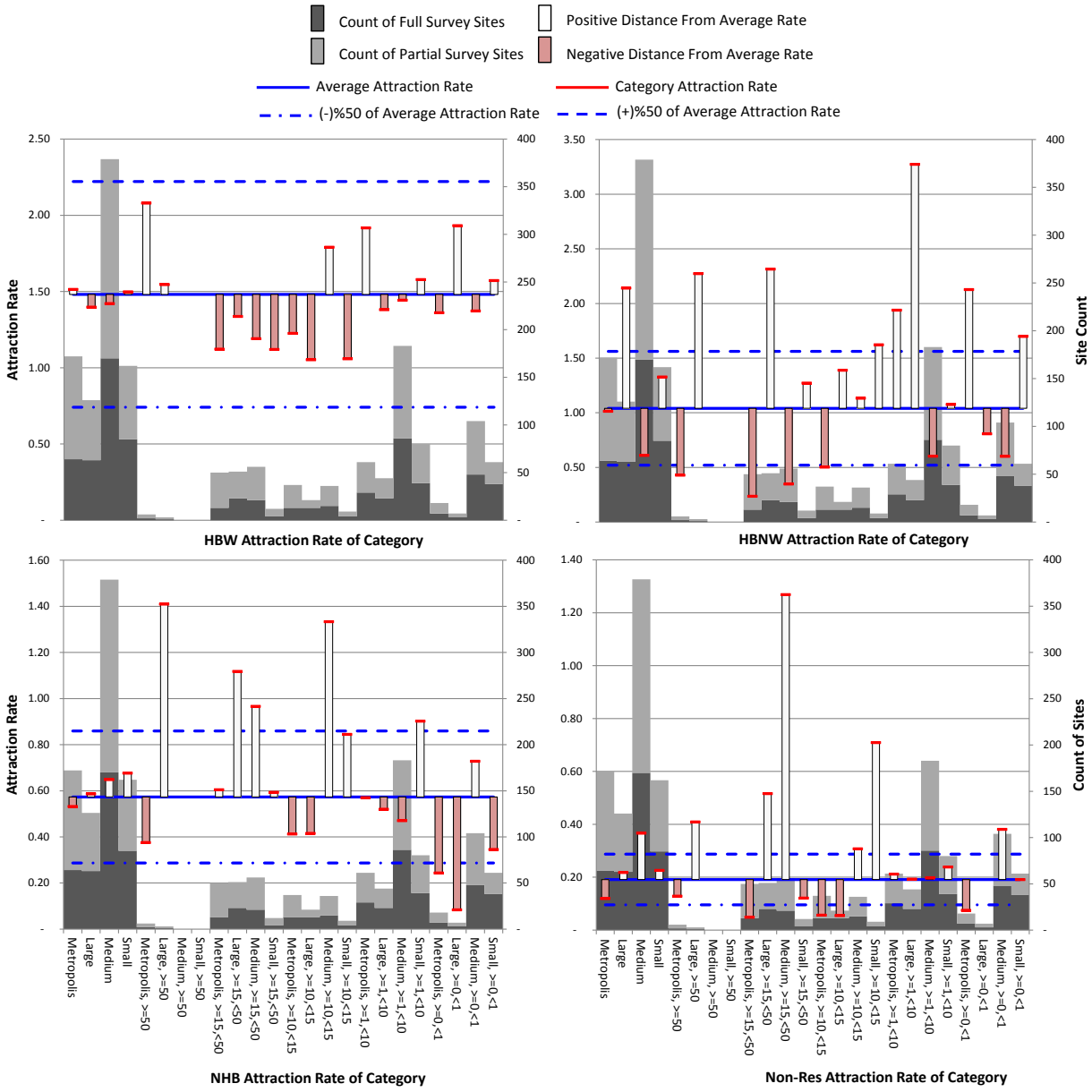

Figure 10. Auto Trip Attraction Rates and Distributions—Basic Establishments.

Table 23. Auto Trip Attraction Rates and Distributions—Service Establishments.

Group/Group Density Break	Count of Sites	Total EMP	Raw Trips	Total Expanded Trips for Rates	HBW Rate	HBNW	NHB	NON-RES	HBW Attraction Rate	HBNW Attraction Rate	NHB Attraction Rate	NON-RES Attraction Rate
All Service	**1,870**	**56,795**	**22,540**	**344,178**	**82,886**	**140,704**	**97,848**	**22,740**	**1.46**	**2.48**	**0.86**	**0.20**
Metropolis	384	20,045	5,165	106,468	36,811	34,680	28,025	6,952	1.84	1.73	0.70	0.17
Metropolis, ≥50	20	4,593	385	18,934	6,770	4,531	6,553	1,080	1.47	0.99	0.71	0.12
Metropolis, ≥15,<50	105	7,689	1,526	34,778	14,259	6,842	9,337	4,340	1.85	0.89	0.61	0.28
Metropolis, ≥10,<15	53	1,485	422	11,711	4,009	4,656	2,984	62	2.70	3.14	1.00	0.02
Metropolis, ≥1,<10	156	5,368	2,187	34,724	10,788	14,481	8,170	1,285	2.01	2.70	0.76	0.12
Metropolis, ≥0,<1	50	910	645	6,321	985	4,170	981	185	1.08	4.58	0.54	0.10
Large	339	10,333	3,739	67,031	11,754	35,976	16,520	2,781	1.14	3.48	0.80	0.13
Large, ≥50	12	2,170	87	4,135	2,418	544	1,037	136	1.11	0.25	0.24	0.03
Large, ≥15,<50	137	4,309	1,622	35,114	4,783	19,642	8,681	2,008	1.11	4.56	1.01	0.23
Large, ≥10,<15	72	1,534	497	9,521	1,259	4,976	3,036	250	0.82	3.24	0.99	0.08
Large, ≥1,<10	111	2,255	1,507	15,710	2,822	9,016	3,485	387	1.25	4.00	0.77	0.09
Large, ≥0,<1	7	65	26	2,551	472	1,798	281	-	7.26	27.66	2.16	-
Medium	735	20,498	7,083	125,017	26,607	50,615	39,826	7,969	1.30	2.47	0.97	0.19
Medium, ≥50	8	565	452	2,514	895	620	876	123	1.58	1.10	0.78	0.11
Medium, ≥15,<50	146	2,145	1,330	14,699	2,488	5,005	5,756	1,450	1.16	2.33	1.34	0.34
Medium, ≥10,<15	144	3,094	1,117	19,884	3,464	8,103	6,663	1,654	1.12	2.62	1.08	0.27
Medium, ≥1,<10	306	13,276	3,149	72,285	18,042	31,767	18,643	3,833	1.36	2.39	0.70	0.14
Medium, ≥0,<1	131	1,418	1,035	15,635	1,718	5,120	7,888	909	1.21	3.61	2.78	0.32
Small	412	5,919	6,553	45,662	7,714	19,433	13,477	5,038	1.30	3.28	1.14	0.43
Small, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Small, ≥15,<50	26	327	400	2,221	344	927	848	102	1.05	2.83	1.30	0.16
Small, ≥10,<15	54	705	950	6,391	826	3,624	1,227	714	1.17	5.14	0.87	0.51
Small, ≥1,<10	262	4,023	4,155	31,293	5,298	11,895	10,109	3,991	1.32	2.96	1.26	0.50
Small, ≥0,<1	70	864	1,048	5,757	1,246	2,987	1,293	231	1.44	3.46	0.75	0.13

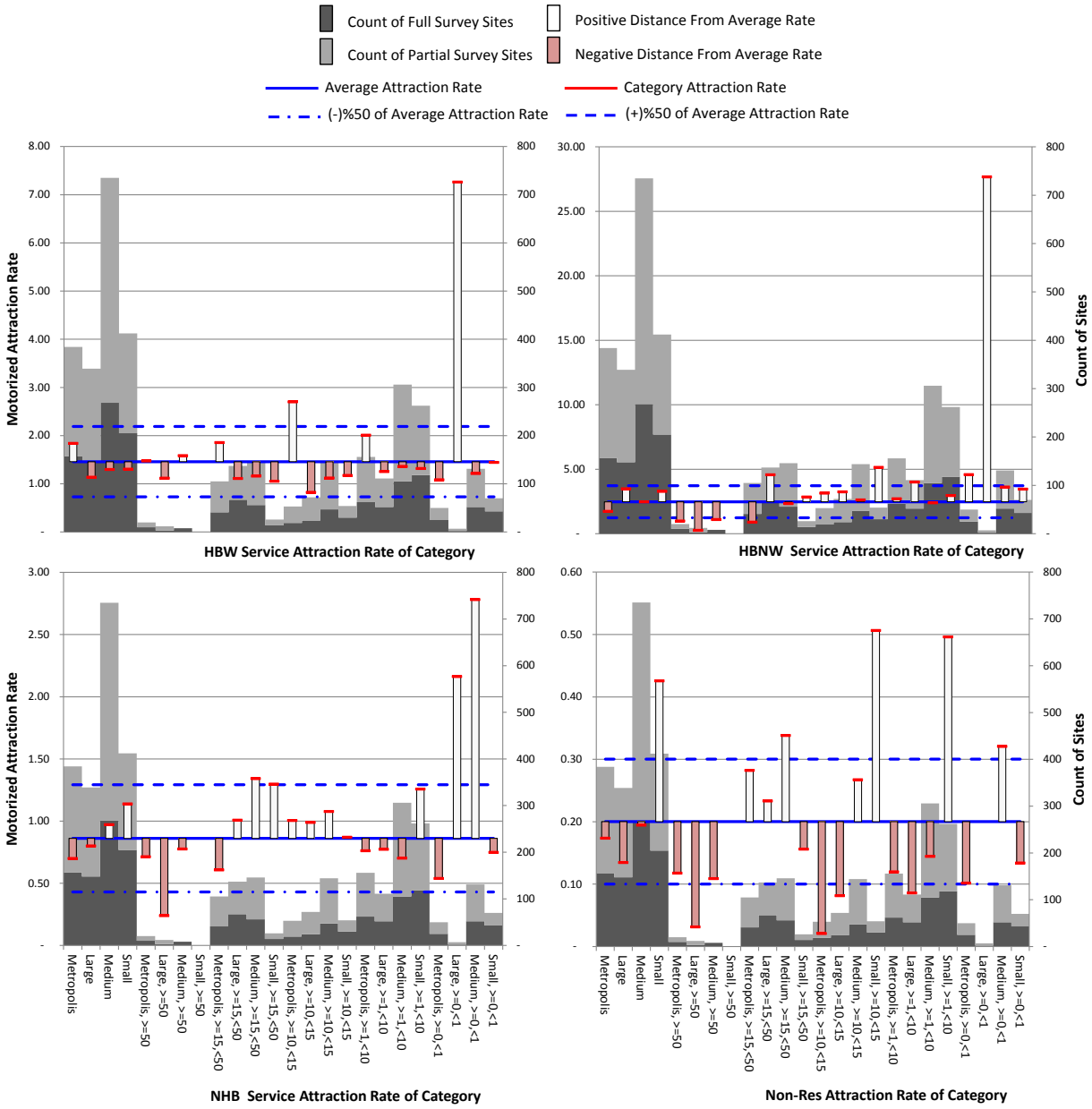

Figure 11. Auto Trip Attraction Rates and Distributions—Service Establishments.

Table 24. Auto Trip Attraction Rates and Distributions—Retail Establishments.

Group/Group Density Break	Count of Sites	Total EMP	Raw Trips	Total Expanded Trips for Rates	HBW Rate	HBNW	NHB	NON-RES	HBW Attraction Rate	HBNW Attraction Rate	NHB Attraction Rate	NON-RES Attraction Rate
All Retail	**1,668**	**38,623**	**53,936**	**939,589**	**47,120**	**552,411**	**252,662**	**87,396**	**1.22**	**14.30**	**3.27**	**1.13**
Metropolis	176	6,834	6,032	158,475	9,003	104,394	41,202	3,876	1.32	15.28	3.01	0.28
Metropolis, ≥50	6	100	174	2,001	134	602	866	399	1.34	6.02	4.33	2.00
Metropolis, ≥15,<50	104	2,598	2,535	75,051	3,346	48,536	14,502	8,667	1.29	18.68	2.79	1.67
Metropolis, ≥10,<15	92	1,802	3,635	69,206	2,078	45,367	18,132	3,629	1.15	25.18	5.03	1.01
Metropolis, ≥1,<10	122	3,821	4,879	128,817	6,379	93,507	24,380	4,551	1.67	24.47	3.19	0.60
Metropolis, ≥0,<1	17	259	400	9,216	236	6,256	750	1,974	0.91	24.15	1.45	3.81
Large	341	8,580	11,623	284,291	12,173	194,268	58,630	19,220	1.42	22.64	3.42	1.12
Large, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Large, ≥15,<50	189	4,004	4,056	68,673	4,698	18,816	27,163	17,996	1.17	4.70	3.39	2.25
Large, ≥10,<15	143	2,489	3,005	47,758	2,711	23,848	17,264	3,935	1.09	9.58	3.47	0.79
Large, ≥1,<10	301	8,491	10,736	193,415	9,879	118,583	50,443	14,510	1.16	13.97	2.97	0.85
Large, ≥0,<1	131	2,020	2,087	49,370	2,101	18,918	13,157	15,194	1.04	9.37	3.26	3.76
Medium	764	17,004	19,884	359,216	19,389	180,165	108,027	51,635	1.14	10.60	3.18	1.52
Medium, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Medium, ≥15,<50	7	43	273	1,134	73	302	726	33	1.70	7.02	8.44	0.38
Medium, ≥10,<15	42	382	779	8,368	418	4,293	2,741	916	1.09	11.24	3.59	1.20
Medium, ≥1,<10	261	4,580	11,516	103,508	4,571	54,200	35,603	9,134	1.00	11.83	3.89	1.00
Medium, ≥0,<1	77	1,200	3,829	24,597	1,493	14,789	5,733	2,582	1.24	12.32	2.39	1.08
Small	387	6,205	16,397	137,607	6,555	73,584	44,803	12,665	1.06	11.86	3.61	1.02
Small, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Small, ≥15,<50	6	41	273	1,108	69	297	709	33	1.68	7.24	8.65	0.40
Small, ≥10,<15	32	317	710	7,376	357	3,758	2,418	843	1.13	11.85	3.81	1.33
Small, ≥1,<10	87	1,485	3,516	26,070	1,500	11,858	9,903	2,809	1.01	7.99	3.33	0.95
Small, ≥0,<1	17	256	850	5,141	458	2,351	1,142	1,190	1.79	9.18	2.23	2.32

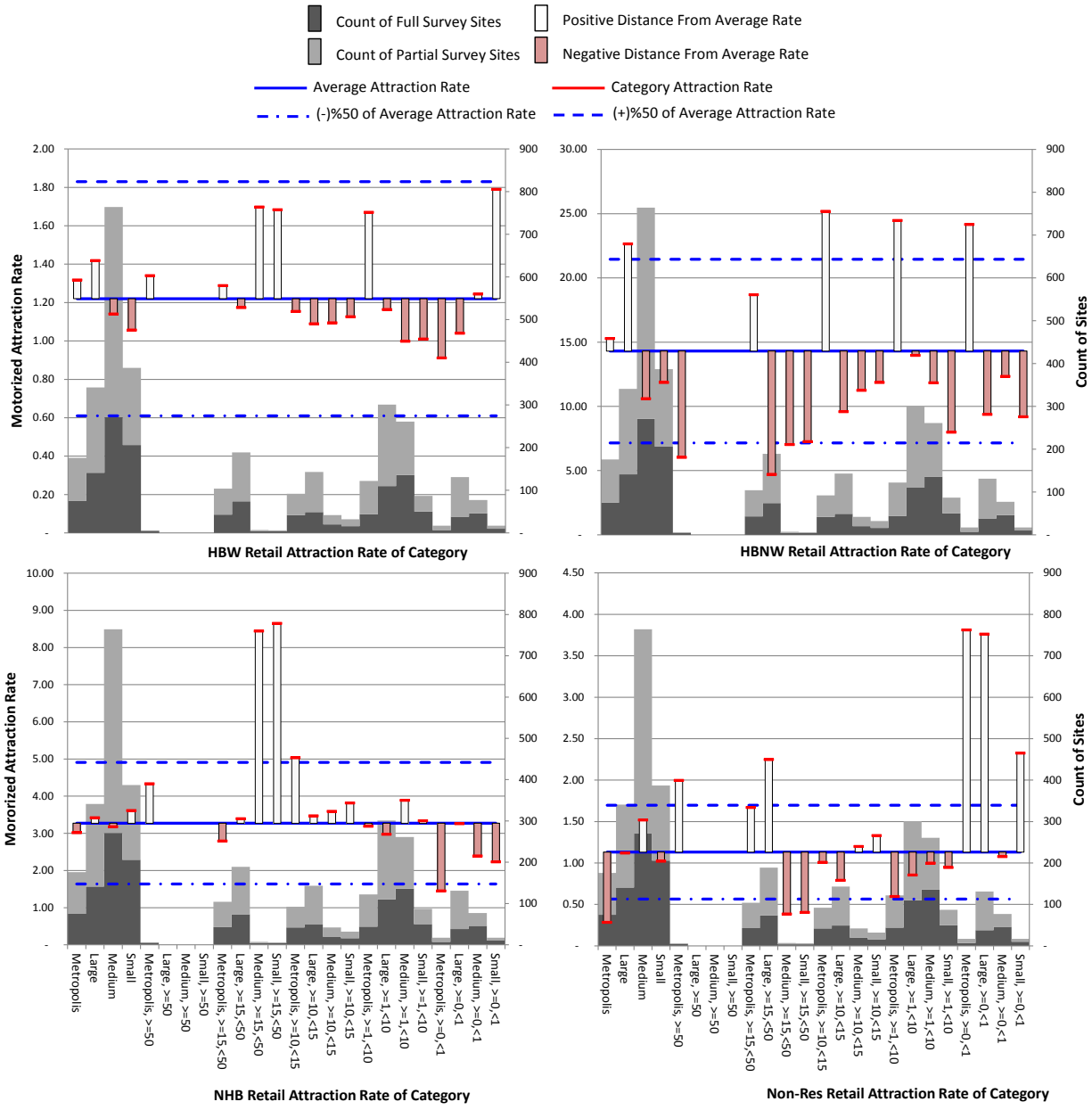

Figure 12. Auto Trip Attraction Rates and Distributions—Retail Establishments.

Table 25. Auto Trip Attraction Rates and Distributions—Education Establishments.

Group/Group Density Break	Count of Sites	Total EMP	Raw Trips	Total Expanded Trips for Rates	HBW Rate	HBNW	NHB	NON-RES	HBW Attraction Rate	HBNW Attraction Rate	NHB Attraction Rate	NON-RES Attraction Rate
All Education	**658**	**49,958**	**23,699**	**722,416**	**104,646**	**450,548**	**140,757**	**26,465**	**2.09**	**9.02**	**1.41**	**0.26**
Metropolis	135	12,862	2,508	180,359	26,217	133,646	18,773	1,723	2.04	10.39	0.73	0.07
Metropolis, ≥50	1	15	16	42	25	7	10	-	1.67	0.47	0.33	-
Metropolis, ≥15,<50	21	1,931	479	26,564	4,303	18,197	3,842	222	2.23	9.42	0.99	0.06
Metropolis, ≥10,<15	31	3,302	496	44,401	7,127	31,928	5,304	42	2.16	9.67	0.80	0.01
Metropolis, ≥1,<10	66	6,245	951	93,232	12,184	72,467	7,339	1,242	1.95	11.60	0.59	0.10
Metropolis, ≥0,<1	16	1,369	566	16,120	2,578	11,047	2,278	217	1.88	8.07	0.83	0.08
Large	94	8,964	3,427	132,766	14,134	91,883	25,136	1,613	1.58	10.25	1.40	0.09
Large, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Large, ≥15,<50	7	448	327	7,248	551	5,434	1,079	184	1.23	12.13	1.20	0.21
Large, ≥10,<15	28	4,098	1,078	53,328	6,417	35,132	11,157	622	1.57	8.57	1.36	0.08
Large, ≥1,<10	51	3,717	1,966	62,129	6,397	44,034	11,064	634	1.72	11.85	1.49	0.09
Large, ≥0,<1	8	701	56	10,061	769	7,283	1,836	173	1.10	10.39	1.31	0.12
Medium	300	20,938	8,762	291,720	49,557	160,210	61,253	20,700	2.37	7.65	1.46	0.49
Medium, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Medium, ≥15,<50	19	1,456	276	8,990	1,280	4,797	2,893	20	0.88	3.29	0.99	0.01
Medium, ≥10,<15	49	3,026	1,304	57,508	5,405	33,011	17,545	1,547	1.79	10.91	2.90	0.26
Medium, ≥1,<10	139	10,432	4,177	143,886	26,276	78,708	31,347	7,555	2.52	7.54	1.50	0.36
Medium, ≥0,<1	93	6,024	3,005	81,336	16,596	43,694	9,468	11,578	2.75	7.25	0.79	0.96
Small	129	7,194	9,002	117,571	14,738	64,809	35,595	2,429	2.05	9.01	2.47	0.17
Small, ≥50	-	-	-	-	-	-	-	-	-	-	-	-
Small, ≥15,<50	2	187	400	1,181	253	421	465	42	1.35	2.25	1.24	0.11
Small, ≥10,<15	3	152	242	2,141	241	1,452	443	5	1.59	9.55	1.46	0.02
Small, ≥1,<10	75	4,890	5,566	84,560	10,699	46,326	26,261	1,274	2.19	9.47	2.69	0.13
Small, ≥0,<1	49	1,965	2,794	29,689	3,545	16,610	8,426	1,108	1.80	8.45	2.14	0.28

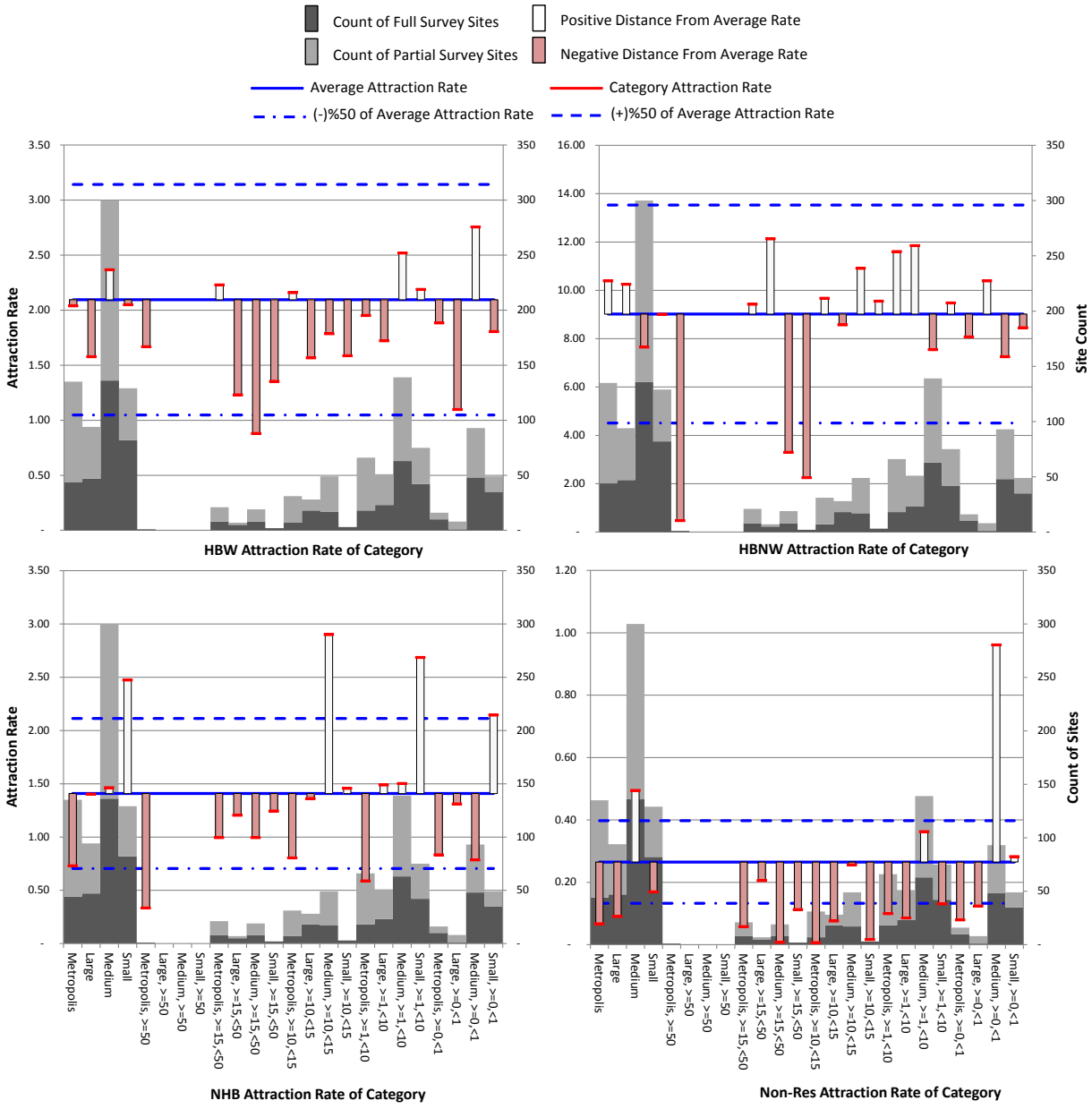

Figure 13. Auto Trip Attraction Rates and Distributions—Education Establishments.

5. CONDUCT ANALYSIS TO DEVELOP TRIP GENERATION RATES FOR LAND DEVELOPMENT

This chapter details how traffic count data obtained from TxDOT work place and special generator surveys, collected as part of the Texas Travel Survey Program, were used to develop trip generation rates for use in land development.

TRIP GENERATION RATES FOR LAND DEVELOPMENT BACKGROUND

As previously mentioned in Chapter 3, trip generation rates for land development are different than the trip generation rates (trip production and attraction rates) used for travel demand modeling in urban areas. Trip generation rates for land development are used in the development of TIA reports to evaluate the impact of new site-level development on the infrastructure and traffic control needs immediately surrounding the site. As a result, trip generation rates for land development are typically calculated for very detailed types of land uses, rather than for broad categories of employment type for trip attraction rates. Additionally, the types of analyses performed as part of the TIA process usually require peak hour data for different peak hours throughout the day as input, whereas 24-hour data are suitable for travel demand modeling purposes. Finally, trip generation rates for land development generally do not consider the trip purpose or other segmentation variables typically used for travel demand modeling.

ITE maintains an extensive database of trip generation data suitable for site-level analysis purposes. The ITE *Trip Generation Manual*, currently in its ninth edition, contains site-level trip generation data for 172 unique land uses and includes data from more than 5500 studies (*37*). The ITE *Trip Generation Manual* is comprised of data collected at establishments across the United States, including Texas, submitted to ITE by transportation professionals. The trip generation rates and equations published in the ITE *Trip Generation Manual* reflect national averages and provide transportation engineers and planners with a starting point for estimating the amount of trips expected to be generated at a proposed land development. However, ITE encourages analysts to collect and utilize local trip generation data at locations where the trip generation characteristics of proposed land development may differ from national averages. Consequently, some states have undertaken research projects to develop trip generation rates based on local conditions. The Vermont Agency of Transportation (AOT) completed a statewide trip generation study in 2010, concluding that the ITE trip generation rates overestimate trip generation in rural and small urban areas (*40*). The South Dakota Department of Transportation completed a similar study in 2005, finding mixed results when comparing the local data with ITE data (*41*). The goal is for transportation engineers and planners to have as much data as possible (national as well as local) for use when developing a TIA.

ANALYSIS METHODOLOGY

The analysis methodology followed in developing trip generation rates for land development consisted of three subtasks completed by TTI researchers in sequence as follows:

- Selection of establishments for inclusion in the analysis.
- Collection of independent variable data for each establishment.
- Calculation of trip generation rates and comparison with ITE rates.

The following sections describe each of these subtasks in greater detail.

SITE SELECTION

The first subtask of this analysis was to review the master list of establishments developed in a previous phase of this project (see Chapters 3 and 4 of this report) to identify suitable sites for the research described in Chapter 5. The following subsections describe the process and rationale for selecting establishments from the master database.

Initial Site Screening

The master list of establishments developed as part of the work described previously in Chapter 4 contained 2244 work place and special generator sites where full surveys have been conducted over the past two decades. Researchers reviewed this list to identify suitable sites for this phase of the trip generation analysis. Screening criteria for site selection included the following:

- **Availability of vehicle counts or person counts.** Trip generation rates for land development are typically calculated on the basis of vehicle trip ends generated per unit of development. Current specifications for the TxDOT work place and special generator surveys require the vendor to collect vehicle counts at freestanding locations and person counts at non-freestanding locations. Prior to 2007, most TxDOT work place and special generator surveys collected person counts at all locations. Therefore, only surveys since 2007 were included in this phase of the analysis.
- **Availability of hourly or 15-minute count data.** Trip generation rates for land development are calculated on the basis of hourly vehicle counts, with 15-minute count data preferred to provide greater detail on intra-hour peaking. Currently, vendors are not required to submit hourly or 15-minute data to TxDOT; however, some vendors provide this information in addition to the required submittals. Therefore, only urban areas where certain vendors were selected for the surveys were included in this phase of the analysis.
- **Availability of complete data from region.** In some urban areas, hourly or 15-minute count data were available in paper form accompanying the hard copy survey forms. However, in some cases, not all establishments surveyed were included in the hard copy files. Therefore, researchers determined that it was not appropriate to include some establishments from a region without having all available sites from that region.

Based on the screening criteria described previously, researchers included the following work place and special generator surveys in this phase of the analysis:

- Bryan–College Station (2013).[2]
- El Paso (*27*).
- Killeen-Temple (*31*).
- Sherman-Denison (2011–2012) (*42*).
- Waco (*43*).

[2] Survey had been conducted but technical report was not yet completed as of the writing of this report.

Collectively, these studies obtained surveys or traffic counts at 1781 establishments, of which 938 (52.7 percent) included vehicle counts (rather than person counts) and, thus, were forwarded to the next subtask phase of analysis. It is reasonable that approximately half of the establishments would be included, as recent specifications for work place surveys require an equal number of freestanding (vehicle counts) and non-freestanding (person counts) in the target quotas for the number of participating establishments.

Identification of ITE Land Use Code

ITE classifies trip generation data according to the characteristics of the land use of the individual site being studied. The current edition of the *Trip Generation Manual* contains trip generation data for 172 different land use codes. The manual contains descriptions of the characteristics and features of each LUC to assist analysts in assigning LUCs for trip generation studies and for classifying proposed developments for estimating trip generation as part of TIA activities.

To maintain consistency with the land uses contained in the ITE database, researchers adopted the ITE LUC classification system and attempted to assign an LUC to as many establishments from the five urban areas as possible. Researchers used descriptions of each LUC as published in the ITE manual, visual inspections of establishments through Internet mapping and street-level imagery, and Internet searches of the establishment name to match establishments with an LUC. In some cases, an establishment could not be matched with an existing ITE LUC. Researchers removed these establishments from this portion of the analysis.

INDEPENDENT VARIABLE DATA COLLECTION

ITE trip generation data are expressed in terms of a trip generation rate per unit of development associated with the site, which is known as an independent variable. Independent variables for a particular LUC are selected based on (1) what characteristics of that land use are expected to influence the amount of trips that are generated by that land use, and (2) the expected types of information that might be available for an LUC at the time when a trip generation analysis would be conducted. Typical independent variables used to estimate trip generation include:

- Size of building(s) on the site.
- Size of the site/parcel.
- Number of employees at the site.

Other independent variables that have been identified as being influential in the amount of traffic generated by a particular land use include the following:

- Number of students (schools, colleges, universities).
- Number of seats and/or movie screens (cinemas).
- Number of fueling positions (gas stations, convenience stores with gas pumps).
- Number of drive-in lanes (banks).
- Number of rooms (hotels, motels, resorts).
- Number of beds (hospitals, nursing homes).
- Number of flights per day (airports).

The second subtask within this portion of the analysis was to identify and obtain appropriate independent variable data associated with each establishment in the database. ITE also recommends that the underlying independent variable data corresponding to a trip generation study be collected through direct observation or provided by the site owner/manager, rather than derived from secondary sources. Collection of independent variable data should clearly state the independent variable data in terms of overall site characteristics, as well as characteristics specific to the site at the time of the study (e.g., the total number of rooms in a hotel and the number of occupied rooms on the day of the study should be documented).

For this analysis, researchers were able to obtain the number of employees for each establishment on the day of the surveys/counts, as this information was available from the standard data collection package. However, for other independent variables (most notably, square footage), it was necessary for researchers to use a variety of secondary, publicly available data sources to fill the gaps in the independent variable database. For most establishments, researchers obtained data on the size of development at the site (square footage) or the total site size (acres) from county-level central appraisal district online databases. Other site-specific independent variable data were obtained by researchers through visual inspections of establishments through Internet mapping and street-level imagery. Researchers used information provided on websites to identify data such as the number of students (junior/community colleges) or number of rooms (hotels). Researchers discarded sites where independent variable data could not be obtained with reasonable confidence.

FINAL SAMPLE SIZE

The final sample for this portion of the analysis consisted of any establishment that met the criteria described in the previous paragraphs for which an LUC could be identified. Additionally, researchers discarded all schools from the analysis due to inconsistencies in counting students on school buses in recent surveys. Finally, researchers set a threshold sample size of three establishments per LUC as a minimum requirement for an LUC to be analyzed. Based on all the screening criteria described in this section, researchers included a total of 390 establishments across 34 unique land uses. Table 26 lists the specific ITE LUCs and the total number of establishments in each LUC included in this portion of the analysis.

Table 26. Total Establishments by ITE LUC.

ITE LUC	Land Use Description	Number in Database
110	General Light Industrial	30
140	Manufacturing	17
150	Warehousing	9
151	Mini-Warehousing (Self-Storage)	6
170	Utilities	14
254	Assisted Living	4
310	Hotel	6
540	Junior/Community College	7
565	Day Care Center	17
610	Hospital	6
620	Nursing Home	4
630	Clinic	3
640	Animal Hospital/Vet Clinic	7
720	Medical-Dental Office Building	16
812	Building Materials and Lumber Store	9
814	Variety Store	9
816	Hardware/Paint Store	5
820	Shopping Center	7
841	Automobile Sales	21
842	Recreational Vehicle Sales	5
843	Automobile Parts Sale	7
852	Convenience Market (Open 15–16 Hours)	3
853	Convenience Market w/ Gas Pumps	26
881	Pharmacy/Drugstore w/ Drive Through	4
890	Furniture Store	7
912	Drive-In Bank	16
932	High-Turnover Sit Down Restaurant	32
933	Fast-Food w/out Drive Through	4
934	Fast-Food w/ Drive Through	26
935	Fast Food w/ Drive Through/No Indoor Seating	5
943	Automobile Parts and Service Center	37
944	Gasoline/Service Station	7
945	Gas Station w/ Convenience Market	11
946	Gas Station w/ Convenience Market/Car Wash	3
	Total Establishments in Database	**390**

TRIP GENERATION RATE CALCULATIONS

The final subtask of this portion of the analysis methodology was to calculate the trip generation rates for the 390 establishments selected from the database and develop a comparison between those rates and the rates published in the ITE *Trip Generation Manual* (*37*). Researchers calculated trip generation rates for the following specific time periods:

- **AM and PM Peak Hour of Adjacent Street Traffic:** Highest hour of traffic demand at a site between 7:00 a.m. and 9:00 a.m. and between 4:00 p.m. and 6:00 p.m. Corresponds approximately to the typical morning and afternoon rush hour periods.
- **AM and PM Peak Hour of the Generator:** Highest hour of traffic demand at a site during any AM and PM period, not necessarily corresponding to the peak hour of traffic on the street adjacent to the site.
- **Daily:** 24-hour total vehicle count.

For each time period, researchers calculated trip generation rates based on the size of the development (1,000 square feet gross floor area), the number of employees (obtained from the work place/special generator survey data), and a "special" independent variable for the following land uses:

- Site size in acres (industrial land uses).
- Number of students (junior/community college).
- Number of fueling positions (gas stations, convenience stores with gas pumps).
- Number of drive-in lanes (banks).
- Number of rooms (hotels).

The following subsections provide the specific steps used by researchers to calculate the trip generation rates for the Texas establishments and the comparison of the Texas rates with the ITE published rates. The analysis procedure follows the ITE recommended practice for estimating trip generation rates (*38*), with specific equations drawn from the recent work of the Vermont AOT (*40*).

Calculation of Trip Generation Rates

For each time period and independent variable combination, researchers calculated a weighted average trip generation rate, weighted standard deviation, weighted average percent entering trips, average independent variable size (unweighted), and range of calculated trip generation rates (also unweighted). Researchers calculated the weighted average trip generation rate using Equation 1 as follows:

$$T = \frac{\sum_{i=1}^{n} T_i}{\sum_{i=1}^{n} X_i} \qquad \text{(Equation 1)}$$

Where:

T = Overall trip generation rate.
T_i = Trips generated at site i.

X_i = Value of independent variable at site *i*.
n = Number of sites.

Researchers also calculated the weighted average percent entering trips using Equation 1 with the percent entering data for each site used instead of the trips generated at each site. Researchers calculated the standard deviation using Equation 2 as follows:

$$s = \sqrt{\frac{1}{1-V_2} \sum_{i=1}^{n} w_i (T_i - T)^2} \quad \text{(Equation 2)}$$

Where:

s = Sample standard deviation.
T, T_i, and *n* are as in Equation 1.
$w_i = \frac{X_i}{\sum_{i=1}^{n} X_i}$.
$V_2 = \sum_{i=1}^{n} w_i^2$.

Researchers calculated the average independent variable size and the trip generation rate for each individual establishment using a simple average formula. They extracted the smallest and largest trip generation rate for each land use, time period, and independent variable to obtain the range of trip generation rates by LUC. The research team calculated a total of 400 weighted average trip generation rates (plus supporting data as described in this subsection) from the Texas data.

Comparison of Texas Rates with ITE Trip Generation Rates

The overall purpose of this portion of the research was to calculate trip generation rates for Texas establishments to support TIA activities for land development. However, it is useful to compare the Texas rates with the published ITE rates to determine if land developments in Texas have similar trip generation characteristics to comparable developments nationwide. To facilitate this comparison, researchers developed two specific comparison criteria. The first criterion was a comparison of the statistical significance of the difference between the Texas rates and the ITE rates using a weighted t-test. The weighted average t-test used by researchers in the first comparison is described as follows, in Equation 3:

$$t = \frac{T - \mu}{s/\sqrt{f}} \quad \text{(Equation 3)}$$

Where:

T, *s*, and V_2 are as in Equation 2.
μ = Trip generation rate from ITE *Trip Generation Manual*.
f = Sample size correction factor, defined as $f = \frac{1}{V_2}$.

The second criterion was an evaluation of the practical significance of the difference between the Texas rates and the ITE rates. ITE lists the following four criteria for examining the difference

between locally developed trip generation rates and the published rates in the *Trip Generation Manual* (*38*):

1. The trip generation rate for each of the locally surveyed sites falls within one standard deviation of the *Trip Generation Manual* rate.
2. Of the sites surveyed locally, at least one has a higher rate than the *Trip Generation Manual* weighted average rate or equation and one has a lower rate; or all of the survey sites generate trips with totals within 15 percent of the *Trip Generation Manual* average rate or equation (calculated using Equation 4, which is given below).
3. The locally collected data generally fall within the scatter of points shown in the current *Trip Generation Manual* data plot.
4. Common sense derived from the local trip generation study indicates that the *Trip Generation Manual* data are valid for local application.

Of the four criteria listed above, only the second criterion could be reasonably evaluated by researchers within the scope of the analysis at hand. Nevertheless, it does provide useful information on the practical relationship between the Texas trip generation rates and the published ITE trip generation rates. Specifically, if the Texas trip generation rate was outside of ±15 percent of the published ITE trip generation rate, it was considered a "practically significant" difference. Researchers calculated the percent difference using Equation 4 as follows:

$$d\ (\%) = \frac{T-\mu}{\mu} * (100\%) \qquad \text{(Equation 4)}$$

Where:

d (%) = Practical difference.
μ and *T* are as in Equation 3.

ANALYSIS RESULTS

This section reports the results of the analysis described within previous sections of this chapter.

Texas Trip Generation Rates—Preliminary Results

Researchers calculated a total of 400 unique weighted average trip generation rates derived from the data extracted from five recent TxDOT work place and special generator surveys. These rates can be used by transportation engineers and planners at TxDOT, local highway agencies, and consultants to estimate the traffic impacts of proposed developments around the state. The Appendix contains data tables reporting the weighted average trip generation rates for each land use, independent variable, and time period analyzed. Additional information provided in each table includes the sample size, weighted standard deviation, weighted average percent entering, range of trip generation rates, p-value, and percent difference for each land use, independent variable, and time period analyzed. Due to the extensive nature of these results, the reader is referred to the Appendix for more information.

Comparison with ITE Trip Generation Rates

The tables, figures, and discussion provided in this subsection highlight findings and key results for the statistical and practical comparison of Texas trip generation rates with published ITE trip generation rates. To assist with interpretation of the analysis results, researchers grouped the LUCs into seven broad types of land use classifications based on general land use functions. Table 27 shows a summary of the comparisons between the Texas trip generation rates developed by the researchers within this portion of the research and the published ITE trip generation rates. Figure 14 displays the results of the statistical difference analysis reported in Table 27 in graphical format, while Figure 15 shows the results of the practical difference analysis in graphical format.

Table 27. Summary of Comparisons between Texas and ITE Trip Generation Rates.

LUC Grouping	Number of Comparisons	Number Statistically Different*	Statistically Lower*	Number Practically Different**	Practically Lower**
Industrial (LUC 100s)	59	24	22	48	36
Assisted Living (254)	2	0	0	0	0
Lodging (300s)	10	5	5	10	5
Institutional (500s)	25	4	4	11	9
Medical/Office (600s/720)	35	8	3	28	9
Retail (800s)	76	31	27	60	39
Service (900s)	49	18	17	29	22
Total	**256**	**90**	**78**	**186**	**120**
*Number of comparisons with a statistically significant difference between Texas and ITE rates ($p \leq 0.1$).					
**Number of comparisons with a practical difference between Texas and ITE rates ($d \leq -15\%$ *or* $\geq 15\%$).					

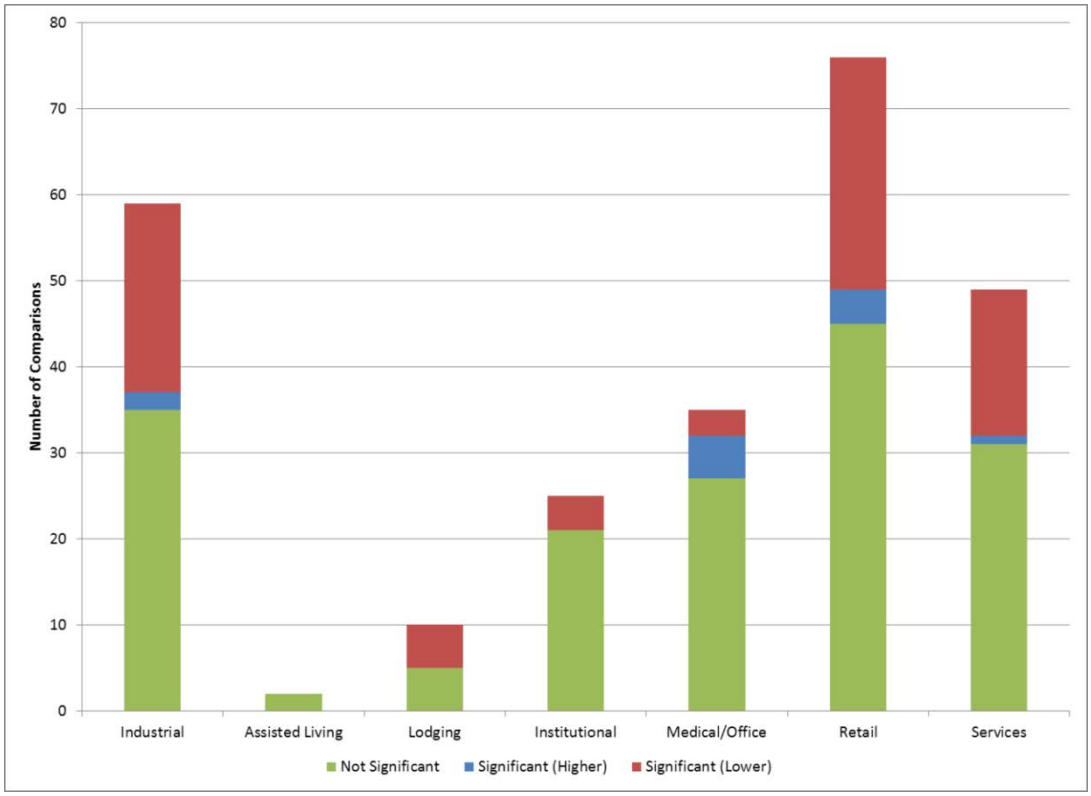

Figure 14. Statistical Difference between Texas and ITE Rates.

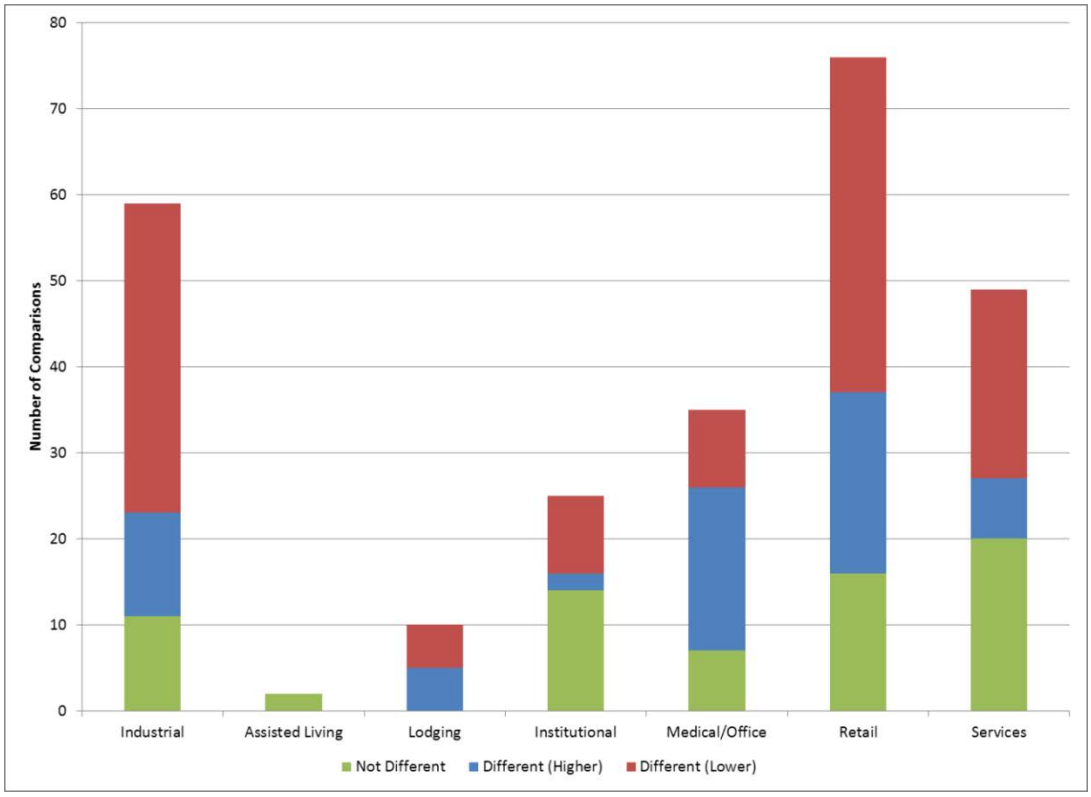

Figure 15. Practical Difference between Texas and ITE Rates.

Researchers developed a total of 400 trip generation rates in this phase of the work, of which 256 (64 percent) could be compared with corresponding rates from the ITE *Trip Generation Manual*. Of the 256 comparisons estimated by researchers, 90 (35.2 percent) indicated a significant difference between the Texas rates and the ITE rates, while 186 (72.7 percent) indicated a practical difference between the two rates. For both sets of comparisons, the Texas rates were lower (either significantly or practically) than the ITE rates a majority of the time. Among the statistical differences, 78 of 90 comparisons (86.7 percent) indicated that the Texas rates were lower than the ITE rates. Similarly, among the practical differences, 120 of the 186 comparisons (64.5 percent) indicated that the Texas rates were lower than the ITE rates.

Researchers also found a select number of comparisons where the Texas trip generation rates were statistically and/or practically higher than the published ITE trip generation rates. When compared on the basis of per employee, LUC 110 (General Light Industrial), LUC 150 (Warehousing), LUC 310 (Hotel), LUC 610 (Hospital), and LUC 720 (Medical-Dental Office Building) had higher rates. On the basis of per 1000 square feet, LUC 610 (Hospital), LUC 841 (Automobile Sales), LUC 881 (Pharmacy/Drugstore w/ Drive Through), and LUC 890 (Furniture Store) had higher rates than the ITE rates. Lastly, on the basis of the "special" independent variables, the only variable that generated higher rates was the number of gas pumps for LUC 945 (Gas Station w/ Convenience Market) and LUC 946 (Gas Station w/ Convenience Market/Car Wash).

CONCLUSIONS

For the research described within this chapter, researchers used traffic count data obtained at TxDOT special generator and work place survey establishments to extract trip generation rates suitable for land development TIA. From five recent studies, researchers calculated 400 unique trip generation rates based on 390 sites encompassing 34 separate land uses. Details of the trip generation rates calculated by researchers include all supporting data for each land use, the independent variable, and time period analyzed. Comparison of 256 of these Texas trip generation rates with published ITE rates found that 35 percent indicated a significant difference between the Texas rates and ITE rates, while 73 percent of the comparisons yielded a practical difference (i.e., outside the ±15 percent of the ITE rate). In both cases, a majority of the differences were the result of Texas rates being lower than ITE rates. The significance of this finding is that based on the trip generation rates calculated for Texas establishments used in the present analysis, the use of trip generation rates published in the ITE *Trip Generation Manual* will tend to overestimate trip generation at the land uses examined in this analysis. The reader should note, however, that the five urban areas used in this study were generally small- or medium-sized areas, which may have different trip generation rates than the national averages published in the ITE *Trip Generation Manual*. Nevertheless, the ITE *Trip Generation Manual* recommends the use of local data if such data are available. Based on these results, there are differences in the trip generation characteristics of Texas establishments compared to national averages. This finding supports the production of a Texas-specific trip generation manual, which is one of the end-goal deliverables associated with this project.

6. ESTABLISH CRITERIA FOR TEXAS TRIP GENERATION MANUAL

SCOPE

This chapter details the process the research team used in determining the format and guidelines associated with creating the Texas Trip Generation Manual, including a description of the logic the researchers followed in making decisions germane to achieving this goal. Previous research results obtained as part of this project, as well as guidelines obtained from the ITE *Trip Generation Manual*, were used in shaping the development of the guidelines for the manual. Specifically, the following issues were addressed:

- Elements of the work place and special generator survey data to include in the manual.
- Time periods to present.
- Classifications to use in displaying the results of work place and special generator data.
- Independent variables to include:
  - Methodology for analyzing the work place and special generator survey data (i.e., constant average trip rate per independent variable unit or a regression equation estimating trips as a function of the independent variable[s]).
  - Minimum required sample size needed to display results for a given land use.
  - Manual form (i.e., summary or full database form).
  - Distribution format (i.e., hard copy or electronic).
  - Frequency the manual should be updated and guidelines for what outside sources can contribute data to the manual.

BACKGROUND INFORMATION

The ITE *Trip Generation Manual* contains data from various locations and is often used in estimating the number of trips that will be generated with the development of a new site (*37*). The ITE *Trip Generation Manual* contains three volumes—with Volume 1 also known as the *User's Guide and Handbook*, and Volumes 2 and 3 displaying trip generation rates, along with plots of the data and relevant equations (*37*, *38*). However, trip rates are generally lower in small- to medium-sized areas, which can lead to estimates that do not yield accurate or meaningful values if the ITE trip rates are used in these settings. Thus, especially in the case of small- and medium-sized cities, it may be beneficial to develop rates based on more local data.

Efforts to develop trip rates more reflective of local data have been undertaken in Vermont (*40*) and in South Dakota (*41*). Within the Vermont study, performed by the Traffic Research Unit of the Vermont Agency of Transportation, the results indicate that, in general, the ITE manual overestimates trip rates in rural and small urban areas (*40*). For the South Dakota study, data collected in Pierre, South Dakota, associated with traffic impact studies were compared to the ITE *Trip Generation Manual* rates. As with Vermont, in most cases the trip rates calculated in fairly rural South Dakota were lower than the ITE trip generation rates (*41*). While it may be beneficial to use trip rates more reflective of a given locality, many small- to medium-sized areas simply do not have a large enough sample size to produce meaningful trip rates.

Data available from travel surveys performed around the state may allow for this barrier to be overcome in Texas. For the past two decades, travel surveys have been performed on a rotational

basis for MPO regions across Texas, as part of the Texas Travel Survey Program. As part of the travel survey data that are collected, work place and special generator surveys are performed. Thus, there is a large amount of data available for analysis in establishing a Texas trip generation manual that will yield trip rates that are more reflective of trips made in small- and medium-sized cities in Texas. Previous research performed as part of this project (described in Chapter 5) alludes to several differences between Texas trip rates and ITE trip rates, often with Texas rates being practically and/or significantly lower. Thus, creation of a Texas trip generation manual, with periodic updates being made when additional survey data are collected, will ultimately lead to more effective transportation planning in Texas.

The development of a Texas trip generation manual necessitates making several decisions about the formatting and guidelines surrounding the manual's creation. As mentioned within the Scope section of this chapter, a number of issues were considered as part of the formatting and guideline efforts. The following section will provide details on the decisions that were made, along with an explanation of some of the underlying rationale.

ELEMENTS FOR INCLUSION AND ANALYSIS METHODOLOGY

The elements to include within the Texas Trip Generation Manual were largely taken from the elements contained within the ITE *Trip Generation Manual* (*37*). This decision was based on a desire to create a Texas manual that mirrored the ITE manual as closely as possible to allow for more straightforward comparisons.

Figure 16 is taken from the *User's Guide* portion of Volume 1 of the ITE *Trip Generation Manual* (*37*, p. 15). It highlights many of the important elements that are included in the ITE *Trip Generation Manual*, and which were subsequently chosen for inclusion in the Texas Trip Generation Manual.

Some of the key features include the following. Note that not every feature is automatically included. Further guidelines about what specific elements are appropriate for inclusion are provided in the Analysis Method section, presented later in this chapter.

- Top Section:
  - Land Use.
  - ITE Land Use Code.
  - Independent Variable.
  - Analysis Time Period.
- Middle Section:
  - Weighted Trip Generation Rate.
  - Range of Trip Rates for Different Study Locations.
  - Standard Deviation of Trip Generation Rates at Different Studies.
- Graph Section:
  - Independent Variable (x-axis).
  - Dependent Variable (y-axis).
  - Coefficient of Determination.
  - Best Fit Regression Equation (linear or logarithmic).

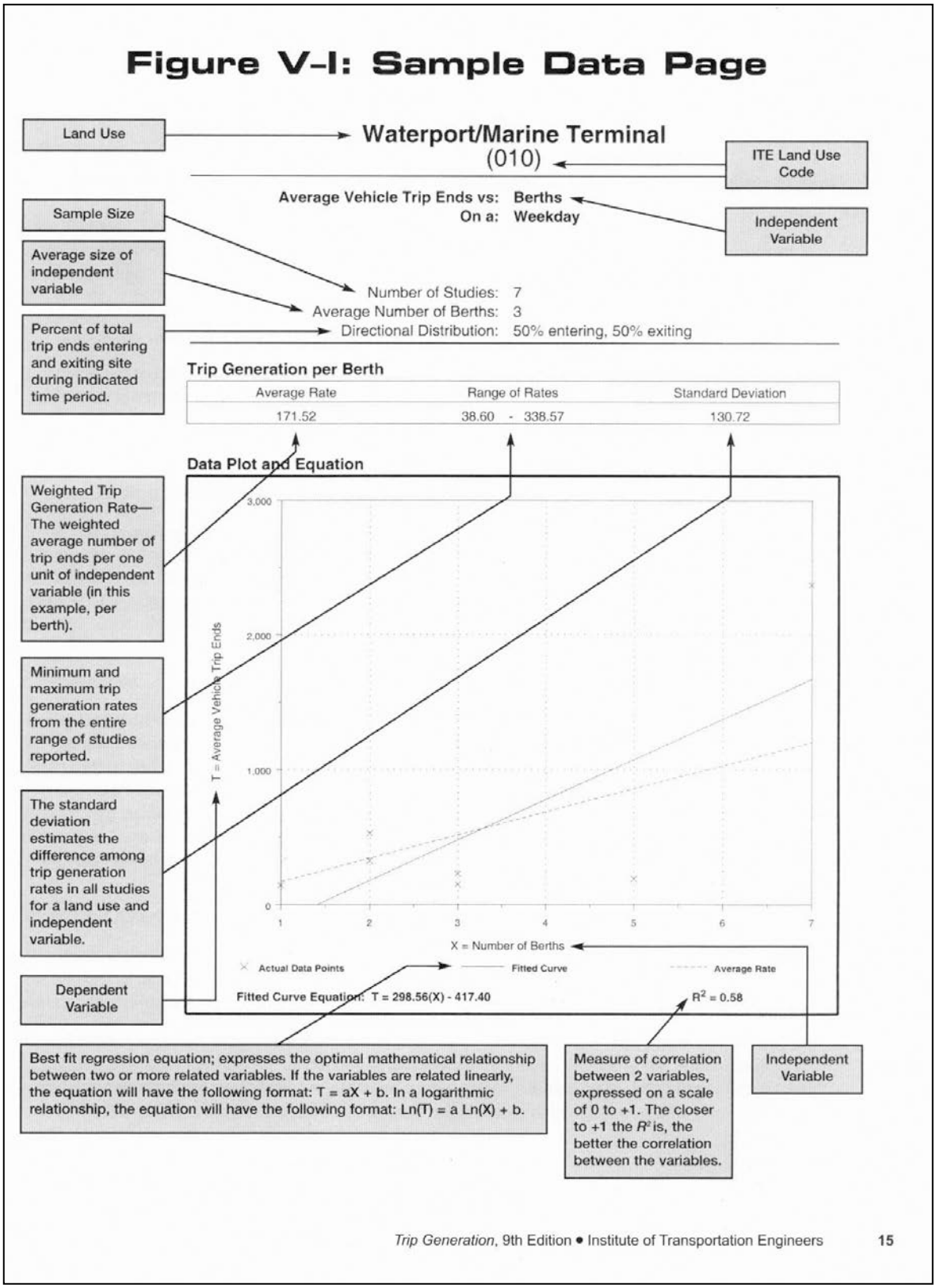

Figure 16. Sample Data Page from the *User's Guide* Portion of Volume 1 of the ITE *Trip Generation Manual* (*37*, p. 15).

TIME PERIODS

Five time periods were selected for inclusion in the Texas Trip Generation Manual, as follows:

- Weekday.
- Weekday AM Peak Hour of Adjacent Street Traffic.
- Weekday PM Peak Hour of Adjacent Street Traffic.
- Weekday AM Peak Hour of Generator.
- Weekday PM Peak Hour of Generator.

To clarify, the "Weekday" time period corresponds to 24-hour total vehicle count. The "AM Peak Hour of Adjacent Street Traffic" generally refers to the highest hour of traffic between 7:00 a.m. and 9:00 a.m.; similarly, the "PM Peak Hour of Adjacent Street Traffic" corresponds with the highest hour of traffic between 4:00 p.m. and 6:00 p.m. The peak hour of the adjacent street traffic and the generator do not necessarily need to be the same (*37*).

These time periods were selected based on data that were available from Texas work place and special generator travel surveys. As previously cited in Chapter 2, generally work place surveys are performed on weekdays when school is in session (i.e., non-summer, non-holiday), which are typical of an average day (*20*). This is reflected in the fact that no weekend time period counts were selected for inclusion in the Texas Trip Generation Manual. Among others, these time periods are also commonly used times within the ITE *Trip Generation Manual* (*37*).

However, as stated within the *Handbook* portion of Volume 1 of the ITE *Trip Generation Manual*, "Selection of the time period for a trip generation study is dictated by the purpose of a traffic impact assessment for which the estimate is being made" (*38*, p. 4). Further, "The time period that should be analyzed is the time period in which the combination of site-generated traffic and adjacent street traffic is at its maximum" (*38*, p. 4).

Thus, different time periods (such as the weekend) should potentially be considered for inclusion in future versions of the manual, taking into consideration when different land uses experience peak traffic. Within the ITE *Handbook* portion of Volume 1 of the ITE *Trip Generation Manual*, it is recommended that site-generated traffic be counted for a full week's time, to aid in determining when peak periods of interest may occur. If a full week's worth of counts is not possible, it is recommended in the *Handbook* portion of Volume 1 of the ITE *Trip Generation Manual* that "at the minimum, automatic traffic recorder counts should be taken through a full 24-hour period, although a preferred length of time would consist of 48 consecutive hours" (*38*, p. 19). While it may not be feasible to collect a full week's worth of counts as part of the Texas Travel Survey Program, future work place and special generator data collection efforts performed as part of the program should take ITE's recommendations into consideration, and the survey specifications should be adjusted if necessary to ensure that meaningful results are obtained.

CLASSIFICATIONS

ITE land use codes were selected as the classification system to be used in the Texas Trip Generation Manual. This was done to mirror the ITE *Trip Generation Manual* as closely as possible. Thirty-four different LUCs will be included in the initial version of the Texas manual,

based on data that were compiled for the research efforts previously described within Chapter 5. Table 28 shows a list of these LUCs. Refer to the ITE *Trip Generation Manual* for a description of the type of establishments grouped into each ITE LUC (*37*). As previously described in Chapter 5, there were 2244 sites remaining in the data set after the research effort described in Chapter 4 was completed. To sum up, the following logic was followed in the research to further minimize the sample size used in the initial Texas Trip Generation Manual:

- **Availability of vehicle counts or person counts**: Data collected prior to 2007 were eliminated because current TxDOT specifications indicate that vehicle counts must be collected at freestanding locations (and person counts at non-freestanding locations). However, prior to 2007, person counts were performed at both freestanding and non-freestanding locations, thus not meeting current specifications.
- **Availability of hourly or 15-minute count data**: Only urban areas where the vendor reported 15-minute count data (despite the fact that it was not required) were kept in the data set.
- **Availability of complete data for region**: Only areas that had hardcopy files of the count data for all available sites within a region were included in the data set used within the analysis that was described in Chapter 5.

Based on these criteria, only the following five work place and special generator surveys were considered in the analysis described previously in Chapter 5:

- Bryan–College Station (2013).[2]
- El Paso (*27*).
- Killeen-Temple (*31*).
- Sherman-Denison (2011–2012) (*42*).
- Waco (*43*).

At this point, the researchers also eliminated establishments where the establishment could not be matched to an existing ITE LUC, or where information related to independent variables could not be obtained with reasonable certainty. They also eliminated all schools from the database because of inconsistencies in the data counts and determined that there must be at least three establishments for a given LUC for it to be included in the data set. Ultimately, this led to 390 establishments, grouped into 34 LUCs, being chosen for inclusion in the original version of the Texas Trip Generation Manual. However, it is anticipated that additional ITE LUCs, and additional establishment data belonging to the LUCs currently being included, will be added to the manual at a future date. This will be possible as more work place and special generator surveys are performed in Texas, and/or when additional existing survey data are analyzed and in a form that may be useful for the manual. The database created as a result of efforts described in Chapter 3 and Chapter 4 was structured to allow for additional data to be merged into the database smoothly.

Table 28. List of LUC Descriptions.

ITE LUC	Description
110	General Light Industrial
140	Manufacturing
150	Warehousing
151	Mini-Warehouse
170	Utilities
254	Assisted Living
310	Hotel
540	Junior/Community College
565	Day Care Center
610	Hospital
620	Nursing Home
630	Clinic
640	Animal Hospital/Veterinary Clinic
720	Medical-Dental Office Building
812	Building Materials and Lumber Store
814	Variety Store
816	Hardware/Paint Store
820	Shopping Center
841	Automobile Sales
842	Recreational Vehicle Sales
843	Automobile Parts Sales
852	Convenience Market (Open 15–16 Hours)
853	Convenience Market with Gasoline Pumps
881	Pharmacy/Drugstore with Drive-Through Window
890	Furniture Store
912	Drive-in Bank
932	High-Turnover (Sit-Down) Restaurant
933	Fast-Food Restaurant without Drive-Through Window
934	Fast-Food Restaurant with Drive-Through Window
935	Fast-Food Restaurant with Drive-Through Window and No Indoor Seating
943	Automobile Parts and Service Center
944	Gasoline/Service Station
945	Gasoline/Service Station with Convenience Market
946	Gasoline/Service Station with Convenience Market and Car Wash

INDEPENDENT VARIABLES

As stated in the *Handbook* portion of Volume 1 of the ITE *Trip Generation Manual*, "An independent variable is defined as a physical, measurable and predictable unit describing the study site or trip generator" (*38*, p. 3). Number of employees and 1000 square foot gross floor area were important independent variables to consider in relation to all 34 LUCs included in the original version of the Texas Trip Generation Manual. However, some LUCs naturally lend themselves to the consideration of additional independent variables.

Table 29 shows a list of those independent variables that were considered, in addition to the standard independent variables of number of employees and 1000 square foot gross floor area, for certain LUCs. As stated in the ITE *Handbook* portion of Volume 1 of the ITE *Trip*

Generation Manual, in determining which independent variable may be most useful in estimating trip generation rates, "It is best to use the one that (1) is most **directly causal for the variation in trip ends** generated by a land use and (2) is **accurately projectable** for proposed development sites" (*38*, p. 3). It will be possible to gain better insight into the usefulness of the independent variables for each LUC as the data are prepared for potential inclusion in the manual. As specified in the *User's Guide* portion of Volume 1 of the ITE *Trip Generation Manual*, the best fit regression curves should only be shown if "the R^2 value is greater than or equal to 0.5, the sample size is greater than or equal to 4, and the number of trips increases as the size of the independent variable increases" (*38*, p. 14).

Table 29. Additional Special Independent Variables and Corresponding LUCs.

Special Independent Variable	LUCs
Acres	110-General Light Industrial 140-Manufacturing 150-Warehousing 151-Mini Warehouse 816-Hardware-Paint Store
Rooms	310-Hotel
Students	540-Junior Community College
Fueling Positions	853-Convenience Market with Gas Pump 944-Gas Service Station 945-Gas Station, Convenience Market 946-Gas Station Convenience Market Car Wash
Drive-Through Lanes	912-Drive-in Bank

ANALYSIS METHOD AND SAMPLE SIZE

The next decision related to the Texas Trip Generation Manual guidelines was which analysis method to use in analyzing the work place and special generator survey data. The two options considered include the following:

- A constant average trip rate per independent variable unit.
- A regression equation estimating trips as a function of the independent variable(s).

Within the ITE *Handbook* portion of Volume 1 of the ITE *Trip Generation Manual*, there is a set of guidelines provided for deciding which of these two methods, if either (as opposed to collecting local data), should be followed. In an effort to maintain consistency, researchers chose to follow the same guidelines for developing the Texas Trip Generation Manual. The following guidelines (shown in Figure 17) were considered (*38*, p. 10, Figure 3.1).

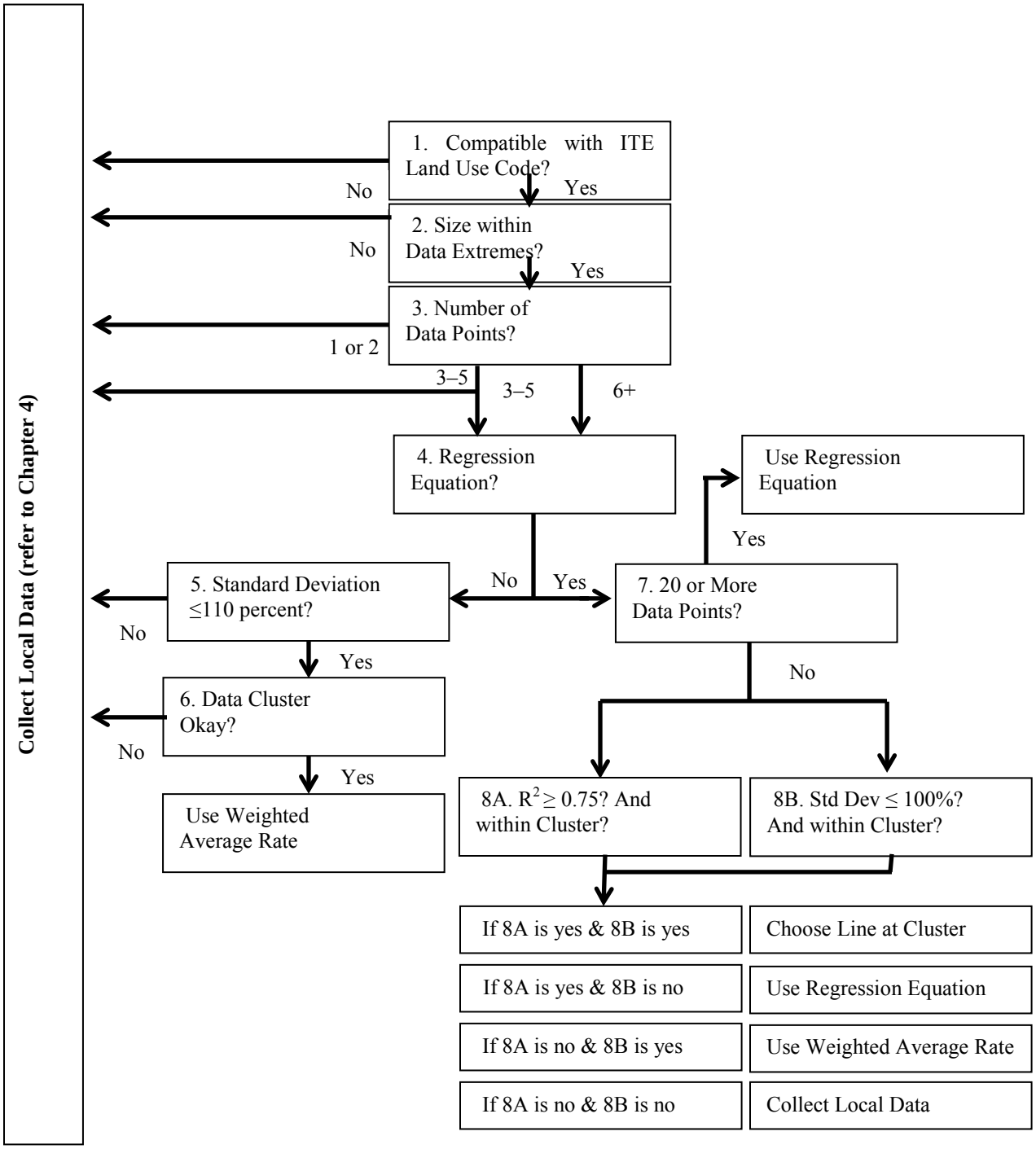

Figure 17. Recommended Procedure for Selecting between Trip Generation Average Rates and Equation (*37*, p. 10, Figure 3.1).

The minimum required sample size was set at three establishments per LUC, as was noted previously. While only three establishments per LUC are required for inclusion in the manual, having more data points is preferable because it will help paint a clearer picture of what a reasonable trip generation rate may be for establishments within a given LUC. Similarly, a small sample size may influence the elements that are included within the data set plot. As specified in the ITE *User's Guide* portion of Volume 1 of the ITE *Trip Generation Manual*, if a data set has five or fewer data points, the chart should state that the values should be used with caution (*37*). Similarly, one of the requirements of showing the best fit regression curve is that there are data from at least four establishments for a given LUC, as stated in the ITE *User's Guide* portion of Volume 1 of the ITE *Trip Generation Manual* (*37*, p. 14). These same guidelines will be followed for the Texas manual.

MANUAL FORM

Many of the procedures associated with the ITE *Trip Generation Manual* will be implemented in the creation of the Texas Trip Generation Manual. However, one notable exception is that the Texas Trip Generation Manual will be made available in an electronic format, rather than in print form as the ITE *Trip Generation Manual* is. This format will allow for updates in the data set to be incorporated on an on-going basis, without being affected by delays associated with waiting for the newest edition of the manual to be finalized and printed.

As with the ITE *Trip Generation Manual*, the Texas Trip Generation Manual will only be made available in summary form, making it impossible for users to link a specific site to its corresponding data, due to the more aggregated, summarized nature of the data displayed.

UPDATING FREQUENCY AND PROCEDURES

According to the ITE *User's Guide*, ITE has an established procedure for updating the data made available through the *Trip Generation Manual* (*37*). ITE has a computer program that aids in the updating process and ensures that when additional data are added to the database, the updated trip generation charts are uniform. Among its specific efforts to update the *Trip Generation Manual*, ITE encourages the collection and submission of new data. As part of this effort, ITE provides the forms needed to collect the data and helps to identify specific land uses that need additional data collection. ITE also stores and maintains a database with all of the data that are submitted, though the data are not available to the public in this disaggregate form.

Many of the techniques employed as part of the Texas Trip Generation Manual will follow a similar approach. Researchers will attempt to automate the process of updating the manual based on additional data becoming available. While data collected by ITE student chapters, government agencies, etc. will be welcome, and potentially solicited, it is anticipated that additional data being added to the manual will largely stem from work place and special generator travel surveys performed as part of the Texas Travel Survey Program. Efforts are underway to ensure that the specifications of these types of travel surveys result in data that are usable within the Texas Trip Generation Manual. One way to address deficiencies in the number of data points associated with a specific land use type may be to earmark a portion of the work place and/or special generator surveys to address this need.

CONCLUSIONS

This chapter has outlined the criteria chosen for the creation of the Texas Trip Generation Manual. Specifically, guidelines addressing the following issues were described:

- Elements Appropriate for Inclusion.
- Time Periods.
- Classifications.
- Independent Variables.
- Analysis Method.
- Minimum Required Sample Size.
- Manual Form.
- Updating Frequency and Procedures.

The guidelines largely stemmed from those used in the ITE *Trip Generation Manual* to allow for easier comparisons between the ITE manual and the Texas manual. As planners use the Texas Trip Generation Manual, the guidelines associated with its creation will evolve to better meet planning needs.

7. EVALUATE MODELS AND POTENTIAL EXPLANATORY VARIABLES

Travel demand forecasting (TDF) is an essential tool in designing future transportation facilities and services. TDF is not only important in the context of future investments but also when evaluating policies and quantifying the impacts of a new facility (either a new road or a large shopping mall) on an area's traffic. As the literature attests, different types of establishments (i.e., retail, recreation, etc.) sited within different land use configurations (central business district vs. non–central business district) attract traffic in different ways—not only in terms of the total number of vehicles but also in terms of time of day. For example, a retail center would certainly attract more traffic and at different times of the day than would a construction office. Transportation planners account for these varying attraction rates by incorporating the appropriate rates into the TDF planning process.

TDF essentially comprises four steps: trip generation, trip distribution, mode split, and trip assignment. The first step of this process, *trip generation*, consists of predicting the total number of trips generated/produced and attracted to each zone of the study area. The study area is generally a county, which is further divided into small blocks called traffic analysis zones for ease in analysis. The trip attraction (TA) component identifies the total number of trips attracted by the various establishments within each TAZ, and the trip production (TP) component identifies the number of trips generated/produced by the households within each TAZ. In general, TP is modeled using TAZ characteristics (residential density, value of land, accessibility, etc.) and household demographic characteristics (household size, income, vehicle ownership, etc.). The TA, on the other hand, is influenced by factors such as the roofed space available for various types of industries and services. Further, the TA is also influenced by zonal employment and accessibility. In other words, each TAZ's TA rate is influenced by the local characteristics. A literature review clearly indicates that the same establishment located in two different land use configurations has different TA rates. TA rate is affected mostly by land use configuration, such as the presence of retail centers, recreation centers, schools, good parking facilities at establishments, etc. At the same time, the TA rate for an establishment depends significantly on the location[3] of the establishment itself. For example, one can expect a higher number of trips to a grocery store located in an urban area compared to a grocery store located in a rural area. Similarly, a shopping mall located in the CBD with good parking facilities would certainly attract more vehicles than would a similar establishment with poor parking facilities.

In summary, different establishments located in different locations have different TA rates. Hence, it is imperative that planners model the attraction rate as accurately as possible by

[3] Task 3 of this research study compiled and analyzed Texas work place survey data to develop TA rates. As part of this task, metropolitan areas in Texas were classified into four metropolitan area types based on population: **small** (population less than 200K), **medium** (population between 200K and 500K), **large** (population between 500K and 1200K), and **metropolis** (population greater than 1200K). The Task 3 analysis also classified TAZs into five area types depending upon the population density (population per unit acre): **central business district** (population density greater than 50), **CBD fringe** (population density between 15 and 50), **urban** (population density between 10 and 15), **suburban** (population density between 1 and 10), and **rural** (population density less than 1). Thus, an establishment's location is indicated by metropolitan area type and TAZ area type.

considering zonal and establishment characteristics in order to obtain accurate travel demand forecasts.

The purpose of this study was to model a TA rate at a disaggregate level. Therefore, instead of classifying employment types into the four well-known categories of basic, retail, service, and education, the research team classified them into 14 categories (as discussed later) and developed the TA rates using various explanatory variables pertaining to the TAZ and the establishment.

ESTABLISHMENT CLASSIFICATION AND EXPLANATORY VARIABLES

Two classification schemes—the Institute of Transportation Engineers land use classification system and the North American Industry Classification System—are used to classify the different establishments into similar sectors based on the type of service (i.e., goods-producing or service-producing sectors) undertaken by the establishment. NAICS sector employment is well established (i.e., standardized) over various classification and modeling schemes. Furthermore, most businesses in the US are classified according to this scheme. At the aggregate level, the NAICS system classifies the establishments into 20 sectors. Further, each sector includes a number of establishments of similar characteristics based on the type of service or production. For example, the aggregate category Agriculture, Forestry, Fishing and Hunting, Mining and Quarrying (one of the 20 NAICS sectors) includes crop production, vegetable and melon farming, etc., as subsectors. On the other hand, ITE LUCS classifies the establishments based on the characteristics of the establishment/site that are expected to influence the number of trips attracted to it. Thus, ITE LUCS may classify a gas station in different categories depending upon its configuration, such as gas station with no store, gas station with a store and a restaurant, etc. Hence, adhering to ITE LUCS for TA modeling can be cumbersome and data intensive. In light of this, the NAICS classification system was selected as the basis for analysis for this portion of the project to ensure sufficient sample size per sector. Further, based on the data set available for the estimation, activity generation was limited to the following 14 employment sector groupings:

1. Agriculture, Forestry, Fishing and Hunting, Mining and Quarrying (referred to in the text as Agriculture).
2. Construction.
3. Manufacturing.
4. Wholesale Trade.
5. Retail Trade.
6. Transportation and Warehousing.
7. Information.
8. Finance, Insurance, and Real Estate (Finance).
9. Professional, Scientific, Management, Administrative, and Waste Management Service (Professional Services).
10. Educational Services.
11. Health Care.
12. Arts, Entertainment, Recreation, Accommodation, and Food Services (Recreation).
13. Public Administration and Other Services (Public Administration).
14. Utilities.

In addition, researchers combined a few employment groupings into one category, either because the employment sectors did not have sufficient sample size or because the average TA rates were the same. For example, they combined the Agriculture, Forestry, Fishing and Hunting employment sector with Mining and Quarrying because the sectors had similar TA rates and also had very few observations as an independent employment grouping. Likewise, they combined Professional, Scientific, Management and Administrative, Waste Management Service, Arts, Entertainment, Recreation and Accommodation, and Food Services into one category.

This final classification scheme is used to acknowledge that different establishments (employment categories) have different TA rates (see Table 30 and Table 31) and to ensure that sufficient sample points are available for each group to develop statistical models. The average attraction rates (per employee) provided in Table 30 and Table 31 were derived in the following manner:

- Based on the NAICS code, researchers grouped the establishments into one of the 14 employment categories as mentioned above.
- For each employment sector, the researchers removed establishments missing values on key variables, such as the following:
  - Parking availability.
  - Employment density.
  - Metropolitan area type.
  - TAZ area type.
  - Establishment/activity center type (freestanding or non-freestanding).
  - Total number of commercial and non-commercial vehicles (vehicles used for delivering goods such as medium to high duty trucks, etc.) that visited the establishment on the day of the survey.
  - Number of employees in the establishment.
- Researchers obtained the attraction rate for each establishment within an employment sector by dividing the total number of commercial and non-commercial vehicles by number of employees at the establishment.

The average attraction rate across each establishment was calculated, irrespective of its location (based on MPO size and TAZ type), for each of the employment sector classifications and is reported in Table 30 and Table 31, along with the corresponding standard deviations. Table 32 provides the p-values indicating that the TA rates are different for commercial and non-commercial vehicle trips for a particular employment sector. Table 33 and Table 34 provide the p-values that indicate whether the TA rates for any two employment sectors are different for commercial and non-commercial vehicle trip categories, respectively.

The p-values provided in Table 32, Table 33, and Table 34 can be interpreted as follows. Set a significance level (alpha level) and compare it to the p-value. If the p-value is less than or equal to the significance level, one can conclude that the corresponding employment sectors have different TA rates. For example, the p-value for the Construction sector is 0.0211. Thus, at a 5 percent level of significance, the TA rates are different for commercial and non-commercial vehicle trip categories for the Construction sector. At a significance level of 20 percent, most of the sectors have different TA rates corresponding to the commercial and non-commercial vehicle trip categories. Thus, one may conclude that there is a strong statistical basis for developing

separate TA models for commercial and non-commercial vehicle trips. Further, at a significance level of 40 percent (see Table 33) and 10 to 20 percent (see Table 34), most of the employment sectors are different in terms of TA rates for the commercial and non-commercial vehicle trips. Thus, the statistical basis for developing employment-sector-specific TA models for the non-commercial vehicle trip category is relatively stronger than for the commercial vehicle trip category, though some of the employment sectors do have differences in TA rates that are statistically significant. Thus, in light of these findings, the research team chose to develop employment-sector-specific TA models for both commercial and non-commercial vehicle trip categories.

Table 30. Number of Sites per Employment Sector Category and Average Attraction Rate for Commercial Vehicle Trips (Standard Deviation in Parentheses).

Employment Sector	# of Sites	Average Attraction Rate (per Employee)
Agriculture, Forestry, Fishing & Hunting, Mining & Quarrying	26	0.117 (0.196)
Construction	106	0.292 (0.655)
Manufacturing	103	0.489 (1.101)
Wholesale Trade	119	0.510 (1.165)
Retail Trade	639	0.595 (1.844)
Transportation & Warehousing	43	0.777 (1.056)
Information	15	0.131 (0.296)
Finance, Insurance, & Real Estate	248	0.346 (1.478)
Professional, Scientific, Management, Administrative, & Waste Management Service	193	0.342 (1.527)
Educational Services	481	0.297 (0.402)
Health Care	273	0.250 (0.447)
Arts, Entertainment, Recreation, Accommodation, & Food Services	278	0.127 (0.237)
Public Administration and Other Services	100	0.478 (0.999)
Utilities	11	0.348 (0.907)
Total	**2,635**	

Table 31. Number of Sites per Employment Sector Category and Average Attraction Rate for Non-Commercial Vehicle Trips (Standard Deviation in Parentheses).

Employment Sector	# of Sites	Average Attraction Rate (per Employee)
Agriculture, Forestry, Fishing & Hunting, Mining & Quarrying	29	1.558 (3.054)
Construction	119	2.410 (3.779)
Manufacturing	114	2.186 (3.744)
Wholesale Trade	136	3.145 (5.633)
Retail Trade	713	29.264 (71.670)
Transportation & Warehousing	44	29.713 (64.098)
Information	17	1.672 (2.945)
Finance, Insurance, & Real Estate	273	6.949 (16.651)
Professional, Scientific, Management, Administrative, & Waste Management Service	224	2.325 (5.606)
Educational Services	512	13.003 (9.259)
Health Care	313	2.994 (5.632)
Arts, Entertainment, Recreation, Accommodation, & Food Services	326	10.457 (18.989)
Public Administration and Other Services	114	4.339 (7.520)
Utilities	14	5.188 (6.450)
Total	**2,948**	

Table 32. P-Values Indicating Whether the TA Rates Are Different for Commercial and Non-Commercial Vehicle Trips for an Employment Sector.

Employment Sector	p-Value
Agriculture, Forestry, Fishing & Hunting, Mining & Quarrying	0.0427
Construction	0.0211
Manufacturing	0.0588
Wholesale Trade	0.1166
Retail Trade	0.2230
Transportation & Warehousing	0.2742
Information	0.1793
Finance, Insurance, & Real Estate	0.3036
Professional, Scientific, Management, Administrative, & Waste Management Service	0.1308
Educational Services	0.0000
Health Care	0.0261
Arts, Entertainment, Recreation, Accommodation, & Food Services	0.2580
Public Administration and Other Services	0.1791
Utilities	0.3098

Table 33. P-Values Indicating Whether the TA Rates Are Different for Commercial Vehicle Trips for Any Two Employment Sectors.

	AGR	CONST	MANF	WHTR	RETR	TRWA	INFOMS	FINC	PROFS	EDUSC	HECA	ARTSC	ADMIN	UTIL
AGR		0.3791	0.409	0.3906	0.4882	0.4812	0.4837	0.4565	0.4467	0.2319	0.4023	0.4452	0.3886	0.2858
CONST			0.452	0.4021	0.4755	0.4445	0.1811	0.4173	0.4883	0.0753	0.4202	0.3898	0.337	0.2819
MANF				0.3749	0.4759	0.4461	0.2625	0.4155	0.4811	0.0758	0.3923	0.3897	0.3227	0.2654
WHTR					0.4743	0.4402	0.0485	0.4266	0.4056	0.0852	0.4816	0.3932	0.4136	0.4118
RETR						0.4822	0	0	0	0	0	0	0	0
TRWA							0.003	0.0119	0.0035	0.0456	0.0042	0.0269	0.006	0.0081
INFOMS								0.468	0.4655	0.2909	0.4312	0.4592	0.4199	0.3404
FINC									0	0	0.0001	0.4473	0.0172	0.1934
PROFS										0.0273	0.4045	0.3397	0.3305	0.3728
EDUSC											0	0.426	0	0.0003
HECA												0.3183	0.3743	0.4013
ARTSC													0	0.0076
ADMIN														0.4783
UTIL														

Key:

Agriculture, Forestry, Fishing & Hunting, Mining & Quarrying (AGR)

Construction (CONST)

Manufacturing (MANF)

Wholesale Trade (WHTR)

Retail Trade (RETR)

Transportation & Warehousing (TRWA)

Information (INFOMS)

Finance, Insurance, & Real Estate (FINC)

Professional, Scientific, Management, Administrative, & Waste Management Service (PROFS)

Educational Services (EDUSC)

Health Care (HECA)

Arts, Entertainment, Recreation, Accommodation, & Food Services (ARTSC)

Public Administration and Other Services (ADMIN)

Utilities (UTIL)

Table 34. P-Values Indicating Whether the TA Rates Are Different for Non-Commercial Vehicle Trips for Any Two Employment Sectors.

	AGR	CONST	MANF	WHTR	RETR	TRWA	INFOMS	FINC	PROFS	EDUSC	HECA	ARTSC	ADMIN	UTIL
AGR		0.0128	0.0436	0.0548	0.2331	0.0002	0.2238	0.2888	0.3023	0	0.0003	0.1878	0.0222	0.0099
CONST			0.0414	0.0386	0.1664	0	0.0571	0.3901	0.4027	0.4698	0.2715	0.0064	0.0304	0.3512
MANF				0.4501	0.3732	0.0911	0.0043	0.2611	0.268	0.0423	0.0175	0.0007	0.4702	0.3539
WHTR					0.3917	0.1247	0.0025	0.2211	0.2305	0.0257	0.0098	0.0003	0.4113	0.2951
RETR						0.1541	0	0.0183	0.0278	0	0	0	0.1718	0.2007
TRWA							0.0003	0.0999	0.1118	0.0025	0.0012	0.0001	0.0574	0.1183
INFOMS								0.3487	0.3597	0	0.0111	0.4802	0.0805	0.0892
FINC									0.492	0.3052	0.1634	0.0111	0.1689	0.4968
PROFS										0.3452	0.2097	0.0274	0.1805	0.4911
EDUSC											0.0002	0	0	0.1691
HECA												0	0	0.0756
ARTSC													0	0
ADMIN														0.3398
UTIL														

Key:

Agriculture, Forestry, Fishing & Hunting, Mining & Quarrying (AGR)

Construction (CONST)

Manufacturing (MANF)

Wholesale Trade (WHTR)

Retail Trade (RETR)

Transportation & Warehousing (TRWA)

Information (INFOMS)

Finance, Insurance, & Real Estate (FINC)

Professional, Scientific, Management, Administrative, & Waste Management Service (PROFS)

Educational Services (EDUSC)

Health Care (HECA)

Arts, Entertainment, Recreation, Accommodation, & Food Services (ARTSC)

Public Administration and Other Services (ADMIN)

Utilities (UTIL)

For the explanatory variables, researchers used parking availability, employment density, metropolitan area type, TAZ area type, establishment/activity center type (freestanding and non-freestanding), and—if available—number of employees in the establishment. All these variables were compiled and arranged to form a master database. The explanatory variables considered here cover most of the factors that might affect the TA rate of an establishment within one of the employment sectors. The following paragraphs explain the rationale for inclusion of each explanatory variable in the analysis.

Parking Availability

An establishment with a parking facility can be expected to attract more vehicular traffic than an establishment with no parking facility, as mentioned earlier; parking plays a major role in CBDs particularly, due to limited availability of parking space. Hence, one can expect a positive sign on the parking availability variable coefficient.

Employment Density

The employment density variable indicates the density of employment in the zone. Employment density is a better measure of zone employment than a total employment figure, as the latter can be misleading, depending on the total area of the zone. A higher value of employment density indicates a higher concentration of people working in a unit area, causing a positive effect on trips related to retail, transportation, recreation, food, and other basic services. Thus, one can expect to observe a positive sign on the employment density variable coefficient for establishments providing retail, transportation, food, and other basic services.

Metropolitan Area Type

The metropolitan area type indicates the general population of a study area, as established in Footnote 2. A metropolitan area classified as large or metropolis will certainly be more developed than an area classified as small or medium, due to the greater number of jobs, higher income, better educational centers, better health care facilities, etc. For example, the Austin area is classified as metropolis while Lubbock is classified as medium, since Austin is more developed than Lubbock. Thus, it is obvious that an establishment located in a large MPO area type will have a larger number of vehicles/people visiting the establishments than an establishment located in a small MPO area. However, since the unit of analysis for the TA rate in the current study is number of vehicles per employee, one can expect a mixed effect for MPO area type; in other words, after normalizing the total attraction (number of vehicles visiting an establishment divided by number of employees working at the establishment), the normalized attraction may be higher for an establishment located in a small MPO area than an establishment located in a large MPO area. This can be attributed to the fact that establishments located in large MPO areas generally employ more personnel to meet higher demands, which may reduce the number of people served by an employee and, thus, may decrease the normalized attraction.

TAZ Area Type

The TAZ area type influences the TA rate generally in the same manner as the metropolitan area size. For example, one can expect a higher attraction rate to a manufacturing center located outside the CBD than one located in the CBD due to ease of goods transportation (the larger

vehicles going to a manufacturing center will encounter less travel time and better maneuverability outside the CBD). Thus, it will be interesting to see the effect of area types on the various establishments.

Establishment Type

An establishment can be classified as freestanding or non-freestanding. A non-freestanding establishment is one where a type of activity center is located in a complex along with other types of activity centers. Thus, one can expect a higher attraction rate for the non-freestanding establishments than for freestanding establishments because people can perform more than one kind of activity in one trip at non-freestanding establishments.

Inclusion of these explanatory variables in the TA model will certainly capture a sufficient amount of variability and, thus, provide an accurate estimate of TA rates for TDF. Table 35 and Table 36 provide the descriptive statistics for the explanatory variables used in the analysis. Several observations can be made from Table 35 and Table 36. First, most of the establishments have their own parking facilities. Second, few establishments are located in a TAZ with an employment density of 10 and more people per acre. However, most of the establishments are located in a CBD area, suggesting that the CBD areas are not highly populated. Third, most of the establishments are located in large metropolitan areas; however, there is a good distribution of establishments in medium- to small-sized metro areas, as well, suggesting that the area coverage in terms of size is reasonable. Finally, on average, more than 50 percent of the establishments are non-freestanding, which is intuitive, as most of the establishments are located in large metropolitan areas and in CBD areas.

Table 35. Descriptive Statistics (Sites Used in Calculating TA Rates Corresponding to Non-Commercial Vehicles).

Variable	% of Sites with Parking Facility	% of Sites with Employment Density Greater than 10 per Acre	Metro Area Type			TAZ Area Type			% of Non-freestanding Sites
			Small	Medium	Large	Non-CBD	CBD Fringe	CBD	
AGR	93	31	10	7	83	3	21	76	66
CONST	93	14	14	13	73	1	15	84	71
MANF	90	11	20	16	64	0	21	79	75
WHTR	88	13	6	17	77	1	18	81	75
RETR	82	10	11	20	69	1	16	83	61
TRWA	89	20	25	23	52	0	14	86	80
INFOMS	76	12	6	12	82	0	18	82	41
FINC	86	10	13	14	73	1	19	80	58
PROFS	78	10	12	20	68	2	29	69	51
EDUSC	95	15	19	17	64	0	9	91	93
HECA	85	5	23	18	59	1	28	71	46
ARTSC	83	12	6	17	77	1	15	84	60
ADMIN	96	14	62	4	34	2	4	94	61
UTIL	93	43	7	7	86	0	14	86	100

Key:

Agriculture, Forestry, Fishing & Hunting, Mining & Quarrying (AGR)

Construction (CONST)

Manufacturing (MANF)

Wholesale Trade (WHTR)

Retail Trade (RETR)

Transportation & Warehousing (TRWA)

Information (INFOMS)

Finance, Insurance, & Real Estate (FINC)

Professional, Scientific, Management, Administrative, & Waste Management Service (PROFS)

Educational Services (EDUSC)

Health Care (HECA)

Arts, Entertainment, Recreation, Accommodation, & Food Services (ARTSC)

Public Administration and Other Services (ADMIN)

Utilities (UTIL)

Table 36. Descriptive Statistics (Sites Used in Calculating TA Rates Corresponding to Commercial Vehicles).

Variable	% of Sites with Parking Facility	% of Sites with Employment Density Greater than 10 per Acre	Metro Area Type			TAZ Area Type			% of Non-freestanding Sites
			Small	Medium	Large	Non-CBD	CBD Fringe	CBD	
AGR	92	27	12	8	80	4	23	73	62
CONST	92	11	16	15	69	1	16	83	70
MANF	90	11	22	17	61	0	21	79	74
WHTR	88	10	7	19	74	2	20	78	76
RETR	82	9	11	22	67	1	17	82	62
TRWA	91	19	26	23	51	0	14	86	81
INFOMS	80	13	7	13	80	0	20	80	40
FINC	87	9	14	16	70	1	19	80	61
PROFS	81	8	13	23	64	2	32	66	52
EDUSC	95	14	20	18	62	0	9	91	93
HECA	87	5	27	21	52	1	32	67	45
ARTSC	82	10	7	20	73	1	18	81	61
ADMIN	98	15	70	4	26	2	5	93	60
UTIL	91	27	9	9	82	0	18	82	100

Key:

Agriculture, Forestry, Fishing & Hunting, Mining & Quarrying (AGR)

Construction (CONST)

Manufacturing (MANF)

Wholesale Trade (WHTR)

Retail Trade (RETR)

Transportation & Warehousing (TRWA)

Information (INFOMS)

Finance, Insurance, & Real Estate (FINC)

Professional, Scientific, Management, Administrative, & Waste Management Service (PROFS)

Educational Services (EDUSC)

Health Care (HECA)

Arts, Entertainment, Recreation, Accommodation, & Food Services (ARTSC)

Public Administration and Other Services (ADMIN)

Utilities (UTIL)

TRIP ATTRACTION MODEL FOR NON-COMMERCIAL VEHICLES

As discussed above, separate linear regression models were developed using TA rates as dependent variables for both non-commercial and commercial vehicle trips. For each employment sector, the research team estimated both ordinary least square (OLS) and a robust multi-linear regression equation; the final model was chosen based on overall model fit and direction of parameters. The robust regression is an iteratively reweighted least square regression with a bisquare weighting function. The robust regression technique is less affected by the presence of outliers compared to the OLS method. One can expect the robust regression to perform better compared to OLS for small sample sizes with geographically distributed observation points. Generally, if the sample points are distributed on a larger geographical scale, there is a chance that some of the points may be outliers simply due to the local effects (i.e., characteristics of the area, where the site is located). The unit of analysis is the number of vehicular trips (commercial or non-commercial) per employee. Table 37 provides the model estimation results for non-commercial vehicle trips.

The alternative specific constants do not have any substantive meaning and simply adjust the location of the regression line in the presence of the other explanatory variables. For explanatory variables, the researchers retained all the variables in the model whose signs were intuitive and had a t-statistic value of greater than or around 1, which corresponds to a 65 percent confidence interval. The research team selected a low confidence interval because most of the explanatory variables used in this analysis have not been used in many previous studies. Thus, given the low sample size of establishments within each employment sector and the need to explore some of the variables' effects (which may provide future studies a starting point for investigation of variables that might affect TA rates), the researchers decided to use a low confidence level. Accordingly, future studies can certainly test the influence of these variables with larger sample sizes that hopefully will provide a better statistical basis for the influence of the explanatory variables used in this study.

As expected, the availability of a parking facility at the establishment positively impacts the attraction to the establishment, as found by other studies, as well. Of all the employment sectors in the model where the presence of a parking facility is significant, the level of significance[4] is the key factor to examine. The magnitude is highest for retail trade and significant (65 percent confidence level) for recreation as well. This result is not surprising, as people spend a good amount of total out-of-home time in retail centers obtaining household goods for daily use, as well as at recreation and food centers. Thus, the presence of a parking facility at these establishment types offers an extra incentive to pursue such activities, especially in the CBD and neighboring areas.

The employment density coefficient also shows an expected sign, as discussed earlier. Employment density has a positive influence on TA for employment sectors, such as Transportation and Warehousing, Finance, Professional Services, Health Care, and Public

[4] To determine the level of significance, multiply the coefficient value by the ratio of standard deviations corresponding to the explanatory variable and the dependent variable.

Administration. The positive influence of employment density on these employment sectors is not surprising, as a large value for employment density indicates more opportunities in terms of jobs, which translates to better income, and consequently more trips to establishments that fulfill basic needs such as food, transportation, health care, entertainment, and recreation.

For metro area size, the small metro area size is considered the base category. Thus, a positive sign on the medium and large metro areas indicates that more trips per employee are attracted to a particular employment sector when it is located in either medium or large metro areas as compared to small metro areas. As expected, the sign on the metro area type coefficient is both positive and negative. Specifically, there is a negative effect for Professional Services, Health Care, Public Administration, and Utility sectors. The negative effect of MPO area type on these sectors can be attributed to the reason discussed earlier (more employees at the establishment to meet higher expected demands and, thus, fewer people served by an employee). At the same time, these results may be a manifestation of the local area characteristics, such as fewer people visiting these sectors, or the number of employees in these sectors may be high. Thus, these results should be used carefully when applied to derive the TA rates in other states.

The TAZ area type coefficient has a negative sign for all the employment sectors (wherever found significant). Thus, a negative sign on the CBD indicator variable indicates that people prefer to drive to less congested areas (non-CBD areas) for pursuing any kind of activity, rather than driving to relatively congested areas such as the CBD and neighboring areas. This outcome is not surprising, as nobody wants to be stuck in traffic. The area type can be viewed as a proxy for travel time because one can generally expect a higher travel time in the CBD area and relatively lower travel times in the non-CBD (CBD fringe, urban, suburban, and rural) areas. Thus, the negative sign on the CBD area type is a direct indication of higher travel time.

The freestanding employment sector indicator variable has a negative sign for all the employment sectors (wherever found significant in the model) except for the Recreation sector. This is indicative of the fact that people prefer to perform as many types of activities as possible (such as shopping, eating out, etc.) in one trip. The non-freestanding activity centers are often located in big complexes that include various other activity centers under one big roof, thus providing the opportunity to pursue multiple activities in one place. Hence, it is not surprising that people tend to prefer non-freestanding activity centers over freestanding activity centers. The positive sign for the Recreation sector can be a manifestation of local area characteristics and, hence, should be used carefully.

The research team notes here one important issue pertaining to model estimation. In any case, the sum of all the coefficients of a model or some combination of parameters, including the constant, should not be less than zero. This condition ensures that the prediction from the model is always positive, which should be the case here, given that the TA rates cannot be less than zero. Thus, for example, one can argue that a freestanding retail establishment located in a non-CBD/small metro area with no parking facility will predict a TA rate of −6.50, which is certainly unacceptable. Hence, before selecting the final model, the researchers checked all possible combinations of parameters to ensure that the model does not predict any negative value. Thus, in the case of the Retail Trade sector, there is no establishment that is located in a CBD area and is also freestanding. Further, all the establishments outside the CBD area have parking facilities, and all the freestanding establishments are either located in medium or large metro areas or have

parking facilities. Thus, any combination of establishment and zonal characteristics will not lead to a negative TA value. The same check was made for the Educational Services sector, as well, to ensure positive TA rates. Thus, future users should be careful when borrowing TA models developed in this study, as some combinations of establishment and zonal characteristics can lead to negative TA rates.

Table 37. Trip Attraction Model for Non-Commercial Vehicles (Number of Vehicles/Employee) (Estimates and t-Statistics in Parentheses).

Employment Classification	Agriculture, Forestry, Fishing & Hunting, Mining & Quarrying	Construction	Manufacturing	Wholesale Trade	Retail Trade	Transportation & Warehousing	Information
Alternative Specific Constant	2.147(1.693)	2.748(6.586)	2.592(6.467)	5.490(4.915)	18.807(1.498)	7.920(1.405)	2.909(1.660)
Parking Availability indicator variable					13.244(1.667)		2.405(1.216)
Employment Density indicator variable (>10 per acre)						54.607(2.366)	
Metro Area Type indicator variable (small is base)							
Medium	1.695(1.774)	1.796(1.823)		1.780(1.533)	10.325(1.159)	14.164(1.659)	1.908(1.491)
Large	1.695(1.774)	1.796(1.823)		1.780(1.533)	10.325(1.159)	14.164(1.659)	2.697(1.772)
TAZ Area Type indicator variable (non-CBD is base)							
CBD		−0.741(−1.992)			−13.318(−1.452)		
Establishment Type indicator variable (freestanding)	−2.045(−1.751)	−2.007(−2.670)	−1.597(−2.010)	−3.885(−3.453)	−24.557(−3.885)		-0.504(-1.282)

Table 37. Trip Attraction Model for Non-Commercial Vehicles (Number of Vehicles/Employee) (Estimates and t-Statistics in Parentheses) (Continued).

Employment Classification	Finance, Insurance, & Real Estate	Professional, Scientific, Management, Administrative, Waste Management	Educational Services	Health Care	Arts, Entertainment, Recreation, Accommodation, & Food Service	Public Administration & Other Services	Utilities
Alternative Specific Constant	9.856(3.138)	5.567(5.066)	12.068(12.987)	6.797(9.470)	12.853(5.438)	6.717(6.732)	10.250(1.867)
Parking Availability indicator variable	1.739(0.600)				2.476(0.924)		
Employment Density indicator variable (>10 per acre)	2.560(1.617)	3.236(1.935)		1.180(1.926)		4.761(2.626)	
Metro Area Type indicator variable (small is base)							
Medium		−1.217(−1.128)	1.923(1.880)	−1.162(−1.714)	2.971(1.706)	−1.632(−1.255)	−5.452(−1.803)
Large		−1.217(−1.128)	1.923(1.880)	−1.162(−1.714)	2.971(1.706)	−1.632(−1.255)	−5.452(−1.803)
TAZ Area Type indicator variable (non-CBD is base)							
CBD			−10.323(−1.620)		−6.770(−1.076)		
Establishment Type indicator variable (freestanding)	−9.490(−4.877)	−4.299(−6.240)	−8.394(−5.406)	−5.504(−9.569)	10.882(1.900)	−6.159(−4.784)	

TRIP ATTRACTION MODEL FOR COMMERCIAL VEHICLES

This section discusses the TA model for commercial vehicle trips. Table 38 presents the TA model for the commercial vehicle trips.

First, the alternative specific constants do not have any substantive meaning, as discussed above. Second, both OLS and robust regression models were estimated and the best one was chosen based on the criteria discussed in the previous section for non-commercial vehicles. Third, a 65 percent confidence level was used for inclusion of variables in the model due to the reasons established. Finally, all the combinations were checked to ensure that the predicted TA rates stay positive.

As with non-commercial vehicles, the availability of a parking facility (wherever found significant) at the establishment impacts the commercial vehicular traffic in a positive way for four employment classifications: (1) Agriculture, (2) Wholesale Trade, (3) Retail Trade, and (4) Transportation and Warehousing. These businesses generally have a single parking facility for both commercial and non-commercial vehicles. Therefore, it is not surprising that a parking facility is significant for commercial vehicles and is insignificant for non-commercial vehicles. Also, except for the Retail Trade sector businesses, these establishments mainly receive commercial vehicles, as they deal in the supply of goods in bulk amounts. On the other hand, note that parking is not significant for the construction, manufacturing, retail trade, art, entertainment, food services, and recreational activity centers for commercial vehicle trips. The data set provided information on parking facilities, which generally indicates the parking spaces available in front of the establishments for cars and in some cases for commercial vehicles. Thus, it is possible that these establishments generally have separate parking facilities for commercial vehicles due to the larger amounts of time required for loading and unloading goods. This factor may explain why parking facility was not significant for these employment sectors.

Employment density has a positive influence on TA for sectors such as Agriculture, Construction, Wholesale Trade, Educational Services, and Health Care. The positive impact of employment density on commercial vehicle trips to these employment sectors is simply indicative of the fact that most of these employment sectors (except Educational Services and Health Care) serve as a supply point for other activities, such as food services and retail trade. Higher employment density means more trips to food services and retail trade, thus requiring more frequent supply from the supply point. Therefore, an establishment that mainly supplies essential goods will have a higher number of commercial vehicle trips in a high employment density area. In contrast, the Health Care and Educational Services sectors do not serve as supply points but as consumers of sector-specific supplies. Health care institutions located in a high employment area may need frequent supply of essentials due to a high number of visitors, which may explain the positive impact on commercial vehicle trips. Similarly, institutions in the Educational Services sector require a continuous supply of campus essentials.

The effect of metro area type on commercial vehicle trips has mixed results. The metro area type has a negative effect for non-basic sectors (Construction, Finance, Professional Services, Educational Services, Health Care, Public Administration, and Utilities), suggesting that these sectors do not require frequent supplies of required goods as compared to basic sectors

(Recreation, Retail, Wholesale Trade, Manufacturing, etc.). This may be because non-basic sectors do not cater to the basic needs and, hence, do not require frequent restocking supplies.

The TAZ area type coefficient has both positive and negative signs, suggesting that, unlike non-commercial vehicle trips, some commercial vehicle trips to a particular employment sector prefer CBD areas over non-CBD areas (wherever found significant). The CBD variable has a negative sign for the Agriculture and Construction sectors. This is understandable, as commercial vehicles face real challenges in terms of travel time and parking in the CBD area, given the high volume of traffic coupled with interrupted movement due to pedestrian-friendly traffic rules and designs (e.g., long pedestrian signal phase, more zebra crossings, etc.). Additionally, sometimes commercial vehicle entry is prohibited during certain times of the day. Further, the Agriculture and Construction sectors are generally located outside the CBD area, which may further decrease the number of commercial vehicle trips to these sectors in the CBD area as compared to non-CBD areas. However, there is a positive coefficient on the CBD variable for the Public Administration sector. One possible explanation for this could be that this sector is generally located in or near the CBD area, which may contribute to the positive likelihood of this sector observing more commercial vehicle trips in the CBD area as compared to the non-CBD area.

The freestanding activity center indicator variable also has mixed signs for different employment sectors. Businesses in employment sectors such as Agriculture, Construction, Manufacturing, and Wholesale Trade are more likely to observe higher volumes of commercial vehicle traffic if they are freestanding establishments (rather than non-freestanding). One possible explanation for this could be that these businesses are generally established as freestanding establishments due to high floor and lot area requirements for storing and manufacturing goods. Also, the construction and manufacturing industries generate more noise due to the use of heavy machinery and equipment, and thus these establishments are usually located slightly away from other activity centers and residential areas. Hence, the positive sign on the freestanding indicator variable is an indicator that these sectors are generally freestanding. On the other hand, the Information, Finance, Professional Services, and Educational Services sectors have a negative sign for the freestanding indicator variable. Again, this is just an indicator that businesses in these sectors are generally non-freestanding.

Table 38. Trip Attraction Model for Commercial Vehicles (Number of Vehicles/Employee) (Estimates and t-Statistics in Parentheses).

Employment Classification	Agriculture, Forestry, Fishing & Hunting, Mining & Quarrying	Construction	Manufacturing	Wholesale Trade	Retail Trade	Transportation & Warehousing	Information
Alternative Specific Constant	0.079(1.362)	0.278(1.607)	0.327(1.751)	0.182(1.425)	0.394(1.681)	0.028(1.049)	0.204(1.747)
Parking Availability indicator variable	0.111(0.727)			0.568(1.373)	0.209(0.962)	0.716(1.270)	
Employment Density indicator variable (>10 per acre)	0.117(1.253)	0.346(1.733)		0.351(0.974)			
Metro Area Type indicator variable (small is base)							
Medium	0.045(1.294)	−0.138(−0.986)					
Large	0.045(1.294)	−0.138(−0.986)	0.156(0.983)	0.421(1.513)	0.748(4.233)	0.428(1.104)	0.384(1.706)
TAZ Area Type indicator variable (non-CBD is base)							
CBD	−0.100(−1.391)	−0.598(−1.097)					
Establishment Type indicator variable (freestanding)	0.068(0.789)	0.310(2.278)	0.157(1.616)	0.318(0.997)	−0.363(−2.136)		−0.200(−1.282)

Table 38. Trip Attraction Model for Commercial Vehicles (Number of Vehicles/Employee) (Estimates and t-Statistics in Parentheses) (Continued).

Employment Classification	Finance, Insurance, & Real Estate	Professional, Scientific, Management, Administrative, Waste Management	Educational Services	Health Care	Arts, Entertainment, Recreation, Accommodation, & Food Service	Public Administration & Other Services	Utilities
Alternative Specific Constant	0.669(2.526)	0.570(2.458)	0.569(14.364)	0.410(7.981)	0.095(6.218)	0.181(4.577)	0.750(1.535)
Parking Availability indicator variable							
Employment Density indicator variable (>10 per acre)			0.047(0.947)	0.105(1.847)			
Metro Area Type indicator variable (small is base)							
Medium	−0.289(−1.069)		−0.339(−7.771)	−0.226(−3.775)			−0.442(−1.464)
Large	−0.289(−1.069)	−0.201(−1.854)	−0.339(−7.771)	−0.226(−3.775)	0.163(4.724)	−0.156(−2.014)	−0.442(−1.464)
TAZ Area Type indicator variable (non-CBD is base)							
CBD						0.231(0.952)	
Establishment Type indicator variable (freestanding)	−0.192(−1.000)	−0.212(−1.933)	−0.080(−1.151)				

TRIP ATTRACTION MODELS FOR DIFFERENT TRIP PURPOSES AND MODE CHOICES

This section of the report discusses the TA models developed for different trip purposes and mode combinations. The researchers considered two trip purposes—home-based work and home-based other[5] (HBO). They also considered three modes—car/van, transit, and bike and walk. The two trip purposes and three modes were considered by analyzing the data and ensuring that a sufficient sample size was available for each combination (trip purpose and mode). In order to derive the total number of trips for all the combinations, average TA rates were derived using the intercept survey data and were then multiplied by the total number of non-commercial trips recorded at each of the establishments.

Table 39 provides the average trip rate for HBW trips using three different modes per day. Most of the HBW trips are made via the car/van trip mode. Very few work trips are made via the transit and walk/bike modes for the Educational Services sector. The researchers did not develop any models for HBW trips, as they depend mainly on the establishment size and employee demand in the respective employment industry. Apart from this, the work trips are mandatory trips that need to be made irrespective of industry location. These rates may also differ from one state to another depending upon the lifestyle of that state's population and, hence, should not be compared directly without taking into account the land use pattern of the state. Currently, TxDOT's current model framework, termed the Texas Package, works with five trip purposes—HBW, home-based non-work, non–home-based, truck-taxi, and non–home-based non-residential external—though it has the capability to handle up to 10 different trip purposes. It also considers four employment groupings—basic, service, retail, and education. The attraction rates for all the internal trip purposes are applied at the zonal level to estimate the unscaled attractions for each internal trip purpose. The attraction rates derived for HBW trips in this study can be used to replace the existing TA rates for HBW trips, given that the current study uses the latest data sets (2003–2012), though local HBW rates are preferred over geographically aggregated HBW rates. Additionally, the employment grouping has been disaggregated in this study as compared to traditional employment groupings (basic, retail, service, and education), which provides additional flexibility for existing Texas Package models in terms of obtaining accurate TA numbers for HBW trip purpose.

Table 40 provides the average trip rate per employee for HBO trips using three different modes per day. Several interesting observations arise from an examination of Table 40. First, the average TA rates are relatively different for all 14 employment categories. Second, the attraction rate is highest for the Retail Trade sector, which is understandable given that it caters to such basic needs as food, clothing, etc. Third, the Educational Services sector has a fairly high attraction rate (third highest among all 14 categories), suggesting a high frequency for pickup and drop-off trips. Finally, similar to HBW trips, few trips are made using transit and bike/walk. However, the Retail Trade sector does have a significant attraction rate (0.286) for the walk/bike mode. Overall, van/car dominates the mode column, and hence the research team developed

[5] The HBO trips include school trips, social/recreational trips, shopping, dining out, personal business, pickup/drop-offs, and others.

employment-sector-specific TA models for van/car mode only. For other modes, one can directly employ the average rates from Table 41 in the trip generation models.

The data set used for modeling TA rates for the HBO trip purpose is the same data set used in the modeling of trip rates for non-commercial vehicles (i.e., the number of sites per employment sector is the same as the number reported in Table 31). Table 41 provides the estimation results for the HBO TA model. First, the alternative specific constants do not have any substantive meaning, as discussed above. Second, both OLS and robust regression models were estimated, and the best one was chosen based on the criteria. Third, a 65 percent confidence level was used for inclusion of variables in the model, as discussed in the non-commercial vehicle section of this report. Finally, all the combinations were checked to ensure that the predicted TA rates stay positive.

Similar to commercial and non-commercial vehicle TA rates, the researchers developed separate linear regression models for HBO trips using the TA rate as a dependent variable. As expected, the availability of a parking facility at an establishment has a positive impact on the vehicular traffic, especially for shopping (Retail Trade), as found by other studies, as well. This outcome is not surprising, as people spend a significant amount of total out-of-home time in retail centers shopping for household goods. The availability of a parking facility is also significant (though only at a 65 percent confidence level) for the Information, Educational Services, and Health Care sectors. This finding is particularly understandable for the Health Care sector, as people visiting these centers may require ease of parking. Of course, parking offers convenience for any sector, which may explain the positive effect of parking on TA rates for Information and Educational Services. As discussed earlier, the researchers retained the variables in the model that had intuitive signs, despite the low significance level. As one of the aims of this study was to suggest potential variables for TA modeling, retaining variables that are of low significance but are intuitive may provide future studies with possible information regarding the use of explanatory variables.

The employment density coefficient also shows an expected positive sign. Employment density has a positive influence on the number of trips attracted to employment sectors such as Agriculture, Construction, Recreation, Public Administration, and Utilities. The positive influence on the above-mentioned employment sectors suggests that high employment density leads to higher earnings due to direct opportunities (e.g., jobs in the Manufacturing or Construction sectors) and indirect opportunities (e.g., jobs in food centers, recreation centers), which ultimately translates to a greater number of trips to places such as shopping malls, recreation centers, etc. The positive effect of employment density for the Agriculture and Construction sectors is not as intuitive as it is for other sectors. However, the research team retained the variables, as they are statistically significant and may be a manifestation of local characteristics.

Next, the study focused on the effect of metro area type on the TA rate. The small metro area type is considered as the base category. The metro area type variable has a positive impact on TA rates for the Wholesale Trade, Retail Trade, and Transportation and Warehousing employment sectors. On the other hand, it has a negative impact on TA rates for sectors such as Information, Professional Services, Public Administration, and Utilities. This finding suggests that people in large metro areas may visit businesses in sectors that cater to basic needs (such as Retail and

Transportation Services), but they do not like to visit business/work-oriented sectors, unlike in small or medium areas. This is understandable, as people in big cities tend to have busier lifestyles and any extra time outside work is fully utilized for shopping or recreation. Additionally, the Information, Professional Services, Public Administration, and Utilities sectors are basically work-oriented sectors (i.e., they only do official business), which may explain the decreased attraction to these sectors for trip purposes apart from work.

The TAZ area type coefficient has a negative sign for all the employment sectors (wherever found significant). Thus, a negative sign on the CBD area type indicator variable indicates a disutility associated with the trip to an employment sector. The travel time values are generally higher for the CBD areas when compared to other area types. Thus, given an option, people chose to drive to a less congested area.

Finally, the freestanding activity center indicator variable has a negative sign for all the activity centers, corroborating the earlier finding that people prefer to perform multiple types of activities in a single trip, as discussed in the commercial vehicle section of this report.

Table 39. Average Trip Rate for HBW Trips Using Different Modes.

Employment Category	Car/Van	Transit	Walk/Bike
Agriculture, Forestry, Fishing & Hunting, Mining & Quarrying	6.963	0	0
Construction	8.693	0	0
Manufacturing	20.178	0	0.02
Wholesale Trade	10.825	0	0
Retail Trade	12.947	0.074	0.086
Transportation & Warehousing	16.484	0	0
Information	1.929	0	0
Finance, Insurance, & Real Estate	5.302	0	0.111
Professional, Scientific, Management, Administrative, & Waste Management Service	4.706	0.01	0.036
Educational Services	48.542	1.421	2.101
Health Care	13.538	0.012	0.081
Arts, Entertainment, Recreation, Accommodation, & Food Services	17.098	0.114	0.439
Public Administration and Other Services	18.446	0.087	0
Utilities	40.583	0	0

Table 40. Average Trip Rate per Employee for HBO Trips Using Different Modes.

Employment Category	Car/Van	Transit	Walk/Bike
Agriculture, Forestry, Fishing & Hunting, Mining & Quarrying	0.187	0	0
Construction	0.130	0	0
Manufacturing	0.457	0	0
Wholesale Trade	0.857	0	0.004
Retail Trade	10.005	0.049	0.286
Transportation & Warehousing	3.399	0	0.040
Information	0.667	0	0
Finance, Insurance, & Real Estate	1.329	0.004	0.034
Professional, Scientific, Management, Administrative, & Waste Management Service	0.164	0	0.003
Educational Services	3.314	0.012	0.081
Health Care	0.603	0.003	0.006
Arts, Entertainment, Recreation, Accommodation, & Food Services	3.829	0.020	0.121
Public Administration and Other Services	1.275	0.001	0
Utilities	0.919	0	0

Table 41. Trip Attraction Model for HBO Trips Using Van/Car as Mode (Number of Vehicles/Employee) (Estimates and t-Statistics in Parentheses).

Employment Classification	Agriculture, Forestry, Fishing & Hunting, Mining & Quarrying	Construction	Manufacturing	Wholesale Trade	Retail Trade	Transportation & Warehousing	Information
Alternative Specific Constant	0.074(1.494)	0.120(1.156)	0.605(3.013)	0.933(2.694)	10.672(2.079)	3.497(1.876)	3.136(1.037)
Parking Availability indicator variable					6.023(1.297)		1.561(0.983)
Employment Density indicator variable (>10 per acre)	0.384(1.400)	0.375(2.840)					
Metro Area Type indicator variable (small is base)							
Medium							
Large				2.212(2.733)	11.405(2.558)	2.3602(0.967)	−1.955(−1.179)
TAZ Area Type indicator variable (non-CBD is base)							
CBD				−1.784(−0.885)			
Establishment Type indicator variable (freestanding)		−0.108(−1.702)	−0.533(−1.399)	−1.362(−2.151)	−15.857(−4.167)	−2.931(−0.949)	−1.576(−1.038)

Table 41. Trip Attraction Model for HBO Trips Using Van/Car as Mode (Number of Vehicles/Employee) (Estimates and t-Statistics in Parentheses) (Continued).

Employment Classification	Finance, Insurance, & Real Estate	Professional, Scientific, Management, Administrative, Waste Management	Educational Services	Health Care	Arts, Entertainment, Recreation, Accommodation, & Food Service	Public Administration & Other Services	Utilities
Alternative Specific Constant	2.814(1.774)	0.730(4.381)	2.887(2.580)	1.715(4.116)	6.859(7.607)	2.560(4.517)	6.396(5.879)
Parking Availability indicator variable			0.802(0.915)	0.289(0.958)			
Employment Density indicator variable (>10 per acre)					2.809(1.466)	1.677(1.863)	0.604(1.045)
Metro Area Type indicator variable (small is base)							
Medium		−0.160(−0.835)				−1.066(−1.610)	−6.250(−6.064)
Large		−0.449(−2.671)				−1.066(−1.610)	−6.250(−6.064)
TAZ Area Type indicator variable (non-CBD is base)							
CBD		−0.201(−0.845)	−2.355(−0.542)		−4.619(−0.982)		
Establishment Type indicator variable (freestanding)	−2.657(−2.690)	−0.409(−3.898)	−2.853(−3.057)	−1.679(−4.694)	−6.723(−5.524)	−2.348(−3.654)	

USE/APPLICATION OF TRIP ATTRACTION RATE IN ADVANCED TRAVEL DEMAND MODELS

The TA rates cannot be employed directly in advanced travel demand models (e.g., activity-based travel demand models). However, they can be used as a benchmark or reference for calibrating certain aspects of activity-based models. An important aspect of activity travel demand modeling is to determine both the work location for an individual and the stop location of a trip within a tour[6] performed by that individual. Now, TA rates can be used in activity-based modeling to obtain the total number of trips attracted to each zone for different internal trip purposes, such as HBW and HBO (shopping, pickup/drop-offs), from the activity-based simulator (a software module that models the individual's daily activity pattern for a 24-hour period) and then compare these values with the results from the corresponding trip purpose attraction model. This section of the report discusses some of the studies making use of TA rates in advanced travel demand models. The subsection names are titles of the published studies.

Development of Microsimulation Activity-Based Model for San Francisco

A paper by Jonnalagadda et al. discusses modeling destination choice and mode choice as part of the TDF model for the San Francisco County Transportation Authority. The destination choice model in this tour-based model resembles a combination of the TA and trip distribution steps in the four-step model under a multinomial logit specification (*44*).

Unlike in the four-step model, the day-pattern models employed to determine the TPs and TAs are based on certain characteristics of the destination. Two day-pattern models are used: (1) a tour-based model that captures the primary destination, and (2) a trip-based model that determines the number and nature of the intermediate stops on the way to and from the primary destination. In this kind of model, every TAZ has attributes and accessibility measures that render it a potential destination based on the utility of its choice and the probability of selection under the multinomial logit model. One example of destination choice is the work location choice model (*44*).

Given that the destination choice model is a multinomial logit specification, there is a need to identify explanatory variables that influence the choice of one destination over the other. These variables are of two types: (1) attributes of the destination, and (2) accessibility measures reflecting the ease of travel to the destination. For example, for the San Francisco TDF model, employment was determined as one of the destination size attributes. Similarly, a CBD dummy was introduced as one of the destination characteristics variables. Moreover, linear distance was introduced as one of the level-of-service variables for the primary tour. For the intermediate stops, another multinomial logit specification is set up and includes origin/destination characteristics as explanatory variables, as well as destination size attributes (*44*).

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[6] A *tour* is a collection of trips such that the first trip corresponds to leaving the home and the last trip corresponds to returning home.

Planning Constrained Destination Choice in the ADAPTS Activity-Based Model

This study (*45*) on destination choice in the Chicago region proved that constraining destination choices based on previously planned activities enhances the accuracy of the travel demand forecast. Similar to the work for the San Francisco County Transportation Authority, the destination choice model for the Chicago area was also a discrete choice multinomial logit. In this model, however, a choice set is introduced where the universal choice set is narrowed down to a number of destination choices based on a time-space prism. In brief, the choice set is determined by identifying the feasible options for the intermediate stops based on the location and end time of the previous activity.

An Activity-Based Trip Generation Model

A paper by Wang (*46*) explores the two conventional means of estimating TPs and TAs: aggregate and disaggregate approaches. The aggregate approach determines the trip rate by running a linear regression on a number of explanatory variables at the zonal level. The disaggregate approach utilizes a cross-classification scheme to determine trip rates at the household or personal level according to trip purpose and other independent variables, such as household size and auto ownership.

The author then proposes an activity-based trip generation model. First, initial trip rates are estimated based on travel patterns, life cycle type, and household role. An outcome of this stage is the identification of representative activity patterns (RAPs) that are distinct in their activity patterns and have a designated average trip rate. Second, household travel pattern types are cross-classified in such a way to mimic the conventional approach to trip generation while maintaining temporal and spatial information about the trips in the RAPs. Third, the estimated activities and trip rates are simulated on a network overlain with land use characteristics to obtain the complete spatial and temporal distribution of activities.

Although this approach aggregates personal activities onto the zonal level, it is more realistic than the conventional aggregate approach because it implicitly reflects the decision variables that go into destination selection and incorporates household socioeconomic and demographic characteristics.

Travel Model Validation and Reasonableness Checking Manual

The four-step modeling process typically requires some checks to validate the reasonableness of the results, as well as to balance the TPs and the TAs. This manual describes how similar checks can be applied to activity-based models; tour and intermediate stops can be compiled to convey trip rates comparable to those output by the traditional trip-based approach (*47*).

The *destination choice submodel* in the activity-based model models the primary tour. The *intermediate stops submodel* models the stops along the way to and from the primary destination. After these submodels are run, trip tables are inferred that are similar to the trip-based trip tables. Trips can then be aggregated to reflect attractions by purpose and implied TA rates. These TA rates can then be compared against the TA rates obtained from the TA models to check how well the destination choice models are working.

Hence, it can be concluded that TA rates can serve as a benchmark and that the average trip rate calculated using travel patterns can be compared against the benchmark to confirm that the derived attraction rates are in accordance with past observed rates and are not unreasonable. In summary, the TA rates can only be used to check the attraction and production for each zone in the activity-based models after the analysis is over or during intermediate stages to ensure reasonable distribution of trips as per activity purpose.

INTRODUCTION OF NEW EXPLANATORY VARIABLE IN THE TRIP ATTRACTION MODEL

This section discusses some of the additional potential explanatory variables (variables that have not been used in the ITE *Trip Generation Manual* or TxDOT's Texas Package) that can be used in the TA models. However, the researchers expect that the new variables should be easy to obtain in the future, as the purpose of developing these models is to forecast future demand for planning and policy purposes. So far, this study used parking facility availability, employment density, metro area type, TAZ area type, and establishment type (freestanding or non-freestanding) as explanatory variables in the TA model. The research team proposes using distance from a major throughway as a potential explanatory variable. The distance to a major throughway can have a significant impact on the number of trips to an establishment. One can expect a higher number of trips to an establishment located close to a major throughway than to an establishment located farther away from the major throughway. Even for the same type of establishments, the one closer to a major throughway will certainly attract more trips. Hence, the researchers tested the variable distance to a major throughway for a potential explanatory variable. At the same time, obtaining the distance to a major throughway for an establishment is a one-time effort, which certainly adds to the convenience when the model is used to predict the future TA rates.

To determine the distance to a major throughway, the research team located the establishments in their TAZ-county shapefile using their geo-coordinates. They then overlaid/joined the network shapefile with the TAZ shapefile and obtained the distance to the establishment from the nearest throughway using the option distance between point and line command in ArcGIS software.

Table 42 provides the result for the HBO trips using van/car as trip mode after including the variable distance to the nearest major throughway in the list of existing explanatory variables (parking availability, employment density, MPO area type, area type, and establishment type). The table only presents the results for the employment sectors where the distance variable was found to be significant. All the variables have the intuitive directional effect (positive or negative sign of the coefficient depending on the nature of the variable) and have already been discussed in the section that discussed models for trip purposes and modes. Hence, in this section, the focus is only on the effect of the new variable distance to the major throughway for different employment sectors. As hypothesized, the sign on the distance to the nearest major throughway is negative (i.e., as distance increases from the nearest major throughway, the attraction decreases) wherever found significant. The distance to the nearest major throughway is found significant for four employment sectors: Wholesale Trade, Retail Trade, Health Care, and Recreation. This is not surprising, as these employment sectors cater to basic needs such as shopping, recreation, and health services. Further, people prefer to conduct shopping activities on

their way home from work, and thus easily accessible centers (close to major throughways) are the obvious choice.

Table 42. Trip Attraction Model for HBO Trips Using Van/Car as Mode with the Additional Distance Variable (Number of Vehicles/Employee) (Estimates and t-Statistics in Parentheses).

Employment Classification	Wholesale Trade	Retail Trade	Health Care	Arts, Entertainment, Recreation, Accommodation & Food Service
Alternative Specific Constant	1.630(2.356)	7.713(1.446)	2.139(4.041)	4.501(7.351)
Parking Availability indicator variable		6.715(1.538)	0.667(1.237)	
Employment Density indicator variable (>10 per acre)				2.052(1.250)
Metro Area Type indicator variable (small is base)				
Medium				
Large	2.183(2.536)	13.081(3.269)		
TAZ Area Type indicator variable (non-CBD is base)				
CBD	−1.715(−0.726)			−3.993(−1.049)
Establishment Type indicator variable (freestanding)	−1.472(−2.065)	−13.498(−3.750)	−1.705(−4.320)	−5.385(−5.281)
Distance to the nearest major throughway (in miles)	−0.813(−2.042)	−1.273(−2.931)	−0.623 (−3.041)	−1.413(−1.937)

The results shown in Table 42 confirm that distance to the nearest major throughway plays an important role in determining the magnitude of the attraction for certain activity centers. Therefore, as suggested, this distance should be included in the analysis of the TA rates whenever possible.

CONVERSION OF TA RATES FROM AGGREGATE TO DISAGGREGATE LEVELS OF EMPLOYMENT CLASSIFICATION

In this study, researchers developed TA rates using the aggregate NAICS system (14 categories based on availability of data). However, in practice, a modeler may need to use the TA rates at a disaggregate level to suit a project's needs or demands, such as a study that focuses on only one industry type or subsector. Further, some travel demand models are designed to use disaggregate employment classification for micro-level analysis. Hence, to allow researchers to derive the disaggregate TA rates from the aggregate TA rates reported in this study, this study provides weights that can be used to map TA rates from NAICS aggregate employment classifications to more disaggregate levels. For mapping, a numerical value that can be multiplied by the aggregate TA rate (the NAICS TA rate) is required to determine the disaggregate TA rate (the subsectors). To obtain that value, for each NAICS employment classification (aggregate) categories, the researchers divided the sample into possible disaggregate categories based on the availability of data in the sample. Next, the contribution of each disaggregate category to the aggregate category was determined by dividing the TA rate of the disaggregate category by the TA rate of the corresponding aggregate category.

Table 43 and Table 44 provide the weights that can be used to determine the TA rates for commercial and non-commercial vehicles. For example, in Table 43, the weight corresponding to greenhouse, nursery, and floriculture production classification is 0.0131. Hence, the average TA rate corresponding to commercial vehicles for this employment category subsector will be 0.0131×0.117, where 0.117 is the average TA rate for the aggregated Agriculture employment category (see Table 30). Please note that the sum of weights for a given employment sector in Table 43 and Table 44 may not add up to 1.00 due to rounding error.

Table 43. Weights for Conversion of TA Rates from NAICS to ITE LUC (Commercial Vehicles).

NAICS Employment Classification	LUC Employment Classification	Weight
Agriculture, Forestry, Fishing & Hunting, Mining, Quarrying	Greenhouse, Nursery, and Floriculture Production	0.0131
	Other Crop Farming	0.1528
	Support Activities for Crop Production	0.2823
	Oil and Gas Extraction	0.1637
	Crude Petroleum and Natural Gas Extraction	0.0298
	Support Activities for Mining	0.3584
Construction	Residential Building Construction	0.1673
	Non-residential Building Construction	0.0503
	Utility System Construction	0.0178
	Highway, Street, and Bridge Construction	0.2403
	Foundation, Structure, and Building Exterior Contractors	0.0924
	Building Equipment Contractors	0.2975
	Building Finishing Contractors	0.0310
	Other Specialty Trade Contractors	0.1034
Manufacturing	Grain and Oilseed Milling	0.0033
	Animal Slaughtering and Processing	0.0424
	Bakeries and Tortilla Manufacturing	0.0770
	Beverage Manufacturing	0.0050
	Textile Furnishings Mills	0.1192
	Other Textile Product Mills	0.0066
	Footwear Manufacturing	0.0199
	Other Wood Product Manufacturing	0.0099
	Converted Paper Product Manufacturing	0.0184
	Printing and Related Support Activities	0.0584
	Plastics Product Manufacturing	0.0426
	Rubber Product Manufacturing	0.0229
	Glass and Glass Product Manufacturing	0.0157
	Cement and Concrete Product Manufacturing	0.2725
	Other Nonmetallic Mineral Product Manufacturing	0.0014
	Architectural and Structural Metals Manufacturing	0.0120
	Boiler, Tank, and Shipping Container Manufacturing	0.0275
	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	0.0462
	Coating, Engraving, Heat Treating, and Allied Activities	0.0099
	Other Fabricated Metal Product Manufacturing	0.0567
	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	0.0066
	Engine, Turbine, and Power Transmission Equipment Manufacturing	0.0007
	Other General Purpose Machinery Manufacturing	0.0576
	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	0.0122
	Electric Lighting Equipment Manufacturing	0.0016

Table 43. Weights for Conversion of TA Rates from NAICS to ITE LUC (Commercial Vehicles) (Continued).

NAICS Employment Classification	LUC Employment Classification	Weight
Manufacturing (Continued)	Electrical Equipment Manufacturing	0.0009
	Other Electrical Equipment and Component Manufacturing	0.0028
	Household and Institutional Furniture and Kitchen Cabinet Manufacturing	0.0132
	Other Miscellaneous Manufacturing	0.0368
Wholesale Trade	Motor Vehicle and Motor Vehicle Parts and Supplies Merchant Wholesalers	0.1036
	Furniture and Home Furnishing Merchant Wholesalers	0.0082
	Lumber and Other Construction Materials Merchant Wholesalers	0.0387
	Professional and Commercial Equipment and Supplies Merchant Wholesalers	0.0889
	Household Appliances and Electrical and Electronic Goods Merchant Wholesalers	0.0825
	Machinery, Equipment, and Supplies Merchant Wholesalers	0.2718
	Miscellaneous Durable Goods Merchant Wholesalers	0.0453
	Paper and Paper Product Merchant Wholesalers	0.0374
	Grocery and Related Product Merchant Wholesalers	0.0384
	Farm Product Raw Material Merchant Wholesalers	0.1271
	Chemical and Allied Products Merchant Wholesalers	0.0022
	Beer, Wine, and Distilled Alcoholic Beverage Merchant Wholesalers	0.0272
	Miscellaneous Nondurable Goods Merchant Wholesalers	0.0181
	Wholesale Electronic Markets and Agents and Brokers	0.1105
Retail Trade	Automobile Dealers	0.0288
	Other Motor Vehicle Dealers	0.0211
	Automotive Parts, Accessories, and Tire Stores	0.0467
	Furniture Stores	0.0067
	Home Furnishings Stores	0.0115
	Electronics and Appliance Stores	0.0146
	Building Material and Supplies Dealers	0.0424
	Lawn and Garden Equipment and Supplies Stores	0.0136
	Grocery Stores	0.0689
	Specialty Food Stores	0.0596
	Beer, Wine, and Liquor Stores	0.0083
	Health and Personal Care Stores	0.0399
	Gasoline Stations	0.4884
	Clothing Stores	0.0054
	Shoe Stores	0.0046
	Jewelry, Luggage, and Leather Goods Stores	0.0024
	Sporting Goods, Hobby, and Musical Instrument Stores	0.0134
	Book Stores and News Dealers	0.0062
	Department Stores	0.0002
	Other General Merchandise Stores	0.0735
	Florists	0.0084
	Office Supplies, Stationery, and Gift Stores	0.0063

Table 43. Weights for Conversion of TA Rates from NAICS to ITE LUC (Commercial Vehicles) (Continued).

NAICS Employment Classification	LUC Employment Classification	Weight
Retail Trade (Continued)	Used Merchandise Stores	0.0125
	Other Miscellaneous Store Retailers	0.0088
	Vending Machine Operators	0.0029
	Direct Selling Establishments	0.0049
Transportation & Warehousing	General Freight Trucking	0.1292
	Specialized Freight Trucking	0.2905
	Scenic and Sightseeing Transportation, Water	0.0030
	Support Activities for Rail Transportation	0.1225
	Other Support Activities for Transportation	0.0888
	Postal Service	0.3051
	Couriers and Express Delivery Services	0.0145
	Local Messengers and Local Delivery	0.0150
	Warehousing and Storage	0.0314
Information	Newspaper, Periodical, Book, and Directory Publishers	0.0846
	Radio and Television Broadcasting	0.0699
	Wired Telecommunications Carriers	0.3382
	Other Information Services	0.5073
Finance, Insurance, & Real Estate	Depository Credit Intermediation	0.3396
	Nondepository Credit Intermediation	0.0231
	Activities Related to Credit Intermediation	0.0023
	Securities and Commodity Contracts Intermediation and Brokerage	0.0004
	Insurance Carriers	0.0078
	Agencies, Brokerages, and Other Insurance Related Activities	0.1143
	Other Investment Pools and Funds	0.0012
	Lessors of Real Estate	0.2743
	Offices of Real Estate Agents and Brokers	0.0322
	Activities Related to Real Estate	0.0752
	Automotive Equipment Rental and Leasing	0.0651
	Consumer Goods Rental	0.0431
	General Rental Centers	0.0021
	Commercial and Industrial Machinery and Equipment Rental and Leasing	0.0116
	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	0.0078
Professional, Scientific, Management, Administrative, & Waste Management Service	Legal Services	0.0811
	Accounting, Tax Preparation, Bookkeeping, and Payroll Services	0.1277
	Architectural, Engineering, and Related Services	0.0470
	Specialized Design Services	0.0440
	Management, Scientific, and Technical Consulting Services	0.0895
	Scientific Research and Development Services	0.0119
	Advertising, Public Relations, and Related Services	0.0316
	Other Professional, Scientific, and Technical Services	0.0448
	Management of Companies and Enterprises	0.0703
	Office Administrative Services	0.0243

Table 43. Weights for Conversion of TA Rates from NAICS to ITE LUC (Commercial Vehicles) (Continued).

NAICS Employment Classification	LUC Employment Classification	Weight
Professional, Scientific, Management, Administrative, & Waste Management Service (Continued)	Employment Services	0.0270
	Business Support Services	0.0297
	Travel Arrangement and Reservation Services	0.3092
	Investigation and Security Services	0.0114
	Services to Buildings and Dwellings	0.0385
	Other Support Services	0.0046
	Remediation and Other Waste Management Services	0.0076
Educational Services	Elementary and Secondary Schools	0.9806
	Junior Colleges	0.0036
	Colleges, Universities, and Professional Schools	0.0007
	Technical and Trade Schools	0.0019
	Other Schools and Instruction	0.0079
	Educational Support Services	0.0053
Health Care	Offices of Physicians	0.2735
	Offices of Dentists	0.1929
	Offices of Other Health Practitioners	0.1687
	Outpatient Care Centers	0.0040
	Medical and Diagnostic Laboratories	0.0292
	Home Health Care Services	0.0161
	Other Ambulatory Health Care Services	0.0101
	General Medical and Surgical Hospitals	0.0064
	Nursing Care Facilities (Skilled Nursing Facilities)	0.0200
	Residential Intellectual and Developmental Disability, Mental Health, and Substance Abuse Facilities	0.0020
	Continuing Care Retirement Communities and Assisted Living Facilities for the Elderly	0.0200
	Other Residential Care Facilities	0.0020
	Individual and Family Services	0.0552
	Community Food and Housing, and Emergency and Other Relief Services	0.0049
	Vocational Rehabilitation Services	0.0059
	Child Day Care Services	0.1810
	Social Assistance	0.0084
Arts, Entertainment, Recreation, Accommodation, & Food Services	Promoters of Performing Arts, Sports, and Similar Events	0.0282
	Museums, Historical Sites, and Similar Institutions	0.0094
	Other Amusement and Recreation Industries	0.0232
	Traveler Accommodation	0.0901
	Food Services and Drinking Places	0.3164
	Food Services and Drinking Places	0.5037
	Special Food Services	0.0120
	Drinking Places (Alcoholic Beverages)	0.0169

Table 43. Weights for Conversion of TA Rates from NAICS to ITE LUC (Commercial Vehicles) (Continued).

NAICS Employment Classification	LUC Employment Classification	Weight
Public Administration and Other Services	Executive, Legislative, and Other General Government Support	0.6303
	Justice, Public Order, and Safety Activities	0.0440
	Administration of Environmental Quality Programs	0.2213
	Administration of Housing Programs, Urban Planning, and Community Development	0.0349
	Administration of Economic Programs	0.0688
	National Security and International Affairs	0.0007
Utilities	Water, Sewage and Other Systems	1.0000

Table 44. Weights for Conversion of TA Rates from NAICS to ITE LUC (Non-Commercial Vehicles).

NAICS Employment Classification	LUC Employment Classification	Weight
Agriculture, Forestry, Fishing & Hunting, Mining, Quarrying	Greenhouse, Nursery, and Floriculture Production	0.0434
	Other Crop Farming	0.3348
	Support Activities for Crop Production	0.0601
	Support Activities for Animal Production	0.2154
	Support Activities for Mining	0.3463
Construction	Residential Building Construction	0.1162
	Non-residential Building Construction	0.2058
	Utility System Construction	0.0408
	Highway, Street, and Bridge Construction	0.0430
	Foundation, Structure, and Building Exterior Contractors	0.1097
	Building Equipment Contractors	0.3266
	Building Finishing Contractors	0.0941
	Other Specialty Trade Contractors	0.0638
Manufacturing	Grain and Oilseed Milling	0.0639
	Animal Slaughtering and Processing	0.0057
	Other Textile Product Mills	0.0294
	Other Wood Product Manufacturing	0.0381
	Converted Paper Product Manufacturing	0.0255
	Printing and Related Support Activities	0.1264
	Basic Chemical Manufacturing	0.0107
	Other Chemical Product and Preparation Manufacturing	0.0125
	Plastics Product Manufacturing	0.0046
	Rubber Product Manufacturing	0.0303
	Glass and Glass Product Manufacturing	0.0159
	Cement and Concrete Product Manufacturing	0.0695
	Other Nonmetallic Mineral Product Manufacturing	0.0031
	Architectural and Structural Metals Manufacturing	0.1299
	Boiler, Tank, and Shipping Container Manufacturing	0.0314
	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	0.0940
	Other Fabricated Metal Product Manufacturing	0.0619
	Agriculture, Construction, and Mining Machinery Manufacturing	0.0401
	Other General Purpose Machinery Manufacturing	0.0301
	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	0.0274
	Electric Lighting Equipment Manufacturing	0.0087
	Other Electrical Equipment and Component Manufacturing	0.0078
	Motor Vehicle Body and Trailer Manufacturing	0.0077
	Household and Institutional Furniture and Kitchen Cabinet Manufacturing	0.0107
	Other Miscellaneous Manufacturing	0.1146

Table 44. Weights for Conversion of TA Rates from NAICS to ITE LUC (Non-Commercial Vehicles) (Continued).

NAICS Employment Classification	LUC Employment Classification	Weight
Wholesale Trade	Motor Vehicle and Motor Vehicle Parts and Supplies Merchant	0.1492
	Furniture and Home Furnishing Merchant Wholesalers	0.0959
	Lumber and Other Construction Materials Merchant Wholesalers	0.0220
	Professional and Commercial Equipment and Supplies Merchant Wholesalers	0.0131
	Metal and Mineral (except Petroleum) Merchant Wholesalers	0.0278
	Household Appliances and Electrical and Electronic Goods Merchant Wholesalers	0.0627
	Hardware, and Plumbing and Heating Equipment and Supplies Merchant Wholesalers	0.0299
	Machinery, Equipment, and Supplies Merchant Wholesalers	0.2213
	Miscellaneous Durable Goods Merchant Wholesalers	0.0839
	Paper and Paper Product Merchant Wholesalers	0.0070
	Grocery and Related Product Merchant Wholesalers	0.0281
	Farm Product Raw Material Merchant Wholesalers	0.0740
	Chemical and Allied Products Merchant Wholesalers	0.0123
	Petroleum and Petroleum Products Merchant Wholesalers	0.0227
	Beer, Wine, and Distilled Alcoholic Beverage Merchant	0.0176
	Miscellaneous Nondurable Goods Merchant Wholesalers	0.0329
	Wholesale Electronic Markets and Agents and Brokers	0.0998
Retail Trade	Automobile Dealers	0.0226
	Other Motor Vehicle Dealers	0.0083
	Automotive Parts, Accessories, and Tire Stores	0.0273
	Furniture Stores	0.0019
	Home Furnishings Stores	0.0023
	Electronics and Appliance Stores	0.0033
	Building Material and Supplies Dealers	0.0219
	Lawn and Garden Equipment and Supplies Stores	0.0136
	Grocery Stores	0.0489
	Specialty Food Stores	0.0082
	Health and Personal Care Stores	0.0633
	Gasoline Stations	0.6941
	Clothing Stores	0.0019
	Shoe Stores	0.0010
	Sporting Goods, Hobby, and Musical Instrument Stores	0.0045
	Book Stores and News Dealers	0.0017
	Other General Merchandise Stores	0.0602
	Florists	0.0010
	Office Supplies, Stationery, and Gift Stores	0.0002
	Used Merchandise Stores	0.0012
	Other Miscellaneous Store Retailers	0.0116
	Vending Machine Operators	0.0002
	Direct Selling Establishments	0.0007

Table 44. Weights for Conversion of TA Rates from NAICS to ITE LUC (Non-Commercial Vehicles) (Continued).

NAICS Employment Classification	LUC Employment Classification	Weight
Transportation & Warehousing	General Freight Trucking	0.0560
	Specialized Freight Trucking	0.0251
	Scenic and Sightseeing Transportation, Water	0.0003
	Support Activities for Rail Transportation	0.0010
	Other Support Activities for Transportation	0.0043
	Postal Service	0.8850
	Couriers and Express Delivery Services	0.0014
	Local Messengers and Local Delivery	0.0023
	Warehousing and Storage	0.0246
Information	Newspaper, Periodical, Book, and Directory Publishers	0.0645
	Radio and Television Broadcasting	0.4548
	Wireless Telecommunications Carriers (except Satellite)	0.0234
	Telecommunications	0.3869
	Other Information Services	0.0703
Finance, Insurance, & Real Estate	Depository Credit Intermediation	0.5149
	Nondepository Credit Intermediation	0.0229
	Securities and Commodity Contracts Intermediation and Brokerage	0.0223
	Insurance Carriers	0.0062
	Agencies, Brokerages, and Other Insurance Related Activities	0.0282
	Lessors of Real Estate	0.3022
	Offices of Real Estate Agents and Brokers	0.0324
	Activities Related to Real Estate	0.0103
	Automotive Equipment Rental and Leasing	0.0418
	Consumer Goods Rental	0.0101
	General Rental Centers	0.0040
	Commercial and Industrial Machinery and Equipment Rental and Leasing	0.0046
Professional, Scientific, Management, Administrative, & Waste Management Service	Legal Services	0.0820
	Accounting, Tax Preparation, Bookkeeping, and Payroll Services	0.0946
	Architectural, Engineering, and Related Services	0.0907
	Specialized Design Services	0.0323
	Management, Scientific, and Technical Consulting Services	0.0217
	Scientific Research and Development Services	0.0038
	Other Professional, Scientific, and Technical Services	0.1906
	Management of Companies and Enterprises	0.0169
	Office Administrative Services	0.1013
	Employment Services	0.0479
	Business Support Services	0.0219
	Travel Arrangement and Reservation Services	0.0671
	Investigation and Security Services	0.0488
	Services to Buildings and Dwellings	0.0664

Table 44. Weights for Conversion of TA Rates from NAICS to ITE LUC (Non-Commercial Vehicles) (Continued).

NAICS Employment Classification	LUC Employment Classification	Weight
Professional, Scientific, Management, Administrative, & Waste Management Service (Continued)	Waste Collection	0.0710
	Other Support Services	0.0071
	Waste Treatment and Disposal	0.0024
	Remediation and Other Waste Management Services	0.0336
Educational Services	Elementary and Secondary Schools	0.9853
	Junior Colleges	0.0074
	Colleges, Universities, and Professional Schools	0.0010
	Technical and Trade Schools	0.0030
	Other Schools and Instruction	0.0018
	Educational Support Services	0.0014
Health Care	Offices of Physicians	0.2207
	Offices of Dentists	0.1029
	Offices of Other Health Practitioners	0.0417
	Outpatient Care Centers	0.0041
	Medical and Diagnostic Laboratories	0.0060
	Home Health Care Services	0.0350
	Other Ambulatory Health Care Services	0.0069
	General Medical and Surgical Hospitals	0.0224
	Nursing Care Facilities (Skilled Nursing Facilities)	0.0341
	Residential Intellectual and Developmental Disability, Mental Health, and Substance Abuse Facilities	0.0054
	Continuing Care Retirement Communities and Assisted Living Facilities for the Elderly	0.0259
	Other Residential Care Facilities	0.0093
	Individual and Family Services	0.0573
	Community Food and Housing, and Emergency Relief Services	0.0169
	Vocational Rehabilitation Services	0.0024
	Child Day Care Services	0.4090
Arts, Entertainment, Recreation, Accommodation, & Food Services	Museums, Historical Sites, and Similar Institutions	0.0080
	Other Amusement and Recreation Industries	0.0260
	Traveler Accommodation	0.0707
	Food Services and Drinking Places	0.2048
	Food Services and Drinking Places	0.6631
	Special Food Services	0.0095
	Drinking Places (Alcoholic Beverages)	0.0180

Table 44. Weights for Conversion of TA Rates from NAICS to ITE LUC (Non-Commercial Vehicles) (Continued).

NAICS Employment Classification	LUC Employment Classification	Weight
Public Administration and Other Services	Executive, Legislative, and Other Government Support	0.7224
	Justice, Public Order, and Safety Activities	0.0461
	Administration of Human Resource Programs	0.0129
	Administration of Environmental Quality Programs	0.1200
	Administration of Housing Programs, Urban Planning, and Community Development	0.0411
	Administration of Economic Programs	0.0539
	National Security and International Affairs	0.0036
Utilities	Water, Sewage and Other Systems	1.0000

CONCLUSION

TA modeling is an important step in obtaining travel demand forecasts. Unlike TP, which mainly depends on household demographic characteristics, TA depends on land use configurations and employment sector location. Thus, to model TA rates, this chapter included possible key variables capturing the characteristics of the zone where the establishment is located, and of the establishment itself. These variables included metro area type, TAZ area type, presence of parking facilities, employment density, and activity center type (freestanding or non-freestanding).

Based on availability of data, the research team grouped the employment sectors into 14 categories using NAICS codes. The employment sectors were grouped to ensure a sufficient sample size for each category. The researchers also observed that the same employment sector had different TA rates for commercial and non-commercial vehicles. Hence, separate linear regression models using TA rate as the dependent variable were developed for commercial and non-commercial vehicle trips. In the analysis, they found parking facility availability, metropolitan area type (small, medium, large, and metropolis), TAZ type (CBD, CBD fringe, urban, suburban, and rural), employment density, and establishment type (freestanding or non-freestanding) to be significant indicators in explaining attraction rate.

Next, the research team analyzed the TA rates for various trip purposes and mode combinations. They considered HBW and HBO as internal trip purposes and car/van, transit, and walk/bike as modes. They found that most of the trips for both trip purposes were made by car/van. However, the researchers did observe a significant mean attraction rate for the HBO trip purpose for walk/bike mode. Further, the TA model was developed for the HBO trip purpose and car/van mode combination only because the average rates obtained for the transit and walk/bike modes were negligible. Similar to the non-commercial vehicle TA model, the same set of variables was found significant in explaining the attraction rate for the HBO purpose and car/van mode combination.

In this phase of the study, the researchers also explored the way one can use TA models or rates in advanced travel demand models. They concluded that one can use TA rates for calibration of

destination choice models in activity-based models. They also discussed those studies that in some way have used TA rates beyond the traditional four-step planning process.

Further, the research team analyzed the effect of an additional explanatory variable—distance to a major throughway—on the TA rate for the HBO trip purpose. They found this variable to be statistically significant, with a negative sign suggesting that people prefer easily accessible establishments, and thus recommend its use in future studies. Finally, the researchers derived the weights that can be used for deriving TA rate at a disaggregate level. This is particularly useful, as most of the travel demand models analyze the travel patterns at a micro level.

RECOMMENDATIONS

Based on the findings in this phase of the study, the researchers recommend the following:

- The ITE classification system classifies industries into 172 unique sectors, while the NAICS uses a 20-sector classification system. The ITE classification system provides greater flexibility in terms of grouping various establishments based on the land use type (one TA rate for each metropolitan area type) than does the NAICS classification scheme. However, use of the ITE classification scheme requires a large amount of data in order to cover all 172 unique sectors. In contrast, the NAICS classification can be used along with land use variables as explanatory variables in the model to obtain TA rates. This ensures that sufficient sample size per category is attained and also allows researchers to easily capture the variability in the TA rate due to land use variables. Further, the disaggregate TA rates can be determined using the aggregate TA rates using the NAICS system. Therefore, this research team recommends using the NAICS classification scheme over the ITE classification scheme.
- The TA rates obtained in this study for Texas are quite different from the rates given in the ITE *Trip Generation Manual*. Generally, the Texas TA rates were found to be lower than the ITE TA rates. Therefore, all future studies involving the use of TA rates may refer to this study for updated rates.
- Two explanatory variables, parking availability and distance to major throughways, were found to be significant in explaining the variation in TA rates, and thus should be used in future studies. Currently, neither of these variables is being used in the existing Texas TA models used in TxDOT's Texas Package, and neither has found a place in the ITE *Trip Generation Manual*.
- The TA rates for both trip purposes (HBW and HBO) using the transit and walk/bike modes were found to be very small and sometimes even zero. However, this result does not mean that future studies should neglect the transit and walk/bike modes in their analysis. Most of the data used in this study are from 2003 to 2012. With better transit and bike/walk facilities and increasing environmental awareness in recent times, researchers can expect a higher number of trips being made using the transit and bike/walk modes in future data sets.

8. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Trip generation rates play an important role in travel demand modeling and in estimating the traffic impacts of new development and potential land use changes. Trip generation includes trip productions that stem from the origin end of trips and trip attractions, which are derived from the destination end of trips. Trip generation is the first step in the traditional four-step travel demand modeling (TDM) process, which includes trip generation, trip distribution, mode choice, and trip assignment. Since TDMs are commonly estimated and then applied in a sequential fashion, errors in the early stage of the four-step trip-based approach model will affect the results in subsequent steps (*2*). In light of this, it is important to obtain accurate estimations in trip generation since errors in this initial step can have substantial implications in subsequent steps of modeling or traffic impact analyses.

From TxDOT/TTI research and research across the United States, it is generally assumed that trip productions are more accurate and less variable than trip attractions. Trip attraction rates typically have higher variances than production rates. The high variability in trip attraction rates is often caused by an insufficient number of surveys or studies used in developing the rate(s). Developing trip attraction/generation rates for models or site-level analyses can be difficult since the surveys and studies needed to derive these rates can be time consuming and expensive.

TxDOT has one of the most robust travel survey and data collection programs in the country, which supports travel demand modeling and transportation planning. Since 2000, TxDOT has conducted over 18 work place surveys for 18 of the state's 25 MPOs. This wealth of data provided a unique opportunity to overcome the problem of high variability in trip attraction rates, by creating a large sample-based trip attraction database that is unique to Texas. Utilizing TxDOT's rich source data (and re-purposing it) to create this large sample of attraction data served as the core element of this project. It allowed for various types of analyses to be undertaken to study trip attraction rates for modeling, as well as for development of ITE-type trip generation rates unique to Texas.

The purpose of the project was to compile and analyze data from more than a decade of work place and special generator travel surveys in Texas to help improve trip generation data. The project included the following six key tasks and outcomes

- Review and examine TxDOT's work place/special generator survey design and methods.
- Conduct analyses to develop trip generation rates for land development.
- Compile and analyze data to develop trip attraction rates for modeling.
- Establish criteria for a Texas trip generation manual.
- Prepare a draft trip generation manual and user's guide.
- Develop disaggregate trip attraction models using explanatory variables.

Some of the above tasks were covered as separate chapters in this report.

The project produced the following four deliverables:

1. A comprehensive research report (0-6760-1; this report).
2. A project summary report (0-6760-S).

3. A trip generation manual and user guide (0-6760-P1).
4. A workshop presenting the manual and user's guide (0-6760-P2).

The workshop, entitled "Improved Trip Generation Data for Texas Using Work Place and Special Generator Surveys," was conducted by TTI and CTR researchers on August 18, 2014, at TTI's Austin office. It included members of the research team and the PMC. Electronic or hard copies of the above reports and products are available for purchase on the TTI website at http://tti.tamu.edu/publications/.

A summary, recommendations, and/or conclusions for each of the project's core tasks are provided in the subsections to follow.

TEXAS WORK PLACE SURVEY DESIGN AND METHODS

Chapter 2 of this report identified the dates and locations of all work place surveys (34 total) that were conducted in Texas from 1984 through 2014. It discussed key methods and practices of work place surveys in Texas and described how some of these have changed and evolved over time.

Work in this chapter determined if any changes or revisions were needed to improve survey methods and results. It also included identifying what changes could be made to the work place survey such that it could collect data to develop ITE-type trip generation rates for site-level analyses, in addition to collecting data to develop trip attraction rates for modeling.

It is recommended that a training day be organized to instruct TxDOT work place survey vendors of critical practices to be used in performing surveys and to review key items that need to be addressed to ensure that high-quality survey results are obtained. One item that should be addressed is how to deal with whether to survey employees twice if they leave the establishment and come back later in the day. The nature of the activity that the employee is engaging in will largely dictate how this issue is addressed (i.e., leaving the premise and returning after making a trip versus walking outside for a cigarette break). Three possible ways to deal with these types of trips are described within Chapter 18 of the Travel Survey Manual maintained by the TRB Travel Survey Methods Committee (*36*):

- Determine during the employer interview if the establishment provides an internal smoking area and if all smokers use it. If the answers to both are yes, then the smoking trips will never be observed and, therefore, never counted.
- Conduct the cordon count outside of where employees are likely to take their breaks, in which case the smoking trips will not be counted.
- Specifically ask employees on the employee questionnaire the number of times they left the building for incidental trips such as smoking.

It may be beneficial to consider how technology can be incorporated into future work place travel surveys performed in Texas. It may be possible to develop a web-based survey for the employee questionnaire portion of data collection. However, it may be difficult to implement this type of survey at work place establishments where employees do not have access to a computer.

It is also recommended that the lack of field checking be addressed. This would help with quality control issues and help to standardize the practice of data collection from establishment to establishment and from MPO area to MPO area.

Another recommendation that may lead to cost savings within the Texas Travel Survey Program would be to incorporate the commercial vehicle survey into the work place survey. There is a great deal of overlap in the data collected in the commercial vehicle survey and the commercial vehicle or truck component of the work place survey. However, if this change were made, the fact that some work places do not have commercial vehicles would need to be taken into consideration.

WORK PLACE SURVEY DATA AND ITE TRIP GENERATION RATES

Chapter 3 of this report reviewed the differences in work place survey data used for modeling applications in relation to trip generation data used for site-level planning applications, such as a traffic impact analysis. It discussed the similarities and differences between the ITE recommended procedures for collection of trip generation data and the Texas procedures for work place/special generator travel surveys. It identified the differences and similarities in the types and uses of data collected in work place surveys and ITE trip generation studies.

The procedures for ITE trip generation studies and the Texas procedures for work place and special generator travel surveys are defined to ensure that the data collection is valid and usable for specific transportation planning applications. However, there are some adjustments that could be made to the Texas procedures for work place and special generator travel surveys that could allow for greater flexibility in terms of using the data collected for ITE trip generation (i.e., site planning) applications. To this end, the following modifications are recommended.

Recommendation 1

The ITE LUC classification system provides greater detail than the NAICS classification system in terms of characterizing the subject land use. In order to utilize the data obtained in work place and special generator surveys for site planning purposes, the ITE LUC for each establishment is needed. Therefore, it is recommended that the ITE LUC for each establishment with a full or partial survey be estimated and reported on the Work Place General Survey Form G and Form A, as appropriate.

Recommendation 2

Trip generation data for site planning typically utilize a greater number of independent variables than trip generation data for travel demand modeling. In order to utilize the data obtained in work place and special generator surveys for site planning purposes, more independent variable data are required from each establishment. Therefore, it is recommended that the initial data collection for work place and special generator travel surveys include, at a minimum, the following additional independent variable data:

- Size of building(s) at the site (square footage).
- Size of the site (acres).

- Number of parking spaces available at the site.
- Number of servicing positions at the site (e.g., bank teller lanes or fuel pumps).

Additional independent variable data may be needed. The final recommendations for this project will reflect those needs, as well as provide an estimate of the time requirements and potential data sources for independent variable data. The Work Place General Survey Form A should be modified to provide a location to document the additional data.

Recommendation 3

The data collection procedures for freestanding work places and special generators include a count of all vehicle trips generated by the establishment during the survey day. These counts are consistent with the type of counts required by ITE for its trip generation studies. However, the current specifications for Texas work place and special generator surveys do not require these counts to be disaggregated by (1) 15-minute periods, and (2) entering and exiting trips. In order to utilize the data obtained in work place and special generator surveys for site planning purposes, it is recommended that the specifications be updated to require greater disaggregation for the vehicle trip counts at surveyed establishments.

COMPILATION AND ANALYSIS OF DATA TO DEVELOP TRIP ATTRACTION RATES FOR MODELING

Chapter 4 documented the research and analysis undertaken to build a master data file of work place, employee, and visitor surveys compiled from work place and special generator surveys around the state of Texas. It also detailed the methods and procedures used to analyze these data for the development of standardized trip attraction rates. Accordingly, this chapter documented:

- Development of a comprehensive database of work place surveys and special generators.
- Development and review of area types and density criteria for use in developing attraction rates by area type and density categories.
- Development and review of NAICS employment types used in developing attraction rates.
- Standardization of attraction rates for possible use in Texas travel demand models.
- Variation in attraction rates.

Development of Comprehensive Master Database

The development of the comprehensive master database of TxDOT work place and special generator surveys to create a generic set of attraction rates for modeling focused on surveys conducted from 2003 to 2012. While the intention of this development process sought to include all surveys within this time frame, some were excluded because analysis of the data in some study areas had not yet been finalized. However, the database structure was developed to allow for those surveys not included, and future surveys, to be added in the future.

Development of the master data set required an extensive and labor-intensive process of reviewing the data structures and elements from each work place survey to determine the best structure and elements to be included. This process required various data elements and attributes

to be normalized in order for them to be consistent and comparable when incorporated into a single data set. Key elements and attributes that were normalized included:

- Combining all work place surveys into basic, service, retail, and education types using the NAICS code identified for the site.
- Converting geographic codes (e.g., county, study area) unique to each survey data set to a FIPS county code.
- Establishing a common data set of density values and area types.
- Establishing a common data set of skims using urban modes and SAM.
- Establishing common trip purposes and modes.

The study areas included in the master database were grouped into five categories based on population. Table 45 lists the categories and study areas included within each category.

Table 45. Study Area Groupings.

Area Size Category	Population (×1000)	Study Areas Included
Small	50–199	Abilene, Sherman-Denison, Wichita Falls
Medium	200–499	Amarillo, Beaumont–Port Arthur, Killeen-Temple, Corpus Christi, Laredo, Lubbock, Waco
Large	500–1200	El Paso, Rio Grande Valley,
Metropolis	1200+	Austin, Houston-Galveston, San Antonio

The final master database of establishments includes surveys of 5140 work places, which were conducted over a 13-year period. It includes 83,750 intercept surveys, which are made up of 26,414 employee surveys and 57,366 visitor surveys. The establishments came from the study areas listed in Table 5 and include 2205 full work place surveys and 2935 partial work place surveys. The breakdown of employment types in the master database include 865 basic, 1894 service, 1673 retail, and 669 education sites. A separate master database of 39 special generator sites was also developed.

Due to different needs of each study area, trip purposes were not consistent across all work place surveys. To make them consistent, the trip purposes were normalized into a common coding scheme using a look-up table of trip purposes for each study area and assigning each purpose to a common code. Area types for each establishment were normalized using a consistent methodology based on population and employment density.

The master database was analyzed to develop attraction rates by basic, service, and retail employment types for each of the four area size categories. This analysis began by determining the total number of raw and expanded trips at each individual site. Raw trips were converted to expanded trips using the count data at each site. The total trips were classified by purpose, both from the origin to the work place and from the work place to the next destination, and summed as person and auto trips for each category of trip purpose. Estimates of total trips by site were

made for person and auto trips. After the data were expanded for each site, the results were aggregated by employment type and area type. The final trips were then categorized into the following travel demand model rate categories:

- HBW—Resident home-based work trips.
- HBNW—Resident home-based non-work trips.
- NHB—Sum of resident non–home-based destination trips and resident non–home-based origin trips.
- EXT—Sum of resident external destination trips and resident external origin trips.
- NON-RES—Sum of all non-resident trips regardless of the trip purpose.

Generic Attraction Rates by MPO Size Categories

A generic set of base trip attraction rates was developed for each employment category and purpose by summing the total number of expanded trips for each category-purpose cell and dividing it by the total employment for the category-purpose cell. The base attraction rates are not the same as the final attraction rates used by TxDOT for modeling. Under TxDOT's current process, attraction rates are not finalized until they have been balanced against productions and have been smoothed to make them, if necessary, more congruent and less irregular. Table 46 and Table 47 show the generic set of base attraction rates for person and auto trips, respectively.

Table 46. Generic Attraction Rates, Person Trips.

Employment Category	MPO Size Category	Attraction Rate			
		HBW	HBNW	NHB	NON-RES
Basic	Metropolis	1.61	1.31	0.57	0.12
	Large	1.47	2.98	0.74	0.32
	Medium	1.47	0.83	0.73	0.50
	Small	1.56	1.62	0.81	0.31
Service	Metropolis	2.05	2.37	0.80	0.24
	Large	1.21	5.20	1.02	0.28
	Medium	1.37	3.68	1.28	0.33
	Small	1.39	4.68	1.49	0.64
Retail	Metropolis	1.38	21.16	3.70	0.54
	Large	1.53	38.12	5.38	1.85
	Medium	1.19	15.03	4.67	2.62
	Small	1.17	17.20	5.07	1.60
Education	Metropolis	2.04	16.38	1.35	0.06
	Large	1.65	19.79	2.58	0.15
	Medium	2.52	13.07	2.19	0.71
	Small	2.04	15.93	3.72	0.22

Table 47. Generic Attraction Rates, Auto Trips.

Employment Category	MPO Size Category	Attraction Rate			
		HBW	HBNW	NHB	NON-RES
Basic	Metropolis	1.51	1.01	0.53	0.12
	Large	1.40	2.14	0.59	0.22
	Medium	1.42	0.61	0.65	0.37
	Small	1.50	1.33	0.68	0.23
Service	Metropolis	1.84	1.73	0.70	0.17
	Large	1.14	3.48	0.80	0.13
	Medium	1.30	2.47	0.97	0.19
	Small	1.30	3.28	1.14	0.43
Retail	Metropolis	1.32	15.28	3.01	0.28
	Large	1.42	22.64	3.42	1.12
	Medium	1.14	10.60	3.18	1.52
	Small	1.06	11.68	3.61	1.02
Education	Metropolis	2.04	10.39	0.73	0.07
	Large	1.58	10.25	1.40	0.09
	Medium	2.37	7.65	1.46	0.49
	Small	2.05	9.01	2.47	0.17

The above generic attraction rates have not been compared to attraction rates developed from study areas having work place surveys. It is recommended that these comparisons be conducted to determine how well the generic rates perform in relation to the attraction rates developed from local work place survey data.

The generic attraction rates in Table 48 and Table 49 should only be used in areas where attraction rates are not available or are considered to be out of date. They should not be used to replace attraction rates developed from the work place survey conducted for the area, unless that is considered out of date.

ITE-TYPE TRIP RATES USING WORK PLACE DATA AND THE TEXAS TRIP GENERATION MANUAL

This task, covered in Chapter 5, details how traffic count data obtained from TxDOT work place and special generator surveys, collected as part of the Texas Travel Survey Program, were used to develop trip generation rates for use in land development.

Finalizing the Sample

Beginning with a list of 2279 WP/SG surveys compiled for research performed germane to establishing generic trip generation rates for modeling, an initial screening was performed. The following three criteria were used in establishing the sample used in the development of Texas trip rates to use in the initial Texas Trip Generation Manual:

- **Availability of vehicle counts or person counts.** Current TxDOT specifications require vehicle counts at freestanding locations and person counts at non-freestanding locations.

This specification was implemented in 2007; therefore, only surveys performed since 2007 were considered for inclusion in the sample.

- **Availability of hourly or 15-minute count data.** Vendors are not required to perform hourly or 15-minute (desirable) counts; however, some vendors obtain these counts. Therefore, only areas where certain vendors performed the survey were considered for inclusion in the sample.
- **Availability of complete data from region.** Only areas where information was available for all sites were considered for inclusion in the model.

This screening process led to the inclusion of data from WP/SG survey data in five areas:

- Bryan–College Station (2013).[2]
- El Paso (*27*).
- Killeen-Temple (*31*).
- Sherman-Denison (2011–2012) (*42*).
- Waco (*43*).

Of the 1781 establishments from these areas, 938 were included because they contained vehicle counts, rather than person counts.

At this point, researchers worked to identify which of the 172 ITE LUCs each establishment fit into. Those establishments that did not fit into an ITE-specified land use were removed from the sample. The next step was to identify information on independent variables of interest. For all establishment sites, number of employees and gross floor area were of interest. Other special independent variables that were considered include the following:

- Site size in acres (industrial land uses).
- Number of students (junior/community college).
- Number of fueling positions (gas stations, convenience stores with gas pumps).
- Number of drive-in lanes (banks).
- Number of rooms (hotels).

Researchers discarded sites where independent variable data could not be obtained with reasonable confidence. Researchers also removed all schools from the sample because of inconsistences in how students on school buses were counted. This resulted in a sample containing 390 establishments, categorized into one of 34 unique ITE LUCs.

The trip generation rates were then calculated for the following five time periods:

- **AM and PM Peak Hour of Adjacent Street Traffic**: Highest hour of traffic demand at a site between 7:00 a.m. and 9:00 a.m. and between 4:00 p.m. and 6:00 p.m. Corresponds approximately to the typical morning and afternoon rush hour periods.
- **AM and PM Peak Hour of the Generator**: Highest hour of traffic demand at a site during any AM and PM period, not necessarily corresponding to the peak hour of traffic on the street adjacent to the site.
- **Weekday**: 24-hour total vehicle count.

Comparison of Texas Rates with ITE Trip Generation Rates

Having established the (weighted) Texas trip generation rates using the sample described previously, researchers then performed some comparisons between the Texas rates and the national ITE trip rates. Tests of practical and statistical significance were performed. Comparison of 256 of these Texas trip generation rates with published ITE rates found that 35 percent indicated a significant difference between the Texas rates and ITE rates, while 73 percent of the comparisons yielded a practical difference (i.e., outside the ±15 percent of the ITE rate). In both cases, a majority of the differences were the result of Texas rates being lower than ITE rates. This finding supports the continued production of a Texas Trip Generation Manual.

CRITERIA FOR TEXAS TRIP GENERATION MANUAL

Chapter 6 detailed the process researchers followed in determining the format and guidelines associated with creating the Texas Trip Generation Manual. Research results obtained from earlier parts of this project, as well as guidelines obtained from the ITE *Trip Generation Manual*, were used in shaping the development of the guidelines for the Texas manual. Specifically, the following items were addressed:

- Elements of the work place and special generator survey data to include in the manual.
- Time periods to present.
- Classifications to use in displaying the results of work place and special generator data.
- Independent variables to include:
  - Methodology for analyzing the work place and special generator survey data (i.e., constant average trip rate per independent variable unit or a regression equation estimating trips as a function of the independent variable[s]).
  - Minimum required sample size needed to display results for a given land use.
  - Manual form (i.e., summary or full database form).
  - Distribution format (i.e., hardcopy or electronic).
  - Frequency the manual should be updated and guidelines for what outside sources can contribute data to the manual.

Elements and Time Periods

The elements included in the Texas Trip Generation Manual were largely taken from the elements contained within the ITE *Trip Generation Manual.* This decision was based on a desire to create a Texas manual that mirrored the ITE manual as closely as possible to allow for more straightforward comparisons. As such, the ITE LUCs were selected as the classification system to be used in the Texas Trip Generation Manual.

Time periods included in the Texas manual were selected based on the data that were available from Texas work place and special generator travel surveys. These time periods included:

- Weekday.
- Weekday AM Peak Hour of Adjacent Street Traffic.
- Weekday PM Peak Hour of Adjacent Street Traffic.

- Weekday AM Peak Hour of Generator.
- Weekday PM Peak Hour of Generator.

The number of employees and 1000 square foot gross floor area were the primary independent variables utilized for the 34 LUCs included in the Texas manual. Other independent variables used included acres, rooms, students, fueling positions, and drive-through lanes.

Analysis Guidelines

The analysis guidelines provided in the *Handbook* portion of Volume 1 of the ITE *Trip Generation Manual* were followed to determine which analysis method to use in analyzing the work place and special generator survey data. The analysis options included:

- A constant average trip rate per independent variable unit.
- A regression equation estimating trips as a function of the independent variable(s).

A detailed procedural flow chart included in the ITE *Handbook* was used to determine which of the above analysis methods should be used. The flow chart takes into consideration numerous factors such as compatibility with LUC, number of data points, size of variation in data points, and many others.

The minimum required sample size was set at three establishments per LUC. While only three establishments per LUC are required for inclusion in the manual, having more data points is preferable because it will help paint a clearer picture of what a reasonable trip generation rate may be for establishments within a given LUC.

Manual Form and Updating Procedures

It is recommended that the Texas Trip Generation Manual only be made available in electronic format, rather than in print form, as the ITE *Trip Generation Manual* is. This format will allow for updates in the data set to be incorporated on an on-going basis, without being affected by delays associated with waiting for the newest edition of the manual to be finalized and printed. The updating process uses a program that ensures that when additional data are added to the database, the updated trip generation charts are uniform.

The *User's Guide* portion of the ITE *Trip Generation Manual* contains established procedures for how data should be updated in the manual. It is recommended that TxDOT adopt a similar approach to updating the Texas manual. Many of the techniques employed as part of the Texas Trip Generation Manual follow a similar approach. Researchers have automated the process of updating the manual based on additional data becoming available.

It is recommended that the Texas manual be updated annually to incorporate new work place survey data collected as part of TxDOT's survey program. It is also recommended that new data that meet ITE/Texas manual criteria be added to the manual. Sources of data could include consultants, government agencies, and ITE student chapters.

DISAGGREGATE TRIP ATTRACTION MODELS USING EXPLANATORY VARIABLES

The master database of Texas work place survey data was utilized to research and model trip attraction rates at a disaggregate level. For this effort, instead of classifying employment types into the four employment categories of basic, retail, service, and education, they were classified into 14 categories where trip attraction rates were developed using various explanatory variables pertaining to the TAZ and the establishment.

The NAICS classification system was selected as the basis for analysis for this portion of the project to ensure sufficient sample size per category. The 14 NAICS categories included:

- Agriculture, Forestry, Fishing and Hunting, Mining and Quarrying.
- Construction.
- Manufacturing.
- Wholesale Trade.
- Retail Trade.
- Transportation and Warehousing.
- Information.
- Finance, Insurance, and Real Estate.
- Professional, Scientific, Management, Administrative, and Waste Management Service.
- Educational Services.
- Health Care.
- Arts, Entertainment, Recreation, Accommodation, and Food Services.
- Public Administration and Other Services.
- Utilities.

Overview and Findings

Based on availability of data, the employment sectors were grouped into 14 categories using NAICS codes. The sectors were grouped in a way to ensure that there was a sufficient sample size for each category. Statistical analyses revealed that the same employment sector had different trip attraction rates for commercial and non-commercial vehicles. Hence, separate linear regression models using trip attraction rate as the dependent variable were developed for commercial and non-commercial vehicle trips. The analysis showed parking facility availability, metropolitan area size (small, medium, large, and metropolis), TAZ area type (CBD, CBD fringe, urban, suburban, and rural), employment density, and establishment type (freestanding or non-freestanding) to be significant indicators in explaining attraction rates.

Next, trip attraction rates were analyzed for various trip purposes and mode combinations. HBW and HBO were considered as internal trip purposes and car/van, transit, and walk/bike as modes. The results found that most of the trips for both trip purposes were made by car/van. However, a significant mean attraction rate for the HBO trip purpose for walk/bike mode was observed. Further, the trip attraction model was developed for the HBO trip purpose and car/van mode combination only because the average rates obtained for the transit and walk/bike modes were negligible. Similar to the non-commercial vehicle trip attraction model, the same set of variables was found significant in explaining the attraction rate for the HBO purpose and car/van mode combination.

Researchers also explored the way one can use trip attraction models or rates in advanced travel demand models. It was concluded that one can use trip attraction rates for calibration of

destination choice models in activity-based models. Several studies that in some way have used TA rates beyond the traditional four-step planning process were discussed.

An analysis was also conducted on the effect of an additional explanatory variable—distance to a major throughway—on the TA rate for the HBO trip purpose. This variable was found to be statistically significant, with a negative sign suggesting that people prefer easily accessible establishments. Thus, the research team recommends its use in future studies. Finally, weights that can be used for deriving trip attraction rate at a disaggregate level were developed. This is particularly useful, as most of the travel demand models analyze the travel patterns at a micro level.

Use/Application of Trip Attraction Rate in Advanced Travel Demand Models

The trip attraction rates cannot be employed directly in advanced travel demand models (e.g., an activity-based travel demand model). However, they can be used as a benchmark or reference for calibrating certain aspects of activity-based models. An important aspect of activity travel demand modeling is to determine both the work location for an individual and the stop location of a trip within a tour performed by that individual. Now, trip attraction rates can be used in activity-based modeling to obtain the total number of trips attracted to each zone for different internal trip purposes, such as HBW and HBO (shopping, pickup/drop-offs) from the activity-based simulator (a software module that models the individual's daily activity pattern for a 24-hour period) and then compare these values with the results from the corresponding trip purpose attraction model.

Trip attraction modeling is an important step in obtaining travel demand forecasts. Unlike trip production, which mainly depends on household demographic characteristics, trip attraction depends on land use configurations and employment sector location. Thus, to model trip attraction rates, the researchers included possible key variables capturing the characteristics of the zone where the establishment is located, and of the establishment itself.

Recommendations Related to Disaggregate Trip Attraction Models

Recommendations related to disaggregate trip attraction models are provided below.

- The ITE classification system classifies industries into 172 unique sectors, while the NAICS uses a 20-sector classification system. The ITE classification system provides greater flexibility in terms of grouping various establishments based on the land use type (one trip attraction rate for each metropolitan area type) than does the NAICS classification scheme. However, use of the ITE classification scheme requires a large amount of data in order to cover all 172 unique sectors. In contrast, the NAICS classification can be used along with land use variables as explanatory variables in the model to obtain trip rates. This ensures that sufficient sample size per category is attained and also allows researchers to easily capture the variability in the TA rate due to land use variables. Further, the disaggregate TA rates can be determined using the aggregate TA rates using NAICS. Therefore, this research team recommends using the NAICS classification scheme over the ITE classification scheme.

- Two explanatory variables, parking availability and distance to major throughways, were found to be significant in explaining the variation in trip attraction rates, and thus should be used in future studies. Currently, neither of these variables is being used in the existing Texas trip attraction models used in the Texas Package, and neither has found a place in the ITE *Trip Generation Manual*.
- The TA rates for both trip purposes (HBW and HBO) using the transit and walk/bike modes were found to be very small and sometimes even zero. However, this result does not mean that future studies should neglect the transit and walk/bike modes in their analysis. Most of the data used in this study are from 2003 to 2012. With better transit and bike/walk facilities and increasing environmental awareness in recent times, researchers can expect a higher number of trips being made using the transit and bike/walk modes in future data sets.

APPENDIX

Table 48. Trip Generation Rates per Employee (Weekday Daily).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	3.86	2.87	50%	1.73–23.5	0.280	27.8%
140	17	2.45	0.92	51%	1.82–5.1	0.498	15.0%
150	9	4.89	2.19	50%	3.44–11.33	0.386	25.7%
151	6	14.72	7.20	50%	8.67–28	No ITE Rate	No ITE Rate
170	14	4.11	2.10	50%	0.8–22	No ITE Rate	No ITE Rate
254	4	4.24	2.74	50%	1.71–9.6	0.846	7.9%
310	6	20.81	28.44	51%	11.73–197	0.671	45.1%
540	7	13.88	10.91	51%	3.39–27.59	0.737	−10.7%
565	17	18.85	11.02	50%	8.7–38.35	0.055	−29.5%
610	6	5.08	2.72	51%	3.61–9.15	0.764	12.9%
620	4	3.27	1.60	50%	2–6.67	0.992	0.3%
630	3	10.66	2.17	51%	9.44–13.42	0.191	33.1%
640	7	10.40	9.91	50%	2.4–37	No ITE Rate	No ITE Rate
720	16	10.55	6.55	50%	5.32–33	0.474	18.4%
812	9	14.40	21.83	50%	1.69–71.6	0.083	−55.2%
814	9	95.59	39.30	51%	40.4–191	No ITE Rate	No ITE Rate
816	5	36.53	18.92	50%	12.5–55.67	0.136	−31.3%
820	7	13.59	14.60	50%	4.63–48.63	No ITE Rate	No ITE Rate
841	21	10.22	4.87	50%	4–40	<0.001	−51.7%
842	5	7.89	5.67	50%	4.17–19.33	No ITE Rate	No ITE Rate
843	7	33.74	17.03	50%	15.75–65.14	No ITE Rate	No ITE Rate
852	3	61.16	33.48	50%	35–114	No ITE Rate	No ITE Rate
853	26	215.11	63.44	50%	91.33–332.17	No ITE Rate	No ITE Rate
881	4	69.18	52.33	50%	39–164.4	No ITE Rate	No ITE Rate
890	7	6.98	3.53	50%	3.2–15.5	0.056	−42.7%
912	16	28.31	14.10	50%	7.33–71.14	0.571	−8.5%
932	32	20.95	17.69	50%	5.2–117	No ITE Rate	No ITE Rate
933	4	66.89	48.43	50%	27.4–121.5	No ITE Rate	No ITE Rate
934	26	45.50	22.15	51%	10.27–74.85	No ITE Rate	No ITE Rate
935	5	34.38	13.03	50%	19.04–44.6	No ITE Rate	No ITE Rate
943	37	11.10	6.30	50%	2.4–56	No ITE Rate	No ITE Rate
944	7	365.00	148.33	50%	237.5–613.33	No ITE Rate	No ITE Rate
945	11	240.84	58.99	50%	151.17–321	No ITE Rate	No ITE Rate
946	3	280.85	147.70	51%	228.82–497.4	No ITE Rate	No ITE Rate

*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.

Table 49. Trip Generation Rates per Employee (Weekday AM Peak Hour of Adjacent Street Traffic).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	0.50	0.44	90%	0–2.07	0.604	13.6%
140	17	0.23	0.18	78%	0.03–0.78	0.066	−42.5%
150	9	0.64	0.44	66%	0.33–2	0.555	25.5%
151	6	1.79	1.05	59%	0–3.5	No ITE Rate	No ITE Rate
170	14	0.68	0.30	79%	0–2	0.507	−10.5%
254	4	0.40	0.19	80%	0.26–0.75	No ITE Rate	No ITE Rate
310	6	1.43	1.22	53%	0.95–9	0.232	107.2%
540	7	1.41	1.00	78%	0.41–3.93	0.597	−14.0%
565	17	5.39	3.50	53%	1.25–12.95	0.655	11.1%
610	6	0.53	0.17	69%	0.29–1.05	0.050	71.0%
620	4	0.34	0.10	82%	0.29–0.67	No ITE Rate	No ITE Rate
630	3	1.12	0.14	77%	1.03–1.28	No ITE Rate	No ITE Rate
640	7	1.52	1.42	69%	0.4–5.25	No ITE Rate	No ITE Rate
720	16	1.14	0.99	78%	0.4–5.67	0.071	115.1%
812	9	1.50	1.75	79%	0.41–5	0.200	−38.0%
814	9	3.04	2.12	49%	0.71–7	No ITE Rate	No ITE Rate
816	5	4.32	2.33	52%	1.5–6.83	0.005	282.3%
820	6	0.42	0.54	53%	0–1.34	No ITE Rate	No ITE Rate
841	21	0.86	0.52	70%	0–3.33	No ITE Rate	No ITE Rate
842	5	0.73	0.51	90%	0.41–2	No ITE Rate	No ITE Rate
843	7	1.92	1.56	61%	0.75–4.13	No ITE Rate	No ITE Rate
852	3	3.74	3.97	50%	3–10.33	No ITE Rate	No ITE Rate
853	26	16.14	5.84	49%	5–31	No ITE Rate	No ITE Rate
881	4	2.51	2.57	59%	0.92–7.2	No ITE Rate	No ITE Rate
890	7	0.56	0.30	69%	0–1.2	0.674	16.7%
912	16	2.12	1.00	62%	0.33–4.79	0.114	−19.4%
932	9	2.00	4.35	25%	0–22	No ITE Rate	No ITE Rate
933	0	0.00	0.00	43%	0–2	No ITE Rate	No ITE Rate
934	9	3.17	1.59	36%	0–5.53	No ITE Rate	No ITE Rate
935	3	2.33	1.31	41%	0–3.44	No ITE Rate	No ITE Rate
943	37	1.15	0.79	71%	0–6	No ITE Rate	No ITE Rate
944	7	22.42	8.38	49%	13.25–33.67	No ITE Rate	No ITE Rate
945	11	15.64	4.77	51%	6.83–20.56	No ITE Rate	No ITE Rate
946	3	20.93	5.17	50%	17.75–28.4	No ITE Rate	No ITE Rate

*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.

Table 50. Trip Generation Rates per Employee (Weekday PM Peak Hour of Adjacent Street Traffic).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	0.46	0.34	13%	0–2.33	0.661	9.5%
140	17	0.23	0.16	24%	0–1.18	0.095	−36.1%
150	9	0.63	0.40	32%	0.17–1.45	0.839	6.8%
151	6	2.15	1.36	22%	0.5–4.5	No ITE Rate	No ITE Rate
170	14	0.70	0.27	16%	0–3	0.587	−7.9%
254	4	0.49	0.27	31%	0.34–1.05	No ITE Rate	No ITE Rate
310	6	1.60	2.12	42%	0.33–13	0.457	100.0%
540	7	1.32	1.11	51%	0.35–3.15	0.884	−5.0%
565	17	2.34	2.08	34%	0.28–6	0.001	−50.5%
610	6	0.41	0.17	32%	0.29–0.67	0.308	41.4%
620	4	0.30	0.11	32%	0.23–0.67	<0.001	−68.8%
630	3	0.99	0.45	26%	0.77–1.57	No ITE Rate	No ITE Rate
640	7	1.05	1.12	34%	0.4–3.75	No ITE Rate	No ITE Rate
720	16	0.87	0.57	27%	0–2.17	0.325	−17.9%
812	9	1.35	2.00	26%	0.18–6.5	0.084	−51.3%
814	9	10.48	5.54	62%	2.4–25	No ITE Rate	No ITE Rate
816	5	3.69	2.37	34%	0.25–6	0.230	−26.9%
820	7	1.36	1.40	50%	0.42–5.16	No ITE Rate	No ITE Rate
841	21	1.04	0.80	44%	0.39–7	No ITE Rate	No ITE Rate
842	5	0.91	0.80	19%	0.39–2.2	No ITE Rate	No ITE Rate
843	7	3.21	1.75	48%	1.5–7.14	No ITE Rate	No ITE Rate
852	3	7.14	8.36	49%	5–21	No ITE Rate	No ITE Rate
853	26	17.07	5.65	50%	7.67–29.25	No ITE Rate	No ITE Rate
881	4	7.30	4.67	49%	4.17–15.53	No ITE Rate	No ITE Rate
890	7	1.05	0.94	31%	0.33–4	0.932	−4.5%
912	16	2.85	1.77	45%	0–8	<0.001	−47.4%
932	32	1.97	1.55	62%	0–6.58	No ITE Rate	No ITE Rate
933	4	4.36	5.27	31%	0–10.25	No ITE Rate	No ITE Rate
934	26	3.16	1.74	54%	0.8–7.2	No ITE Rate	No ITE Rate
935	5	2.96	1.79	51%	0.72–4.36	No ITE Rate	No ITE Rate
943	37	1.32	0.99	38%	0.4–7	No ITE Rate	No ITE Rate
944	7	27.00	9.42	51%	16.75–47	No ITE Rate	No ITE Rate
945	11	21.22	6.42	51%	11.17–34.75	No ITE Rate	No ITE Rate
946	3	20.74	17.12	49%	14.41–45.8	No ITE Rate	No ITE Rate

*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.

Table 51. Trip Generation Rates per Employee (Weekday AM Peak Hour of Generator).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	0.76	0.52	77%	0.35–4	0.043	58.3%
140	17	0.39	0.26	83%	0.23–1.27	1.000	0.0%
150	9	0.74	0.47	59%	0.38–2.33	0.420	34.5%
151	6	3.15	1.80	61%	1.5–6.5	No ITE Rate	No ITE Rate
170	14	0.74	0.49	84%	0.18–7	No ITE Rate	No ITE Rate
254	4	0.51	0.32	81%	0.26–1.15	No ITE Rate	No ITE Rate
310	6	2.25	4.00	50%	0.95–27	0.471	184.8%
540	7	1.66	1.25	71%	0.41–3.93	0.868	−5.1%
565	17	5.46	3.45	53%	2.29–12.95	0.750	7.5%
610	6	0.55	0.20	64%	0.29–1.05	0.126	61.8%
620	4	0.42	0.21	70%	0.29–1	0.210	61.5%
630	3	1.27	0.38	63%	1.03–1.72	0.052	56.8%
640	7	1.83	1.49	51%	0.5–5.75	No ITE Rate	No ITE Rate
720	16	1.71	1.40	51%	0.8–8	0.057	113.8%
812	9	2.08	2.71	76%	0.41–9.2	0.095	−47.2%
814	9	8.32	2.64	53%	5.5–15.25	No ITE Rate	No ITE Rate
816	5	5.37	1.64	55%	3–6.83	0.959	0.8%
820	7	1.28	1.42	56%	0.39–4.1	No ITE Rate	No ITE Rate
841	21	1.20	0.66	58%	0.66–4	0.017	79.1%
842	5	1.35	0.91	54%	0.76–3	No ITE Rate	No ITE Rate
843	7	3.46	1.36	50%	2.3–6.57	No ITE Rate	No ITE Rate
852	3	4.56	4.69	46%	3.85–12.33	No ITE Rate	No ITE Rate
853	26	17.03	5.17	51%	9.33–31	No ITE Rate	No ITE Rate
881	4	6.30	4.59	49%	3.91–14.67	No ITE Rate	No ITE Rate
890	7	1.04	0.52	72%	0.78–2	0.877	−4.6%
912	16	3.35	1.63	52%	0.93–7.71	0.098	35.1%
932	9	2.93	4.29	59%	0–22	No ITE Rate	No ITE Rate
933	4	8.39	4.45	55%	3–13.13	No ITE Rate	No ITE Rate
934	26	4.34	2.57	56%	1.4–10.84	No ITE Rate	No ITE Rate
935	5	4.30	1.84	49%	3.15–9	No ITE Rate	No ITE Rate
943	37	1.68	1.07	57%	0.67–9	No ITE Rate	No ITE Rate
944	7	25.66	9.06	51%	16.75–39.33	No ITE Rate	No ITE Rate
945	11	17.00	4.41	51%	10.18–21.2	No ITE Rate	No ITE Rate
946	3	21.27	6.15	50%	17.75–30.2	No ITE Rate	No ITE Rate

*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.

Table 52. Trip Generation Rates per Employee (Weekday PM Peak Hour of Generator).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	0.71	0.48	26%	0.34–4.25	0.120	39.2%
140	17	0.48	0.16	36%	0.28–1.18	0.332	20.0%
150	9	0.68	0.39	44%	0.39–1.67	0.609	17.2%
151	6	3.08	1.32	58%	1.33–4.5	No ITE Rate	No ITE Rate
170	14	0.75	0.50	20%	0.33–9	No ITE Rate	No ITE Rate
254	4	0.60	0.31	37%	0.46–1.25	0.763	9.1%
310	6	2.48	4.08	67%	1.33–28	0.444	175.6%
540	7	1.68	1.33	52%	0.35–4.01	0.742	12.8%
565	17	4.08	2.26	50%	1.64–8.2	0.182	−20.3%
610	6	0.44	0.22	37%	0.32–0.77	0.842	7.3%
620	4	0.43	0.21	38%	0.31–1.13	0.760	−8.5%
630	3	1.16	0.40	42%	0.94–1.67	0.234	34.9%
640	7	1.85	1.68	51%	0.4–6	No ITE Rate	No ITE Rate
720	16	1.47	1.00	41%	0.72–6.75	0.143	51.5%
812	9	2.04	2.93	28%	0.29–10	0.137	−46.7%
814	9	12.65	5.28	72%	5–25	No ITE Rate	No ITE Rate
816	5	4.53	1.91	50%	1.5–6.17	0.323	−16.6%
820	7	1.54	1.63	51%	0.54–5.31	No ITE Rate	No ITE Rate
841	21	1.41	0.91	52%	0.64–8	0.141	46.9%
842	5	1.22	1.01	29%	0.66–4.33	No ITE Rate	No ITE Rate
843	7	4.33	2.45	50%	2–7.86	No ITE Rate	No ITE Rate
852	3	7.19	8.31	49%	6–21	No ITE Rate	No ITE Rate
853	26	19.66	5.46	50%	11.33–33.75	No ITE Rate	No ITE Rate
881	4	7.82	4.70	48%	5.06–16.2	No ITE Rate	No ITE Rate
890	7	1.22	0.92	45%	0.4–4	0.930	−3.9%
912	16	3.76	1.87	48%	1–8.71	0.114	−20.2%
932	32	3.68	3.18	51%	0.69–14.71	No ITE Rate	No ITE Rate
933	4	11.45	3.13	51%	8.1–14.75	No ITE Rate	No ITE Rate
934	26	5.70	2.94	53%	1.78–12.88	No ITE Rate	No ITE Rate
935	5	5.48	1.67	51%	4.6–10.17	No ITE Rate	No ITE Rate
943	37	1.75	1.07	45%	0.6–8	No ITE Rate	No ITE Rate
944	7	36.32	13.47	53%	24.25–56.67	No ITE Rate	No ITE Rate
945	11	22.02	5.93	51%	11.17–34.75	No ITE Rate	No ITE Rate
946	3	25.27	14.01	50%	20.24–45.8	No ITE Rate	No ITE Rate

*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.

Table 53. Trip Generation Rates per 1000 Sq. Feet Gross Floor Area (Weekday Daily).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	3.58	5.17	50%	0.34–43.86	0.046	−48.6%
140	17	4.64	4.06	50%	0.83–49.5	0.534	21.5%
150	9	2.44	4.75	50%	0.15–16.93	0.687	−31.5%
151	6	0.69	0.53	50%	0.38–3.16	0.001	−72.4%
170	14	13.24	14.20	50%	1.6–65.03	No ITE Rate	No ITE Rate
254	4	4.20	2.96	50%	1.61–9.17	No ITE Rate	No ITE Rate
310	6	9.72	3.96	51%	4.4–16.68	No ITE Rate	No ITE Rate
540	7	17.08	20.43	51%	4.6–81.08	0.259	−37.9%
565	17	63.36	65.66	50%	12.12–259.56	0.555	−14.4%
610	6	42.21	69.38	51%	7.49–261.1	0.529	219.3%
620	4	5.45	5.65	50%	2.54–13.7	0.592	−28.3%
630	3	38.17	31.22	51%	25.25–86.21	0.760	21.3%
640	7	21.22	16.30	50%	5.25–46.25	No ITE Rate	No ITE Rate
720	16	26.45	16.29	50%	9.14–100.75	0.079	−26.8%
812	9	8.73	11.90	50%	1.12–80.45	<0.001	−80.7%
814	9	61.30	29.82	50%	20.51–97.15	0.792	−4.3%
816	5	9.14	4.68	50%	3.82–20.33	<0.001	−82.2%
820	7	24.01	86.02	50%	7.42–3370.15	0.629	−43.8%
841	21	29.93	23.59	50%	4.44–217.81	0.790	−7.3%
842	5	7.26	30.40	50%	3.72–236.36	No ITE Rate	No ITE Rate
843	7	50.58	26.52	50%	15.38–90.41	0.306	−18.3%
852	3	126.52	78.79	50%	21.88–170.24	No ITE Rate	No ITE Rate
853	26	491.81	251.82	50%	115.13–1149.37	<0.001	−41.8%
881	4	139.35	51.44	50%	109.76–329.35	0.235	44.2%
890	7	3.70	4.55	50%	0.8–10.31	0.618	−26.9%
912	16	65.80	50.92	50%	19.15–230.32	<0.001	−55.6%
932	32	90.55	94.01	50%	13.04–742.41	0.120	−28.8%
933	4	297.80	271.65	51%	99.73–663.93	No ITE Rate	No ITE Rate
934	26	427.90	270.31	51%	98.89–1122.37	0.256	−13.8%
935	5	459.20	300.74	50%	95.91–1053.57	No ITE Rate	No ITE Rate
943	37	18.23	16.53	50%	3–113.51	No ITE Rate	No ITE Rate
944	7	1386.20	2217.15	50%	477.82–13281.25	No ITE Rate	No ITE Rate
945	11	613.58	397.26	50%	124.42–1444.21	No ITE Rate	No ITE Rate
946	3	522.92	234.89	51%	263.68–797.12	No ITE Rate	No ITE Rate

*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.

Table 54. Trip Generation Rates per 1000 Sq. Feet Gross Floor Area (Weekday AM Peak Hour of Adjacent Street Traffic).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	0.47	0.77	92%	0–4.46	0.072	−48.9%
140	17	0.43	0.56	72%	0.01–1.9	0.109	−41.1%
150	9	0.32	0.51	80%	0.03–1.8	0.946	6.7%
151	6	0.09	0.04	69%	0–0.14	0.043	−35.7%
170	14	2.18	2.34	74%	0–10.67	0.129	172.5%
254	4	0.39	0.16	81%	0.24–0.68	No ITE Rate	No ITE Rate
310	6	0.67	0.35	53%	0.2–1.07	No ITE Rate	No ITE Rate
540	7	1.73	1.47	79%	0.57–6.09	0.080	−42.1%
565	17	18.11	23.84	52%	1.79–87.65	0.372	48.7%
610	6	4.35	5.35	69%	0.55–19.82	0.351	357.9%
620	4	0.56	0.39	86%	0.36–1.13	0.970	1.8%
630	3	4.01	3.51	79%	2.27–9.36	No ITE Rate	No ITE Rate
640	7	3.09	2.29	64%	0.79–6.56	0.367	−24.3%
720	16	2.85	2.22	75%	0.85–14.3	0.522	19.2%
812	9	0.91	1.33	73%	0.31–10.58	0.017	−65.0%
814	9	1.95	1.36	48%	0.5–4.38	0.004	−48.8%
816	5	1.08	0.40	51%	0.46–1.66	1.000	0.0%
820	6	0.70	1.88	55%	0–64.93	0.781	−27.1%
841	21	2.52	2.64	71%	0–24.69	0.548	31.3%
842	5	0.67	2.49	89%	0.34–19.32	No ITE Rate	No ITE Rate
843	7	2.88	2.26	62%	1.02–7.58	0.467	30.3%
852	3	7.73	3.71	51%	1.88–9.35	0.011	−75.1%
853	26	36.91	17.83	49%	6.3–78.78	0.288	−9.8%
881	4	5.05	2.13	55%	3.42–7.74	0.272	46.4%
890	7	0.30	0.45	35%	0–0.88	0.626	76.5%
912	16	4.92	3.54	62%	0.89–15.4	<0.001	−59.3%
932	9	15.74	25.34	14%	0–102.39	0.642	45.6%
933	0	0.00	0.00	45%	0–5.32	0.000	0.0%
934	9	35.83	25.64	32%	0–87.37	0.346	−21.1%
935	3	37.47	18.10	34%	0–52.79	No ITE Rate	No ITE Rate
943	37	1.88	1.98	73%	0–19.4	No ITE Rate	No ITE Rate
944	7	85.13	128.47	48%	31.55–804.69	No ITE Rate	No ITE Rate
945	11	39.84	26.23	52%	5.62–80.58	0.001	−51.5%
946	3	38.96	13.87	50%	20.24–45.51	No ITE Rate	No ITE Rate

*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.

Table 55. Trip Generation Rates per 1000 Sq. Feet Gross Floor Area (Weekday PM Peak Hour of Adjacent Street Traffic).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	0.43	0.67	11%	0–7.02	0.015	−55.7%
140	17	0.43	0.53	16%	0–6.42	0.093	−41.1%
150	9	0.32	0.54	13%	0.01–1.8	1.000	0.0%
151	6	0.11	0.06	23%	0.04–0.18	0.002	−57.7%
170	14	2.25	2.10	18%	0–9.67	0.074	196.1%
254	4	0.49	0.25	33%	0.26–0.9	No ITE Rate	No ITE Rate
310	6	0.75	0.36	46%	0.22–1.11	No ITE Rate	No ITE Rate
540	7	1.62	1.84	51%	0.37–7.17	0.267	−36.2%
565	17	7.84	6.48	42%	1.56–40.85	0.021	−36.5%
610	6	3.39	5.04	33%	0.58–19.06	0.465	264.5%
620	4	0.50	0.38	30%	0.3–1.05	0.398	−32.4%
630	3	3.52	2.34	33%	1.93–7	No ITE Rate	No ITE Rate
640	7	2.14	1.69	30%	0.53–4.69	0.014	−54.7%
720	16	2.16	1.72	31%	0–7.75	0.020	−39.5%
812	9	0.82	1.39	29%	0.17–10.26	<0.001	−81.7%
814	9	6.72	3.87	66%	1.22–12.72	0.941	−1.5%
816	5	0.93	0.69	34%	0.08–2.4	<0.001	−80.8%
820	7	2.40	7.85	50%	0.74–307.04	0.709	−35.3%
841	21	3.05	2.88	46%	0.56–24.69	0.692	16.4%
842	5	0.84	3.95	10%	0.36–30.68	0.522	−66.9%
843	7	4.81	2.50	48%	1.47–7.65	0.266	−19.6%
852	3	14.76	7.25	49%	3.13–17.63	0.055	−57.3%
853	26	39.02	19.94	50%	9.66–79.12	0.008	−23.4%
881	4	14.71	4.80	49%	12.74–35.19	0.172	48.4%
890	7	0.56	0.81	38%	0.1–1.78	0.819	24.4%
912	16	6.61	5.59	44%	0–26.41	<0.001	−72.8%
932	32	8.50	8.66	57%	0–44.99	0.526	−13.7%
933	4	19.39	27.69	25%	0–56.01	0.662	−25.9%
934	26	29.64	14.56	54%	8.77–57.14	0.350	−9.2%
935	5	39.43	31.28	50%	10.23–89.29	0.732	−12.4%
943	37	2.16	2.04	33%	0.32–13.54	No ITE Rate	No ITE Rate
944	7	102.55	162.13	52%	48.81–1109.38	No ITE Rate	No ITE Rate
945	11	54.05	40.62	52%	9.19–152.89	0.014	−44.5%
946	3	38.60	25.13	50%	18.53–73.4	No ITE Rate	No ITE Rate

*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.

Table 56. Trip Generation Rates per 1000 Sq. Feet Gross Floor Area (Weekday AM Peak Hour of Generator).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	0.71	0.99	76%	0.09–10.53	0.342	−29.7%
140	17	0.73	0.67	83%	0.17–4.58	0.783	−7.6%
150	9	0.37	0.60	46%	0.03–2.08	0.887	−11.9%
151	6	0.15	0.14	66%	0.04–0.79	0.094	−46.4%
170	14	2.37	2.30	79%	0.51–10.67	No ITE Rate	No ITE Rate
254	4	0.51	0.31	78%	0.24–1.01	No ITE Rate	No ITE Rate
310	6	1.05	0.47	51%	0.31–1.52	No ITE Rate	No ITE Rate
540	7	2.05	2.39	74%	0.57–9.59	0.327	−33.7%
565	17	18.36	23.70	54%	2.3–87.65	0.454	36.6%
610	6	4.52	6.07	68%	0.67–22.6	0.386	370.8%
620	4	0.69	0.66	78%	0.36–1.65	0.844	15.0%
630	3	4.55	3.13	56%	3.28–9.36	No ITE Rate	No ITE Rate
640	7	3.72	2.27	57%	1.31–7.19	No ITE Rate	No ITE Rate
720	16	4.28	3.02	53%	1.38–19.28	0.426	22.3%
812	9	1.26	1.49	70%	0.31–10.58	0.002	−69.7%
814	9	5.34	1.81	52%	2.37–7.76	0.036	40.2%
816	5	1.35	0.66	54%	1.02–3.33	0.001	−72.5%
820	7	2.26	7.80	57%	0.57–305.22	No ITE Rate	No ITE Rate
841	21	3.51	3.03	58%	1.39–27.34	0.266	58.1%
842	5	1.24	4.22	54%	0.7–32.95	No ITE Rate	No ITE Rate
843	7	5.18	1.97	50%	2.56–7.58	0.347	17.5%
852	3	9.42	4.22	46%	2.81–11.31	0.015	−71.1%
853	26	38.93	17.40	50%	11.76–90.34	0.286	−9.2%
881	4	12.69	7.12	49%	9.74–42.22	0.357	51.8%
890	7	0.55	0.59	61%	0.11–1.24	0.671	37.5%
912	16	7.78	6.02	51%	2.07–27.97	<0.001	−55.7%
932	9	23.14	26.82	59%	0–112.49	<0.001	−82.6%
933	4	37.33	17.92	54%	16.34–51.46	0.063	−41.2%
934	26	40.74	26.46	55%	8.04–104.19	0.034	−24.0%
935	5	57.34	46.29	49%	24.94–241.07	No ITE Rate	No ITE Rate
943	37	2.76	2.45	57%	0.63–22.27	No ITE Rate	No ITE Rate
944	7	97.44	147.19	51%	36.96–898.44	No ITE Rate	No ITE Rate
945	11	43.32	27.65	51%	8.5–109.5	0.006	−44.5%
946	3	39.61	14.44	50%	20.24–48.4	No ITE Rate	No ITE Rate

*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.

Table 57. Trip Generation Rates per 1000 Sq. Feet Gross Floor Area (Weekday PM Peak Hour of Generator).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	0.66	0.87	25%	0.09–11.4	0.134	−38.9%
140	17	0.91	0.98	31%	0.15–10.08	0.613	21.3%
150	9	0.34	0.56	39%	0.02–1.8	0.738	−24.4%
151	6	0.15	0.17	59%	0.06–1.05	0.130	−48.3%
170	14	2.40	2.07	25%	0.22–9.67	No ITE Rate	No ITE Rate
254	4	0.60	0.26	33%	0.43–1.05	No ITE Rate	No ITE Rate
310	6	1.16	0.51	64%	0.46–1.94	No ITE Rate	No ITE Rate
540	7	2.06	2.49	48%	0.64–9.92	0.590	−22.0%
565	17	13.72	13.98	49%	2.67–55.5	0.994	−0.2%
610	6	3.66	5.84	38%	0.58–22.01	0.520	215.5%
620	4	0.71	0.58	35%	0.4–1.53	0.477	−29.7%
630	3	4.13	2.93	40%	2.53–8.6	No ITE Rate	No ITE Rate
640	7	3.77	2.73	49%	0.92–7.5	No ITE Rate	No ITE Rate
720	16	3.67	2.66	44%	1.49–15.55	0.485	−14.1%
812	9	1.24	1.61	31%	0.19–10.26	<0.001	−77.7%
814	9	8.11	4.04	81%	2.54–12.72	0.432	16.0%
816	5	1.14	0.59	50%	0.46–2.59	<0.001	−75.9%
820	7	2.72	10.10	51%	0.78–395.63	No ITE Rate	No ITE Rate
841	21	4.11	3.18	51%	1.11–26.46	0.280	46.8%
842	5	1.12	4.00	28%	0.54–30.68	No ITE Rate	No ITE Rate
843	7	6.50	3.37	49%	1.95–12.3	0.964	0.9%
852	3	14.87	6.94	49%	3.75–17.63	0.044	−58.9%
853	26	44.94	20.41	50%	14.29–106.09	<0.001	−28.2%
881	4	15.75	8.09	48%	13.18–51.37	0.275	62.0%
890	7	0.65	0.80	51%	0.11–1.78	0.800	22.6%
912	16	8.74	7.06	48%	2.57–35.94	<0.001	−67.3%
932	32	15.88	13.35	53%	3.04–101.24	0.428	−14.1%
933	4	50.95	18.55	51%	24.6–69.67	0.887	−2.8%
934	26	53.61	28.58	52%	17.17–123.8	0.318	13.3%
935	5	73.14	52.33	51%	26.85–272.32	No ITE Rate	No ITE Rate
943	37	2.88	2.79	46%	0.47–19.4	No ITE Rate	No ITE Rate
944	7	137.90	226.04	53%	54.86–1421.88	No ITE Rate	No ITE Rate
945	11	56.09	40.06	52%	9.19–152.89	0.017	−42.3%
946	3	47.05	21.76	50%	23.95–73.4	No ITE Rate	No ITE Rate

*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.

Table 58. Trip Generation Rates per Special Independent Variable (Weekday Daily).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	16.66	21.15	50%	1.21–185.71	<0.001	−67.8%
140	17	27.74	24.84	50%	3.72–222.5	0.263	−28.7%
150	9	20.16	84.66	50%	2.73–746.94	0.453	−64.8%
151	6	11.44	7.40	50%	5.37–30.38	0.001	−67.7%
310	6	3.07	1.12	51%	1.65–4.48	<0.001	−62.4%
540	7	1.07	0.85	51%	0.34–2.7	0.723	−13.0%
816	5	94.17	97.92	50%	14.04–224.49	0.001	−82.7%
853	26	220.69	132.02	50%	68.5–664	<0.001	−59.3%
912	16	123.30	76.70	50%	38.36–314.25	0.448	−11.5%
944	7	179.41	134.88	51%	92.25–460	0.847	6.4%
945	11	161.32	87.89	50%	90.7–481.5	0.959	−0.9%
946	3	260.79	113.81	51%	115.63–324.17	0.249	70.6%
*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.							
Special independent variables for specific land uses as follows: Acres (110, 140, 150, 151, 816), Rooms (310), Students (540), Fueling Positions (853, 944, 945, 946), and Drive-Through Lanes (912).							

Table 59. Trip Generation Rates per Special Independent Variable (Weekday AM Peak Hour of Adjacent Street Traffic).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	2.15	3.35	91%	0–50	<0.001	−249.3%
140	17	2.52	2.82	66%	0.13–15	<0.001	−195.2%
150	9	2.64	8.55	78%	0.48–73.47	0.158	−279.9%
151	6	1.39	0.92	71%	0–2.76	0.035	−85.6%
310	6	0.21	0.08	58%	0.08–0.31	<0.001	−152.4%
540	7	0.11	0.10	77%	0.04–0.33	0.844	−9.1%
816	5	11.13	11.31	45%	1.69–22.04	0.953	−3.7%
853	26	16.56	9.99	50%	3.75–50	0.996	−0.1%
912	16	9.22	5.93	66%	0.55–22.13	0.965	−0.8%
944	7	11.02	7.90	49%	5.5–25.25	0.730	−10.3%
945	11	10.48	5.93	51%	4.1–30.83	0.868	3.1%
946	3	19.43	9.67	50%	8.88–27.58	0.314	39.1%
*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.							
Special independent variables for specific land uses as follows: Acres (110, 140, 150, 151, 816), Rooms (310), Students (540), Fueling Positions (853, 944, 945, 946), and Drive-Through Lanes (912).							

Table 60. Trip Generation Rates per Special Independent Variable (Weekday PM Peak Hour of Adjacent Street Traffic).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	1.99	3.09	9%	0–35.71	<0.001	−264.8%
140	17	2.57	3.76	18%	0–65	0.001	−224.9%
150	9	2.60	9.21	33%	0.24–79.59	0.268	−234.2%
151	6	1.67	1.07	21%	0.86–3.16	0.011	−113.8%
310	6	0.24	0.17	41%	0.06–0.49	0.005	−150.0%
540	7	0.11	0.07	49%	0.04–0.22	0.786	−9.1%
816	5	9.50	12.07	22%	0.28–27.59	0.004	−445.2%
853	26	17.51	10.47	50%	5.75–50	0.507	−8.9%
912	16	12.39	7.12	41%	0–27	<0.001	−168.3%
944	7	13.28	8.97	51%	6.58–35.25	0.875	−4.4%
945	11	14.21	7.16	51%	6.7–34.83	0.763	4.9%
946	3	19.25	9.67	51%	8.13–28.63	0.444	28.0%
*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.							
Special independent variables for specific land uses as follows: Acres (110, 140, 150, 151, 816), Rooms (310), Students (540), Fueling Positions (853, 944, 945, 946), and Drive-Through Lanes (912).							

Table 61. Trip Generation Rates per Special Independent Variable (Weekday AM Peak Hour of Generator).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	3.28	110	74%	0.3–50	0.001	−142.7%
140	17	4.34	140	80%	0.53–52.5	0.023	−114.3%
150	9	3.02	150	42%	0.56–77.55	0.326	−176.2%
151	6	2.45	151	69%	0.54–7.59	0.174	−59.2%
310	6	0.34	310	52%	0.12–0.6	0.043	−52.9%
540	7	0.13	540	70%	0.04–0.33	0.869	7.7%
816	5	13.84	816	58%	3.93–36.73	0.005	−294.7%
853	26	17.47	853	51%	7–50	0.841	2.5%
912	16	14.57	912	52%	5–42.38	0.019	−48.5%
944	7	12.62	944	51%	5.67–29.5	0.991	0.3%
945	11	11.39	945	51%	6.2–30.83	0.646	7.3%
946	3	19.75	946	50%	8.88–27.58	0.374	32.6%
*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.							
Special independent variables for specific land uses as follows: Acres (110, 140, 150, 151, 816), Rooms (310), Students (540), Fueling Positions (853, 944, 945, 946), and Drive-Through Lanes (912).							

Table 62. Trip Generation Rates per Special Independent Variable (Weekday PM Peak Hour of Generator).

ITE LUC	Sample Size	Average Rate	Standard Deviation	Percent Entering	Range of Rates	P-Value*	% Diff.*
110	30	3.06	3.66	22%	0.3–35.71	<0.001	−186.6%
140	17	5.43	5.87	37%	0.62–65	0.115	−69.6%
150	9	2.78	9.26	47%	0.4–79.59	0.277	−215.5%
151	6	2.39	2.23	57%	0.89–10.13	0.196	−62.8%
310	6	0.37	0.16	64%	0.17–0.62	0.016	−64.9%
540	7	0.13	0.11	50%	0.04–0.37	0.867	7.7%
816	5	11.67	12.42	50%	1.69–31.03	0.003	−376.8%
853	26	20.17	10.39	50%	8–55	0.935	0.9%
912	16	16.37	9.14	48%	6–36.75	<0.001	−77.5%
944	7	17.85	12.76	53%	8.5–42.5	0.682	12.3%
945	11	14.75	7.03	51%	6.7–34.83	0.606	8.0%
946	3	23.47	10.15	50%	10.5–28.67	0.273	38.1%
*Comparison of average rate to corresponding ITE trip generation rate. P-value obtained from weighted t-test.							
Special independent variables for specific land uses as follows: Acres (110, 140, 150, 151, 816), Rooms (310), Students (540), Fueling Positions (853, 944, 945, 946), and Drive-Through Lanes (912).							

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