

1. Report No. FHWA/TX-10/5-9032-01-1		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle INTERNAL TRIP CAPTURE ESTIMATOR FOR MIXED-USE DEVELOPMENTS				5. Report Date December 2007 Published: February 2010	
				6. Performing Organization Code	
7. Author(s) Brian S. Bochner and Benjamin R. Sperry				8. Performing Organization Report No. Report 5-9032-01-1	
9. Performing Organization Name and Address Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135				10. Work Unit No. (TRAVIS)	
				11. Contract or Grant No. Project 5-9032-01	
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office P.O. Box 5080 Austin, Texas 78763-5080				13. Type of Report and Period Covered Technical Report: April 2007–October 2007	
				14. Sponsoring Agency Code	
15. Supplementary Notes Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration. Project Title: Mixed-Use Developments Internal Trip Capture Estimator URL: http://tti.tamu.edu/documents/5-9032-01-1.pdf					
16. Abstract This report describes a spreadsheet tool for estimating trip generation for mixed-use developments, accounting for internal trip capture. Internal trip capture is the portion of trips generated by a mixed-use development that both begin and end within the development. The importance of internal trip capture is that those trips satisfy a portion of the total development's trip generation and they do so without using the external road system. As a result, a mixed-use development that generates a given number of total trips creates less demand on the external road system than single-use developments generating the same number of trips. This report describes the spreadsheet estimator and how to use it. It describes the data behind the estimator as well as how those data are applied. The two Texas mixed-use developments from which most of the data were derived are also described. This report is supplemented by the Excel® spreadsheet itself as well as task memoranda that document the survey data collected as part of this project.					
17. Key Words Trip Generation, Mixed-Use Developments, Internal Capture			18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service Springfield, Virginia 22161 http://www.ntis.gov		
19. Security Classif.(of this report) Unclassified		20. Security Classif.(of this page) Unclassified		21. No. of Pages 50	22. Price

INTERNAL TRIP CAPTURE ESTIMATOR FOR MIXED-USE DEVELOPMENTS

by

Brian S. Bochner, P.E.
Senior Research Engineer
Texas Transportation Institute

and

Benjamin R. Sperry
Graduate Research Assistant
Texas Transportation Institute

Report 5-9032-01-1

Project 5-9032-01

Project Title: Mixed-Use Developments Internal Trip Capture Estimator

Performed in cooperation with the
Texas Department of Transportation
and the
Federal Highway Administration

December 2007

Published: February 2010

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

DISCLAIMER

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 the Federal Highway Administration (FHWA) or the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation. The engineer in charge was Brian S. Bochner, P.E. (Texas, #86721).

ACKNOWLEDGMENTS

This project was conducted in cooperation with the Texas Department of Transportation in cooperation with the Federal Highway Administration. The authors wish to acknowledge individuals who collaborated on this project. Guidance was provided by Maria Burke, TxDOT project director, and Duncan Stewart, TxDOT research engineer. The authors thank these individuals for their suggestions, review, and input, and thank the Texas Department of Transportation for its support of this project.

The authors also wish to thank the Trammel Crow Company, and particularly Elizabeth McCoy, Legacy Development Director, as well as Bob Bula, Marriott Legacy Center; Lori Myers, Carr America; Christie Jennings and Johnny McDonald, The Shops at Legacy; Greg LaMaster, Lincoln Property Company; Jan Ullrig, Post Legacy Apartments; and Collin Santos, Legacy Village Apartments for authorizing the survey conducted at Legacy Town Center and for their cooperation in providing background data.

TABLE OF CONTENTS

List of Figures.....	ix
List of Tables	x
1. Introduction.....	1
Mixed-Use Developments	1
Site Trip Generation.....	2
Internal Trip Capture.....	2
Estimation of Site Trip Generation	2
Single-Use Developments.....	2
Mixed-Use Developments	2
Project Purpose	3
2. Internal Capture Estimator Tool	5
Process Overview.....	5
Data Input Requirements	5
Trip Generation by Land Use	5
Vehicle Occupancy	6
Mode Split.....	6
Proximity Inputs.....	6
Internal Trip Computations.....	7
Proximity Adjustments	9
Internal Capture Balancing.....	10
Estimator Spreadsheet Inputs.....	11
3. Texas Mixed-Use Developments	15
Mockingbird Station	15
Legacy Town Center.....	16
4. Conclusions and Future Research.....	19
References	21
Appendix. Summary of Legacy Town Center Internal Capture Survey Results	23
Development Characteristics	25
Travel Survey Findings.....	29

LIST OF FIGURES

Figure 1. Sample Blocks Including Land Uses A and B.	7
Figure 2. Proximity Adjustment Factors to Unconstrained Internal Trip Capture Rates.	10
Figure 3. Estimator Balancing Concept.	10
Figure 4. Balanced Internal Trips from Text Example.	11
Figure 5. Estimator Input and Output Tables (Sheet 1).	13
Figure 6. Estimator Intermediate Computations Sheet Tables (Sheet 2).	14
Figure 7. Locations of Mockingbird Station and Legacy Town Center.	15
Figure 8. Layout of Mockingbird Station.	16
Figure 9. Illustrative Site Plan of Legacy Town Center.	17
Figure A-1. Legacy Town Center Illustrative Site Plan and Data Collection Sites.	26
Figure A-2. Legacy Town Center Retail, Restaurant, Cinema Buildings along Retail Main Street.	27
Figure A-3. Pedestrian Friendly Environment in Main Retail and Restaurant Area.	27
Figure A-4. Apartment Building on South Side of Central Park with Office Building in Background.	28

LIST OF TABLES

Table 1. AM Peak Hour Unconstrained Internal Capture Percentages (Trips from Origins).....	8
Table 2. AM Peak Hour Unconstrained Internal Capture Percentages (Trips to Destinations).....	8
Table 3. PM Peak Hour Unconstrained Internal Capture Percentages (Trips from Origins).....	8
Table 4. PM Peak Hour Unconstrained Internal Capture Percentages (Trips to Destinations).....	8
Table A-1. Legacy Town Center Development Components.....	25
Table A-2. Peak Period Interviews, Exit Movements, and Percent Interviewed - Legacy Town Center.....	29
Table A-3. Peak Period Usable Trips, Exit Movements, and Percent Usable - Legacy Town Center.....	30
Table A-4. Peak Period Interviews, Exit Movements, Percent Interviewed, and Usable Trips - Legacy Town Center.....	31
Table A-5. Morning Peak Period Surveyed Trips, Exit Movements, and Percent Surveyed - Legacy Town Center.....	32
Table A-6. Afternoon Peak Period Surveyed Trips, Exit Movements, and Percent Surveyed - Legacy Town Center.....	32
Table A-7. Peak Period Person-Trips Entering Land Uses, Legacy Town Center.....	33
Table A-8. Morning Peak Period and Peak Hour Person-Trip Cordon Count - Legacy Town Center.....	34
Table A-9. Afternoon Peak Period and Peak Hour Person-Trip Cordon Count - Legacy Town Center.....	34
Table A-10. Peak Period Person-Trips and Percent Internal Trip Capture by Land Use - Legacy Town Center.....	35
Table A-11. Percent Distribution of Internal Trip Destinations for Exiting Trips - Legacy Town Center, Morning Peak Period.....	36
Table A-12. Percent Distribution of Internal Trip Destinations for Exiting Trips - Legacy Town Center, Afternoon Peak Period.....	36
Table A-13. Percent Distribution of Internal Trip Origins for Entering Trips, Legacy Town Center, Morning Peak Period.....	37
Table A-14. Percent Distribution of Internal Trip Origins for Entering Trips - Legacy Town Center, Afternoon Peak Period.....	37
Table A-15. Peak Period Person Trips and Percent Internal Trip Capture by Mode of Travel - Legacy Town Center.....	38
Table A-16. Peak Period Person-Trips and Percent Internal Trip Capture by Mode of Access - Legacy Town Center.....	39
Table A-17. Peak Period Person-Trips and Percent Internal Trip Capture by Automobile Access, Legacy Town Center.....	39

1. INTRODUCTION

This report summarizes the background information related to Project 5-9032-01, Mixed-Use Developments Internal Trip Capture Estimator, and the development of the project's primary deliverable, a spreadsheet tool to estimate internal trip capture at mixed-use developments.

MIXED-USE DEVELOPMENTS

One of the recent new trends in land development is mixed-use developments—single projects that include different integrated, complementary, and interacting land uses such as office, retail, restaurants, entertainment, and/or hotels. The other key features of mixed-use developments are internal connectivity—walkways or internal streets or drives, and the sharing of parking—use of the same on-site parking lots by users of different buildings.

Another term, multi-use developments, describes similar but different combinations of land uses. Multi-use developments also consist of a combination of land uses adjacent to each other, but they are not interconnected and they do not share parking. The land uses may or may not interact. Since the terms sound so similar, they are often mistakenly confused for each other.

The Institute of Transportation Engineers (ITE) produced its *Trip Generation Handbook (1)* in part to aid analysts in estimating trip generation for mixed- and multi-use developments. The *Trip Generation Handbook* defines a multi-use development as a “single real-estate project that consists of two or more ITE land use classifications between which trips can be made without using the off-site road system.” In this handbook, ITE did not distinguish between mixed- and multi-use developments.

ITE also reports in the handbook that multi-use developments are typically between 100,000 and 2 million square feet in size. In its *Trip Generation* report (a different document) (2), ITE classifies land uses into over 100 classifications.

In the ITE definition of multi-use development, the qualification that a multi-use development must include two or more ITE land use classifications excludes land uses such as shopping malls, office buildings or hotels with small retail shops attached, or a service station with a convenience market from being considered multi-use developments, since those land uses have their own classifications in the ITE *Trip Generation* report.

However, this project specifically addresses mixed-use developments. Although ITE derived its data behind the multi-use development portion of the *Trip Generation Handbook* from mixed-use developments, most of those developments were less concentrated and less integrated than more recent mixed-use developments.

The Urban Land Institute categorizes the design and physical configuration of mixed-use projects into three groups: mixed-use towers, integrated multi-tower structures, and mixed-use town centers/urban villages/districts, with the latter being the form that is being assumed by almost all new mixed-use developments in Texas (3).

Researchers sometimes refer to these developments by such names as traditional neighborhood development, New Urbanist town center, or transit-oriented development. Projects conceived under these design principles emphasize mixed land-use, pedestrian-friendly developments that attempt to create a sense of place and community through “traditional” building design elements, a high degree of internal connectivity usually using grid-style street layouts with short block lengths, and the use of parks or open space.

SITE TRIP GENERATION

The number of trips generated by an existing or proposed development is often of interest to transportation engineers and planners. Transportation engineers use trip generation estimates in developing traffic projections for transportation improvements, considering how to plan for new development, considering whether to approve proposed development projects, sizing the long range transportation plan, and other uses. The number of trips using the public street system, usually freeways, arterials, and collectors, are of most interest. For that reason, site trip generation—the number of trips to and from a specific development site—focuses on how many trips move between a site and the road system during a given time.

INTERNAL TRIP CAPTURE

The ITE definition of “multi-use development” requires that some trips between on-site land uses to be made without travel on the off-site street system. As a result, it is important to know for a mixed-use development how much of the trip generation uses the public street system to reach off-site destinations and how much stays within the development without using external roads. This is the impetus behind determining internal trip capture—the portion of trips that stay totally within the development. These trips, which have both ends (origin and destination) within the site, are known as internal trips. Also of concern in the site planning process is the internal trip capture rate, which is the percentage of trips that remain internal to the site.

ESTIMATION OF SITE TRIP GENERATION

Single-Use Developments

The nationally accepted method of estimating site trip generation is to use the ITE *Trip Generation* report trip generation equations and/or rates and apply them as described in the *Trip Generation Handbook*. The basic process is to estimate trip generation for individual land uses, one to a land parcel, consistent with how most suburban development occurs. The analyst then assigns the estimated trips to travel routes (public streets and highways) to and from the site(s) under study.

Mixed-Use Developments

Analysts estimate trip generation for proposed mixed-use developments by adjusting the trip generation estimates for internal capture for each component land use by applying an internal trip capture rate that reflects the anticipated on-site internal trips. Trips that are not estimated to remain internal to the proposed mixed-use development site are considered external trips and are forwarded to the remaining steps of the traffic estimation process to determine the impact of the proposed development on the surrounding transportation system, including access requirements, roadway capacity, and traffic signal improvements.

In 2004, ITE conducted a survey of transportation planning professionals inquiring about their internal trip estimation practices. The results of the survey showed that 65 percent of the respondents indicated the use of a rule of thumb, the ITE method, locally established methodology, or other methods to estimate the internal trip capture rate. The wide range of specific details provided in the survey results regarding the locally established or other methodology reflect the broad yet speculative nature of predicting the amount of internal trip capture.

Chapter 7 of the *Trip Generation Handbook* outlines one procedure that analysts use to estimate the number of internal trips. The ITE procedure involves estimating the number of trips from each individual land use (as a free-standing development), then applying an internal trip capture rate for each land use, and then a balancing process to the original estimates to determine the number of internal and external trips. ITE derived the internal trip capture rates found in the *Trip Generation Handbook* from one early 1990s study of three mixed-use developments in Florida.

The current ITE estimation procedure includes three land uses commonly found in mixed-use developments: office, retail, and residential. ITE provides internal trip capture rates for those land uses for the midday peak hour, the PM peak hour of adjacent street traffic, and the entire day.

The *Trip Generation Handbook* advises users to consider the limitations of the published data and that “local data may be given preference” for several reasons. First, the ITE data are limited to only three mixed-use sites in Florida surveyed in the early 1990s. Second, the ITE method is limited to the mixing of office, retail, and residential uses and does not give any additional guidance for other land use types within a mixed-use development, such as restaurant, entertainment, or hotel. Finally, the ITE method does not account for other characteristics of a mixed-use development such as the availability of transit or the degree of connectivity between land uses within the development.

PROJECT PURPOSE

Recognizing the limitations of the existing ITE internal trip capture estimation method, the National Cooperative Highway Research Program (NCHRP) initiated project 8-51 to enhance the procedure for estimating internal trip capture. The NCHRP project included pilot surveys of two mixed-use development sites (one in Dallas and one in Atlanta), and NCHRP researchers expect the forthcoming project documentation to outline an improved ITE *Trip Generation Handbook* method, which incorporates additional land uses and proximity between on-site land uses into the estimation process.

This Texas Department of Transportation (TxDOT) implementation project adds internal trip capture data from a second Texas mixed-use development site to the internal trip capture estimation process to develop an estimator for use by engineers and planners considering the traffic impact of mixed-use developments in the state of Texas.

2. INTERNAL CAPTURE ESTIMATOR TOOL

The key deliverable of this project is the internal trip capture estimator tool in electronic spreadsheet format. This section of the report describes the development of the estimator tool.

PROCESS OVERVIEW

The estimation process employed in the spreadsheet tool follows the same basic procedure as the method currently outlined in Chapter 7 of the *Trip Generation Handbook*, except with internal trip capture rates for additional land-use pairs and an enhancement to account for proximity. The first step of the process is to estimate directional trip generation (inbound and outbound) for land uses at the proposed site. For a given land use pair, researchers applied separate internal trip capture rates, based on results of the Texas surveys, at both the origin and the destination end to determine the travel demand, with the smaller of the two values being selected as the controlling or “balanced” internal trip estimate. Researchers included this step because while one land use may be able to generate many trips to another internal use, if the destination use is small, it will not be able to accept all of the trips that could be sent to it. After balancing the estimate, the estimator subtracts the sum of internal travel between all internal developments from the original estimate to determine the total external impact.

DATA INPUT REQUIREMENTS

The inputs to the internal trip capture estimator tool are as follows:

- directional (in, out) trip generation estimates for each land use,
- mode split (personal vehicle, transit, non-motorized),
- vehicle occupancy, and
- weighted average internal distances between land uses.

Trip Generation by Land Use

The user can estimate trip generation for each component land use from the *Trip Generation* report or a similar source. Trip generation data for two analysis periods are required: the AM peak period (normal street peak period between 7:00 and 9:00 AM) and the PM peak period (4:00 to 6:00 PM).

The estimator provides internal trip capture rates for the following generic land use categories:

- office,
- retail,
- restaurant,
- residential,
- hotel, and
- cinema.

The estimator computes external trip generation estimates for combinations of these land uses. For the purpose of estimating internal capture, the user must combine appropriate land uses into the above land use classifications before continuing into the estimation process. For example, a

development containing apartments and townhouses, for the purpose of estimating internal capture, combine these two uses as residential.

The estimator tool is only valid for land uses that fall into one of the six categories provided in the estimator. As of this time, no research has been completed to quantify internal capture for other land use categories.

The trip generation estimates should be entered in Table 1-A (for the AM peak period) or 1-P (for the PM peak period) as entering or exiting vehicle-trips. Also included in Tables 1-A and 1-P is a row for the analyst to input the inbound and outbound vehicle-trip generation data for all other land uses that are not subject to internal trip capture computations in the estimator. These trips are automatically assigned to the external street network in subsequent computations.

Vehicle Occupancy

The estimator tool requires vehicle occupancy rates in order to convert the estimated trip generation rates from vehicle-trips to person-trips. Users may utilize a localized vehicle occupancy based on a survey of a similar nearby land use or the average vehicle occupancy for relevant trips in the region to convert these trip generation estimates from vehicle trips to person trips. Enter the vehicle occupancies for each land use category in spreadsheet Table 2-A and 2-P.

Mode Split

The estimator uses the mode split at the end of the process to determine the number of external person trips being taken by personal vehicle, transit, and non-motorized modes such as bicycle or walking. Use the mode split from surveys of similar land uses near the study site or from other estimates relevant to the study location and land uses (e.g., regional or localized travel data available from metropolitan planning organizations [MPO]). Enter the mode split associated with each land use category in spreadsheet Table 2-A and 2-P. Note that the vehicle occupancy and mode split data are also entered for land uses not subject to internal trip capture computations for the purposes of mode assignment for these trips (all external trips).

Proximity Inputs

To adjust the unconstrained internal trip capture rates to account for distance, the estimator uses the average distance between pairs of interacting land uses within the mixed-use development. Determine the average distances between each of the estimator's six land use categories for which blanks exist in Tables 3-A and 3-P and that are present in the development being analyzed (data collected did not support proximity adjustments for other land use pairs).

If there is only one building of each land use classification (e.g., one apartment building and one office building), enter the distance between the entrances of each building. If there is a group of buildings or businesses of one land use category in an area, separate that land use into blocks, with a block being the building faces along both sides of a street (see [Figure 1](#)). Locate the centroid of the entrances of each specific land use for each block and measure distances between each block centroid of that land use and the other interacting land use. If there are multiple

blocks, then make measurements between all pairs of blocks and use the weighted average distance, using square feet involved in each interchange as the weighting factor.

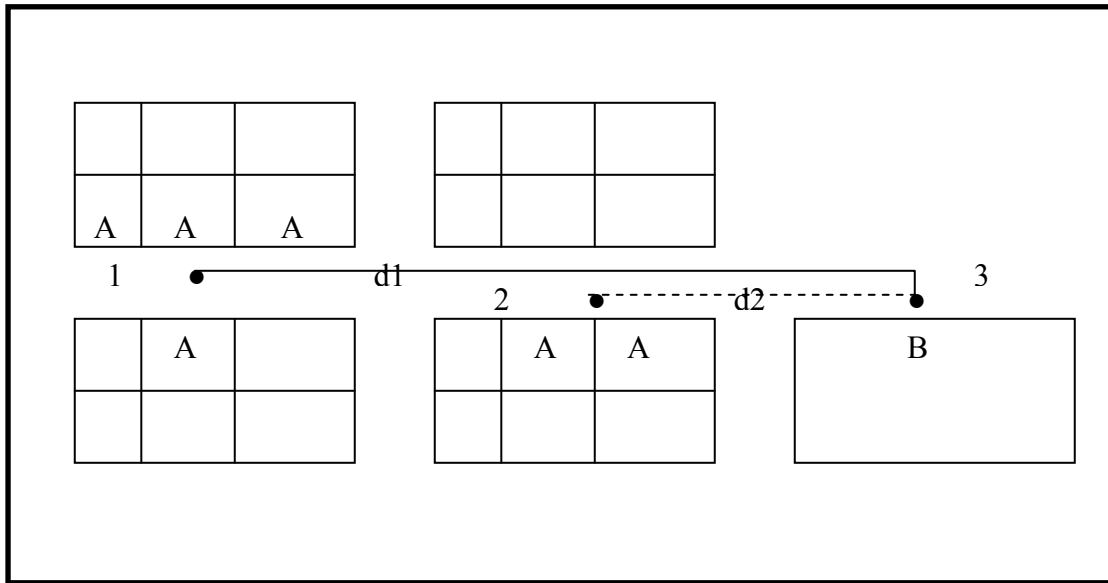


Figure 1. Sample Blocks Including Land Uses A and B.

Figure 1 shows an example of a multi-block scenario. If the dots represent the centroid of the entrances for land use A in each block, and if d1 and d2 are the respective distances to land use B in block 3, then the weighted average distance would be:

$$\frac{d1(\text{square feet in block 1 of land use A}) + d2(\text{square feet in block 2 of land use A})}{(\text{square feet in blocks 1 and 2 of land use A})}$$

For each pair of interacting land uses, enter a distance (in feet) by the prevailing travel mode into spreadsheet Input Table C. In most cases the distance between a pair of land uses will be the same in both directions. However, in the case of one-way circulation or some other directional constraint (affecting the primary travel mode), directional distances may be appropriate.

INTERNAL TRIP COMPUTATIONS

For each peak period, the estimator starts with two tables of “unconstrained” internal capture percentages for each interaction between land uses. These tables are for:

- [Table 1](#) – AM peak hour – trips from origins,
- [Table 2](#) – AM peak hour – trips to destinations,
- [Table 3](#) – PM peak hour – trips from origins, and
- [Table 4](#) – PM peak hour – trips to destinations.

Table 1. AM Peak Hour Unconstrained Internal Capture Percentages (Trips from Origins).

Origin	Destination					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	--	0%	63%	1%	--	
Retail	17%	--	6	14	--	0
Restaurant	25	2	--	4	--	1
Residential	2	1	20	--	--	0
Cinema	--	--	--	--	--	--
Hotel	0	0	9	0	--	--

Table 2. AM Peak Hour Unconstrained Internal Capture Percentages (Trips to Destinations).

Origin	Destination					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	--	3%	14%	3%	--	0%
Retail	0%	--	8	17	--	0
Restaurant	23	1	--	20	--	6
Residential	0	2	5	--	--	0
Cinema	--	--	--	--	--	--
Hotel	0	0	3	0	--	--

Table 3. PM Peak Hour Unconstrained Internal Capture Percentages (Trips from Origins).

Origin	Destination					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	--	9%	4%	2%	0%	0%
Retail	1%	--	29	26	4	5
Restaurant	3	38	--	18	6	3
Residential	4	31	21	--	0	3
Cinema	0	17	31	8	--	2
Hotel	0	5	33	0	0	--

Table 4. PM Peak Hour Unconstrained Internal Capture Percentages (Trips to Destinations).

Origin	Destination					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	--	6%	30%	57%	0%	0%
Retail	5	--	50	10	3	2
Restaurant	1	16	--	14	3	5
Residential	3	19	16	--	4	0
Cinema	1	14	32	0	--	0
Hotel	0	13	10	12	1	--

PROXIMITY ADJUSTMENTS

The percentages reported in [Tables 1](#) through [4](#) are adjusted in accordance with a proximity adjustment. That adjustment, based on the previously mentioned mixed-use development survey data, adjusts the development's internal interaction in accordance with distances between the land uses. [Figure 2](#) shows adjustment values for the PM peak period. Researchers based the adjustments in [Figure 2](#) on survey data applied to the following concept:

- For very short distances (less than about one city block), distance does not influence a person's decision to make or not make a trip to a specific destination.
- For very long distances, a few people will make a trip to a specific destination regardless of distance because they want or need to go to that specific place. For internal trips within a mixed use development, walking distances of 1/2 to 2/3 mile are considered maximum acceptable and most mixed-use developments have shorter maximum internal separation between uses.
- Between about one block and 1/2 to 2/3 mile, distance is a factor, and the greater the distance to a destination, the less likely people will make the trip to that destination, and the greater the likelihood that people will make the trip to another destination instead.

Researchers used survey data from six mixed-use developments in Texas, Georgia, and Florida to develop the curves in [Figure 2](#). The adjustment factor curves are applied to unconstrained trip capture rates for (1) all land uses to residential, origin end only (right curve) or (2) office or residential to retail or restaurant, both origin and destination ends (left curve). The proximity-adjusted internal trip capture percentage is rounded to the nearest whole percent for the subsequent computation steps.

AM peak period trips to and from mixed-use developments consisting of residential, office, hotel, and restaurant uses (most retail and cinema uses are not open for business at this time) are primarily work trips and, at the scale of these developments, not thought to be distance sensitive; data were also too limited to develop relationships similar to what is shown in [Figure 2](#). As a result, no proximity adjustment factors are provided for AM peak period data.

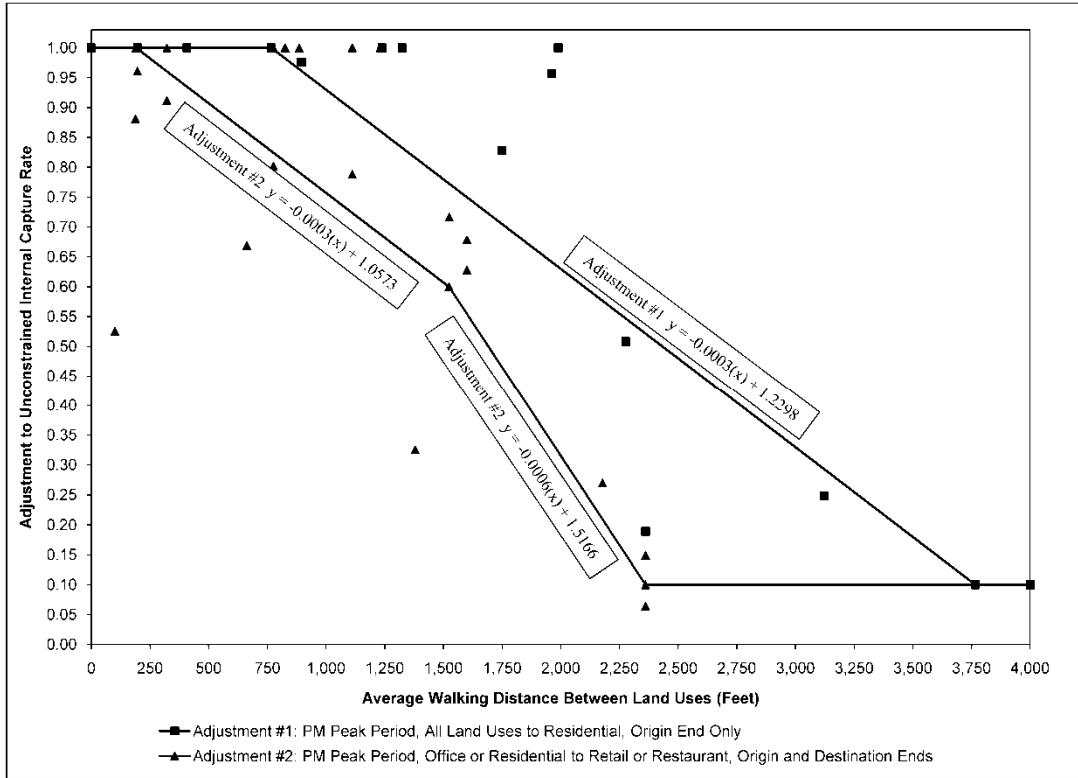


Figure 2. Proximity Adjustment Factors to Unconstrained Internal Trip Capture Rates.

INTERNAL CAPTURE BALANCING

The estimator applies the proximity-adjusted internal capture percentages to trips generated by each of the six land use categories. The estimator applies the percentages on the respective end of the trip (i.e., either origin or destination). [Figure 3](#) illustrates this concept.

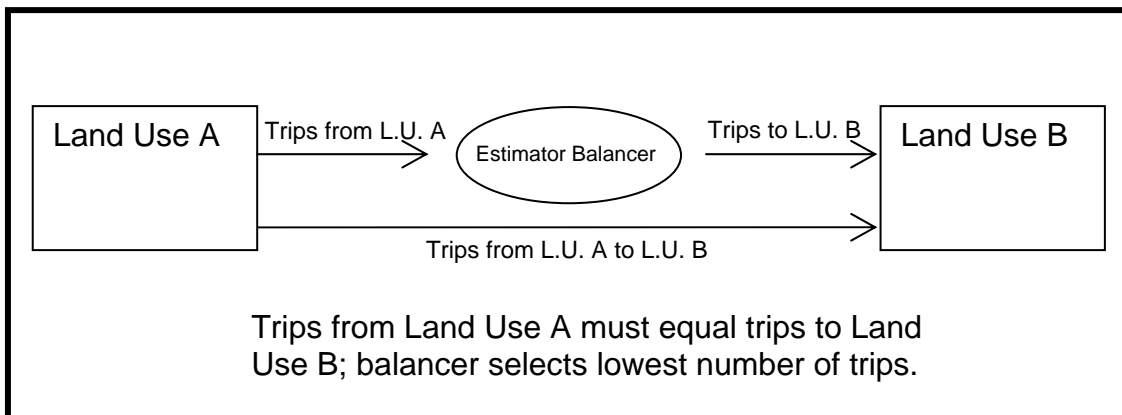


Figure 3. Estimator Balancing Concept.

Using the adjusted internal trip capture rates provided in the estimator tool, the estimator computes a directional internal person-trip origin-destination matrix for each analysis period. For example, for land use A in Figure 4, assume the estimator computed land use A's internal trips with land use B for a given period to be 50 inbound and 75 outbound. Also assume a similar estimate made for land use B for 35 inbound trips and 25 outbound trips (so estimates for land use A are $A \rightarrow B = 75$; $B \rightarrow A = 50$ and for land use B estimates are $A \rightarrow B = 35$; $B \rightarrow A = 25$). Figure 4 illustrates this example.

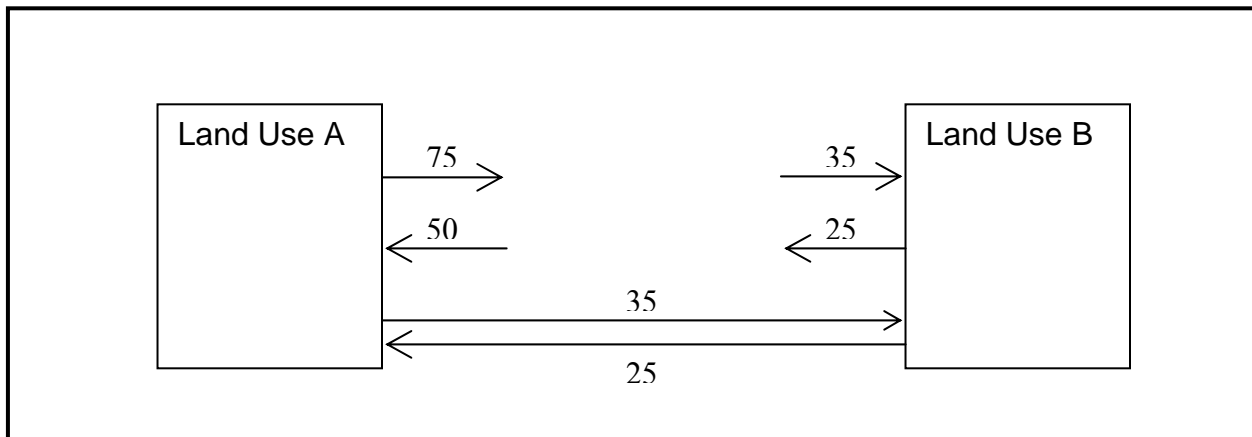


Figure 4. Balanced Internal Trips from Text Example.

The estimator's balancing computation eliminates this imbalance. It selects the minimum value in each direction, reflecting the ability for one land use to satisfy the demand from the other land use. In this example, there are only 35 trips that can enter land use B from land use A, so the number must be 35. In the same manner, the smaller of the $B \rightarrow A$ volumes is selected (25), as shown in Figure 4.

ESTIMATOR SPREADSHEET INPUTS

The estimator is in the form of a Microsoft Excel® spreadsheet. The user enters the required input data in the appropriate fields and Excel® automatically performs the internal trip computations. Figure 5 shows the estimator tool's input and output tables (the AM tables are shown in Figure 5, similar tables for the PM peak period are included in the estimator but are not in this report). Input is entered into the shaded cells of estimator Table 1-A (Base Vehicle-Trip Generation Estimates), estimator Table 2-A (Mode Split and Vehicle Occupancy Estimates), and estimator Table 3-A (Average Land Use Interchange Distances).

The output of the estimator consists of three tables. Estimator Table 4-A shows the balanced internal person-trip matrix. Estimator Table 5-A reports the total person-trips entering and exiting all land uses at the site and also the person-trip internal capture percentage for each direction. Estimator Table 5-A also shows the external travel by personal vehicle, transit, and non-motorized modes (walking and bicycling), suitable for direct entry into further steps of the site impact analysis process. Estimator Table 6-A shows the internal person-trip capture percentages for individual land uses, by direction.

Figure 6 shows the intermediate calculations of the estimator tool. Estimator Table 7-A shows the conversion of estimated vehicle-trips to person-trips. Estimator Table 8-A shows, for each direction of travel, the computation of internal person-trips between on-site land uses utilizing the internal trip capture percentages reported in Tables 1 through 4 of this report, adjusted for proximity as previously discussed. Estimator Table 9-A shows, for each direction of travel, a summary of the internal and external person-trips, and external trips by mode for each land use at the site. Note that the “All Other Land Uses” row is included in estimator Table 9-A as the trips generated by these land uses, while not subject to internal trip capture computations, are included in the estimate of external trips by travel mode.

TxDOT Internal Trip Capture Estimation Tool

Project Name:		Organization:	
Project Location:		Performed By:	
Scenario Description:		Date:	
Analysis Year:		Checked By:	
Analysis Period:	AM Street Peak Hour	Date:	

Land Use	Development Data (For Information Only)			Estimated Vehicle-Trips		
	ITE LUCs ¹	Quantity	Units	Total	Entering	Exiting
Office				0		
Retail				0		
Restaurant				0		
Cinema/Entertainment				0		
Residential				0		
Hotel				0		
All Other Land Uses ²				0		
Total				0	0	0

Land Use	Entering Trips			Exiting Trips		
	Veh. Occ.	% Transit	% Non-Motorized	Veh. Occ.	% Transit	% Non-Motorized
Office						
Retail						
Restaurant						
Cinema/Entertainment						
Residential						
Hotel						
All Other Land Uses ²						

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office						
Retail						
Restaurant						
Cinema/Entertainment						
Residential						
Hotel						

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office						
Retail	0					
Restaurant	0	0				
Cinema/Entertainment	0	0	0			
Residential	0	0	0	0		
Hotel	0	0	0	0	0	

	Total	Entering	Exiting
All Person-Trips	0	0	0
Internal Capture Percentage	0%	0%	0%
External Vehicle-Trips ³	0	0	0
External Transit-Trips ⁴	0	0	0
External Non-Motorized Trips ⁴	0	0	0

Land Use	Entering Trips	Exiting Trips
Office	N/A	N/A
Retail	N/A	N/A
Restaurant	N/A	N/A
Cinema/Entertainment	N/A	N/A
Residential	N/A	N/A
Hotel	N/A	N/A

¹Land Use Codes (LUCs) from *Trip Generation Informational Report*, published by the Institute of Transportation Engineers.

²Total estimate for all other land uses at mixed-use development site-not subject to internal trip capture computations in this estimator

³Vehicle-trips computed using the mode split and vehicle occupancy values provided in Table 2-A

⁴Person-Trips

*Indicates computation that has been rounded to the nearest whole number.

Estimation Tool Developed by the Texas Transportation Institute

Project Name:	0
Analysis Period:	AM Street Peak Hour

Land Use	Table 7-A (D): Entering Trips			Table 7-A (O): Exiting Trips		
	Veh. Occ.	Vehicle-Trips	Person-Trips*	Veh. Occ.	Vehicle-Trips	Person-Trips*
Office	1.00	0	0	1.00	0	0
Retail	1.00	0	0	1.00	0	0
Restaurant	1.00	0	0	1.00	0	0
Cinema/Entertainment	1.00	0	0	1.00	0	0
Residential	1.00	0	0	1.00	0	0
Hotel	1.00	0	0	1.00	0	0

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office		0	0	0	0	0
Retail	0		0	0	0	0
Restaurant	0	0		0	0	0
Cinema/Entertainment	0	0	0		0	0
Residential	0	0	0	0		0
Hotel	0	0	0	0	0	

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office		0	0	0	0	0
Retail	0		0	0	0	0
Restaurant	0	0		0	0	0
Cinema/Entertainment	0	0	0		0	0
Residential	0	0	0	0		0
Hotel	0	0	0	0	0	

Destination Land Use	Person-Trip Estimates			External Trips by Mode*		
	Internal	External	Total	Vehicles ¹	Transit ²	Non-Motorized ²
Office	0	0	0	0	0	0
Retail	0	0	0	0	0	0
Restaurant	0	0	0	0	0	0
Cinema/Entertainment	0	0	0	0	0	0
Residential	0	0	0	0	0	0
Hotel	0	0	0	0	0	0
All Other Land Uses ³	0	0	0	0	0	0

Origin Land Use	Person-Trip Estimates			External Trips by Mode*		
	Internal	External	Total	Vehicles ¹	Transit ²	Non-Motorized ²
Office	0	0	0	0	0	0
Retail	0	0	0	0	0	0
Restaurant	0	0	0	0	0	0
Cinema/Entertainment	0	0	0	0	0	0
Residential	0	0	0	0	0	0
Hotel	0	0	0	0	0	0
All Other Land Uses ³	0	0	0	0	0	0

¹Vehicle-trips computed using the mode split and vehicle occupancy values provided in Table 2-A
²Person-Trips
³Total estimate for all other land uses at mixed-use development site-not subject to internal trip capture computations in this estimator
*Indicates computation that has been rounded to the nearest whole number.

3. TEXAS MIXED-USE DEVELOPMENTS

To develop the Texas internal trip capture estimator, researchers collected data at two sites in Texas—one as a part of this implementation project and another Texas site that was included in the data collection efforts for the NCHRP 8-51 project. The two mixed-use development sites in Texas are Mockingbird Station, an urban infill transit-oriented development in a midtown Dallas location, and Legacy Town Center, a suburban mixed-use development located within the Legacy Business Park in Plano. [Figure 7](#) shows the location of the mixed-use developments.

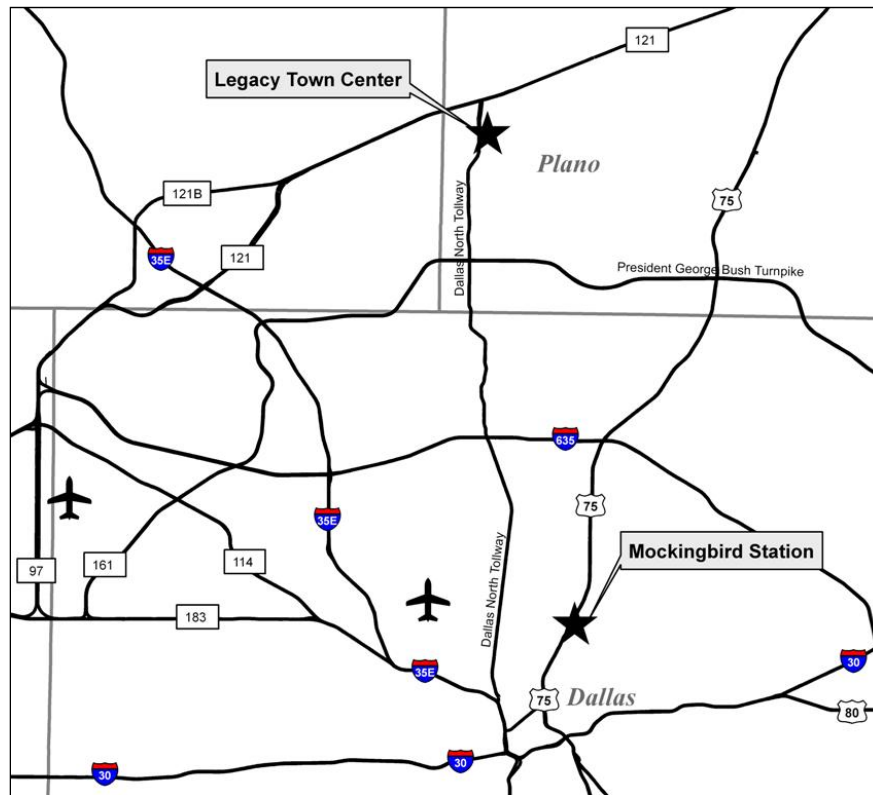


Figure 7. Locations of Mockingbird Station and Legacy Town Center.

MOCKINGBIRD STATION

Mockingbird Station is a 9-acre, mixed-use, transit-oriented, urban infill development located in Dallas, Texas, adjacent to the U.S. Highway 75 (Central Expressway) interchange at Mockingbird Lane. The site is bordered on the east by a Dallas Area Rapid Transit (DART) light rail line. A pedestrian bridge connects the light rail station with the development. Opened in 2001, Mockingbird Station includes retail, restaurants, offices, a cinema, and loft-style residences integrated both horizontally and vertically. The maximum walking distance between building entrances is about 800 feet, so there is virtually no internal trip making by motor vehicle. [Figure 8](#) illustrates the layout of Mockingbird Station with the DART light rail station located on the right. All buildings have retail and/or restaurant uses on the ground floor.



Figure 8. Layout of Mockingbird Station.

LEGACY TOWN CENTER

Legacy Town Center is a larger, 75-acre, suburban, mixed-use development located in Plano, Texas, adjacent to the interchange of the Dallas North Tollway and Legacy Drive. Legacy Town Center is located within the Legacy Business Park. Component land uses are retail, restaurants, office, a cinema, residential apartments, privately-owned townhomes, and a hotel. While the maximum walking distance is about 2,200 feet, most trips can be conveniently made by walking. There is a well connected internal street system, so any internal motor vehicle trips can easily be made on internal streets. [Figure 9](#) shows the general arrangement of land uses, buildings, and internal streets at Legacy Town Center. The lighter shaded buildings contain retail and restaurant uses; the darker shaded buildings are residential.

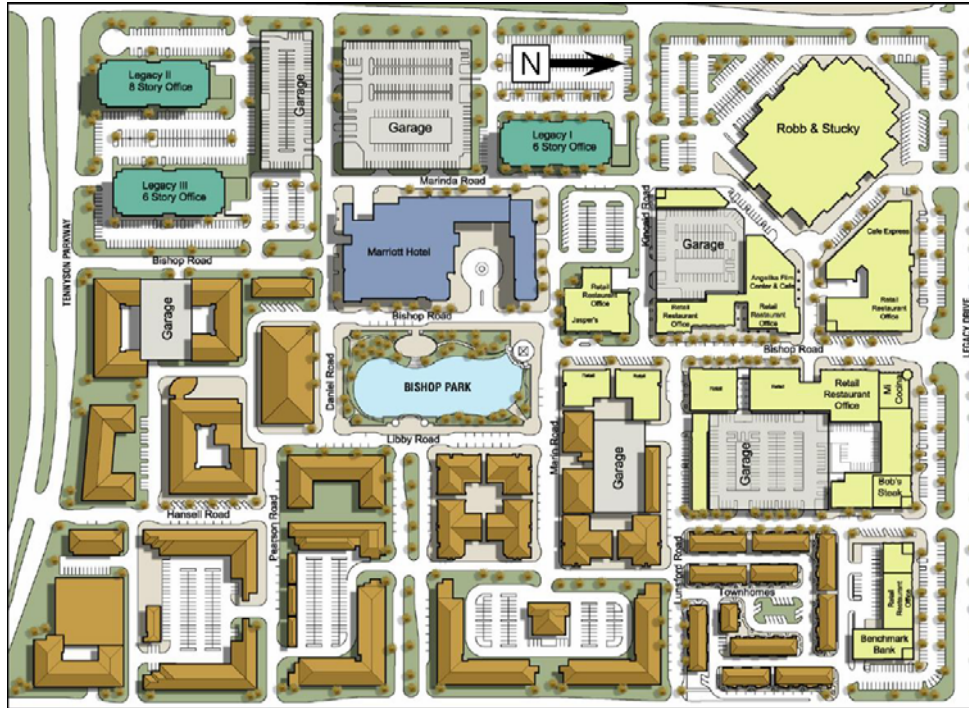


Figure 9. Illustrative Site Plan of Legacy Town Center.

The proximity adjustment also used data from these two Texas developments. However, to provide enough data to develop the curves in [Figure 2](#), researchers also drew on data from the NCHRP 8-51 survey at Atlantic Station in Atlanta, Georgia, and three mixed-use developments in Florida, Boca del Mar, Country Isles, and Village Commons, all of which are in the Ft. Lauderdale-Palm Beach area of Florida. Atlantic Station is somewhat similar to Legacy Town Center. The three Florida developments are mixed-use but tend to be less pedestrian-oriented and have more internal trips by driving.

4. CONCLUSIONS AND FUTURE RESEARCH

In addition to this technical report, deliverables from this project consist of the spreadsheet-based internal trip capture estimation tool. Researchers developed the spreadsheet estimator tool using data obtained from Texas mixed-use developments to represent an improvement upon the estimation procedure described in Chapter 7 of the *ITE Trip Generation Handbook, 2nd Edition*. Enhancements represented in this estimation tool include an increase in the number of land uses with internal trip capture data (from three to six), provisions for transit, non-motorized travel modes, proximity between on-site land uses, and the data being drawn from modern, fully integrated mixed-use developments.

The researchers highly recommend populating the estimation tool with new data from additional mixed-use development sites, land uses, and time periods. More sites are needed to permit more refined adjustment factors. More land uses could be included with additional surveys. Additional types of mixed-use developments should also be surveyed to determine the differences in design features. Also, further research would enhance the data collection methodology with lessons learned.

REFERENCES

- (1) *Trip Generation Handbook*, 2nd Edition, Institute of Transportation Engineers, Washington, DC, June 2004.
- (2) *Trip Generation*, 8th Edition, Institute of Transportation Engineers, Washington, DC, 2008.
- (3) Schwanke, et al. *Mixed-Use Development Handbook*, 2nd Edition, Urban Land Institute, Washington, DC, 2003.

**APPENDIX. SUMMARY OF LEGACY TOWN CENTER INTERNAL
CAPTURE SURVEY RESULTS**

This project surveyed Legacy Town Center in Plano, Texas, for internal capture travel characteristics. Plano is a northern suburb in the Dallas-Ft. Worth area. Plano is located about 20 miles north of downtown Dallas. Development is almost solid to the south and east. Much of the area north and west of Plano is in active development.

Development Characteristics

Phase 1 of Legacy Town Center is completely developed. It is a multiple block single development site bounded on all four sides by major roadways. The site is approximately just over 70 acres. It consists of office, retail, restaurant, cinema, hotel, and residential land uses. Most retail and restaurant buildings are single story. Tenants tend to be specialty retail and restaurants from better fast food to very exclusive. Most office space is in six-to-eight story buildings although a small amount is in second and third stories of two mixed-use buildings (that contain retail, restaurant, office, and/or residential space). Residential development consists of owner occupied townhomes and rental apartments. There is one major full-service hotel and one five-screen cinema that shows mainly artistic movies. [Table A-1](#) contains the development program. Additional phases of Legacy Town Center are being developed to the north of Legacy Drive.

Table A-1. Legacy Town Center Development Components.

Land Use	Occupied Development Units
Residential	1,300 apartment units, 60 townhomes
Retail	196,264 sq. ft.
Office	310,764 sq. ft.
Restaurant	69,318 sq. ft.
Cinema	5 screens (1,019 seats)
Parking	6,070 parking spaces

[Figure A-1](#) shows the illustrative site plan of Legacy Town Center. The site is about 1,600 feet by 2,000 feet. The site is well connected by streets, with block lengths ranging between 300 and 600 feet. The land uses tend to be concentrated in a section of Legacy Town Center. For example, the apartments are in the southeastern section. Retail and restaurants are mixed, but in the north portion. Townhomes are in a small portion of the east side. However, the connectivity provides a high degree of linkages between all blocks and land uses. Almost all blocks have landscaped walkways making them attractive and often shaded to walk along. [Figures A-2](#) through [A-4](#) illustrate the character of Legacy Town Center.

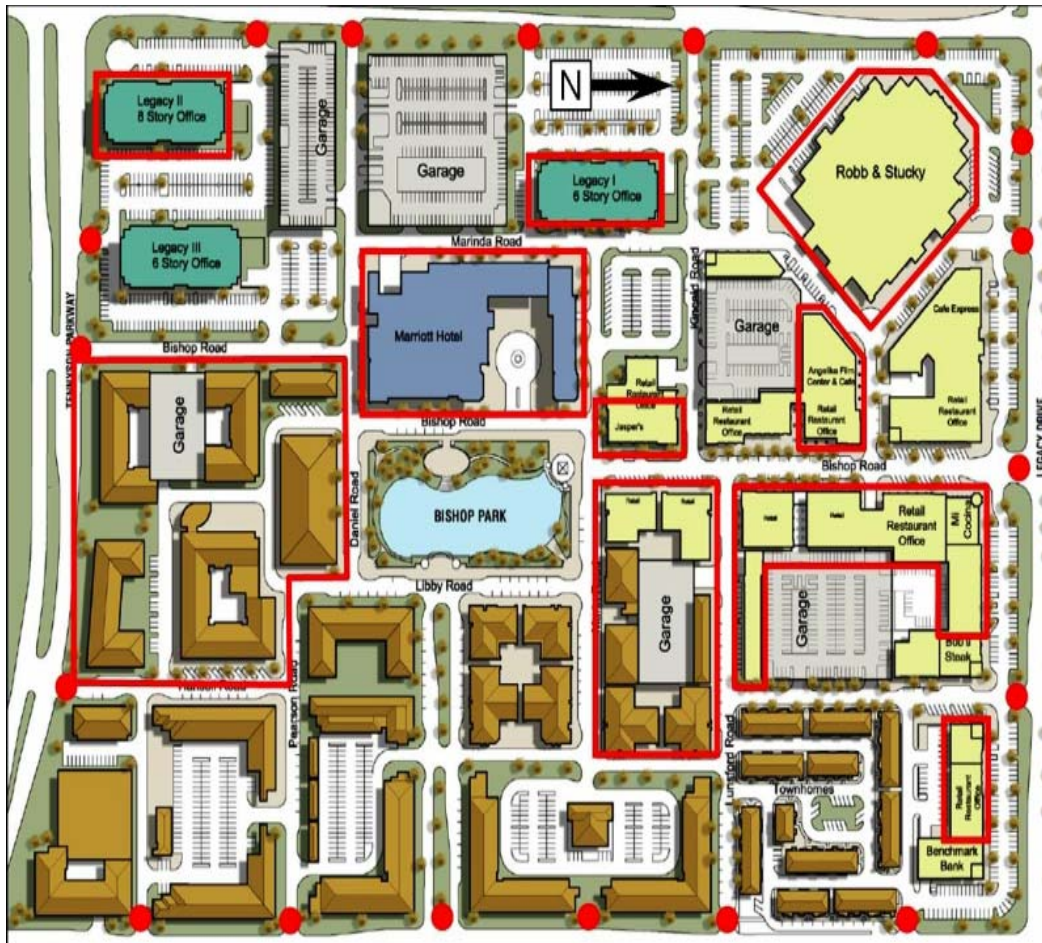


Figure A-1. Legacy Town Center Illustrative Site Plan and Data Collection Sites



Figure A-2. Legacy Town Center Retail, Restaurant, Cinema Buildings along Retail Main Street.



Figure A-3. Pedestrian Friendly Environment in Main Retail and Restaurant Area.



Figure A-4. Apartment Building on South Side of Central Park with Office Building in Background.

Legacy Town Center is actually part of a large business park development, which could evolve upon buildout into a major suburban activity center. Much of the area is occupied by free-standing corporate headquarters buildings, but there are many other types of commercial and residential development close by including hotels, regional shopping centers, and residential complexes.

Observed activity demonstrated that Legacy Town Center has become a center of activity in the area, especially after work and in the evening. Several restaurants were very busy, even during the week. The developer reported that most Legacy Town Center residents work within five miles of Legacy Town Center although few work in Legacy Town Center. Most Legacy Town Center employees also live in the north Dallas region, although again, few are thought by management to live within Legacy Town Center.

Access to Legacy Town Center is provided by the Dallas North Tollway (extends to downtown Dallas) and State Highway (SH) 121 (extends across the region from northeast to central Ft. Worth), which is less than one mile north of Legacy Town Center. Legacy Drive is a regional east-west arterial. Tennyson Parkway and Parkwood Boulevard are minor arterials about 5 miles long.

Transit service to Legacy Town Center is limited. There is one DART bus route (452) that serves Legacy Town Center in a directional loop along both its north and south boundaries. Service operates between 6 a.m. and 11:30 p.m. Headways are 30 minutes during peak periods and 60 minutes during off-peak periods. There are multiple stops on both Legacy Drive and

Tennyson Parkway. No use of this route by travelers to and from Legacy Town Center was observed either during survey periods or occasional additional observations.

The Marriott Hotel offers its patrons free shuttle service to and from destinations in the area. Small shuttle vehicles provide this service. Hotel patrons do use this service.

Travel Survey Findings

Travel surveys virtually identical to those conducted at Mockingbird Station and Atlantic Station were conducted at Legacy Town Center. Surveys were conducted Tuesday afternoon through Thursday morning, May 22–24, 2007. Due to rainy weather, surveys were also conducted on the following Thursday afternoon and Tuesday morning.

One addition was employed for this survey. Inbound office building interviews were conducted during the morning peak period.

Table A-2 shows the number of exit movements and interviews during the 6:30–10 a.m. morning and 3:00–7:00 p.m. afternoon peak periods. Due to the size of Legacy Town Center and number of buildings and businesses, interviews could not be conducted at all buildings and businesses. Samples of each land use were selected based on discussions with the developer and property managers. For example, two of the three office buildings were surveyed and six of the eight major block faces of retail were surveyed. One furniture store declined to be included in the survey.

Table A-2. Peak Period Interviews, Exit Movements, and Percent Interviewed - Legacy Town Center.

Land Use	Morning Peak Period			Afternoon Peak Period		
	Interviews ^a	Exit Movements	Percent Interviewed	Interviews ^a	Exit Movements	Percent Interviewed
Office	9	77	12%	80	362	22%
Retail	24	91	26%	59	595	12%
Restaurant	99	453	22%	74	913	11%
Residential	146	628	23%	80	592	19%
Cinema ^b	--	--	--	48	108	49%
Hotel	49	181	27%	50	299	17%
Total 3	27	1,430	23%	391 2	,869	16%

^a Number of interviews conducted with travelers exiting doors of a particular land use that contained at least one usable trip.

^b Cinema not open during morning peak period.

Overall, 23 percent of people exiting surveyed buildings were interviewed during the AM peak and 16 percent for the PM peak. No land use interview rate was less than 10 percent. The cinema was closed during the AM peak as were almost all non-convenience retail businesses and most restaurants. The only restaurants open were a specialty coffee shop and a bakery/coffee/light breakfast restaurant.

Table A-3 shows the number of usable trips derived from the interviews. These are compared to the counted exit movements during the interview periods (including some buildings for which no interviews were conducted). In all, usable trips constituted 18 percent of the morning people exiting surveyed buildings and 14 percent in the afternoon. The minimum sample rate for the morning was 12 percent and afternoon was 8 percent.

Table A-3. Peak Period Usable Trips, Exit Movements, and Percent Usable - Legacy Town Center.

Land Use	Morning Peak Period			Afternoon Peak Period		
	Usable Trips ^a	Exit Movements	Percent Usable	Usable Trips ^a	Exit Movements	Percent Usable
Office	9	73	12%	74	362	20%
Retail	25	108	23%	62	595	10%
Restaurant	100	551	18%	77	913	8%
Residential	148	710	21%	96	592	16%
Cinema ^b	--	--	--	49	108	45%
Hotel	54	400	14%	50	299	17%
Total 3	36	1,842	18%	408 2	,869	14%

^a Must include specific origin location, location of destination, and land use of destination if internal; the total includes total reported outbound and inbound trips made this period.

^b Cinema not open during morning peak period.

Table A-4 shows a summary of completed interviews, exiting people, and usable trips derived from the interviews. Table A-3 shows the total of the reported trips as usable trips, if they were made during one of the two peak periods. Unusable trips included inbound trips occurred outside the peak periods or trips for which the respondent was unable or unwilling to provide complete enough information to make the inbound trip usable. Finally, some otherwise complete interviews were not usable because the inbound trip reported was not actually the immediately previous trip; many of those trips were made outside the peak periods. First trips of the day from the on-site apartments did not have a previous trip that day.

Table A-4. Peak Period Interviews, Exit Movements, Percent Interviewed, and Usable Trips - Legacy Town Center.

Land Use	Morning Peak Period				Afternoon Peak Period			
	Interviews ^b	Exit Movements	Percent Interviewed	Usable Trips ^c	Interviews ^b	Exit Movements	Percent Interviewed	Usable Trips ^c
Office	9	73 ^d	12	9	80	312 ^e	26	74
Retail	24	108	22	25	59	536 ^f	11	62
Restaurant	99	551	18	100	74	913	8	77
Residential	146	710	21	148	80	592	14	96
Cinema ^a	--	--	--	--	48	108	44	49
Hotel	49	400	12	54	50	299	17	50
Total 32	7	1,842	18	336^g 39	1	2,760	14	408^h

^a No interviews attempted at cinema during the morning peak period since cinema was closed.

^b Number of interviews conducted with travelers exiting doors of a particular land use that contained at least one usable trip.

^c Must include specific origin location, location of destination, and land use of destination if internal; the total includes total reported outbound and inbound trips made this period.

^d Excludes 4 movements counted at establishments where no or too few interviews were completed for valid sample.

^e Excludes 50 movements counted at establishments where no or too few interviews were completed for valid sample.

^f Excludes 59 movements counted at establishments where no or too few interviews were completed for valid sample.

The interviews reported in [Table A-4](#) differ slightly from interviews reported in prior tables. This is because the interviews reported in [Table A-2](#) are associated with the land use for which an exit trip is reported whereas previous tables reported where the interview occurred.

Morning interviews were completed at the open retail outlets. In this case they were a convenience retail store and a dry cleaner throughout the morning peak period. A United Parcel Service (UPS) store opened at 9 a.m.

[Table A-5](#) shows the number of trips exiting Legacy Town Center establishments that are had exit trips described in interviews. That table also shows the number of persons counted exiting at locations where interviews were conducted plus the prorated number estimated to have exited at locations where counts and interviews were not conducted. These locations were judged by the researchers to be represented by similar establishments that were surveyed except one case where the proprietor declined to permit any interviewing. That location was included in the proration by square footage. Legacy Town Center had no direct internal access to parking garages where the interviewers could not intercept exiting people. Approximately two-thirds of all trips were covered by direct interview sampling; the other third was included by proration. For the morning peak period, approximately 12 percent of all exiting trips are represented by surveyed trips.

Table A-5. Morning Peak Period Surveyed Trips, Exit Movements, and Percent Surveyed - Legacy Town Center.

Land Use	Surveyed Trips ^b	Exit Movements				Percent Surveyed ^e
		Doors	Unsurveyed Locations ^c	Garage Direct ^d	Total	
Office	9	77	21	--	98	9%
Retail	25	108	--	--	108	21%
Restaurant	100	551	--	--	551	18%
Residential	148	710	953	--	1,663	9%
Cinema ^a	--	--	--	--	--	--
Hotel	54	400	--	--	400	14%
Total 3	36	1,846	974	--	2,820	12%

^a Cinema did not actively generate trips during the morning peak period.

^b Number of usable trip origins at each land use recorded from traveler interviews.

^c Includes locations where no interviews were attempted (prorated by square feet) and locations where door counts were made but no usable trip origins were recorded on interviews.

^d Person-trips observed exiting on-site parking garages, assumed to be traveling directly to an external location.

^e Includes those trips described in usable interviews or direct exits from a parking garage to the external street system.

Table A-6 displays similar information for the PM peak period. There were about 60 percent more exiting trips in the PM peak period than during the AM peak period. The interviewed trips represent a sample of approximately 9 percent of all exiting trips.

Table A-6. Afternoon Peak Period Surveyed Trips, Exit Movements, and Percent Surveyed - Legacy Town Center.

Land Use	Surveyed Trips ^b	Exit Movements				Percent Surveyed ^e
		Doors	Unsurveyed Locations ^c	Garage Direct ^d	Total	
Office	74	362	155	--	517	14%
Retail	62	595	266	--	861	7%
Restaurant	77	913	491	--	1,404	5%
Residential	96	592	794	--	1,386	7%
Cinema ^a	49	108	--	--	108	45%
Hotel	50	299	--	--	299	17%
Total 4	08	2,869	1,708	--	4,575	9%

^a Cinema did not actively generate trips during the morning peak period.

^b Number of usable trip origins at each land use recorded from traveler interviews.

^c Include locations where no interviews were attempted (prorated by square feet) and locations where door counts were made but no usable trip origins were recorded on interviews.

^d Person trips observed exiting on-site parking garages, assumed to be traveling directly to an external location.

^e Includes those trips described in usable interviews or direct exits from a parking garage to the external street system.

Table A-7 shows for each peak period the sources of entering trip information for trips entering Legacy Town Center establishments. For the morning peak period, interviews represent about 18 percent of the trips and the balance was assumed to all be external. For the evening peak period, about 38 percent of the entering trips are represented by interviews and the remaining 62 percent considered all external.

Table A-7. Peak Period Person-Trips Entering Land Uses, Legacy Town Center.

Land Use	Morning Peak Period					Afternoon Peak Period				
	Survey ^b	Garage Direct ^c	Transit Direct ^d	Balance ^e	Total	Survey ^b	Garage Direct ^c	Transit Direct ^d	Balance ^e	Total
Office	121	--	--	476	597	89	--	--	7	96
Retail	30	--	--	89	119	316	--	--	507	823
Restaurant	156	--	--	437	593	787	--	--	1,217	2,004
Residential	79	--	--	593	672	592	--	--	924	1,516
Cinema ^a	--	--	--	--	--	71	--	--	150	221
Hotel	6	--	--	181	187	115	--	--	200	315
Total 3	92	--	--	1,776	2,168	1,970	--	--	3,005	4,975

^a Cinema did not actively generate trips during the morning peak period.

^b Trip destinations recorded from exit interviews, expanded as described.

^c Person-trips observed entering on-site parking garages, assumed to be traveling directly from an external location.

^d Trips entering on-site land uses from external locations recorded on transit interviews.

^e Balance of person-trips entering on-site land uses; assumed to originate externally.

Table A-8 shows results from the morning cordon count. As might be expected for a suburban development with limited transit service, almost all trips to and from Legacy Town Center were by motor vehicle. Transit, shuttle, walking and bicycling combined accounted for about 4 to 6 percent of the AM and PM peak person trips. Almost none were by bicycle or public transit although some were by hotel shuttle van. Personal vehicle occupancy rates were about 1.07 inbound and 1.12 outbound for the AM peak period.

Table A-8. Morning Peak Period and Peak Hour Person-Trip Cordon Count - Legacy Town Center.

Travel Mode	Peak Period (7:00 a.m.-10:00 a.m.)				Peak Hour (7:30 a.m.-8:30 a.m.)			
	Trips		Percent		Trips		Percent	
	Entering	Exiting	Entering	Exiting	Entering	Exiting	Entering	Exiting
Personal Vehicle ^a	1,767	1,745	93%	91%	770	725	94%	93%
Motorcycle	0	1	0%	<1%	0	0	0%	0%
Delivery Vehicle	77	66	4%	3%	17	12	2%	2%
Transit ^b	15	76	1%	4%	11	29	1%	4%
Walk	49	31	3%	2%	21	13	3%	2%
Bicycle	0	0	0%	0%	0	0	0%	0%
Total All Modes	1,908	1,919	100%	100%	819	79	100%	100%

^a Personal vehicle occupancies (entering/exiting): 1.07/1.12.

^b Transit trips include bus and hotel shuttle.

Table A-9 shows similar data for the PM peak period. As with the AM peak period, the PM shows that nearly all trips to and from Legacy Town Center are by personal vehicle. Transit, bicycle, and walk modes in total comprise slightly lower percentage of trips in the PM than the AM. Vehicle occupancies were significantly higher during the PM peak period, possibly due to the increased percentages of trips to and from retail, restaurants, and entertainment businesses that are open during the PM peak period but not the AM peak period.

Table A-9. Afternoon Peak Period and Peak Hour Person-Trip Cordon Count - Legacy Town Center.

Travel Mode	Peak Period (4:00 p.m.-7:00 p.m.)				Peak Hour (5:00 p.m.-6:00 p.m.)			
	Trips		Percent		Trips		Percent	
	Entering	Exiting	Entering	Exiting	Entering	Exiting	Entering	Exiting
Personal Vehicle ^a	3,192	2,832	94%	95%	1,107	1,066	93%	95%
Motorcycle	5	5	<1%	<1%	3	1	<1%	<1%
Delivery Vehicle	61	57	2%	2%	20	22	2%	2%
Transit ^b	39	13	1%	<1%	22	6	2%	1%
Walk	100	60	3%	2%	35	27	3%	2%
Bicycle	0	0	0%	0%	0	0	0%	0%
Total All Modes	3,397	2,967	100%	100%	1,187	122	100%	100%

^a Personal vehicle occupancies (entering/exiting): peak period 1.23/1.16.

^b Transit trips include bus and hotel shuttle.

Table A-10 shows the AM and PM peak period internal trip capture percentages as reported in the interviews. The AM peak period internal capture was about 15 percent for entering trips and 11 percent for exiting trips. During the PM peak period the internal capture percentages were

higher at 33 percent for entering trips and 37 percent for exiting trips. These summaries include only trips between different land uses; trips between the same land use are not included to remain consistent with the trip generation methodology used by the ITE.

Table A-10. Peak Period Person-Trips and Percent Internal Trip Capture by Land Use - Legacy Town Center.

Land Use	Morning Peak Period				Afternoon Peak Period			
	Entering Ex		iting		Entering Ex		iting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Office	560	15%	61	8%	90	93%	511	3%
Retail	119	25%	109	37%	728	30%	766	61%
Restaurant	593	26%	550	16%	1,833	33%	1,233	39%
Residential	631	6%	1,622	9%	1,352	32%	1,222	34%
Cinema ^a	--	--	--	--	221	32%	108	43%
Hotel	187	3%	400	9%	315	36%	299	38%
Total All Trips	2,090	15%	2,742	11%	4,539	33%	4,139	37%

^a Cinema not open during morning peak period.

As might be expected, the highest AM internal capture rates are for retail (largely convenience). The office, residential, and hotel generated the lowest percentages of internal trips. Residential trips to internal destinations were primarily to convenience retail or coffee shop. During the PM peak period, interaction between retail, restaurant, cinema, and hotel was demonstrated. Many on-site residents also traveled to these destinations. Evening internal trip capture percentages were consistent for most land uses with between 30–43 percent. Although there were few trips destined for the office buildings, a high percentage were from internal origins. However, very few of those leaving office space at Legacy Town Center made trips to other on-site destinations. Trips leaving retail also had a high percentage of internal capture, with leisure shoppers remaining for dinner or a movie or going home to their residence on site.

Table A-11 shows the percentages of internal capture by land use for exiting AM peak period trips, that is, trips leaving those land uses. These percentages are based on the interviews. This table shows the degree of interaction between the various land uses. The greatest synergies during the AM peak period are from (convenience) retail to office and residential. As with Mockingbird Station and Atlantic Station, there is some interchange from restaurant (coffee) to office, although at Legacy Town Center the specialty coffee shop is most of the way across the development from the major office buildings.

Table A-11. Percent Distribution of Internal Trip Destinations for Exiting Trips - Legacy Town Center, Morning Peak Period.

Origin Land Use	Destination Land Use						Summary			
	Office	Retail	Restaurant	Residential	Cinema ^b	Hotel	Internal	External	Total	Total Trips
Office	-- ^a	0	8	0	--	0	8	92	100	61
Retail	17	-- ^a	6	14	--	0	37	63	100	109
Restaurant	9	2	-- ^a	4	--	1	16	84	100	550
Residential	1	1	7	-- ^a	--	0	9	91	100	1,622
Cinema ^b	--	--	--	--	-- ^a	--	--	--	--	--
Hotel	0	0	9	0	--	-- ^a	9	91	100	400
All Origins	3	1	6	1	--	0	11	89	100	2,742

^a Internal trips within a land use are not included in internal trip capture methodology.

^b Cinema not open during morning peak period.

Table A-12 shows similar data for the PM peak period. Exiting trips destined to other internal destinations are most frequent from retail to restaurant and residential; from restaurant to residential; and from residential, cinema, and hotel to restaurant. This reflects what is expected for an area that has significant amounts of synergy between complementary land uses.

Table A-12. Percent Distribution of Internal Trip Destinations for Exiting Trips - Legacy Town Center, Afternoon Peak Period.

Origin Land Use	Destination Land Use						Summary			
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Internal	External	Total	Total Trips
Office	-- ^a	0	1	2	0	0	3	97	100	511
Retail	1	-- ^a	29	26	0	5	61	39	100	766
Restaurant	2	10	-- ^a	18	6	3	39	61	100	1,233
Residential	4	6	21	-- ^a	0	3	34	66	100	1,222
Cinema	0	8	31	2	-- ^a	2	43	57	100	108
Hotel	0	5	33	0	0	-- ^a	38	62	100	299
All Origins	2	5	15	10	2	3	37	63	100	4,139

^a Internal trips within a land use are not included in internal trip capture methodology.

Table A-13 shows the internal trip capture percentages for entering trips by interchange between land uses. These percentages are shown as the percentage of total entering trips from individual land uses in Legacy Town Center. This table is for trips entering the various Legacy Town Center land uses. Internal capture percentages are highest entering (convenience) retail and restaurant from on-site residential.

Table A-13. Percent Distribution of Internal Trip Origins for Entering Trips, Legacy Town Center, Morning Peak Period.

Destination Land Use	Origin Land Use						Summary			
	Office	Retail	Restaurant	Residential	Cinema ^b	Hotel	Internal	External	Total	Total Trips
Office	-- ^a	3	9	3	--	0	15	85	100	560
Retail	0	-- ^a	8	17	--	0	25	74	100	119
Restaurant	1	1	-- ^a	18	--	6	26	74	100	593
Residential	0	2	4	-- ^a	--	0	6	94	100	631
Cinema ^b	--	--	--	--	-- ^a	--	--	--	--	--
Hotel	0	0	3	0	--	-- ^a	3	97	100	187
All Destinations	0	2	4	7	--	2	15	85	100	2,090

^a Internal trips within a land use are not included in internal trip capture methodology.

^b Cinema not open during morning peak period.

Table A-14 shows PM peak period trip capture percentages for entering trips by interchange between land uses. With a higher total internal capture, the PM peak period also exhibits higher percentages of internal trips on individual interchanges with other land uses. The highest percentage of internal trip capture for entering trips was observed for trips entering office buildings from on-site residential and restaurant. However, inbound trips to office are very small in total numbers. More significant were trips entering the cinema and retail from restaurants; trips entering restaurants from residential and retail; trips entering residential from retail and restaurants; and trips entering the hotel from retail, restaurants, and residential. Inbound trips to restaurant and residential make up the great majority of the total inbound trips to Legacy Town Center land uses.

Table A-14. Percent Distribution of Internal Trip Origins for Entering Trips - Legacy Town Center, Afternoon Peak Period.

Destination Land Use	Origin Land Use						Summary			
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Internal	External	Total	Total Trips
Office	-- ^a	6	30	57	0	0	93	7	100	90
Retail	0	-- ^a	17	10	1	2	30	70	100	728
Restaurant	0	12	-- ^a	14	2	5	33	67	100	1,833
Residential	1	15	16	-- ^a	0	0	32	68	100	1,352
Cinema	0	0	32	0	-- ^a	0	32	68	100	221
Hotel	0	13	10	12	1	-- ^a	36	64	100	315
All Destinations	0	10	10	9	1	3	33	67	100	4,539

^a Internal trips within a land use are not included in internal trip capture methodology.

Table A-15 shows the percentages of internal trip capture by mode of travel for each entering and exiting trip. This table shows data for trips for which mode of travel was reported. Unlike

Mockingbird Station where there were almost no internal driving trips, Legacy Town Center has 8–10 percent of personal driving trips that are internal in the AM peak period and 16–20 percent in the PM peak period. By contrast, all inbound and nearly all outbound walk and bike trips remained internal to Legacy Town Center.

Table A-15. Peak Period Person Trips and Percent Internal Trip Capture by Mode of Travel - Legacy Town Center.

Mode of Travel	Morning Peak Period				Afternoon Peak Period ^a			
	Entering Ex		iting		Entering Ex		iting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Vehicle Driver	1,968	10%	2,337	8%	3,569	16%	2,875	20%
Vehicle Passenger	6	100%	102	6%	20	100%	177	11%
Taxi/Car Service	0	0%	15	0%	0	0%	16	0%
Transit (Bus)	0	0%	16	0%	0	0%	0	0%
Transit (Hotel Shuttle)	0	0%	140	0%	5	100%	5	100%
Walk/Bicycle	118	100%	136	87%	943	100%	1,069	89%

^a Travel mode not reported for 2 entering trips and 7 exiting trips.

Table A-16 shows similar data, but these are for trips made by people based on their original mode of access to Legacy Town Center. These results are limited to those who correctly reported mode of access; a few travelers reported mode of access to the area rather than to Legacy Town Center. During the AM peak period, nearly all trips were made by people who arrived at Legacy Town Center as a personal vehicle driver. During the PM peak period, there are more trips made by people who used other modes of access than driving. Of those non-drivers (who presumably did not have a vehicle available to drive the next trip unless they were on-site residents), virtually all of the trips entering Legacy Town Center land uses were internal trips. However, for trips exiting the Legacy Town Center land uses, about 25 percent of the original vehicle passengers were going to other internal land uses and about half of the taxi/car service passengers were destined internally. This compares to 31 percent for people who originally arrived on-site by driving a personal vehicle.

Table A-16. Peak Period Person-Trips and Percent Internal Trip Capture by Mode of Access - Legacy Town Center.

Mode of Access	Morning Peak Period ^a Afternoon				Peak Period ^b			
	Entering Ex		iting		Entering Ex		iting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Vehicle Driver	1,892	6%	670	17%	3,862	22%	2,772	31%
Vehicle Passenger	0	0%	11	0%	40	100%	159	25%
Taxi/Car Service	0	0%	0	0%	23	100%	45	51%
Transit (Bus)	6	100%	6	100%	0	0%	0	0%
Transit (Hotel Shuttle)	0	0%	0	0%	5	100%	5	100%
Walk/Bicycle	9	100%	9	100%	0	0%	0	0%

^a Access mode not reported for 189 entering trips and 2,052 exiting trips.

^b Access mode not reported for 609 entering trips and 1,158 exiting trips.

Given the size of the samples and internal trip capture percentages, no conclusion can be drawn from these data as to whether or not mode of access affects internal capture rates.

Table A-17 shows similar data, but this is based on availability of a personal vehicle for travel. It appears that the internal capture rate for those who did not have a personal vehicle available is higher than for those who could have driven. This is logical since once one travels to a destination it makes sense to combine trips at the destination area.

Table A-17. Peak Period Person-Trips and Percent Internal Trip Capture by Automobile Access, Legacy Town Center.

Vehicle Access	Morning Peak Period ^a Afternoon				Peak Period ^b			
	Entering Ex		iting		Entering Ex		iting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Yes (Vehicle Driver)	1,892	6%	670	17%	3,862	22%	2,772	31%
Yes (Non-Vehicle Driver)	0	0%	11	0%	13	100%	121	11%
No Vehicle Access	9	100%	9	100%	52	100%	90	58%

^a Automobile access not reported for 189 entering trips and 2,052 exiting trips.

^b Automobile access not reported for 612 entering trips and 1,156 exiting trips.

