Test Site 3: St. Johns Town Center (Existing "Power Center" Retail Development)

To highlight the application of the trip reduction factors to a recently developed suburban retail location, the St. Johns Town Center DRI was selected. This 207-acre open-air lifestyle center, owned by the Simon Property Group, opened in March 2005. Located at the northwest corner of J. Turner Butler Boulevard and State Road 9A project construction is estimated at $158 million and includes more than 100 retailers, many of whom used the development as an entry into the Jacksonville market. The second phase of retail may include upscale stores such as Nieman-Marcus and/or Nordstrom. As such, the project development plan at build-out will consist of approximately 2 million square feet of retail, 330,000 square feet of office, 450 multifamily units, 250 hotel rooms, and a 500 seat movie theatre.

Northern section of the St. Johns Town Center, characterized by conventional suburban design and abundant parking

Southern portion of the St. Johns Town Center, with open-air shops and more walkable, urban design features

From a transportation concurrency standpoint, the DRI is part of an established transportation management area (TMA) under the auspices of a private landowner. Under this arrangement, any transportation-related impact fees are paid by the prospective developer through a private agreement between the developer and the landholder. The City draws the resulting trips down following the execution of the development agreement and reserves these trips under its concurrency management system. Based upon the DRI development agreement in 2001, the proportionate share was calculated at $13,339,378 in cash payments and funded transportation improvements to offset the transportation impacts of the DRI, including those to J. Turner Butler Boulevard, State Road 9A, and Southside Boulevard.

When applying the URBEMIS-based mitigation factors under the mobility fee scenario, a negligible reduction in vehicle trips occurs with this site. This is also largely related to the low density characteristics of the area. The 450 multifamily units over the 207 acre parcel yields a net negative density-based credit because of this. While the site receives nominal credits for mix of uses, the presence of local serving retail, and bicycle and pedestrian accommodations, the overall lack of residential density and use mix reduces the overall trip reduction. This case assumes that no TDM credits have been applied to the site recognizing that current frequency of transit service is very low. As proposed, the combined trip reduction adjustment is 3.48%. Under the proposed mobility scenario, the estimated payment is a comparable $13,815,804 based upon the 55,284 net, daily mobility fee-eligible trips.

While the southern portion of the St. Johns Town Center provides, to some extent, an urban and pedestrian orientation, the overall project design could be further modified to capitalize upon the three "D's" and receive additional trip reduction credits. The lack of housing within a safe and comfortable walking distance to available employment combined with the domination of free and abundant parking particularly at the northern shopping area, promotes an autocentric quality to the site. Examples such as **CityPlace** in West Palm Beach and **Mizner Park** in Boca Raton, offer

Mizner Park in Boca Raton embodies traditional neighborhood development (TND) characteristics enabling residents and workers to realistically choose to walk or bike to work, school, or shop.

CityPlace development in West Palm Beach provides a design contrast to the St. Johns Town Center. This project would receive additional trip reduction credits based upon the incorporation of higher residential densities and mix of uses within walking distance.

alternative design and programmatic approaches that could be incorporated into future phases of the Town Center. Such truly mixed-use design and density elements within these projects have resulted in the creation of new, vibrant, walkable places offering a "live/work/play" environment that continues to be in high demand among growing demographic segments—particularly Millenials and downsizing Baby Boomers. These projects have also substantially increased adjacent real property values.

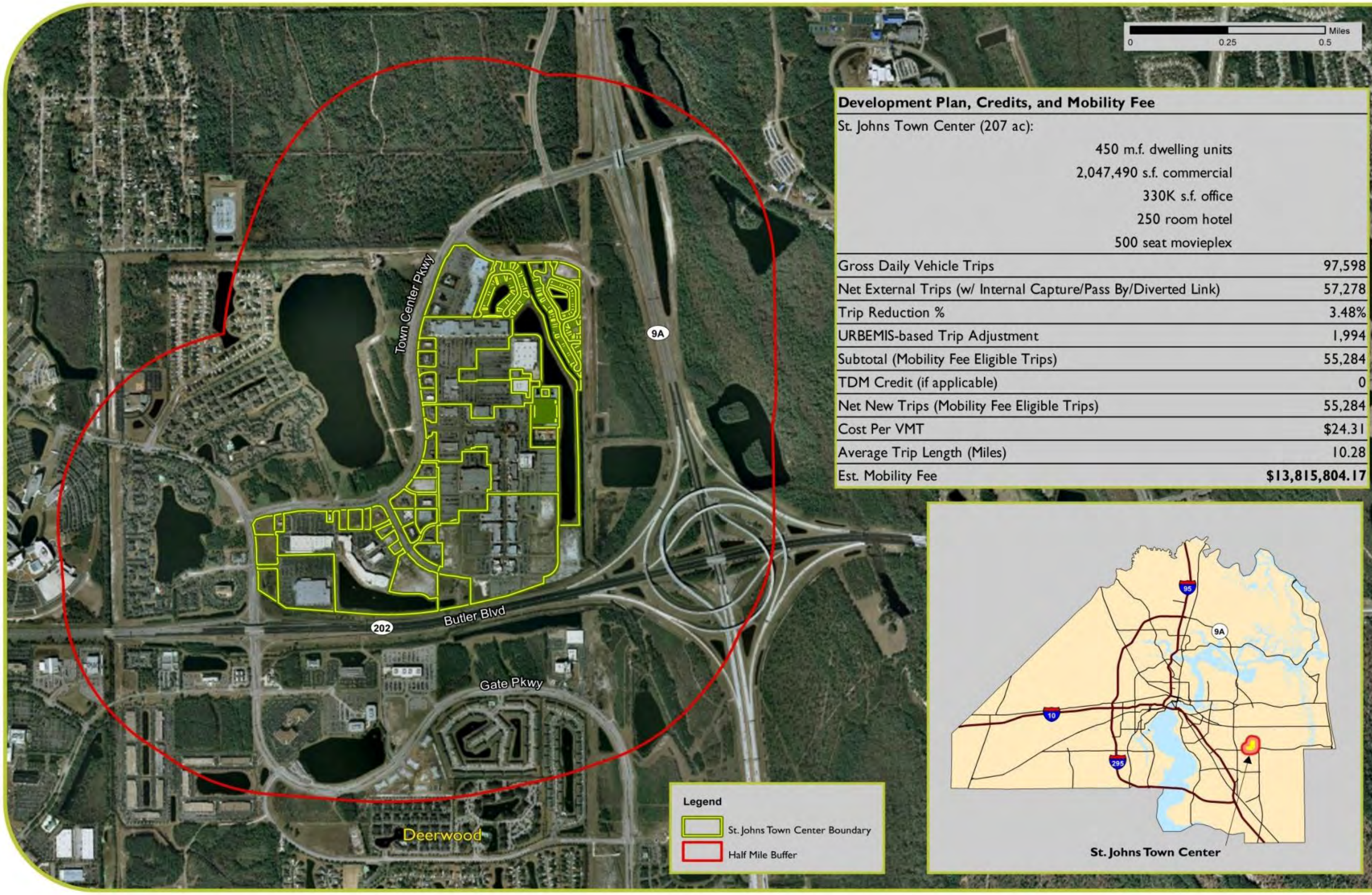
The residential component of Cityplace includes over 2,300 residential units built since 1994. Additionally, over 10,000 new residential units have been built within a one mile radius of the site within the last 12 years. Cityplace includes a wide variety of housing types ranging from affordable three-story garden apartments on the east side of Central Expressway to luxury high rise units and townhouses on the west. Over 1,400 apartments have been built on the west side of the site in buildings ranging from four stories to twenty stories. Roughly 60% of the apartments are within mixed-use buildings and 40% are in stand-alone apartment buildings.

The mixed-use, Mizner Park town center clearly demonstrates how suburban communities can create vital downtowns by redeveloping abandoned shopping centers. Crocker and Company worked with Boca Raton's Community Development Agency to replace the failed shopping mall with a 28.7-acre mixed-use project that includes 272 homes, a public promenade and park, retail shops and restaurants, 262,000 square feet of office space, a movie theater, and a museum.

The success of Mizner Park has sparked other cities in Florida to convert their under-performing shopping malls into new town centers. Mizner Park would likely receive substantial trip reduction credits under this mobility fee credit system based upon redevelopment and the ability to capitalize upon a dense residential context. In addition, this project provides a great reference for the potential redevelopment of the Town and Country Shopping Center, converting the underused shopping mall into a new mixed use center, removing a blighted property and helping to revitalize the surrounding community.

Mizner Park in Boca Raton provides a successful example of "Dead Mall" redevelopment. From the short-lived Boca Raton Mall (above) to its immensely popular transformation (below), this illustrates a typology that would receive substantial trip reduction benefits under the proposed mobility credit system. (Courtesy of Ellen Dunham Jones' "Retrofitting Suburbia")

Test Site 3: St. Johns Town Center



Development Plan, Credits, and Mobility Fee	
St. Johns Town Center (207 ac):	
450 m.f. dwelling units	
2,047,490 s.f. commercial	
330K s.f. office	
250 room hotel	
500 seat movieplex	
Gross Daily Vehicle Trips	97,598
Net External Trips (w/ Internal Capture/Pass By/Diverted Link)	57,278
Trip Reduction %	3.48%
URBEMIS-based Trip Adjustment	1,994
Subtotal (Mobility Fee Eligible Trips)	55,284
TDM Credit (if applicable)	0
Net New Trips (Mobility Fee Eligible Trips)	55,284
Cost Per VMT	$24.31
Average Trip Length (Miles)	10.28
Est. Mobility Fee	**$13,815,804.17**

[design principles for mobility]

Test Site 4: ICI Rural Villages (Approved Planned Unit Development)

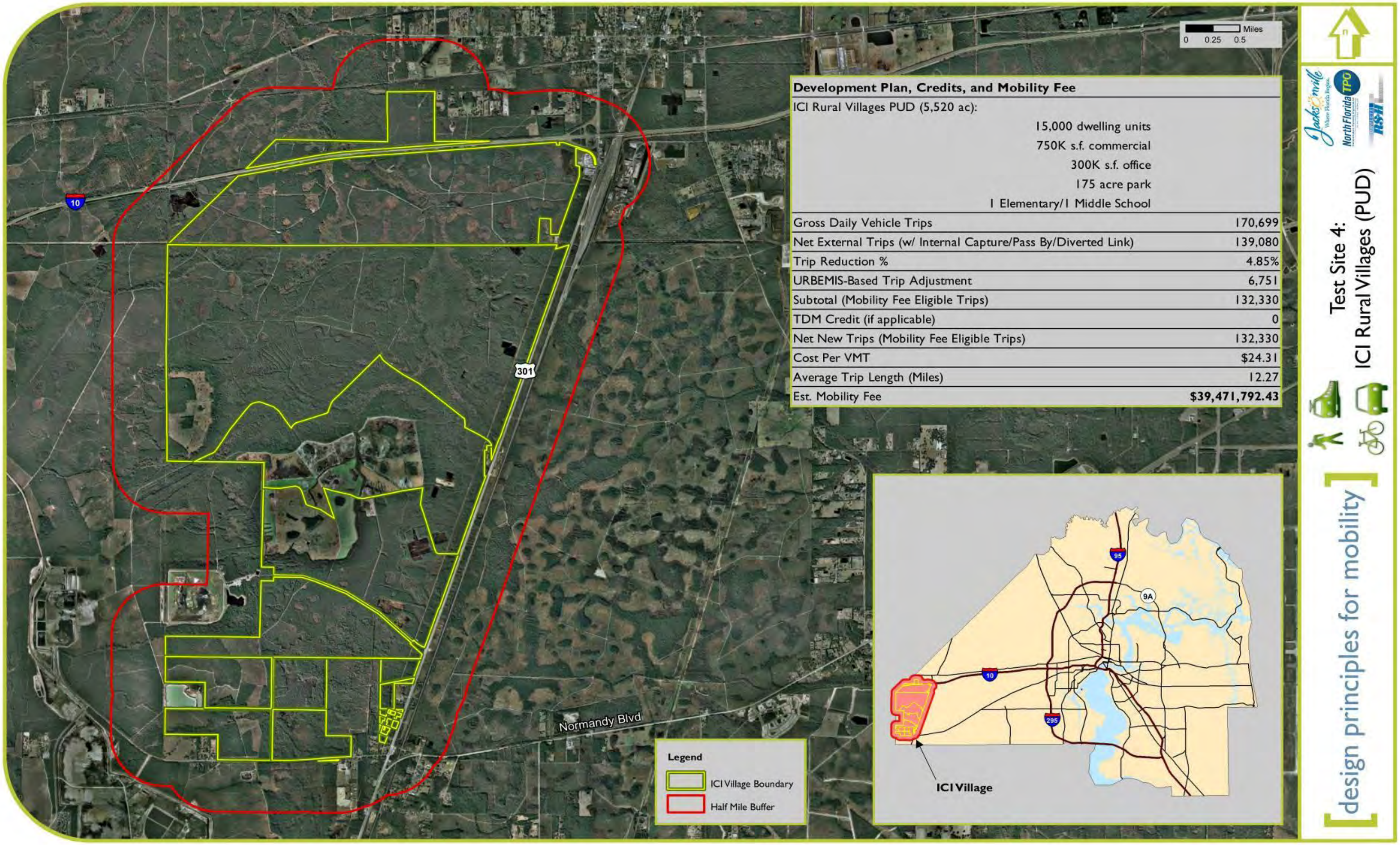
To test a proposed, master planned community in the designated Rural Development area of the City of Jacksonville under the mobility fee scenario, the ICI Rural Villages PUD was selected. The site is located on 5,520 acres in the southwest portion of the City of Jacksonville approximately 1.7 miles south of I-10 with direct frontage on U.S. 301. This large, vacant tract has been rezoned and reclassified from a predominant agricultural and silvicultural district to a planned unit development-satellite community between 2006 and 2010. The project master plan was based on both the criteria for a "Rural Village" as documented the Southwest Vision Plan and "a combination of conventional and traditional master planning principles." The development plan, as proposed, consists of approximately 15,000 dwelling units, 750,000 square feet of regional retail/shopping, 300,000 square feet of office park, as well as two school sites and other community support amenities.

ICI Rural Villages property west and adjacent to U.S. 301 in southwest Duval County.

The site is intended to consist of multiple residential villages connected directly to one or more neighborhood centers with a mix of civic and commercial uses. Over 1,500 acres of the site has been set aside for conservation and open space purposes, which provides a negligible density credit of 3.84%. However, it does not benefit substantially under the overall package of available design and transit-based credits of the URBEMIS model. The site's remote location, low density, and lack of adjacent development and multimodal context results in an overall trip reduction of 4.85%

Under the Fair Share scenario, the gross assessment was estimated at $5,843,668 in 2007. This is reflective of minimal roadway capacity improvements warranted given the lack of congestion and/or constrained facilities within the specified traffic impact area. Using the revised mobility fee methodology and credit system, the development would be assessed $39,471,792. This number is substantially higher based on the amount of daily external trips generated and minimal internal capture as a result of the amount of proposed residential development. While in this case it is also assumed that no TDM component is included, even if such a credit of 5 to 10 percent maximum was applied through a development agreement, the fee would be minimally reduced.

This example continues to illustrate the importance of high density, jobs/housing balance, and the frequency and characteristics of the transit and pedestrian environment in order to maximize the URBEMIS-based trip reduction credits. In order to increase credit opportunities under this example, clustering the proposed villages over a smaller area and providing a greater mix of use within proposed neighborhood centers would result in additional open space preservation and increase the density variable by excluding such lands from the calculation.



Development Plan, Credits, and Mobility Fee	
ICI Rural Villages PUD (5,520 ac):	
15,000 dwelling units	
750K s.f. commercial	
300K s.f. office	
175 acre park	
1 Elementary/1 Middle School	
Gross Daily Vehicle Trips	170,699
Net External Trips (w/ Internal Capture/Pass By/Diverted Link)	139,080
Trip Reduction %	4.85%
URBEMIS-Based Trip Adjustment	6,751
Subtotal (Mobility Fee Eligible Trips)	132,330
TDM Credit (if applicable)	0
Net New Trips (Mobility Fee Eligible Trips)	132,330
Cost Per VMT	$24.31
Average Trip Length (Miles)	12.27
Est. Mobility Fee	**$39,471,792.43**

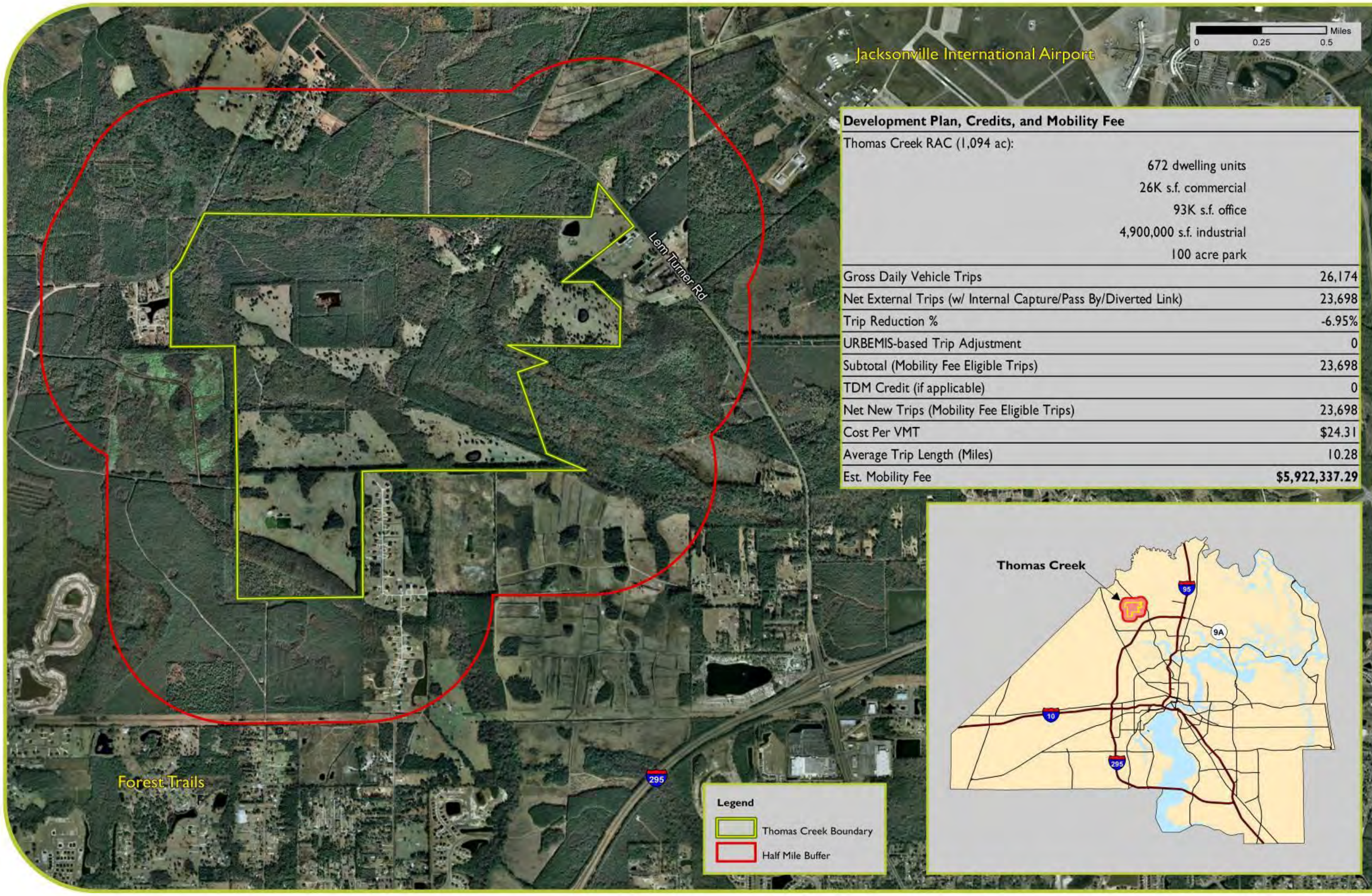
Test Site 5: Thomas Creek (Approved Regional Activity Center)

Thomas Creek Village is a 1,093 acre parcel located on Lem Turner Road approximately two miles north of I-295 in Jacksonville, Florida. The property is currently owned by Transworld Investment Corporation and was originally entitled for approximately 2,600 residential units. The original development plan has been adjusted to reflect the current residential market downturn to include the following uses: 319 acres of warehouse distribution uses or approximately 4.9 million square feet; 180 acres or approximately 672 units of single family residential; and 33 acres of general office/commercial uses, including 93,000 square feet of office and 26,000 square feet of retail.

Thomas Creek Industrial Park information sign and entrance to property along Lem Turner Road

The warehouse, office and commercial parcels will be accessed from Lem Turner Road on the east side of the property. This access point is adjacent to lands with industrial and commercial land uses that are within ½ mile of the cargo entrance to Jacksonville International Airport. The residential development is buffered from the other uses by large wetland areas and would be accessed from Braddock Road on the west side of the property. The area surrounding this access point is largely low-density residential in nature.

Based upon the latest information provided by the City, this project was assessed a Fair Share contribution of $4,047,697 for adjacent roadway improvements. This amount is slightly less than what would be assessed under the mobility fee system. As can be shown in the following table, the resulting mobility fee is estimated at $5,922,337 and includes no trip adjustment credits. While the project receives a notable 6.51% reduction in trips associated with the proposed use mix, the gains are offset by the substantial reduction in single family homes over the same acreage. This has resulted in a density of less than one unit per acre and a net negative reduction. Combined with the vicinity's lack of meaningful transit service and bicycle/pedestrian provisions and connectivity, no trip reduction adjustments are provided. If the project were to remove the residential component, thereby eliminating the density parameter from the model, a combined trip reduction percentage of 8.77% would result and the fee would drop to approximately $5.4 million.



Development Plan, Credits, and Mobility Fee

Thomas Creek RAC (1,094 ac):

- 672 dwelling units
- 26K s.f. commercial
- 93K s.f. office
- 4,900,000 s.f. industrial
- 100 acre park

Gross Daily Vehicle Trips	26,174
Net External Trips (w/ Internal Capture/Pass By/Diverted Link)	23,698
Trip Reduction %	-6.95%
URBEMIS-based Trip Adjustment	0
Subtotal (Mobility Fee Eligible Trips)	23,698
TDM Credit (if applicable)	0
Net New Trips (Mobility Fee Eligible Trips)	23,698
Cost Per VMT	$24.31
Average Trip Length (Miles)	10.28
Est. Mobility Fee	**$5,922,337.29**

Test Site 5:
Thomas Creek RAC

[design principles for mobility]

Test Site 6: Jackson Square TOD (Proposed Transit Oriented Development)

View north along Philips Highway from the Jackson Square property entrance

The proposed Jackson Square project occupies the former site of an automotive dealership and repair facility on approximately 17.3 acres along the west side of Philips Highway, south of Atlantic Boulevard between Mitchell Avenue and River Oaks Road. The project is also adjacent to the existing Florida East Coast rail line, well positioning the site for potential commuter rail service along JTA's proposed Southeast Commuter Rail Corridor. The property was rezoned and reclassified from largely commercial and light industrial uses to planned unit development in 2008. The project provides a unique opportunity to demonstrate to the City and the region the implementation of transit oriented development at an infill site strategically located near Downtown.

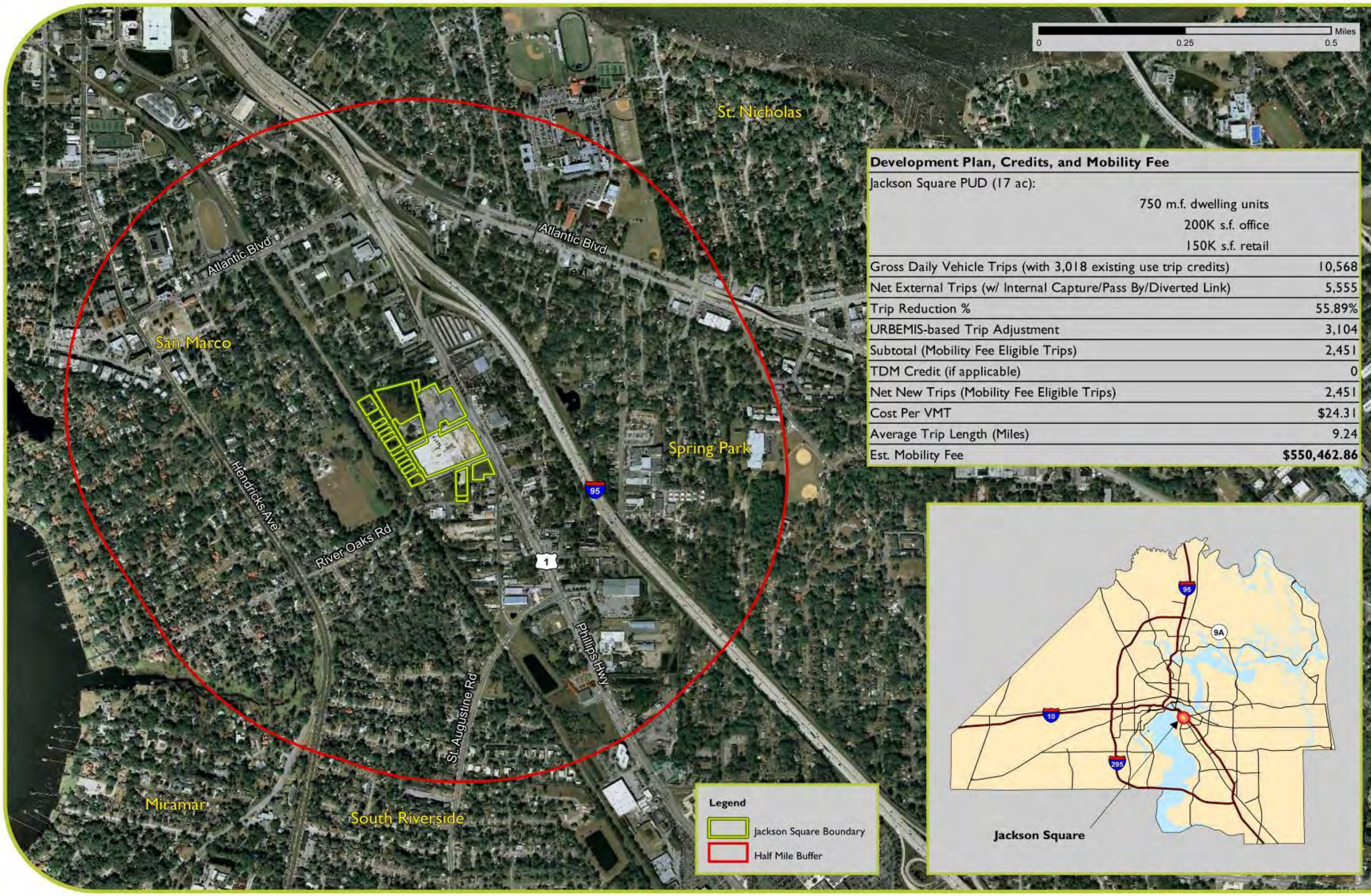
The development plan consists of 750 multifamily units, 150,000 square feet of commercial/retail and 200,000 square feet of general office use. Under the latest adopted ordinance, the project, prior to any development beyond 30 residential units per acre, must incorporate an enhanced mass transit station and amenities. These features are designed to be consistent with long-range transit development options including potential BRT, commuter rail, and/or other modes identified or implemented by the Jacksonville Transportation Authority. The following conceptual master plan, prepared by Basham and Lucas, illustrates the placement and orientation of the proposed mix of uses, including multimodal features such as the required transit amenities, roundabouts, landscaping, signage and wayfinding, as well as traffic calming and internal circulation elements.

Western perimeter of Jackson Square site adjacent to Florida East Coast Rail line and FEC Park

As tested under a preliminary Fair Share calculation, the site would be responsible for $1,243,311 in transportation-related improvement costs associated with project traffic impacts to I-95 near Downtown. Applying the alternative mobility fee and credit methodology, the costs are approximately 60% less. Based upon the existing use credit, the site receives a deduction of 3,018 daily trips from the gross daily vehicle trips. The average density of 44 units per acre alone provides an additional 41.4% reduction in trips. The project nearly achieves the 9% maximum possible reduction associated with use mix. The combination of the design and density credits provides an approximate 56% reduction in daily external vehicle trips. Based upon the location, density, and transit-supportive characteristics, the site would also likely be eligible for substantial TDM credits. This, of course, assumes a revised development agreement that would ensure such provisions are included and monitored. The project's urban priority location also reduces the average VMT in the calculation and as a result the estimated mobility fee is $550,462.

The proposed Jackson Square Conceptual Master Site Plan (above), courtesy of Basham and Lucas, illustrates desired use and design features, such as office space above retail and a new transit hub, within the dense urban fabric of the vicinity (below). Such projects amplify the significance of the 3Ds in promoting mobility and maximizing the available trip reduction credits.

Test Site 6: Jackson Square TOD



Development Plan, Credits, and Mobility Fee	
Jackson Square PUD (17 ac):	
750 m.f. dwelling units	
200K s.f. office	
150K s.f. retail	
Gross Daily Vehicle Trips (with 3,018 existing use trip credits)	10,568
Net External Trips (w/ Internal Capture/Pass By/Diverted Link)	5,555
Trip Reduction %	55.89%
URBEMIS-based Trip Adjustment	3,104
Subtotal (Mobility Fee Eligible Trips)	2,451
TDM Credit (if applicable)	0
Net New Trips (Mobility Fee Eligible Trips)	2,451
Cost Per VMT	$24.31
Average Trip Length (Miles)	9.24
Est. Mobility Fee	**$550,462.86**

[design principles for mobility]

Jacksonville Smart Growth Concept Development Opportunities

As a next step, or concurrent to the development of an automated system (to be discussed in the next section), it is recommended that the City create a Smart Growth Development Opportunities manual linked to the implementation of the mobility fee and design-based credit system. As a further extension of this section, which tests a number of existing and proposed locations and projects, the purpose of this value-added document would be to explore and showcase particular development sites in Jacksonville where trip reduction credits could be maximized.

Actual locations would be surveyed in terms of accommodating mixed use opportunities and multimodal design features. Within the manual, realistic pro-formas, photo and place type documentation, as well as conceptual site plans and renderings would be included with each of the identified locations. The selected examples will illustrate both development potential and the corresponding discounted mobility fees or even credits that result from a net surplus of trips that could be banked and transferred to other sites. More importantly, such a manual could serve as a potential real estate development marketing guide to be used by the Planning Department and the Chamber of Commerce in order to attract investment to strategic locations which optimize such incentives.

This effort is also strongly supportive of the City's Comprehensive Plan Future Land Use Element Policies 6.3.1 and 6.3.2, which encourage new investment and multimodal design elements in targeted infill and redevelopment areas.

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Framework for Prototype Automated Software

An interactive, web-based application is proposed as a means to automate the trip generation, credit, and mobility fee estimation process. Combining the City's established trip generation and internal capture/pass-by procedures with the URBEMIS-based mitigation measures, this proposed application (preliminarily referred to as "**MOBILJax**") will enable the City, developers and other parties of interest to test various site locations, compare preliminary fee estimates, and potentially determine optimal location(s) for development "on the fly".

The web application will require minimal user input with calculations for trip generation, internal capture, credit reduction and estimated fee processing automatically in the background on a hosted server. The adjacent table lists the data variables needed to calculate the trip reduction credits along with which items represent user inputs and which calculations would be performed by the application on a remote server.

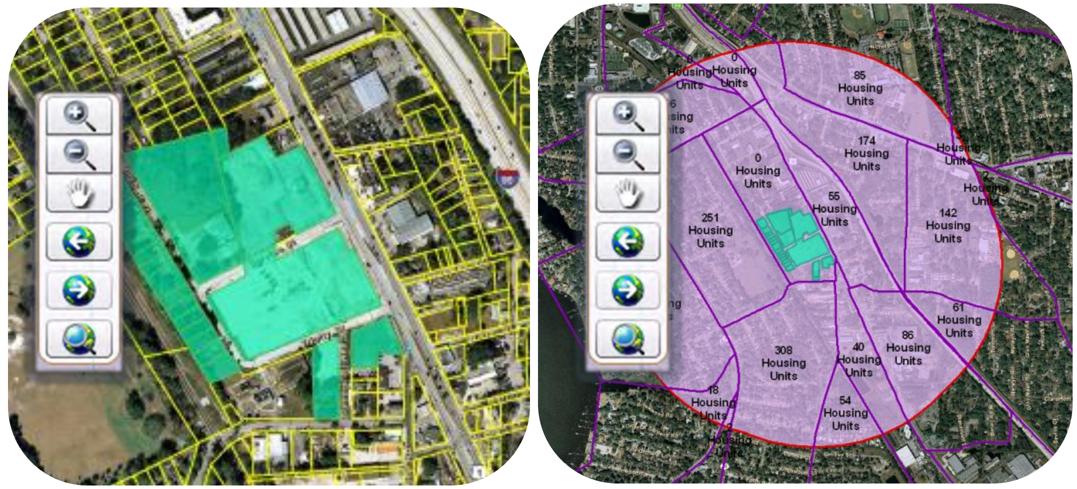
"MOBILJax" Variables		Source	Update Frequency
Project Location			
	Development Area	*City of Jacksonville*	*5 Years*
Land Use (Residential / Non-Residential)			
	Project Acreage/Units/Sq Ft (entered in trip generation section)	*User Input*	*N/A*
Housing Units			
	Proposed Units (automatically populated from trip generation section)	*Census or NERPM TAZ*	*10 years or As Available*
	Households Per Acre	*Census or NERPM TAZ*	*10 years or As Available*
	Total Housing Units	*Census or NERPM TAZ*	*10 years or As Available*
Employment			
	Proposed Employees (automatically populated from trip generation section)	*User Input*	*N/A*
	Total Employees	*InfoUSA*	*As Available*
Local Serving Retail			
	Yes/No	*User Input*	*N/A*
Transit			
	Number Weekday Buses Stops	*Jacksonville Transportation Authority (JTA)*	*6 months*
	Number of Daily Rapid Transit Buses Stops	*Jacksonville Transportation Authority (JTA)*	*6 months*
	Number Daily Shuttles	*Jacksonville Transportation Authority (JTA)*	*6 months*
Intersection Density		*City of Jacksonville*	*Continually maintain file and update as needed*
Sidewalk Coverage		*City of Jacksonville*	*Continually maintain file and update as needed*
Bike Lane Coverage		*City of Jacksonville*	*Continually maintain file and update as needed*
Existing Use Trip Credit		*City of Jacksonville*	*N/A*
Transportation Demand Management (TDM) Credit		*City of Jacksonville*	*N/A*

The following datasets will be required to perform the automated processes listed above: Based on accurate trip reduction calculations, it is anticipated that particular datasets will need to be updated on a minimum annual or semi-annual basis to account for changes in both JTA's transit service and/or property appraiser (parcel) information.

1. Development Area Boundaries
2. NERPM TAZ Information, updated as 2010 Census becomes available
3. Info USA
4. Daily Weekday Bus Schedule and Stops
5. Daily Rapid Transit Bus Schedule and Stops
6. Dedicated Daily Shuttles
7. Scored Intersections
8. Sidewalk Inventory
9. Bike Lane Inventory

Project Location

The system will consist of a GIS-based graphical interface enabling the user to select the project location. Parcel boundaries and road names will be visible to assist the user in finding the desired location. The project area can also be selected based on the real estate (RE #) number. Once the project location is selected, the application will automatically determine the appropriate Development Area from which to populate the average trip length (VMT) into the fee calculation parameter—including Downtown Development, Urban Priority, Urban Development,

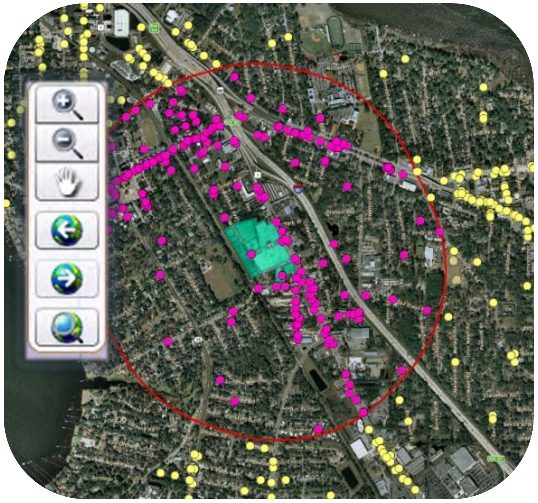


Potential graphical user interface illustrating buffered project location and population by TAZ.

Suburban Development, or Rural Development Area. The Development Area category boundaries are predefined and the web application performs a spatial selection of the category that contains the project location. The Development Area category dictates the average VMT that is used in the mobility fee formula calculation.

Land Use (Residential Household Density)

A simple, pull down menu or radio button will be provided in the Land Use section of the web interface to allow the user to choose if the development is residential or exclusively non-residential. This component is directly linked to the density calculation model to determine the extent of trip reduction credits associated with residential density. Under exclusively non-residential developments, the density calculation would be eliminated from the sum of credit percentages.



Potential graphical user interface illustrating buffered project location and employment by TAZ.

Housing Units (Mix of Uses)

The use mix credit model is a function of the total number of housing units relative to employees within ½ mile of a project boundary. The total number of housing units reflects both existing units within the immediate area and the proposed number of units associated with a project. The user will input the number of proposed housing units in the trip generation interface as planned for the development. The number of households per acre will be calculated based on the number of proposed housing units divided by the total acreage of the project. The application will also calculate the number of existing housing units within ½ mile of the project boundary. Until the 2010 Census Data is readily available by block group or traffic analysis zone (TAZ), it is recommended to obtain the existing housing units from the Northeast Regional Planning Model (NERPM). The NERPM model provides number of total housing units as of 2008 for each TAZ. The application will automatically create a ½ mile buffer of the project boundary and clip the TAZ data layer. The total housing units will be extracted from the TAZ data based on the coverage of the project location buffer. The proposed and existing housing units will be added together for the total number of Housing Units that is used to calculate any potential trip adjustments associated with mix of uses.

Employment (Mix of Uses)

The number of proposed employees as planned for the development will be derived from the trip generation component. This is based upon an established rate of employees per 1,000 square feet associated with the specific, non-residential square footage as input by the user. The web application will estimate the existing ("other") employees utilizing the most current InfoUSA point data. InfoUSA is a comprehensive database that provides total number of employees for each point representing businesses. By spatially selecting the InfoUSA data points that fall within the ½ mile buffer of the project location, the total number of existing employees is determined. The proposed project and existing employees are then automatically added together to yield a total number of employees that is incorporated into the mix of uses trip reduction equation.

Local Serving Retail

A 2% maximum credit is incorporated relative to the presence of local serving retail within the ½ mile buffer radius. A simple, pull down menu or radio button will be provided for the user to choose if there is or is not retail property within ½ mile of the project boundary.

Transit Service

Comprehensive data files of weekday buses, rapid transit buses, and daily shuttles are required for the web application to calculate transit use within the project area. Currently, the user would be required to manually check the posted schedule from JTA's website to confirm the number of weekday stops within the ½ mile buffer of the project. It is recommended that the City coordinate with the JTA to link the schedule database to the stop point files so that the information is geo-referenced and can be automatically selected out of the buffer and incorporated into the server-based calculations.

Potential graphical user interface illustrating buffered project location and bike lane coverage.

The URBEMIS guidance provides a ¼ mile radius for buses and ½ mile radius for high capacity shuttles or rail service.

However, for ease of analysis and to be able to capture all potential modes of high capacity transit service within a 10 minute walk distance, it is recommended to use ½ mile radius in order to capture all available services. Upon receipt of the appropriate data, the web application will spatially select the bus stops within ½ mile of the project's center and multiply by the bus frequency schedule to obtain the number of weekday buses, rapid transit buses, and daily shuttles stopping within the project area.

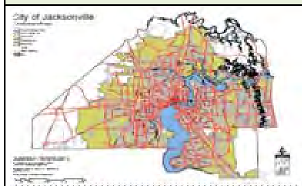
Intersection Density (Bicycle/Pedestrian Friendliness)
As an excellent measure of the walkability characteristics within the project influence area, intersection network density per square mile is built-in to the trip reduction credit component.

The City of Jacksonville Planning and Development Department has developed a point file of all intersections in Duval County, to which each point is provided a score. The scoring process is based on the number of legs at a given intersection. A three-legged intersection receives a score of "3" with four and five-legged intersections receiving scores of "4" and "5" respectively. The web application will automatically select the points within the ½ mile buffer of the project location and sum these scores. The total score is then divided by 0.79 to obtain the number of intersections per square mile.

Sidewalk Coverage (Bicycle/Pedestrian Friendliness)
The total sidewalk coverage is based on the City's sidewalk inventory file provided by the City of Jacksonville Planning and Development Department. This file provides the percentage of sidewalks on one side or both sides of the street. The web application will clip the sidewalk inventory file to contain only those segments which fall in the ½ mile buffer of the project location. The percentage of sidewalk coverage on one side and both sides will be calculated relative to the total roadway length and the sidewalk percentage.

Bike Lane Coverage (Bicycle/Pedestrian Friendliness)
The total bike lane coverage is based on the 2009 City of Jacksonville Bike and Pedestrian Network file. This file contains attributes describing the type of bike path as developed by the City: Bike Lane, Limited Access, Multi-Use Path, Nonstandard Path, Parking Lane, Paved Shoulder and None. The application will spatially select the features that are within ½ mile of the project's center. The lengths of the features that are attributed as Bike Path, Limited Access, Multi-Use Path, and Non-standard Path are summed and divided by the total roadway length. This calculation results in the percentage of arterials/collectors with bike lanes that is incorporated into the bicycle/pedestrian trip reduction measures.

The following summary tables illustrate how the preceding information is populated via the discrete variables inputs, as well as the resulting trip reduction credits and estimated mobility fee for the Town and Country example:

Project Name:	**Sample Project - Town and Country Redevelopment Mixed Use Town Center**		
Mobility Zone:			
Date:	**August 26, 2011**		
Required Data		***Data Provided by JPDD***	
Project Location (Development Area)	Choose From Below	Average Trip Length	2
	1 Downtown Development Area	9.09	
	2 Urban Priority Area	9.24	
	3 Urban Development Area	9.46	
	4 Suburban Development Area	10.28	
	5 Rural Development Area	12.27	

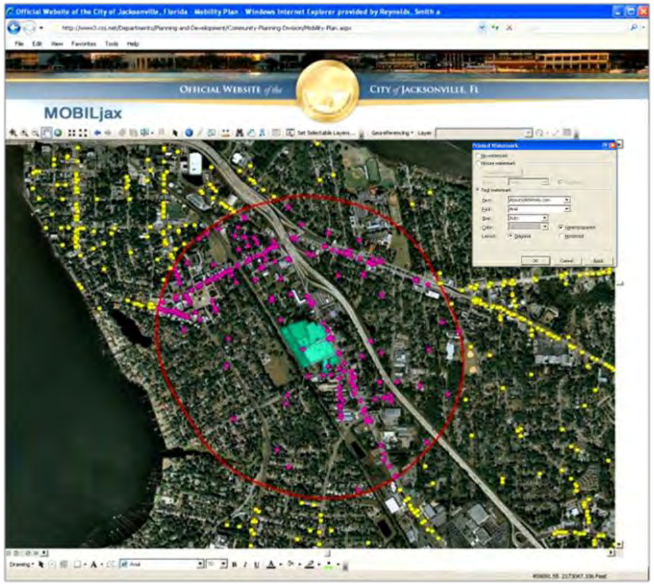
Land Use ("R" Residential or "N" Non-Residential)	R
Number of Housing Units within 1/2 Mile of project center or project boundary whichever is greater	2,840
This Project's Housing Units (From Trip Generation Worksheet)	600
Other Housing Units Within 1/2 Mile of project center or project boundary whichever is greater	2,240
Study Area Employment (No. of employees within 1/2 mi. of project center or project boundary whichever is greater)	5,484
This Project's Employment (From Trip Generation Worksheet)	1,076
Other employees within 1/2 mile of project center or project boundary whichever is greater	4,408
Households per Acre (From trip Generation worksheet)	30.00
Local Serving Retail (Yes/No) (Yes if any retail land uses within 1/2 mile of project's center.)	Yes
Number of Daily Weekday Buses Stopping Within 1/4 Mile of Site	150
Number of Daily Rapid Transit Buses Stopping Within 1/2 Mile	0
Number of Dedicated Daily Shuttles	0
Number of Intersections Per Square Mile (½ Mile R =.79 Square Mile)	591.14
Intersections Within .5 Mile R	467
Percent of Streets with Sidewalk on One Side (%)	12.00%
Percent of Streets with Sidewalk on Both Sides (%)	14.00%
Percent of Arterials/Collectors with Bike Lanes	4.00%
Transit Service Index Transit service Index =	0.166666667
Number of average daily weekday buses stopping within 1/4 mile of the site	150
Plus twice the number of daily rail or bus rapid transit trips stopping within 1/2 mile of the site	0
Plus twice the number of dedicated daily shuttle trips	0
Divided by 900, the point at which the maximum benefits are assumed.	900

All estimates for bike an pedestrian data should be based on estimates within a 1/2 mile radius from the project's center or the entire project, whichever is larger.

Trip Adjustment Calculations	Sample Project - Town and Country Redevelopment Mixed Use Town Center
A. Mix of Uses **Trip Reduction =**	**7.49%**
Trip reduction =(1– (ABS(1.5 * h – e) / (1.5 * h + e)) – 0.25) / 0.25 *0.03	
Where: h = study area households (or housing units)	
e = study area employment	
(Negative reductions of up to 3% can result, and should be included.)	
The maximum possible reduction using this formula is 9%.	
B. Household Density	**36.91%**
Trip reduction = 0.6*(1-(19749*((4.814+ households per residential acre)/(4.814+7.14))-0.639)/25914)	
The maximum allowable reduction is 55% (equivalent to a 380 unit per acre development)	
C. Local Serving Retail **Trip Reduction =**	**2.00%**
The presence of local serving retail can be expected to bring further trip reduction benefits, and an additional reduction of 2% is recommended.	
D. Transit Service **Trip Reduction =**	**1.54%**
Trip reduction = t * 0.075+ t * ped/bike score * 0.075	
Where t = transit service index	
E. Bicycle and Pedestrian Measures **Trip Reduction = 9% of ped/bike factor =**	**2.08%**
Ped/bike factor = (network density + sidewalk completeness + bike lane completeness) / 3	
Ped/bike factor =	0.23
Network density = intersections per square mile / 1300 (or 1.0, whichever is less)	
Network density =	0.4547
Sidewalk completeness = % streets with sidewalks on both sides + 0.5 * % streets with sidewalk on one side	
Sidewalk completeness =	0.2
Bike lane completeness = % arterials and collectors with bicycle lanes.	
Bike lane completeness =	0.04
F. Trip Reduction = A+B+C+D+E (For Non-residential, A+C+D+E)	**50.02%**
Mobility Fee Eligible Trip Calculation	
G. Gross Vehicle Trips (Average daily trips from trip generation worksheet)	18,406
H. Existing Trip Credit (Average daily trips from current use)	8,716
I. Adjusted Gross Vehicle Trips (G - H)	9,690
J. Internal Trips (from internal capture worksheet)	3,142
K. Gross External Trips = (I – J)	6,548
L. Pass-By Trips (from trip generation worksheet)	4,656
M. 25% of Diverted Linked Trips (from trip generation worksheet)	1,018
N. Net External Trips = (K - L - M)	874
O. Trip Adjustment = F * N	437
P. Subtotal Mobility Fee Eligible Trips = (N - O)	437
Q. TDM Credit = P * x% (as determined through City review)	0
R. Net New Trips (Mobility Fee Eligible trips) = (P - Q)	**437**
Mobility Fee Calculation	
S. Cost per VMT (County Wide)	$24.31
T. Average Trip Length in Project Development Area	9.24
U. Mobility Fee = R * S * T	**$98,116.34**

Source: URBEMIS2007 for Windows Users' Guide Appendix D – URBEMIS2007 Mobile Source Mitigation Component,

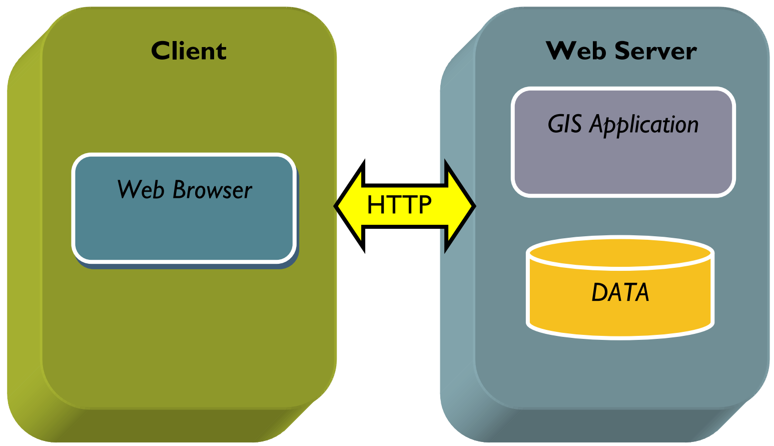
Interactive Web Mapping Application Features ("MOBILJax")



The customizable, web mapping application, or "**MOBILJax"**, will consist of a user-friendly platform designed for non-technical users. Inputs will be kept to a minimum and the tools and map navigation will be designed to be very intuitive. As much automation as possible will be built into the application in order to minimize the amount of user inputs and enable "on-the-fly" testing.

Support/maintenance of the website will also be very flexible. Depending on the select variables, the web based application can be maintained and hosted internally at the City or externally on a web server. The latest technologies will be used to deploy the system and the application will be written using industry standard web authoring tools.

Typical of many mapping applications accessible on a web server, the users send a request to a server (i.e. an address) and the server processes the request and sends the results back as an image embedded in an HTML page via standard HTTP. The response is a standard web page that most browsers can view. In server-side internet GIS applications, all the complex and/or proprietary software, in addition to the spatial and tabular data remain on the server. This architecture has several advantages because the application and data are centralized on a server. These advantages include simplified development, deployment, and maintenance. As such, the basic framework of the application will consist of the following:



- Windows server-based
- 100% browser-based using Adobe Flash
- Accessible to users via password protected, encrypted (SSL) log in page
- All data would reside on server – no cross domain/server queries necessary
- Trip Generation and Trip Reduction Credits sections would be selectable via a sequential "tabbed" section that guides users in steps, such as *"I. Trip Generation and Internal Capture"; "II. Trip Adjustment Credits"; "III. Mobility Fee Calculation"*
- User-friendly, graphical "tools" and/or "icons" selectable from toolbar for zoom, pan, and calculate commands
- Users would be guided via overlaid instructions/tips
- Users would have clearly labeled fields to enter necessary input data (both the user's project information and JPDD provided data) for the server-based calculations
- All data manually entered by the user would be validated client-side in order to correct invalid data quickly. Before form results are submitted land use and trip reduction inputs would be presented via copy/paste/downloadable window

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Urban Core Vision Plan
Southeast Vision Plan
Southwest Vision Plan
Northwest Vision Plan
North Vision Plan

Adopted Town Center Program (Phase I) Plans (2004-2006)

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Department of Civil, Construction,
& Environmental Engineering

Carolina Transportation Program

Final Report

Traditional Neighborhood Development Trip Generation Study

Prepared by

Asad J. Khattak, Ph.D.

Associate Professor of Transportation &
Director of Carolina Transportation Program
Department of City and Regional Planning
University of North Carolina at Chapel Hill
Campus Box 3140
Chapel Hill, NC 27599

John Stone, Ph.D.

Associate Professor of Civil Engineering
North Carolina State University
424-A Mann Hall
Raleigh NC 27695-8601

William E. Letchworth, E.I.

Graduate Research Assistant in Civil Engineering

Ben K. Rasmussen

Graduate Research Assistant in City and Regional Planning

Bastian J. Schroeder

Undergraduate Research Assistant in Civil Engineering

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16. Abstract

Since the beginning of the new urbanist movement, alternately referred to as Traditional Neighborhood Developments (TNDs), planners and architects have touted their neighborhood and community designs for reducing residents' reliance on the automobile by creating compact, mixed use, and pedestrian-friendly developments. However, researchers have not explicitly examined how travel behavior and traffic impacts differ in a tightly controlled comparison of conventional and traditional developments. Additionally, current forecasting models and trip generation procedures need to be tested for their applicability to these new developments. This report aims to fill that void by studying a matched-pair of neighborhoods: One conventional and one traditional. The neighborhoods are located in the Chapel Hill/Carrboro area of North Carolina. Traffic counts were taken at all entrances and exits to the developments and a detailed behavioral survey of the residents was conducted in the two neighborhoods during 2003. The results show that households in Southern Village, the TND, make about the same amount of total trips, but significantly fewer automobile trips, fewer external trips and they travel fewer miles, when compared to households in the conventional neighborhoods. However, this reduction of trips in a suburban environment does little to decrease delay at "over-designed" intersections along major highways. Finally, ITE trip generation methods and rates are acceptable for predicting the trip generation of the study neighborhoods. The implications of these results are discussed in the report.

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Executive Summary

Introduction

Traditional Neighborhood Developments (TNDs) are characterized by human-scale, walkable, and transit friendly communities with moderate to high densities and a mixed-use core. TNDs are becoming increasingly popular in the United States and North Carolina, and they are expected to encourage walking and bicycling and increase the percentage of trips performed inside the development, due to the mixture of land uses.

Over the past decade, a number of Traditional Neighborhood Developments were completed in the Triangle Area. Examples include Southern Village and Meadowmont in Chapel Hill, and Carpenter Village in Cary. As these types of neighborhoods become increasingly popular, a closer assessment of the traffic impacts of TND designs becomes warranted. Conceptually, TND design encourages walking by decreasing distances to shops and businesses and creating a pleasant and safe neighborhood environment. Even without an increase in walking, TND designs intend to capture vehicular trips within neighborhood boundaries by providing amenities in the village centers, as well as, cause a mode shift towards public transportation, the implementation of which becomes more viable in a more denser development style.

However, the differences in traveler behavior and the resulting effects on traffic of these developments are yet to be determined and scientific analyses are required to assess whether proclaimed benefits of the design are indeed occurring. Current forecasting models and trip generation procedures need to be tested for their applicability to these new developments. This research report assesses the impacts of a TND neighborhood by comparing trip generation and traffic impact analysis results to actual traffic counts taken at the neighborhood boundaries and by investigating the results of resident and business surveys taken in the Southern Village (TND neighborhood) and Northern Carrboro developments (conventional neighborhoods) near Chapel Hill North, Carolina.

Project Scope and Objectives

Traditional Neighborhood Developments (TNDs) are planned in a relatively high-density design and combine a mix of land uses within the boundaries of the development. Chapter 7 of the Institute of Transportation Engineers (ITE) Trip Generation Handbook defines Multi-Use Developments as “typically a single real-estate project that consists of two of more ITE land use classifications between which trips can be made without using the off-site road system”. Southern Village, a development south of Chapel Hill, NC was designed in the style of TNDs and fits the ITE definition of multi-use development because it contains houses, shops, restaurants, a grocery store, a movie theatre, offices, a day care center, and a an elementary school within its boundaries.

For comparative purposes, a second residential area was chosen, which was not designed in the style of TNDs. The Northern Carrboro neighborhoods, also near Chapel Hill, NC, were selected because they were determined to best represent the opposite side of the spectrum in relation to Southern Village with respect to factors that might influence the number of trips people make and how likely people are to use walking, biking or transit for trips. These factors include: mix of uses, density or “compactness” of development, availability/quality of pedestrian and bike features (sidewalks, bike lanes, etc.), availability/quality of transit service, street connectivity, site design/layout features, and proximity to destinations. By choosing the Northern Carrboro neighborhoods, we get to see two ends of the spectrum on these related factors for what are expected to be similar demographic groups, thus any differences in travel behavior should represent two endpoints.

By comparing Southern Village with Lake Hogan Farms (a conventional development within the Northern Carrboro neighborhoods), we can compare differences in trip generation and actual traffic volumes for one example of each development form. In this study, only these two neighborhoods were assessed and all results are only proven to be applicable for these two examples. Generalizations for other TNDs in North Carolina or nationwide, therefore have to be treated with care.

TNDs are expected to encourage the use of alternative modes, and increase internal trip capture rates ultimately reducing congestion, vehicle miles traveled and to improve air quality. The behavioral trip generation portion of this study assesses if indeed trip generation rates and alternative mode use are any different in Southern Village compared with more conventional developments in Northern Carrboro. The study conducted a resident survey of Southern Village TND and Northern Carrboro conventional neighborhoods (N=453 households) and also collected spatial data on the developments. In addition, data regarding trips to on-site commercial and retail offices in the Southern Village TND was collected to understand the travel characteristics of office and retail users. The study survey attempts to distinguish between trip types, such as home-based-work or home-based-other, and to estimate the effects of TND design such as trip chaining, mode choice, internal capture, and pass-by trips.

For the two neighborhoods, typical traffic impact analysis (TIA) methods were also utilized to explore TND trip generation. Traffic generation was performed using the methods developed by ITE, as well as, spreadsheet implementations of these methods developed by a consultant. As an additional method to explore trip generation the study used the Triangle Regional Travel Demand Model to obtain further trip estimates. It was not the objective of this study to develop new methods for traffic forecasting, but rather to apply, verify and validate existing ones. In that regard all traffic generation estimates were compared to traffic counts taken on streets entering/exiting the neighborhood.

The focus of the traffic generation portion of this study is on the total site traffic generated and overall volumes counted at the entrances and exits to the developments. The study did not look at internal distribution and did not distinguish between trip types, such as home-based-work or home-based-other. Other proclaimed features and effects of TND design such as trip chaining, mode choice, internal capture, and pass-by trips are discussed in the literature review, and are analyzed in the traffic generation portion of the document to the extent that they affect the total traffic volumes entering and exiting the neighborhood. The traffic generation estimates and methods reflect and validate current practice of consultants and public agencies.

Conclusions

In terms of traveler behavior this study finds no statistically significant difference between the *total* trips made by households in the Southern Village TND and the comparable conventional developments. However, TND households substituted driving trips with alternative modes, i.e., the *automobile* trip generation rate for the TND was significantly lower (by 1.25 trips per day per household) than conventional neighborhoods. In addition, empirical evidence suggests that TND households have:

- Lower vehicle miles traveled—on average, the TND single-family households travel 18 miles less per day.
- Higher share of alternative modes—in the TND, 78.4 percent of the trips were by personal vehicle compared with 89.9 percent in the conventional neighborhoods.
- Lower external trips—on average, the TND households made 1.53 fewer external trips per day.

The TND examined in this study internally captured a substantial share of the total trips produced (20.2 percent). By comparison, the conventional neighborhoods internally captured a much smaller share of the total trips (5.5 percent). Therefore the difference between the internal trip capture rates for the two development types is 14.7 percent.

The Southern Village TND business survey asked business managers about their employees and customers/visitors. It revealed that only 5.2 percent of the 432 employees reside in Southern Village and a large majority of the employees (92.4 percent) use personal vehicles to commute to work. This is not surprising given the free employee parking in Southern Village and relatively high levels of automobile ownership by people who work. A significant percentage of customers/visitors (39.2 percent) reside in Southern Village; about 18.1 percent of the total trips attracted to Southern Village businesses are reportedly by walking. The results show that Southern Village employees use passenger cars as often as employees in conventional facilities, but that customers/visitors are more likely to walk. Off-site employees and customers/visitors make up a majority of trips attracted to the TND businesses.

Examination of the ITE methods for trip generation, and comparison of trip generation results to counts taken at both Southern Village and Lake Hogan Farms, verify the ITE methods for trip generation for mixed-use and conventional neighborhoods. The Triangle Regional Model was too aggregate to study single neighborhoods. A study of the micro-simulation VISSIM and other simulation models shows that such simulations hold promise for single neighborhood analysis, particularly with respect to internal vehicle and pedestrian circulation.

A sensitivity analysis of the affect of internal capture on access traffic indicated that the reduction in vehicle trips due to the internal capture of Southern Village does not significantly improve the level of service of the intersections adjacent to the development, even during the peak hour. A development located in a more urban area may have larger internal capture effects due to the greater interconnectivity of surface streets and an increase in the number of shopping and work opportunities available to the residents of the area.

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Chapter 1: Introduction

This report presents the findings of a study on travel behavior and trip generation associated with a traditional neighborhood development (TND) and how TND travel characteristics are different from those in a nearby conventional suburban development. The Department of City and Regional Planning of the University of North Carolina at Chapel Hill and the Department of Civil, Construction, and Environmental Engineering at North Carolina State University completed the research for the North Carolina Department of Transportation (NCDOT). While the UNC-Chapel Hill team focused on resident and business surveys and the travel behavior of the residents of the neighborhoods, the N.C. State team concentrated on trip generation procedures, vehicle counts leaving the development, and traffic impacts on adjacent streets.

Problem

The number of neighborhood-scale new urbanist projects completed or under construction rose 37 percent between 2000 and 2001 and has risen by 20 percent or more per year over the past five years.[1] An estimated 1.4 million people reside in new urbanist communities (Berke *et al*. 2003). More than half of these projects were built on Greenfield sites. Such neighborhoods are emerging in North Carolina, and in fact, North Carolina Department of Transportation (NCDOT) has issued guidelines for designing Traditional Neighborhood Developments (TNDs). Over the past decade, a number of TNDs have been completed in the Research Triangle Area. Examples include Southern Village and Meadowmont in Chapel Hill, Carpenter Village in Cary, and North Hills in Raleigh. Unlike the conventional development practices of the 1970s and 1980s, typified by single-use, large lot residential developments with strip commercial centers located on the periphery and businesses located in separate business parks, new urbanist/traditional community design stresses a mix of uses compactly arranged in a single development. Planning theorists believe that individuals rely on automobiles to travel from place to place in conventional communities because each land use, such as residential, commercial, and business, is separated and spread out. When pedestrian-oriented design features such as continuous sidewalks and street trees are combined with the mixed land uses typically found in traditional communities, individuals should theoretically drive less and walk more. To investigate this hypothesis, the following report explores the impacts of a TND on trip production and attraction, mode choice, and trip chaining by comparing and analyzing the differences in travel behavior between a conventional neighborhood, a TND, and the Triangle region (Raleigh-Durham-Chapel Hill). One fundamental research question that we will attempt to answer is: Do residents of TNDs in North Carolina have lower trip generation rates, automobile use and vehicle miles traveled compared with more conventional, auto-oriented neighborhoods?

Additionally, as these types of neighborhoods become increasingly popular, a closer assessment of traffic impacts caused by TND designs becomes warranted. The TND development form is a fairly new design concept, and there are few existing TNDs in North Carolina upon which to base trip generation and traffic forecasts. Trip generation and traffic impact analysis methods that are commonly used for new suburban neighborhoods may or may not be appropriate for TND traffic impact analyses. It is essential, however, for traffic forecasting and trip generation

[1] These projects are greater than 15 acres. Source: New Urban News, 2001, "New urbanist project construction starts soar." http://www.newurbannews.com/annualsurvey.html

professionals to obtain reliable estimates of traffic volumes resulting from a new TND plan in order to develop street access and have the plan approved by local officials.

Without reliable forecasting techniques, disputes may arise for a new TND. Developers may claim reduced TND traffic impacts while city officials seek mitigation for the TND traffic generated. Furthermore, if the TND access uses state roads, NCDOT must review and approve the TND plan. Thus, it is essential for NCDOT to have a reliable method to substantiate TND traffic impact analyses.

This research report assesses impacts of a TND neighborhood by comparing trip generation and traffic impact analysis results to actual traffic counts taken at the neighborhood boundaries. The study includes one neighborhood that meets TND standards and one neighborhood that is designed in a conventional single-use suburban design.

Scope and Definition of Terms for Travel Behavior

Before proceeding further, we will define and discuss a number of key terms. A trip is defined as the movement of a person in space (at least 300 feet) and time. In this study we focus on daily trips, which are mostly done within a city/region, i.e., the trips studied are less than 100 miles. The two neighborhood types that were surveyed in the study had distinctly different land use characteristics and their boundaries were clearly defined, e.g., Southern Village is a TND, with residents having a fairly clear idea of the shape and size of the development. We will refer to new urbanist, neotraditional neighborhoods as traditional neighborhood developments.

Trip generation is composed of both trip productions and trip attractions. We analyze residential trip productions and the trips analyzed include bicycling and walking modes. The trip purposes analyzed included: Home-based work, home-based shop, home-based school, home-based other, and non-home-based. While trip production is expressed as a function of socio-economic data and/or population at the household level, such as household size, number of cars present, and household income, trip attraction is expressed as function of land use, employment, and/or other economic activities such as shopping and entertainment destinations. As part of our study, we will estimate trip generation models to quantify and compare trip generation rates across traditional and conventional neighborhoods and also compare them with the larger Triangle region trip generation rates. This study also explores trip attractions in the TND by surveying the businesses.

Mode choice is an individual’s selection from a variety of transportation options, including private vehicle, bus, walking, and bicycling. It is most often a function of time, cost and socioeconomic variables; and of course it depends on the availability of alternatives. For instance, an individual may choose to drive because their destination is far away, they need to transport people or goods, and/or there are no alternatives, such as public transportation. Conversely, a person may choose to walk when their destination is nearby, they are not transporting other people or goods, and/or there is a network of sidewalks and trails connecting them to their destination. More intangible, however, is the appeal of using various modes of transportation. For instance, some people may prefer driving because of the freedom this choice permits, while other people prefer riding the bus so they can work while they commute. This study will examine mode choice within the framework trip generation, i.e., number of automobile trips that are generated.

Trip chaining is another component of trip generation and is defined as the process of making a series of non-home based trips in a row. Trip chaining is composed of stops and each chain of stops is known as a tour. An example of trip chaining is running errands, which is more convenient for single occupant automobile users than for carpoolers or transit users. Trip chaining is generally considered more efficient than returning home after each destination is reached. However, the distribution and distance of the destinations should be considered before such conclusions can accurately be made. For instance, it may be more efficient to chain trips when the origination is located far from destinations and/or when the destinations are clustered in one or a few areas, away from the origination of the trip. However, it may not necessarily be efficient to chain trips when alternative modes, such as transit or walking, are available, the origination is close to the destinations and the destinations are spread out around the origination. Regardless, many people may choose to chain trips once they have begun running errands despite what may be most efficient. Because trip chaining has not been thoroughly studied, this study attempts to understand trip chaining in the traditional versus conventional context.

Scope and Objectives for Trip Generation

The objective of this portion of the study is to determine the reliability of currently accepted traffic forecasting methods, not to develop new methods. The focus of this report is on the total site traffic generated and the traffic volumes at the entrances and exits to Southern Village (TND) and Lake Hogan Farms (conventional suburban development, or CSD) in Chapel Hill, NC. The specific objectives of the study are:

- To estimate, count, and compare site traffic at a TND and a CSD using conventional traffic impact analysis (TIA) and travel demand model (TDM) methods
- To compare TND and CSD trip rates implied from travel diaries to published trip rates, including internal capture rates
- To recommend changes (if any) in NCDOT traffic impact analysis methods and TDM methods to address the specific travel impacts of TNDs

Chapter 7 of the ITE Trip Generation Handbook defines multi-use developments as "typically 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" (ITE, 2001). Southern Village was designed as a TND and fits the ITE definition of a multi-use development. The Southern Village area contains houses, shops, restaurants, a grocery store, a movie theatre, offices, a day care center, and an elementary school within its boundaries.

For comparative purposes, a conventional suburban development (CSD) was studied. Lake Hogan Farms was selected as the comparison neighborhood because it is similar to the size, location, and demographics of Southern Village. However, such factors as mix of land uses, density or "compactness" of development, availability/quality of pedestrian and bike features (sidewalks, bike lanes, etc.), availability/quality of transit service, street connectivity, site design/layout features, and proximity to destinations are quite different from Southern Village.

By comparing these two neighborhoods that share similar demographic groups but have different design elements, it is possible to compare trip generation and actual traffic volumes for each type of development. This study should yield significant insight into the trip generation characteristics of TNDs but generalizations for other TNDs in North Carolina or nationwide must be treated with care, due to the location and relative youth of the Southern Village development in comparison to older developments that may have the same retail and commercial opportunities but are more integrated into the urban fabric.

Typical traffic impact analysis (TIA) methods were utilized for both neighborhoods. Trip generation was performed using the methods developed by ITE and implemented in spreadsheets. The study used the travel demand model (TDM) “Triangle Regional Model” to obtain additional trip estimates for further comparison

Chapter Summary

This chapter gave an overview of the project. Various problems related to TNDs were highlighted and the cope and objectives of this study were determined. Various terms related to trip making were also defined.

Chapter 2: Literature Review
Traffic Impacts and Assessment Methods For Traditional Neighborhood Developments

Introduction

In the 1990's, a planning movement known as "The New Urbanism" led to the design and construction of a new category of neighborhoods across the nation. These "*Neotraditional Neighborhood Developments*" create more livable mixed land-use communities that promote walking and bicycle use, thereby reducing traffic congestion and related impacts. They feature compact residential development combined with additional land-uses like retail, office, and recreational facilities in a grid-pattern street design. The term "neotraditional" refers to the revitalized idea of the pre-World War II "traditional" design of closely connected, higher density urban neighborhoods, that preceded the 1950's trend of "suburban" neighborhood developments. In this review, the term "traditional neighborhood development" (TND) will be used. TND examples in North Carolina include Falls River in Raleigh, Carpenter Village in Cary, and Meadowmont and Southern Village in Chapel Hill. Street and land-use design concepts for such TNDs are available to planners, engineers and architects. Relatively few U.S. researchers have attempted to determine how effective the neotraditional street and land-use designs really are in reducing traffic impacts compared to conventional suburban developments. Studies for North Carolina TNDs do not exist. This literature review examines TND features, particularly related to resident travel behavior and traffic issues, and evaluates alternative methods to estimate traffic impacts caused by these types of neighborhoods.

TND Design Issues and Resident Travel Behavior

This section provides a summary of the literature and identifies gaps in the literature. While the relationship between design and travel behavior has been studied broadly for large areas, it has not been studied specifically on the neighborhood scale for actual traditional neighborhoods. As the following literature shows, not only have the study areas been much larger and more difficult to define than actual neighborhoods, but studies have used traditional neighborhoods as a proxy for traditional neighborhoods primarily because few "mature" traditional neighborhoods exist (Crane, 1996; Cervero, 1995). However, this substitution is often not justifiable because (neo)traditional neighborhoods are often constructed on undeveloped areas on the fringe of city limits, whereas traditional neighborhoods, usually defined as neighborhoods built prior to World War II, are well-integrated into the urban fabric of the city as subsequent development has occurred around these neighborhoods. Additionally, some studies have found that income levels in traditional neighborhoods are lower than in more auto-oriented areas (Cervero, 1996), while this is not always the case for residents of (neo)traditional neighborhoods. Finally, many of the findings of the studies that examine the relationship between travel behavior and urban form may be applicable for the area where the studies were conducted, mainly in highly-urbanized regions of California, but are not applicable to other areas of the country. For these reasons and in the context of the current breadth of literature, we feel that the findings of our study will help broaden the understanding of the relationship between travel behavior and urban form and will be more useful in considering future traditional developments in North Carolina.

First, it is necessary to look at the existing literature on the topic. A number of studies have broadly examined the impact of community form on travel behavior (Appendix A).[2] Using factor analysis, Cervero and Kockelman (1997) found that density, diverse land-uses, and pedestrian-oriented design dimensions of the built environment encourage non-auto travel in marginally statistically significant ways that differed between trip purposes and modal choice: compact development had the strongest influence on personal business trips, within-neighborhood retail shops had the strongest influence on mode choice for work trips, and people living in neighborhoods with grid street designs and restricted commercial parking averaged significantly fewer vehicle miles of travel and relied less on single-occupant vehicles for non-work trips.

Because urban form has the potential to increase walking and therefore physical activity rates, a number of public health related studies have been undertaken on the topic. Two such studies illustrate the type of work being done in the public health field. Craig *et al.* (2002) studied the effect of the physical environment on physical activity by rating eighteen neighborhood characteristics and correlating the scores with walking to work, as reported by households in the Canadian census. Though some of the characteristics could have been rated subjectively, they found that characteristics associated with traditional design, including density and the presence of mixed land uses, were correlated with walking to work. In a national study of the relationship between walking and urban form, Berrigan and Troiano (2002) found that people who lived in urbanized areas in homes built prior to 1946 and between 1946 and 1973 were significantly more likely to walk than people living in homes built after 1973. They argue that home age is a useful proxy for neighborhood design; however the designs of neighborhoods built between 1946 and 1973 vary greatly and are not always consistent with neighborhoods built before 1946.

On the transportation and city planning side of the neighborhood design, Ewing and Cervero (2001) recently conducted a seminal literature review of the topic. With respect to neighborhood/activity center design impacts on travel behavior, many of the cases they reviewed used traditional neighborhoods as a proxy for neotraditional neighborhoods and were mainly set in California. Additionally, the conventional neighborhoods used in those studies were built anytime between the end of World War II and present day. The authors found that trip frequencies depend mainly on household socioeconomic characteristics and that travel demand is inelastic with respect to accessibility. Trip frequencies are therefore a secondary function of the built environment.

Ewing and Cervero (2001) also found that walking is more prevalent and that trip lengths are generally shorter in traditional urban settings. While trip lengths are primarily a function of the built environment and secondarily a factor of socioeconomic characteristics, mode choices depend on both, though perhaps less so on the built environment. With respect to the prevalence of walking, Ewing and Cervero (2001) make two important points. First, the prevalence of walking may be due to a self-selecting process, that is to say that people who like to walk choose to live in neighborhoods with a supportive walking environment. Second, it is unclear as to whether walking trips in traditional neighborhoods substitute or supplement longer automobile trips. However, the findings of at least two studies (Cervero and Radisch, 1996; Handy 1996) support the substitution possibility.

[2] Handy *et al* (2002) recently identified over 70 such studies in just the 1990s.

In most instances, these studies involve the use of travel behavior data over large urban areas or multiple neighborhood sites. While travel behavior data usually come from metropolitan travel surveys, neighborhood data are extracted from census tract information or local land use inventory databases and are sometimes supplemented with neighborhood surveys created by the authors of the study. These approaches are fraught with difficulties. Travel behavior data from metropolitan surveys rarely yield enough observations per census tract; therefore, tracts are often combined. These methods may not adequately represent neighborhoods, as single or multiple census tracts rarely follow or capture neighborhood boundaries (Crane and Crepeau, 1998).

Additionally, neighborhood environmental data is usually separated into multiple attributes, such as sidewalk width, social dynamics, four-way intersection frequency, street layout (grid vs. curvilinear), mix of uses, population density, job density, the presence of other people, and visual interest. In line with Cervero (1993), design elements, such as sidewalk width or presence of street trees "are too 'micro' to exert any fundamental influences on travel behavior." Additionally, not only are some of these attributes, such as "visual interest" or "ease of street crossing", difficult to measure objectively and/or consistently (Handy *et al.*, 2002; Ewing and Cervero, 2001), but the multicolinearity and statistical interaction between the attributes render many of the built environment variables statistically insignificant.[3]

Each of the attributes mentioned above can be grouped into what Cervero refers to as the '3-Ds': density, diversity, and design. While density may be relatively easy to measure, diversity and design elements typically are not. Cervero and Kockelman (1997) correctly note that it is the synergy of the 3-Ds in combination that is more likely to yield appreciable impacts with regard to travel behavior. Instead of attempting to determine the impact of each neighborhood attribute or to use complicated factor analysis that results in multiple, difficult to interpret variables (Ewing and Cervero, 2001), neighborhood qualities are best identified as a whole. In this manner, we can best capture the interaction between the 3-Ds.

As in the design of this study, Cervero and Radisch (1996) use a matched-pair comparison of two neighborhood types in the San Francisco Bay Area to measure the impact of the synergy of the 3-Ds. They found that the compact, mixed-use, and pedestrian-oriented nature of a traditional neighborhood resulted in a significantly lower share of automobile trips. These trips were replaced by a higher share of walking and transit trips compared to the trips made in a conventional neighborhood.

While Cervero and Radisch's (1996) study is rightly criticized for failing to isolate the effects of different elements of urban design on travel behavior and their magnitudes (Ewing and Cervero, 2001; Crane and Crepeau, 1998; Handy, 1996), we believe it is a simple and effective way to gauge the overall impact of such developments on travel behavior. Past studies have attempted to tease out the individual effects of various design elements with limited success. Unfortunately, few elements are found to be statistically significant influences in multiple studies (Boarnet and Crane, 2001) and some are regarded as spurious (Ewing and Cervero, 2001). Hypothetically, even if such elements were consistently identified, the utility of such findings would be debatable, as planners and developers who then incorporated statistically significant elements

[3] Cervero and Kockelman (1997)

into their designs (such as street trees) and ignored statistically insignificant elements (such as having continuous sidewalks) may yield little change in travel behavior (in this case, walking).

Though their methodology is similar to our study, significant differences exist. Whereas Cervero and Radisch used two neighborhoods built before and after World War II in their study – Lafayette as a conventional suburban neighborhood and Rockbridge as a proxy for a neo-traditional neighborhood – we use new neighborhoods built in the last decade – the northern Carrboro neighborhoods (Lake Hogan Farms, Wexford, Fairoaks, Sunset Creek, and the Highlands) as conventional suburban neighborhoods and Southern Village as an actual neo-traditional neighborhood. A number of other studies have used traditional neighborhoods as a proxy for neotraditional neighborhoods.[4] By using an actual neotraditional neighborhood in our study, we are able to control for the age of the development with respect to its more conventional counterpart and we are better able to represent the travel behavior impacts of proposed and existing traditional neighborhoods.

Though the neighborhoods Cervero and Radisch used contain a similar mix of elements to those of our neighborhoods (Lafayette and the northern Carrboro neighborhoods are primarily single use neighborhoods with homes placed on large lots and Rockbridge and Southern Village are denser, mixed-use neighborhoods), noticeable differences exist. First, Lafayette and Rockbridge are larger than the northern Carrboro neighborhoods and Southern Village. Additionally, because these neighborhoods are older, they are also surrounded by development, while the northern Carrboro neighborhoods and Southern Village are located on the fringe of the city limits. Additionally, Lafayette has a commercial corridor while the northern Carrboro neighborhoods do not. Both Bay Area neighborhoods have rail (BART) stations near their commercial districts while only Southern Village is served by bus transit. Finally, Handy (1996) correctly notes that, “the findings of the numerous West Coast studies, especially those in the Bay area, may not prove to be fully generalizable to other parts of the U.S.” due to such differences as urban form, culture, and topography. Our study is the first of its kind in this area of the country and will broaden our understanding of how travel patterns may differ in various geographic regions. Overall, while Lafayette and Rockbridge best capture the differences in travel behavior between older, larger, transit-served neighborhoods that are more integrated into urban areas, the northern Carrboro neighborhoods and Southern Village best capture the differences in travel behavior between new, smaller, less transit-oriented developments that are less integrated into urban areas. While not typical of all new development, the northern Carrboro neighborhoods and Southern Village do represent the types of neighborhoods being proposed and built in many areas of North Carolina (e.g., Afton Village, Vermillion and Cheshire) and the rest of the country.

TND Issues Related to Traffic Impact Analyses

In the early 1990’s, around the time when the first neotraditional neighborhoods were being constructed, several studies attempted to predict the effect of the new land-use design on vehicular traffic by comparing hypothetical models of traditional neighborhood developments (TND) to conventional suburban developments (CSD). Cevero and Landis (1995) concluded in their study that land-use could be an important contributor to transportation trends and vice

[4] Dozens of such studies exist; see Ewing and Cervero (2001) for a listing.

versa. Stone, Foster and Johnson (1992) examined two hypothetical street designs and found that TND land-use strategies would lead to a significant reduction in vehicle miles traveled (VMT) for a 5%-15% transit/pedestrian modal split compared to a suburban neighborhood; even with 100% automobile travel, the TND would still reduce VMT, though marginally. Additional infrastructure savings accrue to efficient TND design.

Similarly, McNally and Ryan (1993) used transportation planning models to evaluate and compare the performance of two hypothetical TND and CSD street systems and found relative benefits in VMT and average trip length, as well as congestion on links, in the neotraditional design. They determined trip rates by trip generation and then used a gravity model for trip distribution. The proportions of internal and external trips as well as the production/attraction split were based on assumptions, since it was a hypothetical study with no actual traffic counts available. In an earlier study, Ryan (1991) performed a quantitative analysis of two hypothetical street networks and obtained similar results of reduced VMT and average trip length. But again, the researchers had to make assumptions and generalizations about travel behavior as no actual counts or surveys were taken. The study focused on the internal operation of the street network and neglected external street effects of the development. In yet another study Kulash, Anglin and Marks (1990) found the TND design to have lower vehicle miles traveled on arterials and collectors, a lower volume-to-capacity ratio and higher level of service (LOS) on arterials compared to suburban neighborhoods.

In his 1998 dissertation study, Fatih Rifki (1998) concluded, after applying a series of multiple regression models to data from metropolitan Washington, DC, that aspects of urban spatial structure such as land-use, density, and accessibility do indeed have an effect on travel patterns of city dwellers. Stephen P. Gordon (1991), whose study predicted a reduction in VMT, listed three reasons for the benefits of TNDs: a large internalization of trips, a reduction in auto mode split, and a high capture of jobs within the development. In 1992 Gordon participated in a second study together with Friedman and Peers (1992) in which the researchers also concluded that TNDs have characteristics that result in fewer automobile trips than do current suburban developments. Bookout (1992) pointed to another potential benefit of traditional neighborhoods when he argued that congestion at individual links in the street network would be reduced because the drivers have alternate routes between points. Supporting the notion that traditional neighborhood development reduces traffic impacts, a recent study by Rajamani, Bhat, Handy, Knaap and Song (2002), found that "higher residential densities and mixed-uses promote walking behavior for non-work activities." Together with their claim that only one quarter of urban trips are actually work related, it seems likely that a traditional street system that promotes pedestrian walking to nearby destinations on pleasant walkways does indeed result in a reduction of vehicular traffic within as well as out of the development.

One of the authors who question the actual transportation benefits of TND design is Randall Crane (1996), who claimed that analyses of a potential change in demand of the new street pattern had to be made. He stated in explanation that the grid design results in an increase in access, which reduces the cost of travel and thus may encourage people to take more trips. In contradiction to the hypothetical studies mentioned in the previous paragraph, Crane's (1998) statistical regression analysis of actual travel data showed "no evidence that the neighborhood street pattern affects either car-trip generation or mode choice." In another study, Ewing and

DeAnna (1996) also found “no significant, independent effects of residential density, mixed land-use, and accessibility on household trip rates.” As an explanation, Kitamura, Mokhtarian, and Laidet (1994) argue that “attitudes were more strongly correlated to travel behavior than neighborhood characteristics,” and TND design would therefore have at best indirect effects on traffic. For example, TNDs may attract people who inherently prefer walking rather than to actually cause a reduction in automobile trips of all residents through design. Another important issue related to neotraditional neighborhood design in this context is externally attracted traffic. This phenomenon that Pryne (2003) referred to in a *Seattle Times* article as “induced travel,” describes an increase in traffic volume that is not generated by growth or other demographic forces but by the expansion of the road system, or in this case, the neighborhood development itself. In other words, it is unclear how much additional traffic is generated by a neotraditional development due to the attraction of its nature of mixed land-use, which would not be an issue in a conventional single land-use residential development. According to Stephen Littman (2001), “generated traffic reduces the congestion-reduction benefit that can result from increased road capacity.” The improved road network of a TND may therefore induce additional traffic as residents and possibly shoppers from outside the development wish to take advantage of the lower delay times and convenient on-street parking as compared to shopping in a strip mall, for example.

These results from the literature suggest that despite the compact, mixed-use development and the new grid pattern, traditional neighborhood developments do not inherently reduce travel. If so, conventional trip generation models for single use sites as outlined in Institute of Transportation Engineer’s (ITE) “Trip Generation Manual” (1997) may be applicable to traditional, mixed-use developments, with little or no trip rate reductions for “internal capture.” However, as a result of its own research, ITE has recently published the “Trip Generation Handbook” (2001) as a supplement to its current manual to account for assumed internal capture and pass-by trips in multi-use developments. In several studies conducted by the Florida DOT (Tindale et. al 1994 and Keller 1995) that form the empirical justification for the new ITE handbook, internal capture rates, which reduce site traffic impacts, were as great as 30-40% and reductions in trip rates from pass-by trips approached 30%. The FDOT studies utilized large-scale mixed-use developments and are not necessarily representative of the traffic impacts of smaller neotraditional neighborhoods such as those in North Carolina. They do suggest, however, that further research on trip generation methods and their applicability to local TNDs is necessary.

Research on traditional neighborhood street and land-use design using hypothetical models suggests reductions in vehicle miles traveled within, as well as external to, the development. This conclusion is supported by traffic studies on large-scale multi-use developments by FDOT. ITE applies these findings to modify conventional trip generation methods in its “Trip Generation Handbook.” However, no work has been accomplished for actual traditional neighborhoods of a scale typical in North Carolina. Other studies show no statistically significant traffic reductions. Thus, the premise of reduced traffic impacts of TNDs may not be fulfilled.

In summary, the conflicting views regarding traffic impacts at traditional neighborhood developments are as follows:

1. Internal TND automobile traffic decreases if walking trips to internal attractions increase.
2. Exiting TND traffic decreases if internal attractions capture trips and increase trip chaining
3. Congestion at TND intersections decreases if an increased number of intersections distribute traffic more evenly.

On the other hand …

4. TNDs with shopping, employment and entertainment opportunities may attract traffic from external origins, which increases internal and external traffic.
5. Relatively uncongested TND streets may induce additional internal automobile travel due to efficient street network and convenient on-street parking.

Traffic Impact Analysis Methods Applicable to TNDs

Due to the relative "youth" of the "New Urbanism" planning movement, research on neotraditional neighborhood developments is relatively scarce. The majority of the studies mentioned in this review either utilized hypothetical computer models of TND and CSD street designs for comparison or used older traditional developments as a proxy for neo-traditional design (Ewing and Cervero 2001). Considering the relative scarcity of applicable studies, the question for adequate models and means of analyzing TND traffic behavior is difficult to approach. Even after extensively searching online databases, scientific journals, and engineering libraries, no reference to published results of research evaluating methods of traffic impact analysis in their applicability and validity for TND street systems could be found. A likely explanation for the lack of studies is that traffic impact analyses are typically completed by consultants for specific project sites and, therefore, have very practical applications, rather than publishable extensions of theory. Consequently, the following review concentrates on traffic impact analyses (TIA) by consultants. Furthermore, it will evaluate which method will be most appropriate for the case of a traditional neighborhood development.

The Oberlin case is a recent example of a traffic impact analysis of a proposed mixed-use development that caused significant public controversy in Raleigh, NC. According to Geary (2001), the traffic consultants found that the proposed mixed-use development would not push the adjacent Oberlin Road and Wade Avenue over capacity. Interestingly, citizen groups from the surrounding traditional neighborhoods of modest homes strongly opposed this construction of several six to eight story buildings. Ultimately, the citizens convinced City Council and the developer to withdraw plans for the development after completing their own local traffic counts and producing an independent estimate of unacceptable traffic impacts. This case highlights the issues of using appropriate methods of TIA analysis, local or national trip generation rates, and professional judgment or guidelines to adjust trip rates for internal capture, pass-by traffic and transit. Other available TIA studies for proposed developments in North Carolina show that the typical method for trip generation uses ITE trip generation rates and adjustments combined with professional estimates of the reductions for pass-by trips and internal capture. The ITE trip generation method was also utilized in the original traffic impact study for the Southern Village TND. As the ITE trip generation handbook had not been published at that time, adjustments for internal capture were made based on estimates derived from a local transportation study and a total of 33% of trips were predicted to remain within the development. Furthermore, a 5% reduction of trips related to the use of public transportation and non-motorized transportation modes was assumed. Traffic distribution and assignment at entrances to the development were estimated from existing traffic counts and turning volumes.

The critical issues related to TIA studies and trip generation are the "professional estimates" of trip rates and their adjustments to account for local travel preferences and behavior. It therefore seems necessary to choose or possibly generate a TIA methodology or a combination of acceptable methods that can predict the impacts of mixed-use TNDs in North Carolina accurately and with confidence. Clear guidelines on how traveler preferences and attitudes are best modeled need to be developed. A systematic review of different categories of TIA methods will help accomplish this goal. Then testing one method against the other for actual North Carolina TND and CSD sites will demonstrate the need for modifications to the TIA methods.

Synopsis of Methods for Traffic Impact Analysis

Consultants use TIA methods to predict internal and external traffic impacts of proposed neotraditional neighborhood design as well as conventional suburban developments, commercial developments, etc. City and State agencies require TIAs from developers as part of the site review process. Before agencies issue building permits, developers must agree to pay for any needed traffic mitigation measures such as signals and turn lanes on roadways adjacent to the site. In addition, the agencies may constrain locations for driveways and access to roads to the proposed sites, all depending on the results of the TIA.

Methods for traffic impact analysis include four broad categories:

I. Site-specific deterministic methods
II. Site-specific traffic simulations
III. Regional travel demand models
IV. Travel demand models integrated with simulation

Some of these methods represent complete traffic impact analyses; others rely on additional techniques to estimate site generated traffic and its distribution and assignment to streets and highways. Most methods generate traffic using ITE trip rates and adjustments or professional judgment. Subsequent trip distribution and assignment may result from integrates and automated computer programs or from manual methods based on professional judgment and assumptions. The resulting internal and external site traffic, plus "background" traffic are evaluated using Highway Capacity Manual (2000) methods to estimate traffic congestion and to test geometric and signal mitigation options.

Planners and engineers usually make the following assumptions for TIAs of typical developments and TNDs:

1. Study Area: (scope/area, land-use, network) The extent of the traffic impact study area may be as close as bordering streets and intersections or as far as all facilities having 10%-15% traffic increase or level of service decrement. Proposed total build-out land-uses must be

known for the development, as well as existing and proposed roadways and transit services for the built-out (design) year.

2. Build-out year and phasing: Construction phasing and intended built-out year give the annual and future year traffic impacts that are added to forecast background traffic.

3. Background traffic growth: Background traffic represents the traffic that would be on the roadways adjacent to the site whether it is built or not. Initial (base year) estimates result from detailed traffic counts in the study area. Usually background traffic increases at rates of 2% to 5% per year depending on the local economy and the capacity of the network to absorb additional traffic.

4. Trip generation: ITE trip generation rates reflect site traffic demand. They are the usual default values most professionals use unless better local data are available. Analysts reduce the rates depending on demonstrated or assumed pass-by traffic, transit use, internal capture of site traffic and trip chaining, which all tend to reduce the site's traffic impacts. Increases in site traffic impacts occur if the site attracts external trips.

5. Trip distribution: Trip distribution mathematically describes how the site's trips disperse throughout the surrounding study area. Larger activity areas with employment and shopping opportunities attract the most trips, however, precise estimates using gravity model approaches are rarely used. Instead, professionals often assume that site traffic distributes proportionally to current year traffic counts on study area streets.

6. Mode choice: Reductions to site automobile traffic usually occur in the trip generation step. Among the possibilities for alternate transportation use are public transit and walking trips, which are especially important in the consideration of mixed use developments like TNDs.

7. Traffic assignment: How the network is loaded depends on the traffic assignment method. Manual methods typically assume all-or-nothing loading with no adjustments for street capacity constraints. Such assignment highlights street, driveways and intersections needing mitigation. Computerized methods recognize street capacities and divert traffic to less traveled links in the network.

8. Traffic impacts: The usual measurements of a site's external traffic impacts on adjacent streets and intersections are levels of service based on traffic volume, speeds, and delays. Highway Capacity Manual (HCM 2000) methods estimate the levels of service for the study area network with and without the proposed site in the future year or during critical phased built-out years. Depending on local and agency requirements and the estimated future traffic congestion, the developer may have to pay for roadway and signal improvements before building permits are issued. Internal traffic impacts in the development are not usually of concern to the agency.

Depending on the extent of the study area, the available data and the resources available for the TIA, more or less constraining assumptions will be made and appropriate TIA methods applied. The following review will compare TIA methods on the basis of several factors regarding their practicality and feasibility for application to neotraditional neighborhoods and conventional neighborhoods. In particular the factors that are important in this context are:

a. Type of method
- site-specific deterministic method
- site-specific traffic simulations
- regional travel demand model
- travel demand model with simulation

b. Functionality of method
- breadth of study area
- characteristics of land-use and transportation network
- build-out year and project phasing
- background traffic growth
- trip generation and adjustments for internal capture, pass-bys, etc.
- mode choice
- traffic assignment
- traffic impacts

c. Practical Issues
- availability and cost
- amount of data required for input
- user friendliness, training required and model development time

d. Applicability to TND-specific issues
- internal capture and trip chaining
- multi-use design features versus single use CSD
- pass-by trips and externally attracted traffic
- generated or induced traffic
- pedestrian friendliness and walkability of development

e. Inclusion of regional features
- accessibility to transit
- residential and retail employment zones
- demographics of residents' work sites

Site-Specific Deterministic Methods

In this most basic type of traffic impact analysis, trip generation is performed using mathematical equations and graphs derived from site-specific studies in the ITE Trip Generation Manual (ITE 1997). In most practical applications and consulting work for small-scale projects, the resulting vehicle trips are distributed and assigned to the exits and entrances of the site by expert judgment. Usually the trip distribution and assignments are proportional to non-site traffic counts at the site entrances and exits. It is also possible to use more analytical methods like the "gravity model" to distribute trips. The recently published ITE Trip Generation Handbook (ITE 2001) adjusts trip generation values for multi-use developments to account for internal capture and trip chaining. A variety of commercial, public domain and "ad hoc" spreadsheets are available and commonly used by consultants. The methods have quick, user-friendly input of study area and development features, they provide quick results, and the spreadsheet programming can be easily customized. Internal capture rates that underlie the adjustments for multi-use TND trip generation may be standard ITE adjustments or may be adaptable for various site designs. The site-specific deterministic method neither allows for considerations of street design and other TND features nor makes differentiations between urban and rural location of development or adjustments for other regional features. Finally, the ITE based methods output daily or hourly estimates of traffic volumes for intersections. Traffic distributions and assignments are usually accomplished manually by ad hoc methods. NCDOT utilizes such methods for limited site, intersection and corridor analyses. They are not appropriate for large site developments with regional traffic impacts.

<u>Site-Specific Time-Dependent Simulations</u>

A more sophisticated and time-consuming approach for traffic impact analysis is microscopic traffic simulation using software such as "Vissim" (2002), "Corsim" (2002), and "Traffix" (1999) and others. "Traffix" is a spreadsheet-like program designed for modeling and quantifying turning movements for smaller sites in smaller study areas. It does not feature real-time graphical simulation like the other examples do. Vissim and Corsim are software products that simulate short-term (15-60 minutes) operational models that allow a probabilistic analysis of a specific corridor or street system. The models give TIA output including traffic as a function of time, delay travel time, headway gaps, etc. Animations may be developed, as well as LOS and capacity analyses. Typically, trip generation has to be performed using the ITE method, or local trip rates of similar developments can be used in the model. The simulations are capable of modeling impacts on the network LOS from adding lanes or changes intersection timing plans.

"Corsim" is the model most currently used in the U.S. It is a flow-based simulation model that obtains performance of links from inputting entry and turn volumes. "Vissim" on the other hand is path-based and is recommended practice in most European countries. Path-based simulations reproduce network trip-making behavior and use origin-destination matrices as input. All of the simulation models do, however, require significant user input in the form of traffic counts and trip generation rates and, with the exception of Vissim, trip distribution and network assignments have to be performed manually as well. Simulations, therefore, are particularly useful to evaluate LOS of existing street systems. Similarly, they can estimate performance and impacts of new TND designs, and they are gaining broad acceptance for predicting traffic impacts and testing mitigation measures. However, none of these models reflects demographic factors and socioeconomic data that may be important for TND traffic impact analyses in order to model mixed land-uses and related travel behavior. Also, the simulation programs require significant financial and time investments, which make their application for small-scale projects inefficient. The clear advantage compared to the spreadsheet methods is that simulation models consider and display the actual physical layout of the street network and animate resulting traffic flows. This can be done at the subarea scale of a single neighborhood development, which may permit integration with a regional travel demand model.

Regional Travel Demand Models

Travel Demand Models like "Tranplan" (2002) or "TransCAD" (2002) use socioeconomic census data and survey results to estimate trip generation based on household sizes and income groups, while accounting for area type (urban and rural) and employment features of retail and office locations in the development. In contrast to the simulation models discussed earlier, regional models lead the user through the entire four-step forecasting procedure before the user conducts the actual traffic impact analysis. TransCAD and similar models based on geographic data commonly support regional planning, and thus require significant input as well as specifically trained users. It is also a very time consuming process to develop and calibrate a travel demand model for the particular area of interest. A local North Carolina application of TransCAD is the Triangle Regional Model (TRM) (2002), which divides trip generation into five categories: home-based work, home-based shopping, home-based school, home-based other, and non-home-based. Socioeconomic data of the study area are entered in a regression model in combination with a cross-classification model to give deterministic estimate of traffic volumes throughout the region. The TRM clearly accounts for a number of TND design issues and, therefore, would appear to be a good choice for traffic impact analyses of traditional neighborhood developments. However, the travel demand models do not give time-dependent representations of traffic behavior, as the site-specific simulations are capable of doing. It is also essential that up-to-date data are available; otherwise, the travel demand model will give incorrect traffic estimates. In summary, the use of a regional model is very time consuming, costly, and out of scale for most site development analyses.

Travel Demand Model Integrated with Simulation

Recent research has addressed the question whether it is possible to integrate travel demand models into time-dependent operational simulations of traffic behavior. This would allow for a visual and dynamic modeling of TND street networks, while accounting for their socioeconomic characteristics as well as regional features. In his master's thesis, Greg Saur (2003) addressed this question by successfully combining TransCAD and Vissim to accomplish sub-area analysis for transportation projects, specifically two north-south bypass alternatives around Pittsboro, NC. Another program that will feature simulation methods integrated in a TransCAD regional model is Transmodeler, which is expected to be available from Caliper, Inc. It may be feasible to transfer a similar approach to traditional neighborhood developments and use similar combinations of tools in the assessment of the Southern Village development; however, more research on this issue as well as development of user-friendly software is required.

Chapter Summary

As Table 2-1 indicates, this chapter reviewed the applicability of various models to perform TND traffic impact analyses. The four models discussed are site-specific deterministic, site-specific simulation, travel demand model and travel demand model integrated with simulation. The features for each category include scale, functionality and cost/resource requirements. The table shows that while the ITE trip generation method with adjustments from the "Trip Generation Handbook" considers mixed land-uses, the specific layout of the street system cannot be modeled explicitly. Yet it is a cost and time efficient way to obtain trip generation rates and traffic, which professionals can then distribute, assign and interpret using engineering judgment. To take the specific street pattern into consideration, a simulation model of the projected traffic volumes can be used. This requires much user input and still has to deal with the issue of traffic assignment and distribution, which in a program like Corsim has to be performed manually. Since a simulation model still fails to take regional land-use characteristics and effects into consideration, a regional travel demand model may be the most appropriate. Yet again, a lot of user input and extensive knowledge of the respective software are prerequisites and even then, the focus on a small area like a single development remains difficult and perhaps inappropriate. In the future, programs that feature simulation integrated into a regional model may transform some of the currently required input into routine and automated operations and become a powerful alternative even for smaller study areas like TNDs.

Table 2-1: TND Modeling Capabilities of TIA Methods

Does this specific model have the capability to mathematically assess the following? (rather than to rely on professional judgment)	**Site-specific deterministic model**	**Site-specific simulation**	**Travel Demand Model (TDM)**	**TDM + Simulation**
Regional land use and street network	NO	NO	**YES**	**YES**
TND scale street network	NO	**YES**	NO	**YES**
Trip generation	**YES**	NO	**YES**	**YES**
Adjustments to TND trip generation for …				
… pass-by trips	**YES**	NO	**YES**	**YES**
… internal capture	**YES**	NO	**YES**	**YES**
… externally attracted traffic	**YES**	NO	**YES**	**YES**
… transit trips	**YES**	NO	**YES**	**YES**
… induced travel (internal)	NO	NO	NO	NO
TND internal trip distribution (intra-zonal trips)	NO	**YES**	NO	**YES**
TND external trip distribution (inter-zonal trips)	NO	NO	**YES**	**YES**
Capacity, travel time or delay analysis	NO	**YES**	**YES**	**YES**
TND traffic assignment (trip chaining)	NO	NO	NO	NO
Model refinement to fit small scale of TNDs	**GOOD**	**GOOD**	POOR	**GOOD**
Training Requirements	**LOW**	HIGH	HIGH	HIGH
Cost Requirements	**LOW**	MED-HIGH	HIGH	HIGH
Data Requirements	**LOW**	HIGH	HIGH	HIGH

As a result, this review suggests that conventional TIA methods using ITE methods and professional judgment are appropriate and cost effective with relatively low data requirements. Simulation and TDMs are out-of-scale for most TND analyses; however, consultants are beginning to use simulations more frequently. Regional transportation planning agencies are also becoming more interested in testing alternative land-use strategies, like TNDs, yet their travel demand models for regional studies do not have the proper refinement for small-scale TNDs. Hence, a need exists for integrating site-specific methods, including simulations, with TDM methods.

This project, as the following section on the methods illustrates, will apply and compare the conventional ITE site-specific deterministic method to both TND and CSD sites. Traffic forecasts will be compared to actual traffic counts taken at the entrances/exits of the developments. Furthermore, the project will test the feasibility of directly using the Triangle Regional Model for TND and CSD trip generation and traffic impact analyses. The results of this comparison, the accuracy of the TDM forecasts, will then lead to the decision of whether additional analyses using simulations, either alone or in combination with TDM analysis, will be performed.

Chapter 3: Methods for Traveler Behavior

This chapter discusses the methodology for the traveler behavior portion of the study. Specifically, we begin by hypothesizing the relationships that might influence household trip generation. Then the neighborhoods where the survey was implemented are described. The sampling and survey design are discussed next. Then the data files generated from the survey and socioeconomics of the respondents are discussed.

Hypotheses

Based on NCDOT needs and the findings of past studies, we will formulate and test four fundamental hypotheses (Table 3-1). First, with respect to trip frequencies, we hypothesize that households in the TND will make more trips than households in the conventional neighborhoods, owing to the proximity of mixed land uses. We also believe that households in study will make more trips than other households in the region, largely due to their higher incomes. This hypothesis is partly based on our analysis of the regional model, which found that households with higher incomes make more trips than households with lower incomes.[5] This finding may be due to the likelihood that households with higher incomes have more finances available to fund activities such as shopping and recreation that induce travel. Therefore, we expect that households in the study will generally make more trips partly because they have higher incomes than the regional average. Second, following from the findings in the literature review, we also hypothesize that households in the traditional neighborhood will make fewer auto trips than households in the conventional neighborhood (of course, we do not know how much fewer). This may be because more trips will be made by alternative modes of transportation in the traditional neighborhood than in the conventional neighborhoods, as distances between origins and destinations are shorter in traditional neighborhoods and are therefore more conducive for walking or bicycling. Third, we hypothesize that trip lengths will be shorter for households in the traditional neighborhood than for households in the conventional neighborhoods since destinations are closer in mixed use neighborhoods than in single use neighborhoods. Finally, and in line with a number of studies from the public health field, we hypothesize that people in the traditional neighborhood will make more trips using active forms of transportation (walking and bicycling) than people in the conventional neighborhoods.

In light of the multicolinearity and statistical interaction observed in studies where each attribute is analyzed independently, an indicator variable representing neighborhood type will be used when testing these hypotheses to capture the collective effects of density, diversity, and design. Additionally, we will control for the traditional predictors of trip generation models – household size and number of cars – by including these variables in our models.

[5] This is also consistent with that of McNally and Kulkarni (1997).

Table 3-1: Hypotheses Tested

	Trip Generation
Hypothesis	Households (HHs) in a TND neighborhood make more trips than HHs in a conventional neighborhood
Alternative Hypothesis	HHs in a TND neighborhood make fewer trips than HHs in a conventional neighborhood
Null Hypothesis	HHs in a TND neighborhood make the same amount of trips as HHs in a conventional neighborhood
	Automobile Trips
Hypothesis	HHs in a TND neighborhood make fewer automobile trips than HHs in a conventional neighborhood
Alternative Hypothesis	HHs in a TND neighborhood make more automobile trips than HHs in a convetional neighborhood
Null Hypothesis	HHs in a TND neighborhood make the same amount of automobile trips as HHs in a conventional neighborhood
	Trip Distances
Hypothesis	HHs in a TND neighborhood make shorter trips (and travel less) than HHs in a conventional neighborhood
Alternative Hypothesis	HHs in a TND neighborhood make longer trips than HHs in a conventional neighborhood
Null Hypothesis	HHs in a TND neighborhood make the same length of trips as HHS in a convetional neighborhood
	Physical Activity Trips
Hypothesis	People in a TND neighborhood make more walking and bicycling trips than people in a conventional neighborhoc
Alternative Hypothesis	People in a TND neighborhood make fewer walking and bicycling trips than people in a conventional neighborhoc
Null Hypothesis	People in a TND neighborhood make the same amount of walking and bicycling trips as people in a conventional

Description of Neighborhoods

To best understand how the study is framed, it is important to compare the two neighborhoods selected for our study. In order to control for a number of confounding variables, many of studies suggest normalization between neighborhoods when the goal is to compare travel behavior and accessibility (Handy and Clifton, 2001; Ewing and Cervero, 2001). Accordingly, we selected (see Appendix B) Southern Village and the northern Carrboro neighborhoods (Figure 3-1) because they share many common characteristics, but differ in aspects relevant to our study, as outlined in Tables 3-2 and 3-3. They are between 7 to 8 miles apart and we had initially intended to survey Lake Hogan Farms only, but due to a relatively small development size (438 home sites) and hence sample size, we expanded the study to include other conventional neighborhoods nearby. Appendix I contains the site plans for the two developments.

Southern Village is a traditional neighborhood and was developed and annexed to southern Chapel Hill, North Carolina. Market Street, which is located in the southern sector of the development, serves as the neighborhood's "Main Street". A number of businesses (Appendix E) are located along Market Street with open space and parking spaces situated in the center. The area is situated on a small hill. Most of the buildings are two or three story brick structures, and several are mixed use—the first floor is used for office space while the second floor is residential. There are a few vacant lots and commercial spaces available for future growth (as of 2003). Surrounding this ring of businesses are apartments and condominiums.

Figure 3-1: Location of Northern Carrboro and Southern Village

Table 3-2: Density, Diversity and Design Characteristics of Our Study Sites

	Southern Village	Northern Carrboro
Density		
Number of households	920[1]	891
Average lot size[2]	6,969 sq. ft.	16,812 sq. ft.
Employees	Approx. 432	0
Diversity of land uses		
Uses present	Retail, Office, School, Residential	Residential
Commercial sq. ft.	Approx. 200,000[3,4]	0
Design		
Street design	Modified Grid	Curvilinear
Pedestrian provisions	Sidewalks on both sides of the street, parks, street trees	Sidewalk on one side of the street, parks, street trees

[1] 611 single family homes, 197 apartments, and 112 occupied condominiums
[2] Calculation does not include lot size approximations for apartments or condominiums
[3] Calculation does not include the school (90,000 sq. ft.), daycare center (6,000 sq. ft.), or church (27,000 sq. ft.)
[4] Retail sq. ft. = 50,000 sq. ft., 30,000 sq. ft. of which is built; office sq. ft. = 145,000 sq. ft., 95,000 sq. ft. of which is built.

Row houses, alleyways, pocket parks and sidewalks on both sides of the street are found throughout Southern Village. A paved greenway trail and the neighborhood's recreational facility divide the northwest portion of the development from the rest of the neighborhood.

Homes are situated in relatively close to the streets and have wide front porches facing the sidewalk and street. Garages are accessed from the alleyways and sidewalks are separated from the street by a strip of grass planted consistently with young trees. Existing vegetation prior to the development of the neighborhood remains in areas through the neighborhood.

Table 3-3: Additional Characteristics of Our Study Sites

	Southern Village	Northern Carrboro
Age of Development	Late 1990s	Late 1980s – 1990s
Average Housing Value	$301,787	$303,357
Distance to Downtown	2.5 miles	3.5 miles
Average Resident Age	33	31
# of People per Household	2.28	3.26
# of Cars per Household	1.65	2.11
T- Intersections	35	19
Four-way Intersections	16	8
Cul-de-sacs and Dead Ends	2	56
# of Buslines Serving Area	2	0

The northern Carrboro neighborhoods – Lake Hogan Farms, Wexford, Fairoaks, Sunset Creek, and the Highlands – are located west of Chapel Hill, in northern Carrboro. While manicured open space with young trees and ponds occupy the land between the various developed areas of Lake Hogan Farms, more mature trees and stands of trees exist in the older northern Carrboro neighborhoods. Two recreational facilities exist in the area, one in the geographic center of Lake Hogan Farms and the other in the northern portion of Wexford. Farmland and forests separate the northern Carrboro neighborhoods and similar single-use neighborhoods are slated for development on this land. Throughout all of the northern Carrboro neighborhoods, homes are deeply setback from the streets, sidewalks are on one side of the roads, cul-de-sacs and dead ends are common and two- or three-car garages face and are accessed from the street. Small parks are scattered through each neighborhood.

It is important to note that neither Southern Village nor Lake Hogan Farms are fully “mature.” Most notably, commercial space in Southern Village is still under construction and some remains vacant, some homes in Lake Hogan Farms have yet to be built and occupied, and landscaping features such as street trees in both developments are not mature. It would be worthwhile to undertake a follow-up study in ten or more years after the areas have matured to further examine people’s travel behaviors.

Because it is best to compare like cohorts, our analysis compares single-family homes in Southern Village to single-family homes in northern Carrboro. As will become apparent in the descriptive analysis section, socioeconomic measures in the condominium and apartment households in Southern Village vary greatly from the single-family homes in Southern Village and the northern Carrboro neighborhoods. Accordingly, we control for or omit the condominiums and apartments of Southern Village as often as possible from our analyses and models.

Sampling

Like most mixed-use neighborhoods, different types of housing exist within Southern Village (Figure 3-1). Since the travel behavior of apartment and condominium dwellers may differ from single-family households (in large part due to differences in socioeconomic factors, such as income), we divided the population of Southern Village accordingly.

$$SE = \sigma\sqrt{\frac{1}{n} - \frac{1}{N}}$$

Using the equation above, we determined the Standard Error (SE), measured in trips, for each neighborhood division based on the division's response rate (Table 3-4). The standard deviation (σ) we used in our equation, 6.25, comes from the Triangle Transit Authority's 1995 travel behavior survey discussed below. It was selected because it best approximates the standard deviation of the variable in which we are most interested: trips per household per day. According to our sampling equation, the results for trips per household per day can be estimated for the various populations in bold, which are the divisions that will be used in our analyses, with a standard error of about ± 0.5 trips.

The results show a relatively good response rate of 25 percent. The sample sizes are as follows: Households = 453; Trips for persons above 16 years of age = 723; Persons of all ages in the data = 1261; Total trips reported = 3736.

Table 3-4: Response Rates

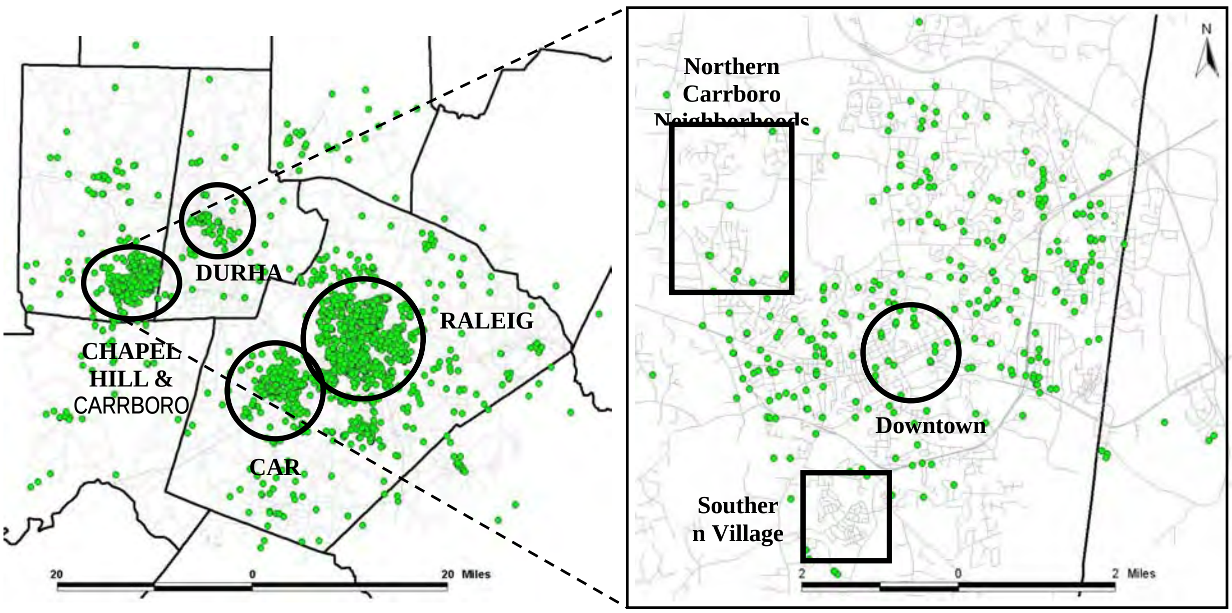
	Neighborhood Division	Population (N)	Responses (n)	Response Rate	Standard Error
Southern Village	Apts.	197	44	22.3%	0.83
	Condos.	112	31	27.7%	0.95
	Condos & Apts.	309	75	24.3%	0.63
	Single-Family Homes	**611**	**168**	**27.5%**	**0.41**
	Total So. Vill. HHs	920	243	26.4%	0.34
Conventional Neighborhoods	Lake Hogan Farms	244	61	25.0%	0.69
	The Highlands	179	37	20.7%	0.92
	Sunset Creek	65	23	35.4%	1.05
	Wexford	248	51	20.6%	0.78
	Fairoaks	155	38	24.5%	0.88
	Total No. Carr. HHs	**891**	**210**	**23.6%**	**0.38**

Survey Design

A handful of travel surveys have been administered in the Triangle region of North Carolina. In 1995, the Triangle Transit Agency (TTA) administered a household travel survey. These data are being used in the Triangle Regional Model (TRM). The distributions of households sampled for this survey in the Triangle region and in Chapel Hill/Carrboro are shown in Figure 3-2. The database that resulted from this survey has been useful to TTA in estimating people's travel behavior within the Triangle region and is compared to the travel behavior of residents of the northern Carrboro neighborhoods and Southern Village later in this report. However, the survey yielded no observations in a traditional neighborhood, since no traditional neighborhood existed in the Triangle at that time.

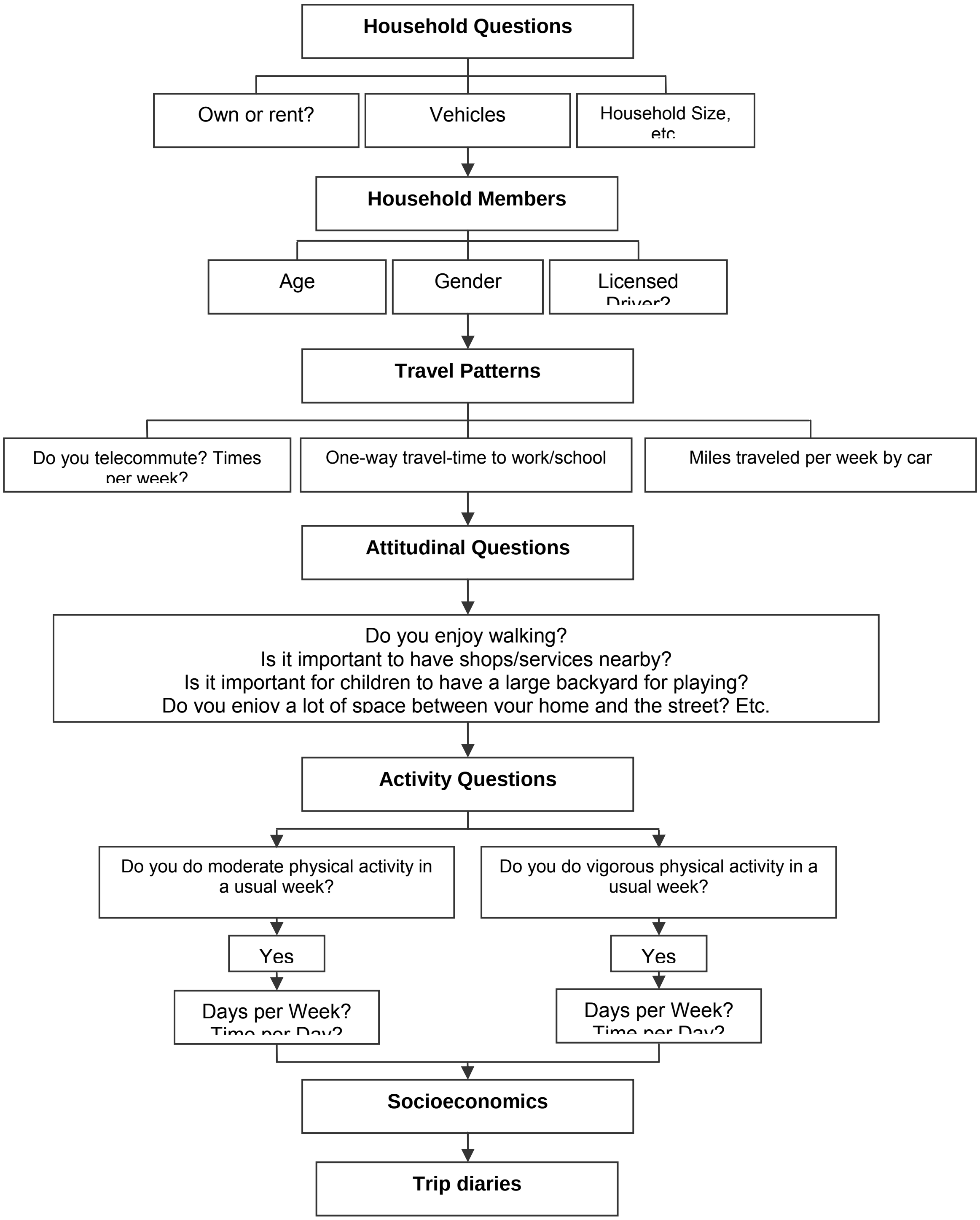
In the late 1990s and early 2000s, the three major universities in the area – the University of North Carolina, North Carolina State University, and Duke University – administered surveys to their employees and students. Though these surveys were helpful in investigating the travel behavior of people affiliated with the universities, the studies failed to examine the travel behavior of individuals not affiliated with the university. Therefore, in order to collect primary travel data, this study utilized mailback surveys (Appendix F) sent to the residents of the northern Carrboro neighborhoods and Southern Village.

Figure 3-2: Distribution of Households Sampled in the Triangle (left) and the Chapel Hill-Carrboro Area (right)



The survey was divided into two sections (Appendix G). Section one was to be filled out be the head of household and section two was to be filled out by all members of the household 16 years or older. Section one was divided into four parts. Part one asked questions related to the respondent's household such as whether they own or rent their home, how many vehicles they own, and the number and ages of people in their homes. Part two asked questions about the respondent's travel patterns, such as the number and type of trips made in a typical week, employment status and job type. Part three asked questions related to the respondent's attitudes and part four asked questions about the respondent's activities, such as how much exercise they do in and away from their neighborhood, their education and household income level. A conceptual structure is provided in Figure 3-3. Section two was composed of a travel diary with detailed instructions for completion. Many of the questions were based on questions asked in other surveys, primarily from TTA's 1995 survey, the National Household Travel Survey, and physical activity surveys. Though every member of the household regardless of age should ideally complete both sections of the survey, we decided this would be too laborious and felt additional requests would negatively impact our response rate.

Figure 3-3: Household Survey Conceptual Structure (selected questions asked of respondents)



The attitudinal questions were included in part to investigate the issue of self-selection. As mentioned by a number of studies[6], people may choose their residential location based at least in part on their desired travel patterns. Accordingly, certain urban designs might not draw would-be motorists out of their cars so much as they would provide homes for people who already prefer to drive less (Boarnet and Crane, 2001). Therefore, simply having the option to walk without also having the desire may not be enough to encourage people to walk instead of drive (Handy and Clifton, 2001). One study (Krizek, 2000) that does address self-selection with respect to mode choice and urban form took a longitudinal approach to the issue and found small increases in the use of non-automobile transportation when people moved from more to less auto-dependent neighborhoods and small decreases associated with moves to more auto-dependent neighborhoods. Though this study did not attempt to account for life-changing occurrences, such as the birth of a child, this finding lends credence to the possibility that people's mode choice varies depending on the transportation orientation of their neighborhood.

To investigate this issue, we ask twenty attitudinal questions based on a five-point Likert scale to identify any relationships that may exist between certain attitudes, travel behavior, and the decision to move into a neighborhood with particular urban design features. If certain relationships exist, then it is likely that a person may be predisposed to move into a certain neighborhood type (Appendix D). If no relationships exist, then it is likely that no such predisposition exists. Kitamura *et al.* (1997) took a similar approach and found that attitudes were a more significant predictor of travel behavior than either characteristics of the built environment or socioeconomic attributes. Much like our study, however, Kitamura *et al.* (1997) were not able to establish causality, only association. Accordingly, it is debatable as to whether people's attitudes are independent of urban form or whether they may be affected by urban form. If the latter is true, attitudinal questions may not be useful in investigating self-selection.

The time of year and the specific days of travel that we chose to administer our survey also impact people's travel behavior. March, April, and May were chosen as the appropriate months since they best approximate the average local conditions. However, some attributes of the pedestrian environment may not be present; for instance, the value of street trees in providing shade along the walking corridor is limited during the early spring and on overcast days.[7] Though we specified that the travel diaries should be filled-out on a Tuesday, Wednesday, or Thursday, some diaries were filled out for Mondays or Fridays and a small portion were filled out on weekends. While these later diaries were included in our study, they only accounted for 36 of 3736 trips.

Data Files

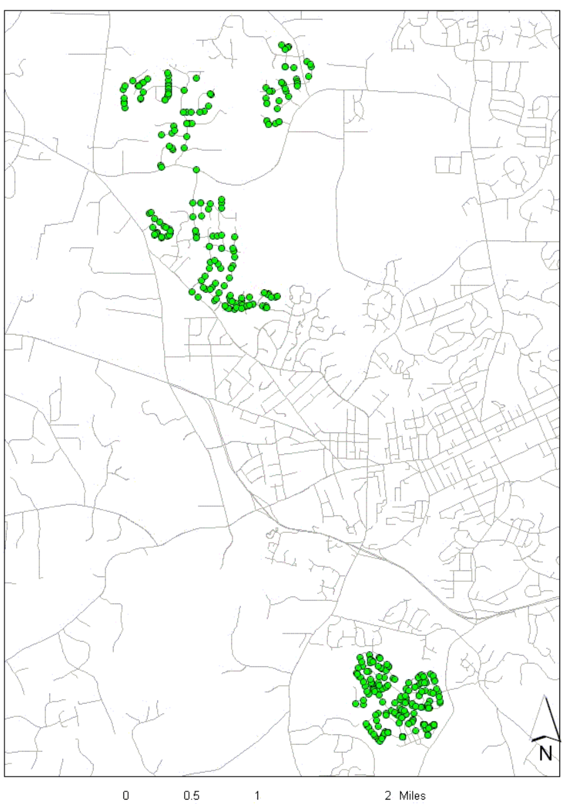
Four data files are provided with this report. The Household File codes responses to the household survey while the Trip File codes travel information from the travel diaries. The Person File provides information on all of the members of households that completed the household survey. The Trips per Household File links travel diary information to the household level. Appendix H provides a 'data dictionary' that describes the variables in the four data files.

[6] These studies include Boarnet and Crane (2001), Craig *et al* (2002), Handy (2002), Handy (1993), Handy and Clifton (2001), Kockelman (1997), Crane (2000), Boarnet and Sarmiento (1998), Boarnet and Crane (2001 – Book)
[7] Cervero and Kockelman (1997)

Socioeconomics

In this section socioeconomic data are presented at both the household head level and at the person level for Southern Village single-family homes, Southern Village multi-family homes, and northern Carrboro. Figure 3-4 shows the location of households that completed the survey. As expected there was missing data on income (29 percent of the households did not report their income). The median income of the reporting households varies considerably. Residents of Southern Village multi-family homes report the lowest median incomes, between $40,001 and $50,000. However, when Southern Village single-family homes are compared to Carrboro single-family homes, less variation is apparent. Both categories report median incomes between $100,001 and $150,000. The median head of household has attained a graduate or professional school degree. The variation among gender at the household level is considerable. In Southern Village single-family homes, 51.8 percent of household heads are male, compared with 60.6 percent in northern Carrboro and 28.0 percent in Southern Village multi-family homes. Median age for household heads displays moderate variation, with the most obvious disparities between single-family homes and apartments/condominiums. The median age of household heads in Southern Village multi-family homes is 38.04 years. For single-family homes, the average in Southern Village is 46.44 years and in northern Carrboro is 47.17 years. The average tenure at Southern Village is 2.98 years (N=214) and in northern Carrboro is 5.21 years (N=187).

Figure 3-4: Location of Households that Completed TND Survey



At the person level, which includes all adult members of the household above 16, the average age is 34.2 years in Southern Village multi-family homes, 33.0 years in Southern Village single-family homes, and 31.2 years in Carrboro single-family homes. The gender distribution is similar in both single-family study areas, with 46.9 percent male in Southern Village and 47.8 percent male in Carrboro. However, only 31.6 percent of the household members in Southern Village multi-family homes are male. The percentage of licensed drivers in Southern Village single-family homes and Carrboro single-family homes are 69 percent and 62.5 percent respectively. For Southern Village multi-family homes the percentage of licensed drivers is 90.4 percent. The household heads reported traveling, on average, 162 miles per week.

Although 26.5 percent of the cases were missing, among the household heads that responded, 51 percent did not telecommute. In addition, 84 percent had used the Internet almost everyday, while 6 percent reported never using it during the past 6 months. Overall, the respondents represent higher socioeconomic status and the neighborhoods are fairly comparable in terms of socioeconomic attributes.

Chapter 4: Analysis and Findings for Traveler Behavior

In this Chapter, we analyze the traveler behavior results in three broad ways. First, we will look at the descriptive statistics for each of the neighborhoods and how the households in our study compare to households surveyed in TTA's study. Next, we will estimate trip generation models for the neighborhood types and see how they compare to the trip generation model created from TTA's data. Finally, we will estimate other travel behavior models for each neighborhood. This chapter concludes with an analysis of the trip generation rates of the businesses located within Southern Village and how they compare to ITE trip generation rates.

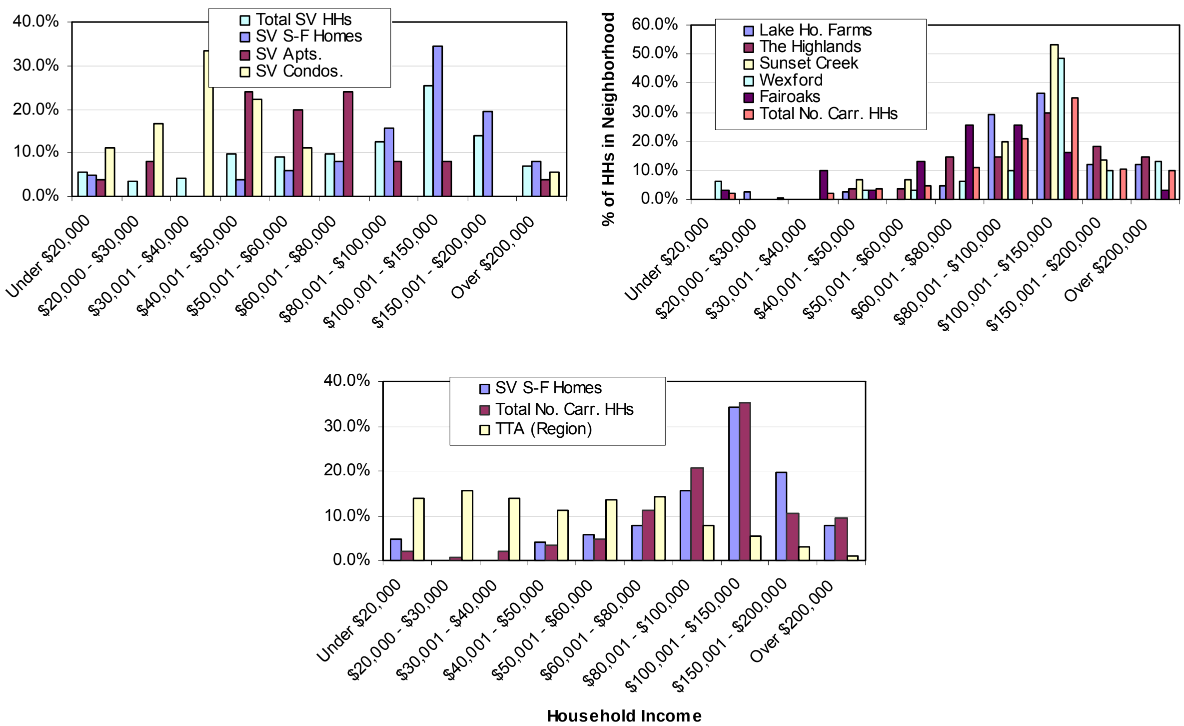
Descriptive Analysis

The following descriptive analysis will illustrate how the neighborhoods compare to one another and to the regional baseline. This analysis will show how travel behavior differs among the neighborhoods and the region as a whole and will help us identify what variables should be controlled for in our trip generation models. Unless noted otherwise, the analyses below discuss differences between households in the northern Carrboro neighborhood *taken in sum* and the *single-family* households in Southern Village so that we are comparing like cohorts. The variables in which we are most interested include income, housing values, the number of cars and people per households, the number of overall trips and chained trips, trip distances and times, and trip purposes, trip modes, and physical activity trips. For this and our subsequent trip generation analyses, we filtered out people under the age of 16 and the transit-enhanced cohort within the TTA dataset so that our and TTA's datasets and our subsequent analyses would be consistent and not over represent any one group.

Several of the analyses in this section contain two tables. The first is the trip data reported in by respondents in the surveys. The second accounts for 'missing' trip data, where one or more eligible people did not complete a travel diary. This occurred in 63 households. If these individuals were left unaccounted for, our analysis at the household level might misrepresent travel behavior. The 'missing' people were assigned the mean of each travel behavior attribute and then were linked at the household level. No new households were created in instances where every eligible person in that household failed to complete a travel diary. The inclusion of this missing data provides a more accurate picture of household travel behavior that can be compared to the TTA regional data.

Though only 64 percent (Southern Village apartments) to 94 percent (Wexford) of the households in each neighborhood reported their incomes (Appendix C), this is sufficient to determine how comparable our neighborhoods are to one another. Figure 4-1a shows that condominium dwellers in Southern Village have lower household incomes than apartment dwellers. Typically, condominium households contained fewer people, and therefore wage earners, than apartment dwellers. Household sizes are discussed later. Figure 4-1b shows that while households in most of the northern Carrboro neighborhoods have comparable incomes, households in Fairoaks have lower household incomes and Sunset Creek and Wexford have higher household incomes when compared to the average of the neighborhoods. Finally, Figure 4-1c shows that while the single-family homes of Southern Village have comparable household incomes to the homes in the northern Carrboro neighborhood, the households in the region have significantly smaller incomes than the households in our study. This difference is intuitive, however, since we purposefully selected neighborhoods that we feel are indicative of new and forthcoming developments in the area and because housing prices in Chapel Hill and Carrboro are notably higher than elsewhere in the region. In sum, the incomes of the neighborhoods that we will be analyzing in our study are comparable. Although they are higher than the region as a whole; accordingly, we will include income as an influencing variable across neighborhood types.

Figure 4-1: Comparative Household Income in a) Southern Village (66.5 percent reporting—145/218), b) Northern Carrboro (77 percent reporting—145/189) and c) the Triangle region



An analysis of housing values is important because housing values can be a more accurate indicator of income when compared to the self-reported household incomes analyzed above. This is because housing values represent what the household can afford based on all incomes, including non-occupational incomes such as retirement benefits, interest from saving accounts, payouts from trusts and stocks, and social security checks. Table 4-1 shows that the assessed value of homes is quite high (relative to the rest of the region). However, respondents to our survey live in slightly less highly valued homes on average when compared to the actual average household values in their neighborhood. Additionally, while there are differences between the neighborhoods of northern Carrboro, the mean housing values of Southern Village and the northern Carrboro neighborhoods are similar. However, the standard deviation and range of the housing values for the northern Carrboro neighborhoods are greater than the standard deviation and range of the housing values for Southern Village. This difference is largely due to the inclusion of the less expensive homes of the Fairoaks neighborhood. Yet, without the inclusion of these homes, the overall mean housing values for the northern Carrboro neighborhoods would be higher than the mean for the Southern Village homes (which, by definition, do not include apartment or condominium households). In sum, the housing values are comparable between our paired cohorts, i.e., the single-family homes of Southern Village and the homes in the northern Carrboro neighborhoods. Therefore our subsequent analyses will not have to take difference in housing prices into account.

Table 4-1: Assessed Housing Values of the Population

		Population				*Sample*		
	Pop.	Mean	Standard Deviation	Range	Sample	Mean	Standard Deviation	Range
Southern Village	**611**	**$301,787**	**$77,288**	**$559,528**	**167**	**$296,645**	**$69,575**	**$462,278**
Lake Hogan Farms	244	$346,765	$103,976	$537,387	58	$334,686	$100,456	$445,154
The Highlands	179	$327,484	$67,041	$339,666	37	$340,002	$72,264	$284,900
Sunset Creek	65	$315,153	$22,526	$108,310	23	$314,068	$19,676	$63,471
Wexford	248	$315,085	$74,921	$546,591	50	$307,971	$75,642	$374,293
Fairoaks	155	$182,905	$24,559	$131,755	38	$178,406	$25,120	$131,755
Total No. Carr. HHs	**891**	**$303,357**	**$93,720**	**$612,558**	**206**	**$298,026**	**$93,004**	**$520,823**

Note: Southern Village values are for single-family homes only.

Table 4-2 shows that, on average, households in Southern Village single-family homes are smaller than households in the northern Carrboro neighborhoods (2.72 versus 3.31 persons per household respectively) but larger than households in the greater Triangle region (2.32). Southern Village has 17.8 percent less people than households in the northern Carrboro and 17.2 percent more people than households in the region. While the apartment and condominium households in Southern Village have fewer people on average and smaller standard deviations than households elsewhere in the region, the single-family households in Southern Village have more people on average.

Additionally, Table 4-2 shows that households in Southern Village have fewer vehicles than households in the northern Carrboro neighborhoods and in the region. Specifically, in Southern Village, households have 11.3 percent less vehicles than households in the northern Carrboro neighborhoods ($p < 0.05$) and 2.6 percent less vehicles than households in the region. The greater number of vehicles per household in the northern Carrboro neighborhoods is most likely a result of several socioeconomic factors. We found that statistically controlling for the effects of income, household size and number of licensed drivers, the households in Southern Village own about 0.24 less vehicles per household. This issue of automobile ownership is critically important, partly because it is a major determinant of trip generation, and it needs further investigation. We will use these two variables in the trip generation model specification.

The results are largely consistent with NHTS (2003), which shows that the mean number of vehicles owned or available to U.S. households is 1.9. These data provides a useful national perspective and a reality check when used as a basis for comparison. Nationally, a majority of daily trips, 87 percent, were taken by personal vehicle. In addition, U.S. residents averaged 4 trips per day, totaling on average 40 miles of travel—most of it (35 miles) in a personal vehicle. For all adults nationally, including non-drivers and those who may not have driven on a given day, 55 minutes are spent behind the wheel driving 29 miles a day.

Table 4-2: Number of People and Cars in Household

		N	Number of People per HH: Mean	Standard Deviation	Range	Number of Cars per HH: Mean	Standard Deviation	Range
Southern Village	**Single-Family Homes**	**152**	**2.72**	**1.22**	**5**	**1.89**	**0.61**	**4**
	Apts.	39	1.77	0.96	3	1.31	0.57	3
	Condos.	26	1.23	0.43	1	1.15	0.37	1
	Total So. Vill. HHs	217	2.37	1.24	5	1.70	0.65	4
Conventional Neighborhoods	Lake Hogan Farms	54	3.09	1.17	4	2.13	0.62	4
	The Highlands	36	3.61	1.32	5	2.25	0.69	3
	Sunset Creek	19	3.68	0.95	4	2.16	0.37	1
	Wexford	47	3.49	1.28	6	2.15	0.59	3
	Fairoaks	33	2.88	1.08	4	1.97	0.64	2
	Total No. Carr. HHs	**189**	**3.31**	**1.22**	**6**	**2.13**	**0.61**	**4**
	Region (TTA)	1732	2.32	1.21	6	1.94	0.95	7

Note: The sample size reflects the households that completed the trip diaries.

An analysis of travel behavior shows that households in Southern Village make fewer trips than households in the northern Carrboro neighborhoods but more trips than households in the region (Table 4-3b). In the Southern Village, households make 12.1 percent fewer trips than households in the northern Carrboro neighborhoods (although this difference is not statistically significant—see later) and 29.6 percent more trips than households in the region. Also, the difference between Southern Village and the northern Carrboro neighborhoods does not hold at the person level. It is logical that households in Carrboro and Southern Village make more trips than households in the Triangle since households with higher income levels make more trips than households with lower income levels. There might be differences in reporting pedestrian/bicycle trips, as our survey stressed the importance of reporting such trips. Also, households in northern Carrboro have more people than households in Southern Village and elsewhere in the region.[8] As previously mentioned, household size will be included in the trip generation models.

Table 4-3: Number of Total Trips and Car Trips per Household

a. Descriptive Analysis (not accounting for missing data)

		N	Trips: Mean	Standard Deviation	Range	Auto Trips: Mean	Standard Deviation	Range
Southern Village	**Single-Family Homes**	**153**	**9.1**	**4.21**	**23**	**7.1**	**3.84**	**21**
	Apts.	39	7.2	4.59	21	5.0	3.27	15
	Condos.	26	5.6	2.28	10	3.3	1.72	8
	Total So. Vill. HHs	218	8.3	4.26	23	6.3	3.79	21
Conventional Neighborhoods	Lake Hogan Farms	54	9.4	4.27	19	8.9	4.18	19
	The Highlands	36	11.3	4.21	15	10.2	3.60	14
	Sunset Creek	19	9.5	5.03	18	8.7	4.53	17
	Wexford	47	10.6	4.01	17	9.3	3.56	16
	Fairoaks	33	10.1	5.63	23	8.5	5.17	21
	Total No. Carr. HHs	**189**	**10.2**	**4.55**	**24**	**9.2**	**4.16**	**22**
	TTA (Region)	1692	7.6	4.698	27	7	4.58	26

[8] See Targa's study in Appendix F.

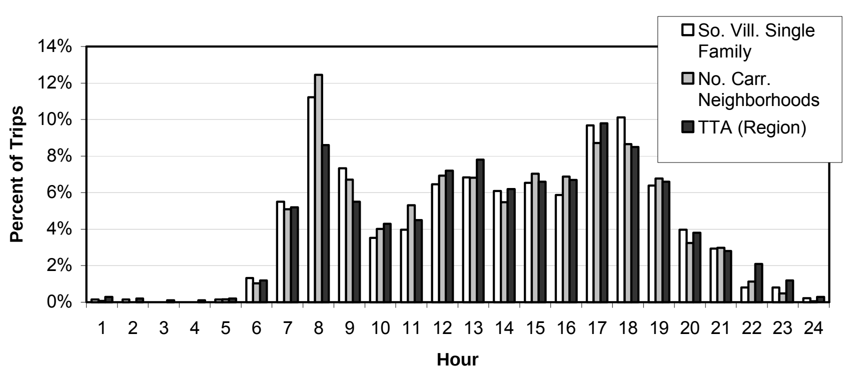
b. Descriptive Analysis (accounting for missing data)

		N	*Trips* Mean	Standard Deviation	Range	*Auto Trips* Mean	Standard Deviation	Range
Southern Village	**Single-Family Homes**	**153**	**9.8**	**4.33**	**26**	**7.7**	**3.99**	**25**
	Apts.	39	7.7	4.89	21	5.3	3.47	15
	Condos.	26	5.8	2.51	10	3.4	1.58	8
	Total So. Vill. HHs	218	9.0	4.48	25	6.8	3.99	26
Conventional Neighborhoods	Lake Hogan Farms	54	10.4	4.27	22	9.8	4.21	22
	The Highlands	36	12.3	4.10	15	11.1	3.59	13
	Sunset Creek	19	11.2	3.81	14	10.2	3.35	13
	Wexford	47	11.6	4.08	17	10.2	3.62	16
	Fairoaks	33	10.7	5.40	23	9.0	5.04	21
	Total No. Carr. HHs	**189**	**11.2**	**4.38**	**23**	**10.1**	**4.06**	**24**
	TTA (Region)	1692	7.6	4.698	27	7	4.58	26

Table 4-3b also shows that households in Southern Village make substantially less automobile trips than households in the northern Carrboro neighborhoods. Specifically, households in Southern Village make 23.4 percent fewer auto trips than households in the northern Carrboro neighborhoods. This observation is theoretically logical, because households in the traditional neighborhood are located within walking and bicycling distance of the village retail center, and because two bus routes serve the community. Households in the traditional neighborhood, on the other hand, make only 10.1 percent more auto trips than households in the region, which probably reflects differences in socioeconomic status. The standard deviation for auto trips per household in the northern Carrboro neighborhoods is slightly higher than the standard deviation for car trips per household in Southern Village but not as high as the standard deviation for auto trips per household in the region, meaning there is greater variability in car trips in the region than in northern Carrboro neighborhoods and Southern Village.

Figure 4-2 shows the start time of trips for households in Southern Village, in the northern Carrboro neighborhoods, and in the region. This figure provides us with an idea of when traffic volumes on area roads are highest. The distributions are quite similar and bimodal, reflecting the two peak periods in a typical weekday. While households in Southern Village and the northern Carrboro neighborhoods begin more trips during the morning rush hour, households in the region make slightly more trips during the middle of the day.

Figure 4-2: Start Time of Trips



Note: Sample size for Southern Village = 1363 trips; Northern Carrboro = 1847 and Triangle region = 12,087.

As mentioned earlier, trip chaining is another component of trip generation and is defined as the process of making a series of non-home based trips in a row. Trip chaining is composed of stops and each chain of stops is known as a tour, i.e., a tour starts and ends at home. Therefore,

No. of TRIPS = No. of TOURS + No. of STOPS

That is, number of trips equals the number of tours and stops.[9] Greater chaining of trips (i.e., fewer tours and more stops) is more convenient for single occupant automobile users than for carpoolers or transit users. Trip chaining is generally considered more efficient, from a transportation network perspective, than people returning home after accessing a non-home destination. Table 4-4b shows that households in Southern Village single family households make 11.9 percent fewer tours than households in the northern Carrboro neighborhoods (3.7 versus 4.2 tours respectively). However, tours made by households in the Southern Village single family households have fewer stops than households in the northern Carrboro neighborhoods (6.1 stops versus 6.9 stops). Specifically, households in the Southern Village make 11.6 percent fewer stops than the northern Carrboro neighborhoods. These findings do not show a clear trend on way or another and owning to the large standard deviation, the differences are not statistically significant (p = 0.05).

Table 4-4: Tours and Stops per Household

a. Descriptive Analysis (not accounting for missing data)

			Tours			*Stops*		
		N	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range
Southern Village	**Single-Family Homes**	**153**	**3.1**	**2.0**	**11.0**	**5.7**	**2.9**	**16.0**
	Apts.	38	2.9	2.1	9.0	4.1	2.7	12.0
	Condos.	27	2.6	1.4	5.0	3.2	1.8	9.0
	Total So. Vill. HHs	218	3.2	1.9	10.0	5.1	2.9	16.0
Conventional Neighborhoods	Lake Hogan Farms	54	3.6	1.6	6.0	5.8	3.2	13.0
	The Highlands	36	4.2	1.7	6.0	7.1	3.1	12.0
	Sunset Creek	19	3.6	2.0	7.0	5.9	3.4	12.0
	Wexford	47	4.0	1.9	7.0	6.5	2.5	10.0
	Fairoaks	33	3.7	2.3	10.0	6.3	3.9	15.0
	Total No. Carr. HHs	**189**	**3.9**	**1.8**	**10.0**	**6.3**	**3.2**	**16.0**

[9] Except in instances where a trip's origin and destination are home, such as a leisure walk, jog or bicycle ride. These trips are considered as a tour without a stop.

b. Descriptive Analysis (accounting for missing data)

		N	*Tours* Mean	*Tours* Standard Deviation	*Tours* Range	*Stops* Mean	*Stops* Standard Deviation	*Stops* Range
Southern Village	**Single-Family Homes**	**153**	**3.7**	**1.9**	**11.7**	**6.1**	**3.0**	**16.0**
	Apts.	38	3.1	2.1	9.0	4.4	3.1	12.0
	Condos.	27	2.7	1.5	5.0	3.3	1.9	9.0
	Total So. Vill. HHs	218	3.4	1.9	11.7	5.5	3.1	16.0
Conventional Neighborhoods	Lake Hogan Farms	54	4.0	1.5	6.8	6.4	3.2	15.3
	The Highlands	36	4.6	1.6	6.0	7.7	3.0	11.0
	Sunset Creek	19	4.2	1.7	6.0	7.0	2.6	9.0
	Wexford	47	4.4	1.8	7.0	7.1	2.6	10.5
	Fairoaks	33	3.9	2.2	10.0	6.7	3.8	15.0
	Total No. Carr. HHs	**189**	**4.2**	**1.7**	**10.0**	**6.9**	**3.1**	**15.3**

Households in the Southern Village on average travel shorter distances (52 miles per day) than households in the northern Carrboro neighborhoods (80 miles a day) (Table 4-5b). Indeed, average daily miles traveled are over 28 miles less for households in Southern Village than households in the northern Carrboro neighborhoods. The standard deviation for trip distance per household in the northern Carrboro neighborhood is higher than the standard deviation for trip distance per household in Southern Village, meaning there is greater variability in trip distance per household in the northern Carrboro neighborhood than in Southern Village. Trip distances from the regional dataset are unavailable. Because it has been postulated that households in the northern Carrboro neighborhoods make more regional trips than households in Southern Village due to their proximities to the Interstates (40 and 85) and to the University of North Carolina respectively, we tested trips that are greater than 10 miles in order to more closely examine these regional trips.

Households in Southern Village single family homes spend 2.8 hours and northern Carrboro households spend 3.1 hours making their daily trips. This is in line with the national average of nearly 55 minutes per resident—the average for Southern Village *resident* is approximately 62 minutes ([2.8*60]/2.72) and for northern Carrboro, it is 56 minutes ([3.1*60/3.31]). Clearly, households in Southern Village spend 20 minutes less making trips than household in the northern Carrboro neighborhoods but on a per person basis, this difference does not hold. Also note that compared to the region, the households spend more time on their travel (Table 4-5b). The standard deviations for trip length in terms of daily travel time per household are notably smaller for the two study areas than for the region, which may be a result of greater homogeneity in households in the study areas than in the region with respect to socioeconomic characteristics, such as income.

Table 4-5: Daily Length of Trips per Household in Time and Distance

a. Descriptive Analysis (not accounting for missing data)

			Distance (miles)			*Duration (hours)*		
		N	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range
Southern Village	**Single-Family Homes**	**153**	**52**	**33.1**	**160**	**2.6**	**1.13**	**4.8**
	Apts.	39	39	35.5	122	1.9	1.31	5.6
	Condos.	26	39	39.2	136	1.7	1.00	3.9
	Total So. Vill. HHs	218	48	34.6	160	2.3	1.20	5.6
Conventional Neighborhoods	Lake Hogan Farms	54	75	37.5	166	2.8	1.02	3.9
	The Highlands	36	75	36.3	144	3.0	1.23	5.1
	Sunset Creek	19	52	36.9	156	2.3	1.36	4.6
	Wexford	47	71	47.5	227	2.9	1.27	5.8
	Fairoaks	33	81	64.4	311	3.1	1.49	5.7
	Total No. Carr. HHs	**189**	**73**	**45.7**	**317**	**2.9**	**1.25**	**6.5**
	TTA (Region)	1692	n/a	n/a	n/a	2.2	1.68	15.4

b. Descriptive Analysis (accounting for missing data)

			Distance (miles)			*Duration (hours)*		
		N	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range
Southern Village	**Single-Family Homes**	**153**	**56**	**33.1**	**160**	**2.8**	**1.15**	**5.8**
	Apts.	39	43	38.9	151	2.0	1.40	5.6
	Condos.	26	40	38.6	136	1.8	1.02	3.9
	Total So. Vill. HHs	218	52	35.4	160	2.5	1.25	6.2
Conventional Neighborhoods	Lake Hogan Farms	54	82	35.1	190	3.1	0.98	4.6
	The Highlands	36	82	37.1	144	3.3	1.28	5.1
	Sunset Creek	19	64	33.9	156	2.8	1.02	3.6
	Wexford	47	78	47.5	227	3.2	1.25	5.7
	Fairoaks	33	85	67.1	344	3.3	1.52	6.8
	Total No. Carr. HHs	**189**	**80**	**45.4**	**355**	**3.1**	**1.21**	**6.9**
	TTA (Region)	1692	n/a	n/a	n/a	2.2	1.68	15.4

Note: N = 407 due to missing data

Households in Southern Village make 30.3 percent fewer regional trips (defined as greater than 10 miles) per day than households in the northern Carrboro neighborhoods (Table 4-6b). Due to the northern Carrboro neighborhoods proximity to major Interstates and State roads, it is likely that the regional trips are work related. Accordingly, we will attempt to account for these regional trips in our statistical analyses. The standard deviation for regional trips per household in the northern Carrboro neighborhood is higher than the standard deviation for regional trips per household in Southern Village, meaning there is greater variability in regional trips per household in the northern Carrboro neighborhood than in Southern Village.

Table 4-6: Regional Trips (> 10 miles) per Household per Day

a. Descriptive Analysis (not accounting for missing data)

		N	*Regional Trips* Mean	Standard Deviation	Range
Southern Village	**Single-Family Homes**	**153**	**1.4**	**1.39**	**6**
	Apts.	39	1.0	1.46	5
	Condos.	26	0.7	1.09	4
	Total So. Vill. HHs	218	1.2	1.39	6
Conventional Neighborhoods	Lake Hogan Farms	54	2.1	1.91	7
	The Highlands	36	2.1	1.19	4
	Sunset Creek	19	1.2	1.17	4
	Wexford	47	1.7	1.43	4
	Fairoaks	33	2.2	1.79	7
	Total No. Carr. HHs	**189**	**1.9**	**1.60**	**7**
	TTA (Region)	1692	n/a	n/a	n/a

b. Descriptive Analysis (accounting for missing data)

		N	*Regional Trips* Mean	Standard Deviation	Range
Southern Village	**Single-Family Homes**	**153**	**1.5**	**1.37**	**6**
	Apts.	39	1.1	1.54	6
	Condos.	26	0.7	1.09	4
	Total So. Vill. HHs	218	1.3	1.40	6
Conventional Neighborhoods	Lake Hogan Farms	54	2.3	1.85	8
	The Highlands	36	2.3	1.24	5
	Sunset Creek	19	1.5	1.12	4
	Wexford	47	1.9	1.46	5
	Fairoaks	33	2.3	1.78	7
	Total No. Carr. HHs	**189**	**2.1**	**1.58**	**8**
	TTA (Region)	1692	n/a	n/a	n/a

As Table 4-2 showed, northern Carrboro has more people and cars per household than the single-family homes in Southern Village. While a number of the observations and discussions mentioned above, such as the higher number of auto trips and the longer trips for households in northern Carrboro, can be largely attributed simply to the fact that those households have more people and more cars than the single-family households in Southern Village, some of the observations still hold true at the person level (Table 4-7). In particular, people in Northern Carrboro make 15.2 percent more auto trips and travel over 8 miles more than people in Southern Village. However, some of the observations discussed above, such as the differences in trip chaining across neighborhoods, do not appear to hold at the person level. These and other observations will be further analyzed by statistically controlling for such factors as household size and number of vehicles in the following section.

Table 4-7: Variable Means at the Person Level – Residents of Single Family Homes

Variable	Southern Village Single-Family N	Mean	Std Dev	Northern Carrboro N	Mean	Std Dev
Trips	271	5.12	2.48	366	5.26	2.89
Auto Trips*	271	4.01	2.37	366	4.73	2.64
Tours	271	1.92	1.06	366	1.99	1.15
Stops	271	3.20	1.90	366	3.27	2.05
Trip Distance (miles)*	270	29.35	21.88	364	37.70	30.99
Trip Time (hours)	271	1.45	0.66	366	1.48	0.79

* Means are statistically different at the 95% confidence level

External automobile trips are of interest because they are contributors to traffic congestion and related environmental impacts. Households in Southern Village make fewer external trips that are shorter in both distance and time (Table 4-8b). Households in Southern Village make on average 25.8 percent fewer external trips, defined as trips outside the neighborhood, when compared to households in the northern Carrboro neighborhoods. This observation is not surprising since there are more non-residential destinations in the traditional neighborhood than within the conventional neighborhoods. Additionally, households in Southern Village make shorter external trips than households in the northern Carrboro neighborhoods, measured both in hours and in miles. External trips in Southern Village are about 37 minutes shorter and 24.6 miles less (per household per day) than in the conventional neighborhoods. This observation may be due to the fact that more people in Southern Village work in the Chapel Hill area than do people in northern Carrboro. This possibility will be investigated in more depth later. For each variable, the smaller standard deviations for households in Southern Village mean that there is less variation (greater uniformity) in external trips than there is for households in northern Carrboro.

Table 4-8: External Trips and External Trip Duration and Distance per Household per Day

a. Descriptive Analysis (not accounting for missing data)

			Trips			*Duration*			*Distance*		
		N	Mean	Stan. Dev.	Range	Mean	Stan. Dev.	Range	Mean	Stan. Dev.	Range
Southern Village	**Single-Family Homes**	**153**	**7.24**	**3.77**	**22**	**2.10**	**1.05**	**5.10**	**50.13**	**32.98**	**163**
	Apts.	39	5.90	3.48	15	1.57	1.08	4.98	37.58	35.03	122
	Condos.	26	4.15	2.13	10	1.34	0.82	2.75	37.63	37.64	137
	Total So. Vill. HHs	218	6.63	3.70	22	1.91	1.07	5.10	46.40	34.48	163
Conventional Neighborhoods	Lake Hogan Farms	54	8.87	4.15	19	2.57	1.03	4.25	74.02	37.72	174
	The Highlands	36	10.47	3.98	15	2.71	1.18	4.26	74.07	38.54	144
	Sunset Creek	19	9.37	5.02	18	2.28	1.34	4.58	51.89	36.76	156
	Wexford	47	10.13	3.79	16	2.67	1.14	5.42	70.32	47.55	225
	Fairoaks	33	9.39	5.29	21	2.80	1.49	5.66	79.92	64.72	311
	Total No. Carr. HHs	**189**	**9.63**	**4.35**	**22**	**2.63**	**1.20**	**6.03**	**71.91**	**45.82**	**317**

b. Descriptive Analysis (accounting for missing data)

		N	Trips: Mean	Trips: Stan. Dev.	Trips: Range	Duration: Mean	Duration: Stan. Dev.	Duration: Range	Distance: Mean	Distance: Stan. Dev.	Distance: Range
Southern Village	**Single-Family Homes**	**153**	**7.85**	**3.95**	**25.08**	**2.28**	**1.08**	**6.03**	**54.40**	**33.07**	**162**
	Apts.	39	6.30	3.75	15	1.68	1.17	4.98	40.50	38.36	148
	Condos.	26	4.31	2.11	10	1.38	0.83	2.75	38.73	38.85	137
	Total So. Vill. HHs	218	7.15	3.92	25.08	2.06	1.12	6.03	50.05	35.25	162
Conventional Neighborhoods	Lake Hogan Farms	54	9.79	4.21	21.97	2.82	0.98	4.69	80.93	35.28	189
	The Highlands	36	11.44	3.97	15	2.98	1.23	4.87	81.33	37.32	144
	Sunset Creek	19	10.94	3.84	14	2.71	1.01	3.58	63.68	33.75	156
	Wexford	47	11.08	3.82	16	2.93	1.10	5.17	77.47	47.54	225
	Fairoaks	33	10.00	5.12	21	2.96	1.54	6.73	84.45	67.50	346
	Total No. Carr. HHs	**189**	**10.58**	**4.22**	**22.97**	**2.89**	**1.16**	**6.91**	**79.03**	**45.60**	**354**

Table 4-9 and Figure 4-3 show the percent of trips by mode by neighborhood and housing type. Compared to households in the northern Carrboro neighborhoods and households in the region, households in Southern Village make more walking and bus trips and fewer auto trips. In particular, in Southern Village, 78.4 percent of trips are by car, compared with 89.9 percent in the northern Carrboro neighborhoods and 92.4 percent in the region and 87 percent nationally. Additionally, 17.2 percent of all trips in Southern Village are walking, compared with 7.3 percent in the northern Carrboro neighborhoods and 5.1 percent in the region. The significant mode choice differences in the traditional neighborhood are likely attributable to three factors: The walkable distance between residences and the commercial center, the pedestrian-oriented design of the neighborhood and its network of trails and sidewalks, and the availability of direct bus routes from the neighborhood to the university and downtown areas. The lower bicycle mode share in the traditional neighborhood is probably related to the hilly condition of the neighborhood and because it is connected to the rest of Chapel Hill via a local highway that makes bicycling outside of the neighborhood rather unsafe.

Table 4-9: Trips by Mode by Neighborhood

		N	Car	Bus	Walk	Bike	Other
Southern Village	***Single-Family Homes***	152	78.4%	3.5%	17.2%	0.5%	0.4%
	Apts.	39	69.2%	10.8%	19.7%	0.4%	0.0%
	Condos.	26	58.9%	13.7%	27.4%	0.0%	0.0%
	Total SV HHs	217	75.4%	5.5%	18.4%	0.4%	0.3%
Conventional Neighborhoods	Lake Hogan Farms	54	94.9%	0.0%	4.7%	0.4%	0.0%
	The Highlands	36	90.4%	0.5%	8.1%	0.7%	0.2%
	Sunset Creek	19	91.7%	1.1%	3.9%	3.3%	0.0%
	Wexford	47	87.7%	1.0%	8.7%	2.4%	0.2%
	Fairoaks	33	84.0%	1.2%	10.3%	4.5%	0.0%
	Total Conv HHs	189	89.9%	0.8%	7.3%	2.0%	0.1%
	TTA (Region)	1692	92.4%	1.4%	5.1%	0.6%	0.6%

Figure 4-3: Trips by Mode by Neighborhood

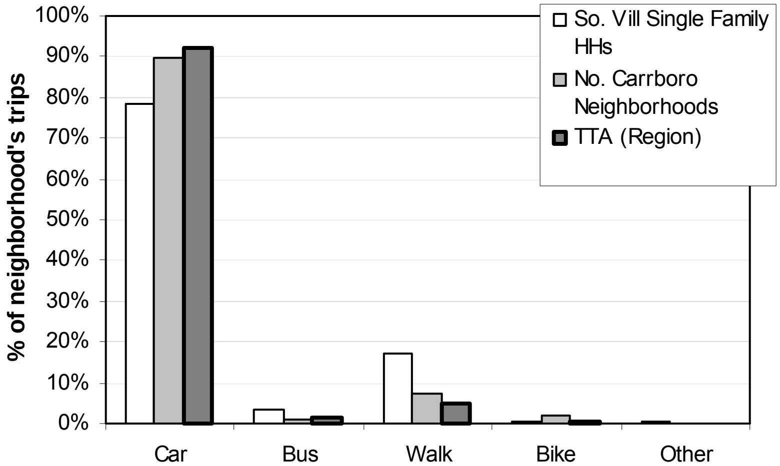


Figure 4-4 shows the mode share of internal and external trips in Southern Village and northern Carrboro single-family homes. It provides additional insights by comparing modal choices by the type of trip (internal or external). Trips that do not begin and end in the neighborhood are classified as external trips. Even though the conventional neighborhood has very few internal trips (5.5 percent), the vast majority of those trips are by pedestrian mode (84 percent). By contrast, Southern Village has much more internal trips (20.2 percent), though fewer of the internal trips were by pedestrian mode (63 percent). Thus, 1) the internal trip capture rate of Southern Village is substantially higher (14.7 percent) and 2) the percentage of internal auto trips is higher in Southern Village. This probably indicates that a greater percentage of internal trips in the northern Carrboro neighborhoods are for recreational purposes, such as jogging or walking a dog, while in Southern Village, internal trips represent both recreational trips as well as utilitarian trips, such as to the retail/office center or to the elementary school, which can be made by several modes. The differences are less pronounced for external trips. In both neighborhood types, more than 90 percent of external trips were made by auto and less than 10 percent were made by other modes.

Figure 4-4: External and Internal Trips by Mode Share

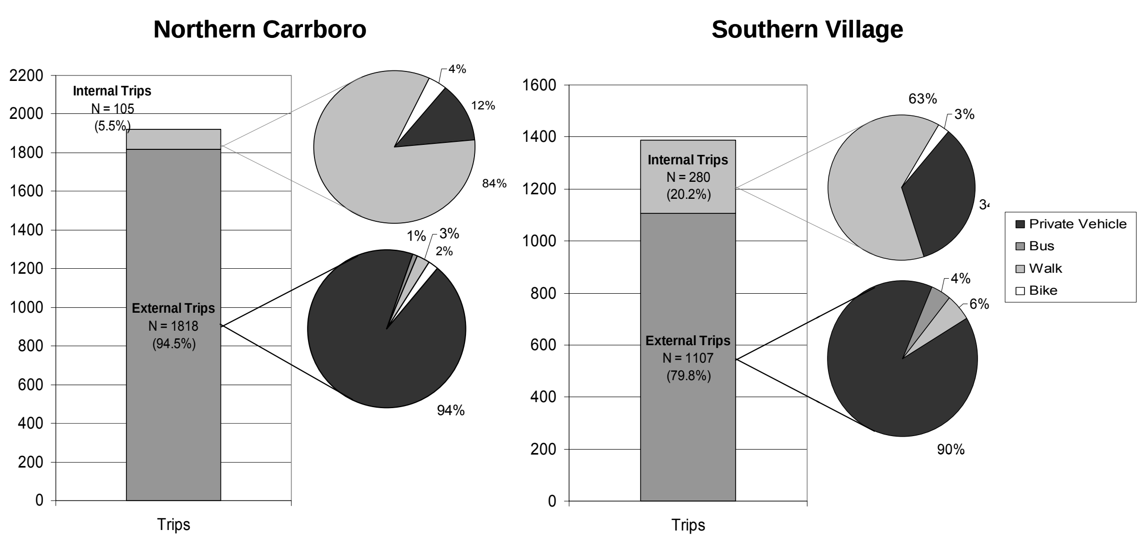
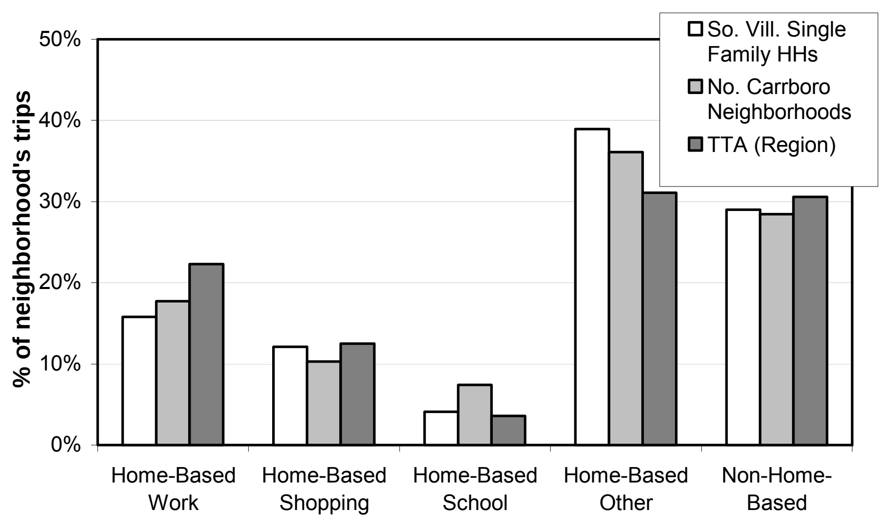


Table 4-10 and Figure 4-5 show the percent of trips by purpose by neighborhood or housing type. The breakdown is quite similar across the two neighborhoods. Compared to the regional baseline, households in Southern Village and the northern Carrboro neighborhoods make fewer home-based work trips per day. Conversely, both neighborhoods make more home-based other and home-based school trips per day. Home-based other trips are composed of trips with a home end made to and/or from services such as doctor's appointments, restaurants, and dry cleaners, and trips made to transport people to places such as school and work. These differences may be attributable to the presence of the University of North Carolina in Chapel Hill, older couples with high school-aged children, and the presence of college-aged and furthering education students living in both of these neighborhoods.

Table 4-10: Trip Type per Neighborhood

		N	Home-Based Work	Home-Based Shopping	Home-Based School	Home-Based Other	Non-Home-Based
Southern Village	***Single-Family Homes***	**152**	15.8%	12.1%	4.1%	39.0%	29.0%
	Apts.	39	24.0%	14.0%	9.3%	31.2%	21.5%
	Condos.	26	20.5%	10.3%	12.3%	41.8%	15.1%
	Total SV HHs	217	17.4%	12.3%	5.6%	38.0%	26.7%
Conventional Neighborhoods	Lake Hogan Farms	54	15.3%	15.9%	5.3%	35.4%	28.1%
	The Highlands	36	18.4%	9.1%	7.6%	35.4%	29.5%
	Sunset Creek	19	14.4%	6.6%	12.7%	40.3%	26.0%
	Wexford	47	18.5%	7.7%	8.1%	39.9%	25.8%
	Fairoaks	33	21.7%	9.6%	6.9%	30.4%	31.3%
	Total Conv HHs	**189**	17.7%	10.3%	7.4%	36.1%	28.4%
	TTA (Region)	1692	22.3%	12.5%	3.6%	31.1%	30.6%

Figure 4-5: Trip Type by Neighborhood



Figures 4-6 and 4-7 show the mode choice of Southern Village and northern Carrboro residents by trip type. In each of the five trip types below, home-based work, home-based shop, home-based school, home-based other and non-home based, single-family households in Southern Village report significantly less automobile usage. In northern Carrboro, about 98 percent of home-based work trips and 83 percent of home-based school trips are by auto compared with 84 percent 70 percent respectively in Southern Village. This makes sense, due to the direct bus routes from Southern Village to the university and the proximity of Scroggs Elementary School. Interestingly, in northern Carrboro 99 percent of home-based shopping trips are made by auto compared with 80 percent in Southern Village (a 19 percent difference). Again, this is logical, due to the presence of a grocery store and other services in the Southern Village commercial area. Walking trips are made for shopping (usually to the grocery store located in the commercial area of the neighborhood) as well as to other locations in the neighborhood, including trips to neighbor's homes, to escort children to school, and trips to the service-related businesses in the commercial area, such as the cleaners, the restaurant, and the movie theater. Finally, 94 percent of non-home-based trips are by auto in northern Carrboro, compared with 81 percent in Southern Village. Non-home-based walking trips represent the chaining of trips. Walking accounts for 16.1 percent of non-home-based trips in Southern Village (4.4 percent in northern Carrboro), which were usually from one destination in the commercial area to another or trips from escorting children to school and then going to the commercial area.

Figure 4-6: Trips by Mode by Type (Southern Village)

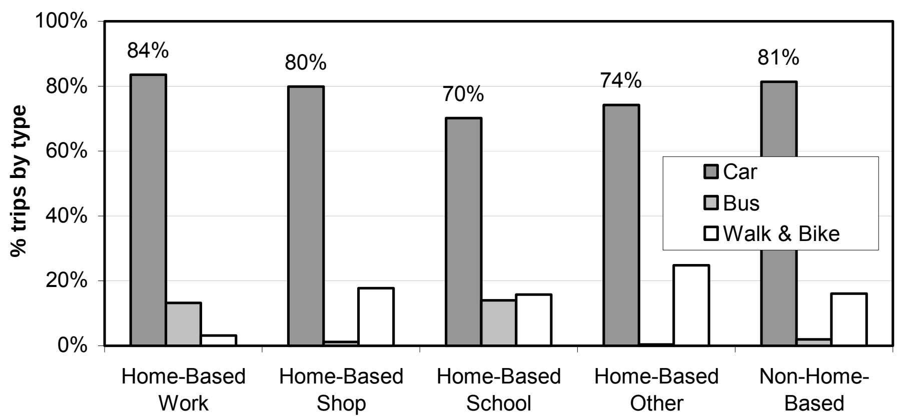
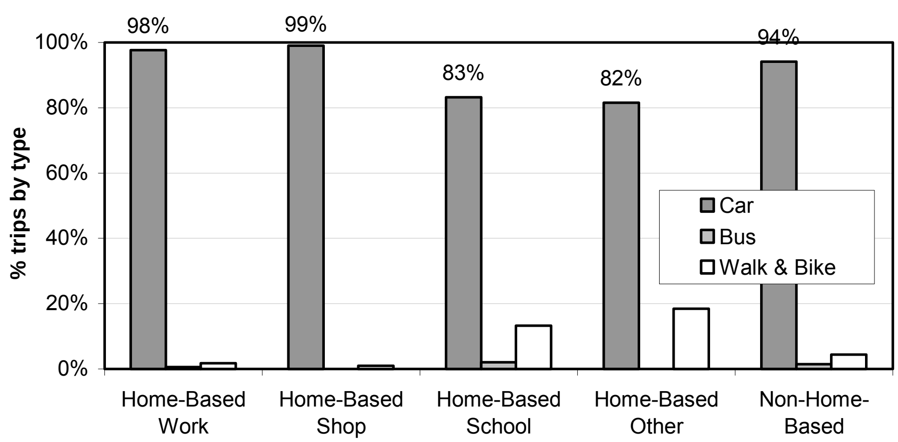


Figure 4-7: Trips by Mode by Type (northern Carrboro)



The distance of trips per person by mode for the residents of Southern Village is shown in Figure 4-8. These distances correspond with the trip purposes discussed above, namely, that walking trips represent shorter trips within the neighborhood and car and bus trips represent trips outside of the neighborhood to school and to work.

Figure 4-8: Trip Distance by Mode (Southern Village)

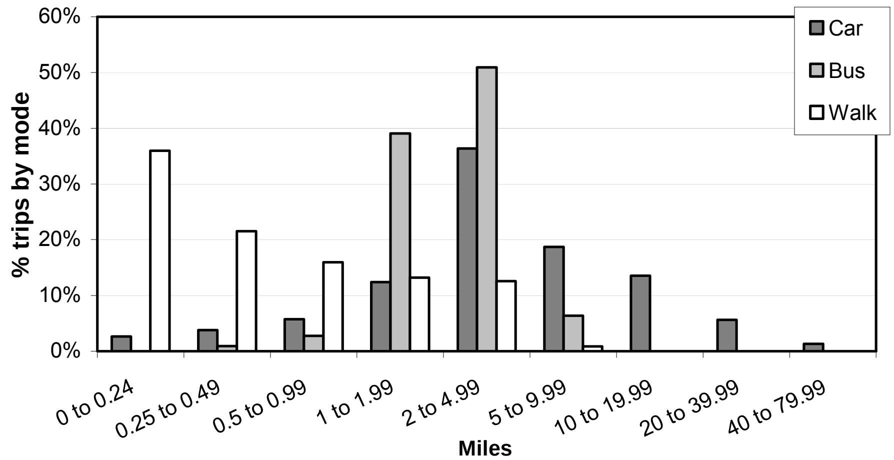
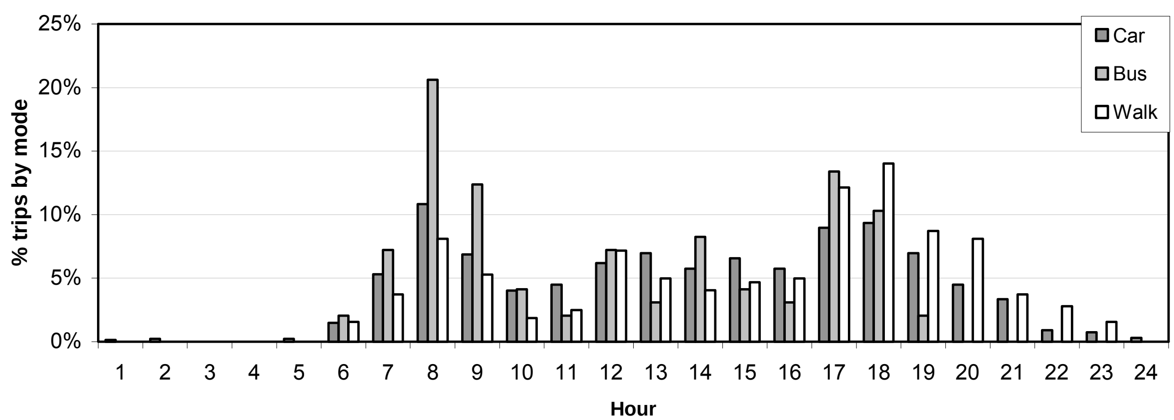


Figure 4-9 shows the start time of trips per person by mode for the residents of Southern Village. These start times also correspond with the types of trips discussed above. Specifically, most walking trips are made in the morning to escort children to school and in the evening to go to the commercial area. Likewise, but to a greater extent in the morning, most bus trips occur in the morning and in the evening with some trips around the lunch hour as well, perhaps for students and employees of the university attending classes and going to their work shifts, respectively. Unsurprisingly, most car trips are made equally in the morning and evening as people travel to work and in between these times as people shop, run errands, and go to lunch.

Figure 4-9: Trip Start Times by Mode -- Southern Village (N=1,337)



Physical activity is becoming increasingly important as people and the government becomes more aware of the overweight and obesity problem in the U.S. population. People might also be moving to traditional neighborhoods, based on their physical activity needs. Table 4-11 shows the mean number of physical activity trips, duration, and distance for the *people* living in single-family homes in Southern Village and the conventional neighborhoods. This analysis is done at the person level because the choice to be physically active is made by the person, whereas a decision to drive somewhere can be a choice of the household. A base set of data for northern Carrboro is presented, along with corrected data that removed four long recreational bicycle trips. The analysis is conducted between Southern Village and the corrected northern Carrboro data.

In Southern Village, residents make 89.1 percent more physical activity trips for 60.2 percent longer durations and 27.2 percent longer distances (Table 4-11a). However, subdividing physical activity into recreational physical activity and utilitarian physical activity reveals that this difference is largely driven by utilitarian physical activity trips. For recreational physical activity trips, Southern Village residents make 29.1 percent more trips that are 28.6 percent longer in duration and 10.6 percent longer in distance (Table 4-11b). For utilitarian physical activity trips, Southern Village residents make nearly 2.6 times more trips, for 2.2 times longer duration and 1.65 times longer distance (Table 4-11c). This is not surprising, since the retail core is located within walking distance of most Southern Village residences. A more in depth study of these trips should include the geocoding of the location and, if possible, the path of the physical activity trip in order to determine if the trip did in fact take place within the neighborhood.

Table 4-11: Physical Activity Trips by People by Neighborhood

a. All Physical Activity Trips

		Total Trips			All Physical Activity Trips								
					Trips			Duration (hours)			Distance (miles)		
	N	Mean	Std Dev	Range	Mean	Std Dev	Range	Mean	Std Dev	Range	Mean	Std Dev	Range
SV Single Family Homes	271	5.11	2.47	12.00	0.90	1.52	9.00	0.29	0.45	2.58	0.85	1.50	8.40
No Carrboro	366	5.26	2.89	16.00	0.49	1.06	8.00	0.20	0.43	3.06	0.89	2.92	30.00
No Carrboro (no outliers)*	366	5.26	2.89	16.00	0.48	1.05	8.00	0.18	0.40	3.06	0.67	1.68	10.00

b. Recreational Physical Activity Trips

		Total Trips			Recreational Physical Activity Trips								
					Trips			Duration (hours)			Distance (miles)		
	N	Mean	Std Dev	Range	Mean	Std Dev	Range	Mean	Std Dev	Range	Mean	Std Dev	Range
SV Single Family Homes	271	5.11	2.47	12.00	0.31	0.59	4.00	0.18	0.36	2.25	0.52	1.11	6.00
No Carrboro	366	5.26	2.89	16.00	0.25	0.57	4.00	0.15	0.35	2.50	0.69	2.51	28.00
No Carrboro (no outliers)*	366	5.25	2.89	16.00	0.24	0.56	4.00	0.14	0.33	2.50	0.47	1.31	10.00

c. Utilitarian Physical Activity Trips

		Total Trips			Utilitarian Physical Activity Trips								
					Trips			Duration (hours)			Distance (miles)		
	N	Mean	Std Dev	Range	Mean	Std Dev	Range	Mean	Std Dev	Range	Mean	Std Dev	Range
SV Single Family Homes	271	5.11	2.47	12.00	0.60	1.37	8.00	0.11	0.28	2.08	0.33	0.98	7.00
No Carrboro	366	5.26	2.89	16.00	0.23	0.80	6.00	0.05	0.18	1.74	0.20	0.92	10.00
No Carrboro (no outliers)*	366	5.25	2.89	16.00	0.23	0.80	6.00	0.05	0.18	1.74	0.20	0.92	10.00

* four outlying trips were removed - 15, 19, 20 and 28 mile bike rides

This section analyzed how our two neighborhoods compare to one another and to the regional baseline. It showed that while residents in Southern Village single-family homes own less automobiles per household, take less trips and auto trips, drive less distance and for less duration, and make fewer regional trips than northern Carrboro, these differences only hold for auto trips and trip distance at the person level.

Estimation of Trip Generation Models

Typically, category analysis or regression models are used to predict trip frequency for a region or a major development. In this section, we estimate regression models that are intended to understand the factors that influence travel behavior and that can also be used for prediction purposes. Therefore, we restrict the model specifications to variables that can be forecasted. Also, category analysis can be subsumed into regressions, therefore we focus on analyzing the data using regression.

In order to compare the results of our trip generation model to a regional baseline, we first estimated a household-level trip generation model using the abbreviated TTA dataset with household size, number of vehicles, and income ranges as the independent variables (Table 4-12). This last set of variables is indicator variables. The most interesting result of this model is that, in general terms, households with higher incomes are associated with more trips per household.

Table 4-12: Trip generation model of the Triangle

		Coeff.	T stat
Constant		2.262***	9.00
Size of Household		1.302***	15.76
Number of Vehicles		0.827***	7.75
Household Income	$20-30,000	-0.204	-0.70
	$30-40,000	0.323	1.06
	$40-50,000	0.890***	2.67
	$50-60,000	0.707**	2.23
	$60-80,000	1.036***	3.29
	$80-100,000	1.156***	2.93
	$100-150,000	1.347***	2.95
	$150-200,000	0.356	0.62
	> $200,000	3.267***	3.40
N		1731	
F statistic		63.48	
R-square		0.289	
Adjusted R-square		0.284	

Note: The mean, standard deviation, and range of the dependent variable (total trips) are 7.37, 4.31, and 25, respectively

*** Significant at the 99% confidence level

** Significant at the 95% confidence level

* Significant at the 90% confidence level

A more complete trip generation model developed by Targa (2002) is attached as Appendix F. Targa's model takes into account census block level information such as race, density, and proportions of people commuting to work by various modes and is a better model for trip generation than a simple trip generation model when used at the regional level. However, Targa's model is not appropriate for our study at the household level since no comparable variables to those used in his model exist for our study.

With a baseline model in place, we then estimated trip generation models for each neighborhood. However, the income range variables that were significant at the regional level were not statistically significant for the neighborhood models and were therefore dropped from the neighborhood models. The insignificance of the income range variables at the household level may be due to the fact that there is not sufficient variation, given the high socioeconomic status of the respondents and also due to missing income data. Additionally, a linearity test between the dependent and independent variables showed that the relationship between the number of vehicles per household and number of trips was linear while the relationship between household size and the number of trips was not.

In this analysis, three sets of models are presented. The first model is an Ordinary Least Squares (OLS) regression that does not account for missing data[10] while the second model accounts for missing data. The third model is a negative binomial regression using the corrected data and the marginal effects. Negative binomial models account for the non-negative and discrete nature of trips. However, these models are more complex and difficult to interpret. Their marginal effects must be calculated at the variable means to analyze changes in independent variables, given that the changes are non-linear. Since the negative binomial regressions are generally consistent with the OLS regressions, the analysis in this section relies on interpreting the (simpler) corrected OLS regression.

The resulting trip generation models for the neighborhoods and for the region are presented in Table 4-13. These models allow us to distinguish between the effects of independent variables, i.e., household size and vehicle ownership across neighborhoods. The results of the negative binomial model are largely similar to the OLS regression, so we focus on discussing them. The trip generation models are significant at the 99 percent confidence level as measured by the F statistic, which means that the explanatory variables (household size and number of household vehicles) chosen for the models explain the variation in the dependent variable (number of household trips). The adjusted R^2 for the models, which indicates the ability of the explanatory variables to explain the variation in the dependent variable, is greatest for Southern Village. For example, the adjusted R^2 of 0.396 for Southern Village indicates that 39.6 percent of the variation in the dependent variable (number of household trips) is explained by the explanatory variables, while in northern Carrboro the adjusted R^2 is 25.8 percent and in the region as a whole it is 27.3 percent. In each of the models the coefficients of the explanatory variables are significant at the 99 percent confidence level. Variations in the effect of household size and number of vehicles on trip generation rates between Southern Village and northern Carrboro appear small (Table 4-13); as we see in the next section, the differences between total trips are statistically insignificant (90 percent confidence level). However, the households in Southern Village and northern Carrboro make substantially more trips than in the region. In northern Carrboro, the addition of one vehicle per household adds 2.40 household trips, compared with 2.25 in Southern Village and 0.97 in the region.

[10] In 63 households, one or more eligible people did not complete a travel diary. These people were assigned the mean number of trips per person and then were aggregated at the household level. However, no households were created in instances were each eligible person in that household did not complete a travel diary.

Table 4-13: Trip Generation Models

a. OLS (not accounting for missing data)

	TTA		All Households		Southern Village		Northern Carrboro	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	2.240***	9.994	2.104***	3.584	2.167***	3.173	1.998	1.650
Size of Household	1.396***	17.192	1.074***	6.534	1.198***	5.108	0.986***	3.879
Number of Vehicles	0.971***	9.411	2.138***	6.590	1.951***	4.376	2.307***	4.543
Mean of Dep. Var			9.18		8.31		10.19	
N	1732		405		217		188	
F statistic	326.345***		85.82***		51.566***		24.543***	
R-square	0.274		0.299		0.325		0.21	
Adjusted R-square	0.273		0.295		0.319		0.201	

b. OLS (accounting for missing data)

	TTA		All Households		Southern Village		Northern Carrboro	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	2.240***	9.994	1.946***	3.460	1.806***	2.674	2.358**	2.096
Size of Household	1.396***	17.192	1.270***	8.061	1.415***	6.094	1.123***	4.756
Number of Vehicles	0.971***	9.411	2.363***	7.606	2.248***	5.095	2.399***	5.087
Mean of Dep. Var			9.99		8.97		11.19	
N	1732		405		217		188	
F statistic	326.345***		122.34***		71.813***		33.433***	
R-square	0.274		0.378		0.402		0.265	
Adjusted R-square	0.273		0.375		0.396		0.258	

c. Negative Binomial

	All Households		Southern Village		Northern Carrboro	
	Coeff.	Z stat	Coeff.	Z stat	Coeff.	Z stat
Constant	1.431***	8.910	1.354***	5.440	1.581***	15.040
Size of Household	0.134***	8.220	0.153***	6.370	0.109***	5.270
Number of Vehicles	0.240***	23.550	0.252***	16.990	0.212***	5.400
Alpha	0.027	(p=0.000)	0.033	(p=0.001)	0.021	(p=0.013)
N	406		217		188	
Psuedo-R^2	0.087		0.0927		0.057	
LR χ^2(var)	202.88		114.31		60.84	
Prob > χ^2	0.000		0.000		0.000	
Log likelihood	-1069.6605		-559.4717		-506.138	

*** Significant at the 99% confidence level

** Significant at the 95% confidence level

* Significant at the 90% confidence level

d. Marginal Effects

	All Households			Southern Village			Northern Carrboro		
	Mean	Coeff.	Z	Mean	Coeff.	Z	Mean	Coeff.	Z
Size of Household	2.80	1.28	(p=0.000)	2.37	1.31	(p=0.000)	3.31	1.19	(p=0.000)
Number of Vehicles	1.90	2.30	(p=0.000)	1.70	2.16	(p=0.000)	2.13	2.32	(p=0.000)

With X_1 as the number of people in household, X_2 as the number of cars in household, E as our error term and Y as the resulting number of trips per household the following regression equations can be formulated:

Regional Model: $Y = 2.240 + 1.396\ X_1 + 0.971\ X_2 + E$

Southern Village Model: $Y = 1.806 + 1.415\ X_1 + 2.248\ X_2 + E$

Northern Carrboro Model: $Y = 2.358 + 1.123\ X_1 + 2.399\ X_2 + E$

These models can be used to predict total residential trips per day for a zone or a new development. For instance, a 1 person, 1 car household will make 5.5 trips in Southern Village and 5.9 tips in northern Carrboro. A 2 person, 2 car household will make 9.1 and 9.4 trips in Southern Village and northern Carrboro neighborhoods respectively. These predictions are reasonable and consistent with our expectations. It should be noted that while the above Southern Village trip generation model can be replicated for similar traditional neighborhoods that have a mix of housing types, it would probably not work as well for traditionally designed neighborhoods that include only single-family homes. As mentioned earlier, it is best to compare like cohorts in our analysis. Accordingly, trip generation and subsequent models should be developed to separate out the single- and multi-family homes in Southern Village and compare these models to the households in Lake Hogan Farms, our original study site (and very equivalent to Southern Village in terms of age of development and socioeconomic status of the residents), and the rest of northern Carrboro, which are all single-family homes (5-3). This analysis of like cohorts is particularly important for our study since apartment and condominium households are smaller, have fewer cars, are less expensive to own or rent, and have lower incomes. Combined, these factors can cause apartment and condominium dwellers to have notably different travel behavior than single-family households.

Table 4-14 presents trip generation models for single-family homes. The models are highly statistically significant overall, as indicated by the F-statistic. For *single-family homes*, the Lake Hogan Farms model is the most explanatory, with an adjusted R^2 of 38.7 percent compared with adjusted R^2 of 32.4 percent in Southern Village and 20.6 percent in the other northern Carrboro neighborhoods. In each of the models the coefficients of the explanatory variables are significant at the 95 percent confidence level, though the constant for Southern Village multi-family homes and Lake Hogan Farms are insignificant. While the number of trips that an additional vehicle generates in Southern Village single-family homes (2.22) is similar to that in the other northern Carrboro neighborhood model (2.04), it is notably smaller than the single-family homes in Lake Hogan Farms (3.34). Each additional household vehicle in the Lake Hogan Farms generates 50.5 percent more trips than Southern Village single-family homes and 63.7 percent more trips than in the other northern Carrboro neighborhoods.

Table 4-14: Trip Generation Models (Single-Family Homes)

a. OLS (not accounting for missing data)

	Southern Village				*Northern Carrboro*			
	Single-Family		Multi-Family		Lake Hogan Farms		Other Neighborhoods	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	2.598**	2.567	0.865	0.782	0.693	0.324	2.615*	1.776
Size of Household	1.165***	4.285	1.485**	2.602	0.918**	2.020	0.971***	3.128
Number of Vehicles	1.753***	3.227	2.702***	2.858	3.211***	3.211	2.143***	3.416
Mean of Dep. Var	9.07		6.54		9.43		10.49	
N	152		65		53		135	
F statistic	25.375***		15.918***		8.814***		15.474***	
R-square	0.254		0.339		0.261		0.19	
Adjusted R-square	0.244		0.318		0.231		0.178	

b. OLS (accounting for missing data)

	Southern Village				*Northern Carrboro*			
	Single-Family		Multi-Family		Lake Hogan Farms		Other Neighborhoods	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	2.122**	2.155	0.625	0.548	-0.551	-0.288	3.561**	2.594
Size of Household	1.302***	4.924	2.196***	3.730	1.242***	3.053	1.054***	3.641
Number of Vehicles	2.216***	4.194	2.312**	2.371	3.339***	4.344	2.042***	3.490
Mean of Dep. Var	9.84		6.92		10.40		11.50	
N	152		65		53		135	
F statistic	37.187***		20.166***		17.383***		18.359***	
R-square	0.333		0.394		0.41		0.218	
Adjusted R-square	0.324		0.375		0.387		0.206	

c. Negative Binomial

	Southern Village				*Northern Carrboro*			
	Single-Family		Multi-Family		Lake Hogan Farms		Other Neighborhoods	
	Coeff.	Z stat	Coeff.	Z stat	Coeff.	Z stat	Coeff.	Z stat
Constant	1.463***	14.040	1.076***	6.920	1.270***	6.880	1.700***	13.500
Size of Household	0.131***	5.190	0.292***	4.000	0.139***	3.670	0.097***	3.950
Number of Vehicles	0.231***	4.490	0.276**	2.370	0.286***	4.850	0.185***	3.760
Alpha	0.022	(p=0.032)	0.056	(p=0.011)	0.000	(p=0.500)	0.026	(p=0.010)
N	152		65		53		135	
Psuedo-R^2	0.075		0.094		0.096		0.046	
LR χ^2(var)	64.030		32.670		28.540		35.110	
Prob > χ^2	0.000		0.000		0.000		0.000	
Log likelihood	-397.1961		-158.0717		-134.689		-368.7211	

*** Significant at the 99% confidence level

** Significant at the 95% confidence level

* Significant at the 90% confidence level

d. Marginal Effects

	Southern Village					
	Single-Family			Multi-Family		
	Mean	Coeff.	Z	Mean	Coeff.	Z
Size of Household	2.72	1.25	(p=0.000)	1.55	1.90	(p=0.000)
Number of Vehicles	1.89	2.21	(p=0.000)	1.25	1.80	(p=0.018)

	Northern Carrboro					
	Lake Hogan Farms			Other Neighborhoods		
	Mean	Coeff.	Z	Mean	Coeff.	Z
Size of Household	3.08	1.40	(p=0.000)	3.40	1.10	(p=0.000)
Number of Vehicles	2.13	2.87	(p=0.000)	2.13	2.09	(p=0.000)

Table 4-15 shows the external trip generation model for single-family homes in Southern Village and Lake Hogan Farms. These models are important since they focus on the two neighborhoods specified in our original study design. Overall, these models are statistically significant at the 99 percent confidence level, based on the F-statistic. The Lake Hogan Farms model is better at explaining the variation in number of household trips, with an adjusted R^2 of 34.5 percent, compared with 28.0 percent for Southern Village (this can be largely due to difference in sample sizes). While the coefficients of the explanatory variables are significant at the 95 percent confidence level, the constants are not statistically significant, even at the 10 percent confidence internal. Each additional vehicle per household in Lake Hogan Farms contributes 3.31 additional external trips per household, compared with 2.61 external trips per household in Southern Village. Thus there seems to be a stronger effect of automobile ownership on trip making in conventional neighborhoods.

Table 4-15: External Trip Generation Models (Single-Family Homes)

a. OLS (not accounting for missing data)

	Southern Village		Lake Hogan Farms	
	Coeff.	T stat	Coeff.	T stat
Constant	1.372	1.490	0.781	0.370
Size of Household	0.600***	2.428	0.723	1.612
Number of Vehicles	2.245***	4.542	2.759***	3.255
Mean of Dep. Var	7.24		8.87	
N	153		53	
F statistic	22.450***		7.938***	
R-square	0.232		0.241	
Adjusted R-square	0.221		0.211	

b. OLS (accounting for missing data)

	Southern Village		Lake Hogan Farms	
	Coeff.	T stat	Coeff.	T stat
Constant	0.993	1.072	-0.395	-0.203
Size of Household	0.710***	2.852	1.029**	2.489
Number of Vehicles	2.614***	5.255	3.308***	4.232
Mean of Dep. Var	7.85		9.79	
N	152		53	
F statistic	30.329***		14.698***	
R-square	0.289		0.370	
Adjusted R-square	0.28		0.345	

c. Negative Binomial

	Southern Village		Lake Hogan Farms	
	Coeff.	Z stat	Coeff.	Z stat
Constant	1.157***	9.610	1.246***	6.480
Size of Household	0.093***	3.170	0.125***	3.140
Number of Vehicles	0.325***	5.500	0.292***	4.700
Alpha	0.038	(p=0.007)	0.004	(p=0.429)
N	152		53	
Psuedo-R^2	0.066		0.084	
LR χ^2(var)	54.010		24.600	
Prob > χ^2	0.000		0.000	
Log likelihood	-384.553		-135.046	

*** Significant at the 99% confidence level
** Significant at the 95% confidence level
* Significant at the 90% confidence level

d. Marginal Effects

	Southern Village			Lake Hogan Farms		
	Mean	Coeff.	Z	Mean	Coeff.	Z
Size of Household	2.72	0.71	(p=0.002)	3.08	1.19	(p=0.001)
Number of Vehicles	1.89	2.47	(p=0.000)	2.13	2.78	(p=0.000)

Tables 4-16 and 4-17 show auto trip generation models for Southern Village and northern Carrboro respectively. In each Table, ‘All’ indicates that the analysis is conducted for the entire (pooled) study area and allows us to make comparisons between both single-family and multifamily households in Southern Village and with single-family homes in northern Carrboro. The other models attempt to find differences in travel patterns within the Southern Village and northern Carrboro study areas.

The overall significance of the auto trip generation models for both Southern Village and northern Carrboro are significant at the 99 percent confidence level. The Lake Hogan Farms and Southern Village single-family homes models are the most explanatory, with R^2 of 36.2 percent and 33.6 percent respectively. Pooled auto trip generation models in Southern Village show that each vehicle contributes 2.22 additional trips compared with 2.54 in northern Carrboro—not much of a difference. However, automobile ownership exerts a strong but differential effect within and across the two types of neighborhoods. Specifically, an additional vehicle is associated with fewer trips in multi-family homes than single family homes in Southern Village (1.4 versus 2.3 respectively). As expected, within Southern Village, the travel behavior of households with respect to number of vehicles owned, is notably different across single family and multi-family. Each additional vehicle in the single-family homes generates 0.91 (or 65.7 percent) more trips per household than in the multi-family homes. Also, within northern Carrboro, automobiles generate 1.06 (or 47.5 percent) more trips per household in Lake Hogan Farms than in the other northern Carrboro neighborhoods. The effect of vehicle ownership on single-family households in Southern Village is smaller than in Lake Hogan Farms (2.3 versus 3.3 respectively).

While the external trip model for Southern Village mirrors the pooled model, since it contains external trips for both housing types, the external trip model for northern Carrboro closely mirrors the Lake Hogan Farms model (the original study site in northern Carrboro). Since the external trip models only count automobile traffic in and out of each neighborhood, they can be used in conjunction with traffic count results that were performed during the study period to see how the two traffic generation approaches compare. Also note that the empirical effect of automobile ownership is higher in Lake Hogan Farms than in Southern Village, by about 1 external trip.

Table 4-16: Auto Trip Generation Models (Southern Village)

a. OLS (not accounting for missing data)

	All		Multi-Family		Single-Family		All External	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	0.510	0.861	0.932	1.056	0.767	0.851	0.654	1.134
Size of Household	1.024***	5.029	0.846*	1.855	0.999***	4.124	0.701***	3.539
Number of Vehicles	1.972***	5.095	1.641**	2.174	1.934***	3.997	2.064***	5.479
Mean of Dep. Var	6.27		4.29		7.11		5.81	
N	217		65		152		217	
F statistic	58.662***		8.679***		29.426***		47.155***	
R-square	0.354		0.219		0.283		0.306	
Adjusted R-square	0.348		0.194		0.274		0.299	

b. OLS (accounting for missing data)

	All		Multi-Family		Single-Family		All External	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	0.200	0.339	0.775	0.870	0.394	0.440	0.379	0.646
Size of Household	1.186***	5.836	1.313***	2.852	1.106***	4.601	0.852***	4.225
Number of Vehicles	2.223***	5.757	1.386*	1.818	2.297***	4.780	2.288***	5.972
Mean of Dep. Var	6.768		4.542		7.714		6.270	
N	217		65		152		217	
F statistic	76.926***		11.81***		39.274***		60.006***	
R-square	0.418		0.276		0.345		0.359	
Adjusted R-square	0.413		0.253		0.336		0.353	

c. Negative Binomial

	All		Multi-Family		Single-Family		All External	
	Coeff.	Z stat	Coeff.	Z stat	Coeff.	Z stat	Coeff.	Z stat
Constant	0.887***	9.380	0.735***	3.900	1.043***	8.490	0.857***	8.670
Size of Household	0.169***	6.060	0.265***	2.950	0.142***	4.850	0.136***	4.560
Number of Vehicles	0.329***	6.090	0.254*	1.760	0.303***	5.050	0.351***	6.150
Alpha	0.049	(p=.001)	0.080	(p=0.026)	0.038	(p=0.012)	0.060	(p=0.000)
N	217		65		152		217	
Psuedo-R^2	0.097		0.063		0.077		0.084	
LR χ^2(var)	114.910		19.540		64.490		96.330	
Prob > χ^2	0.000		0.000		0.000		0.000	
Log likelihood	-534.354		-146.188		-385.377		-527.865	

*** Significant at the 99% confidence level

** Significant at the 95% confidence level

* Significant at the 90% confidence level

d. Marginal Effects

	All			Multi-Family			Single-Family		
	Mean	Coeff.	Z	Mean	Coeff.	Z	Mean	Coeff.	Z
Size of Household	2.37	1.07	(p=0.000)	1.55	1.14	(p=0.003)	2.72	1.05	(p=0.000)
Number of Vehicles	1.70	2.08	(p=0.000)	1.25	1.10	(p=0.078)	1.89	2.24	(p=0.000)

	All External		
	Mean	Coeff.	Z
Size of Household	2.37	0.80	(p=0.000)
Number of Vehicles	1.70	2.07	(p=0.000)

Table 4-17: Auto Trip Generation Models (Northern Carrboro)

a. OLS (not accounting for missing data)

	All		Other Neighborhoods		Lake Hogan Farms		Lake Hogan External	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	1.187	1.090	1.411	1.095	0.622	0.295	0.546	0.266
Size of Household	0.831***	3.637	0.852***	3.137	0.789*	1.755	0.754*	1.731
Number of Vehicles	2.453***	5.371	2.320***	4.227	2.765***	3.255	2.780***	3.379
Mean of Dep. Var	9.164		9.260		8.926		9.090	
N	188		135		53		53	
F statistic	28.575***		19.804***		8.284***		8.696***	
R-square	0.236		0.231		0.249		0.258	
Adjusted R-square	0.228		0.219		0.219		0.228	

b. OLS (accounting for missing data)

	All		Other Neighborhoods		Lake Hogan Farms		Lake Hogan External	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	1.51	1.473	2.262*	1.855	-0.496	-0.257	-0.564	-0.288
Size of Household	0.954***	4.437	0.927***	3.604	1.084**	2.633	1.043**	2.605
Number of Vehicles	2.536***	5.901	2.229***	4.291	3.287***	4.239	3.299***	4.359
Mean of Dep. Var	10.065		10.17		9.802		9.98	
N	188		135		53		53	
F statistic	37.275***		22.588***		15.242***		15.74***	
R-square	0.287		0.255		0.379		0.386	
Adjusted R-square	0.28		0.244		0.354		0.362	

c. Negative Binomial

	All		Other Neighborhoods		Lake Hogan Farms		Lake Hogan External	
	Coeff.	Z stat	Coeff.	Z stat	Coeff.	Z stat	Coeff.	Z stat
Constant	1.417***	13.25	1.485***	11.55	1.230***	6.44	1.208***	6.36
Size of Household	0.105***	5.02	0.099***	3.95	0.130***	3.31	0.128***	3.26
Number of Vehicles	0.244***	6.23	0.224***	4.55	0.292***	4.76	0.297***	4.93
Alpha	0.014	(p=0.080)	0.017	(p=0.081)	0.002	(p=0.468)	0.000	(p=0.636
N	188		135		53		53	
Psuedo-R^2	0.063		0.055		0.087		0.090	
LR χ^2(var)	66.100		41.560		25.670		26.270	
Prob > χ^2	0.000		0.000		0.000		0.000	
Log likelihood	-489.138		-354.125		-134.241		-132.948	

*** Significant at the 99% confidence level

** Significant at the 95% confidence level

* Significant at the 90% confidence level

d. Marginal Effects

	All			Other Neighborhoods			Lake Hogan Farms		
	Mean	Coeff.	Z	Mean	Coeff.	Z	Mean	Coeff.	Z
Size of Household	3.31	1.04	(p=0.000)	3.40	0.98	(p=0.000)	3.08	1.24	(p=0.001)
Number of Vehicles	2.13	2.40	(p=0.000)	2.13	2.23	(p=0.000)	2.13	2.78	(p=0.000)

	Lake Hogan Farms External		
	Mean	Coeff.	Z
Size of Household	3.08	1.20	(p=0.001)
Number of Vehicles	2.13	2.78	(p=0.000)

Tables 4-18 and 4-19 show the trip distance models for Southern Village and northern Carrboro. For consistency, we use the same model specifications. For the Southern Village study area (Table 4-18), the F statistic indicates that each model is significant at the 99 percent confidence level. However, only for the pooled 'All' and the single-family models are the explanatory variables significant at the 95 percent confidence level. For the pooled Southern Village model, each additional vehicle generates 16 additional miles per household; while in single-family homes each vehicle generates approximately 15.5 additional miles. However, in both models, the constant is insignificant. For the northern Carrboro study area (Table 4-19), the F statistic shows that only the pooled 'All' and Other Neighborhoods models for northern Carrboro are statistically significant. Each additional vehicle in the pooled model generates approximately 17.5 additional miles traveled compared with 24.2 additional miles for the Other Neighborhoods model. In addition, the constant for the pooled model is substantially larger than for the Other Neighborhoods model. In both models, the size of household variable is statistically insignificant (10 percent level). Thus automobile ownership has a differential effect across the two types of neighborhoods

Table 4-18: Trip Distance Models for Southern Village (miles)

a. OLS (not accounting for missing data)

	All		Multi-Family		Single-Family		All External	
	Coeff.	Z stat	Coeff.	Z stat	Coeff.	Z stat	Coeff.	Z stat
Constant	11.311*	1.838	3.954	0.331	12.01	1.416	10.622*	1.726
Size of Household	5.219**	2.468	3.808	0.618	5.790**	2.542	5.003**	2.365
Number of Vehicles	14.376***	3.578	23.272**	2.282	12.841***	2.822	14.168***	3.525
Mean of Dep. Var	47.946		38.872		51.802		40.368	
N	217		65		152		217	
F statistic	21.123***		4.939***		12.849***		20.074***	
R-square	0.165		0.137		0.147		0.158	
Adjusted R-square	0.157		0.11		0.136		0.15	

b. OLS (accounting for missing data)

	All		Multi-Family		Single-Family		All External	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	9.294	1.522	2.527	0.204	9.282	1.13	8.669	1.417
Size of Household	6.472***	3.084	8.04	1.258	6.578***	2.981	6.215***	2.957
Number of Vehicles	16.045***	4.024	20.955*	1.979	15.496***	3.515	15.784***	3.953
Mean of Dep. Var	51.717		41.132		56.214		50.046	
N	217		65		152		217	
F statistic	29.057***		5.676***		18.879***		27.49***	
R-square	0.214		0.155		0.202		0.204	
Adjusted R-square	0.206		0.127		0.191		0.197	

Table 4-19: Trip Distance Models for Northern Carrboro (miles)

a. OLS (not accounting for missing data)

	All		Other Neighborhoods		Lake Hogan Farms		Lake Hogan External	
	Coeff.	Z stat	Coeff.	Z stat	Coeff.	Z stat	Coeff.	Z stat
Constant	45.352***	3.395	33.701**	2.055	74.202***	3.404	74.069***	3.383
Size of Household	-2.610	-0.931	-4.445	-1.285	1.493	0.322	1.223	0.263
Number of Vehicles	16.873***	3.013	24.919***	3.567	-1.711	-0.195	-1.577	-0.179
Mean of Dep. Var	72.612		71.748		74.772		74.017	
N	188		135		53		53	
F statistic	4.545**		6.381***		0.061		0.043	
R-square	0.047		0.088		0.002		0.002	
Adjusted R-square	0.037		0.074		-0.037		-0.038	

b. OLS (accounting for missing data)

	All		Other Neighborhoods		Lake Hogan Farms		Lake Hogan External	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	47.925***	3.617	16.597**	2.439	65.285***	20.134	65.237***	3.223
Size of Household	-1.631	-0.587	-3.851	-1.100	3.817***	4.282	3.525	0.819
Number of Vehicles	17.533***	3.156	24.195***	3.422	2.456	8.092	2.549	0.313
Mean of Dep. Var	79.793		79.009		81.754		80.931	
N	188		135		53		53	
F statistic	5.024***		5.856***		0.517		0.453	
R-square	0.052		0.081		0.02		0.018	
Adjusted R-square	0.041		0.068		-0.019		-0.022	

Tables 4-20 and 4-21 show the trip duration models for Southern Village and northern Carrboro neighborhoods. Each of the models is significant at the 95 percent confidence level except for the Lake Hogan Farms external trip duration model. The adjusted R^2 for the pooled model in Southern Village is notably greater than that of northern Carrboro. Within Southern Village, the multi-family models explain 31.9 percent of the variation in trip duration, compared with 8.4 percent for single-family homes of northern Carrboro. The pooled models show that the effect of vehicle ownership on trip duration is about the same—0.683 hours for Southern Village and 0.567 for northern Carrboro.

Table 4-20: Trip Duration Models for Southern Village (hours)

a. OLS (not accounting for missing data)

	All		Multi-Family		Single-Family		All External	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	0.795***	3.925	0.107	0.311	1.230***	4.233	0.497***	2.767
Size of Household	0.226***	3.251	0.173	0.967	0.218***	2.795	0.173***	2.809
Number of Vehicles	0.598***	4.518	1.150***	0.390	0.399**	2.559	0.593***	5.060
Mean of Dep. Var	2.342		1.809		2.568		1.912	
N	217		65		152		217	
F statistic	34.804***		14.017***		12.796***		36.252***	
R-square	0.245		0.311		0.147		0.253	
Adjusted R-square	0.238		0.289		0.135		0.246	

b. OLS (accounting for missing data)

	All		Multi-Family		Single-Family		All External	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	0.692***	3.466	0.041	0.115	1.095***	3.887	0.412**	2.300
Size of Household	0.287***	4.188	0.369**	2.002	0.257***	3.396	0.223***	3.620
Number of Vehicles	0.683***	5.237	1.043***	3.411	0.530***	3.506	0.663***	5.662
Mean of Dep. Var	2.526		1.914		2.786		2.062	
N	217		65		152		217	
F statistic	51.021***		15.961***		21.254***		49.979***	
R-square	0.323		0.34		0.222		0.318	
Adjusted R-square	0.317		0.319		0.212		0.312	

Table 4-21: Trip Duration Models for Northern Carrboro (hours)

a. OLS (not accounting for missing data)

	All		Other Neighborhoods		Lake Hogan Farms		Lake Hogan External	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	1.637	4.535	1.518***	3.365	1.97***	3.410	1.905***	3.254
Size of Household	0.018	0.243	0.639***	3.325	0.321	1.382	0.356	1.512
Number of Vehicles	0.541	3.578	-0.003	-0.028	0.047	0.383	-0.026	-0.206
Mean of Dep. Var	2.858		2.873		2.819		2.572	
N	188		135		53		53	
F statistic	7.217***		6.073***		1.179		1.147	
R-square	0.072		0.084		0.045		0.044	
Adjusted R-square	0.062		0.070		0.007		0.006	

b. OLS (accounting for missing data)

	All		Other Neighborhoods		Lake Hogan Farms		Lake Hogan External	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	1.737***	5.036	1.784***	4.090	1.621	3.070	1.584***	2.975
Size of Household	0.057	0.784	0.611***	3.287	0.484	2.281	0.506**	2.365
Number of Vehicles	0.567***	3.922	0.020	0.224	0.138	1.230	0.058	0.513
Mean of Dep. Var	3.139		3.157		3.092		2.824	
N	188		135		53		53	
F statistic	9.569***		6.245***		4.068**		3.294*	
R-square	0.094		0.086		0.140		0.116	
Adjusted R-square	0.084		0.073		0.106		0.081	

In sum, the trip generation models estimated give reasonable results. There are intra-neighborhood and inter-neighborhood variations in travel behavior—though there is a substantial difference in travel behavior across the Southern Village and northern Carrboro study areas, especially in terms of automobile trips, miles traveled and external trips. In particular, the effect of automobile ownership on trips is more pronounced in households of the conventional neighborhoods. In the next section, we investigate the statistical significance of differences in travel behavior across TNDs and conventional neighborhoods.

TND Travel Behavior Models

This section examines the effect of TND's on travel behavior. To rigorously examine the effect of neo-traditional neighborhoods on aspects of travel behavior several models are estimated. The aspects of travel behavior include the number of daily auto trips, trip distances and external trips. Negative binomial models are appropriate when the dependent variable is a count variable and therefore, they are presented in addition to the more familiar (and simpler) OLS models. For each of the models, the specification included household size and number of vehicles, while the TND effect, captured through an indicator variable, was of primary interest. In addition, physical activity can be a motivation for moving into TNDs. The effect of the traditional neighborhood on physical activity trip generation is also examined at the person level, while controlling for age and gender.

We tested the effect of the traditional neighborhood in other models—trip duration, trips tours, and trip stops—but they the TND effect was found to be statistically insignificant. Therefore we do not report those models. We do report the total trips model with a TND indicator variable in Appendix J. It shows that there is no statistical difference (90 percent confidence level) in terms of total household trips between the TND and conventional neighborhoods. This refutes our original hypothesis that households in TND will make more total trips, given their proximity to a mix of land uses.

Table 4-22 shows the neighborhood travel behavior model for auto trips. Overall, this model is significant at the 99 percent confidence level. The adjusted R^2 for the model indicates that 35.9 percent of the variation in the dependent variable is explained by the three explanatory variables (household size, number of household vehicles, and the Southern Village indicator variable). Additionally, each variable and the constant are statistically significant. The model shows that single-family households in Southern Village are associated with 1.25 fewer auto trips than households in northern Carrboro. These findings support our hypothesis that households in traditional neighborhoods make fewer automobile trips than households in conventional neighborhoods (despite them making about the same amount of total trips). The results of the negative binomial model are consistent with OLS. In addition, it shows that there is significant overdispersion in the data, i.e., the variance is greater than the mean of the distribution. This is indicated by the parameter α, which is an estimate of the degree of overdispersion.

Table 4-22: Regression Models for Auto Trips

a. OLS (not accounting for missing data)

	Coeff.	T stat
Constant	1.39**	2.13
Size of Household	0.91***	6.05
Number of Vehicles	2.27***	7.65
Southern Village	-1.06***	-2.93
Mean of Dep. Var	7.61	
N	406	
F statistic	81.08***	
R-square	0.377	
Adjusted R-square	0.372	

b. OLS (accounting for missing data)

	Coeff.	T stat
Constant	1.41**	2.24
Size of Household	1.06***	7.29
Number of Vehicles	2.42***	8.55
Southern Village	-1.25***	-3.57
Mean of Dep. Var	8.30	
N	406	
F statistic	109.58***	
R-square	0.450	
Adjusted R-square	0.446	

c. Negative Binomial

	Coeff.	Z stat
Constant	1.19***	14.84
Size of Household	0.14***	8.32
Number of Vehicles	0.29***	9.23
Southern Village	-0.16***	-3.81
Alpha	0.03	(p=0.00)
N	406	
Psuedo-R^2	0.108	
LR χ^2(var)	250.17	
Prob > χ^2	0.000	
Log likelihood	-1030.560	

*** Significant at the 99% confidence level

** Significant at the 95% confidence level

* Significant at the 90% confidence level

d. Marginal Effects

	Mean	Coeff.	Z
Size of Household	2.80	1.08	8.39
Number of Vehicles	1.90	2.29	9.31
Southern Village	0.54	-1.25	-3.79

The regression models for external trips show that households in Southern Village make 1.53 fewer external trips, on average (Appendix J).

Table 4-23 shows the neighborhood travel model for trip distance. Overall, this model is statistically significant at the 99 percent confidence level. The adjusted R^2 for the model indicates that 19.5 percent of the variation in the dependent variable is explained by the three explanatory variables (household size, number of household vehicles, and the Southern Village indicator variable).

With regard to daily total trip lengths, we controlled for the number of vehicles and household size (which was insignificant) and found that single-family households in Southern Village travel approximately 18 fewer miles daily than households in northern Carrboro. This is a large number and is in part due to our anecdotal observation that proportionally more people who live in Southern Village work or go to school at the university whereas more people who live in northern Carrboro work at the Research Triangle Park or Raleigh or Greensboro, which are over 20 miles away. To test this anecdotal observation, we removed work trips from our model and found that single-family households in Southern Village still travel approximately 11 fewer miles daily than households in northern Carrboro. (This model is significant at the 99 percent confidence level and explains 7.9 percent of the variation in the dependent variable.) Because this difference is still large, it is likely that this finding is attributable to the fact that Southern

Village has a mix of uses (most notably a neighborhood grocery store and an elementary school) that bring origins and destinations closer whereas northern Carrboro does not. Accordingly, residents of northern Carrboro must travel several miles to the nearest commercial center when shopping or when taking their kids to school. Both of these findings are consistent with the findings in Table 4-7 and, taken in sum, support our hypothesis that households in a traditional neighborhood travel less distance than households in a conventional neighborhood.

Table 4-23: Trip Distance Models (miles)

a. OLS (not accounting for missing data)

	All Trips		Without Work Trips	
	Coeff.	T stat	Coeff.	T stat
Constant	32.19***	4.28	22.98***	4.020
Size of Household	1.25	0.72	0.33	0.250
Number of Vehicles	17.05***	5.06	6.55**	2.560
Southern Village	-16.14***	-3.86	-10.27***	-3.230
Mean of Dep. Var	59.40		30.89	
N	406		406	
F statistic	25.93***		10.02***	
R-square	0.1621		0.0696	
Adjusted R-square	0.1559		0.0626	

b. OLS (accounting for missing data)

	All Trips		Without Work Trips	
	Coeff.	T stat	Coeff.	T stat
Constant	32.90***	4.41	23.40***	4.010
Size of Household	2.41	1.40	0.93	0.690
Number of Vehicles	18.30***	5.47	7.20***	2.750
Southern Village	-17.95***	-4.32	-11.26***	-3.470
Mean of Dep. Var	64.75		33.67	
N	406		406	
F statistic	34.11		12.79	
R-square	0.2029		0.0871	
Adjusted R-square	0.197		0.0803	

Combined with the results of Table 4-7, Table 4-24 shows that while daily travel distances are shorter for single-family households in Southern Village than for households in northern Carrboro, there is no statistically significant difference in the time each household spends traveling daily. This finding makes sense (given the constant travel budget hypothesis, first suggested by Y. Zahavi), since alternative modes of transportation (available only in Southern Village) are typically slower than driving.

Table 4-24: Trip Duration Models (hours)

a. OLS (not accounting for missing data)

	Duration	
	Coeff.	T stat
Constant	1.13***	5.12
Size of Household	0.13**	2.48
Number of Vehicles	0.61***	6.19
Southern Villlage	-0.13	-1.01
Mean of Depend Var	2.58	
N	406	
F statistic	30.67***	
R-square	0.186	
Adjusted R-square	0.180	

b. OLS (accounting for missing data)

	Duration	
	Coeff.	T stat
Constant	1.11***	5.16
Size of Household	0.18***	3.61
Number of Vehicles	0.67***	7.00
Southern Villlage	-0.15	-1.23
Mean of Depend Var	2.81	
N	406	
F statistic	44.90***	
R-square	0.251	
Adjusted R-square	0.245	

With regard to physical activity trips, person level data for adults 16 years or older were analyzed. Table 4-25 shows that, on a daily basis, people on average make 0.670 physical activity trips for about 0.239 hours (about 14 minutes) and they travel about 0.873 miles. In the model, we controlled for gender (men are associated with 0.28 fewer physical activity trips per day than women) and age (for every year a person gains, that person is associated with 0.002 fewer physical activity trips per day, although this effect is statistically insignificant) and found that people in Southern are associated with 0.45 more exercise trips per day than people in northern Carrboro (Table 4-25). This finding is consistent with the finding in Table 4-11 that showed that people in Southern Village make on average 0.41 more exercise trips per day than people in northern Carrboro. While exercise trips are historically underreported in travel diary type studies, presumably the underreporting is consistent between the two neighborhoods. Additionally, the duration of exercise trips are about 6 minutes longer per day, for people in single-family households in Southern Village than people in northern Carrboro. This is consistent with the finding in Table 4-11 that showed that people in Southern Village make on average 10 minutes more physical activity trips per day than people in northern Carrboro. There was no statistically significant difference in the distance people traveled across neighborhood types, even with the exclusion of the four outliers discussed earlier. Overall, however, our findings support the hypothesis that people in traditional neighborhoods make more physical activity trips than people in a conventional neighborhood.

Table 4-25: Physical Activity Trip Generation, Duration and Distance Models^

a. OLS

	All Physical Activity Trips					
	Trips		Duration (hours)		Distance (miles)	
	Coeff.	T stat	Coeff.	T stat	Coeff.	T stat
Constant	0.805***	4.57	0.136**	2.39	0.650***	3.02
Age	-0.004	-1.13	0.002*	1.94	0.003	0.73
Male	-0.315***	-3.26	-0.111***	-3.56	-0.238**	-2.01
Southern Village	0.452***	4.69	0.107***	3.46	0.146	1.24
Mean of Dep. Var	0.72		0.24			
N	713		713		711	
F statistic	12.60***		9.20***		2.02	
R-square	0.051		0.038		0.009	
Adjusted R-square	0.047		0.033		0.004	

*** Significant at the 99% confidence level
** Significant at the 95% confidence level
* Significant at the 90% confidence level
^Four outlying trips were removed: 15, 19, 20 and 28 mile bike rides

In sum, our original hypotheses that households in TNDs make fewer automobile trips, make shorter trips overall and make more physical activity trips than households in conventional neighborhoods appear to be correct. However, our hypothesis that traditional neighborhoods make more overall trips appears to have no statistical support.

Business Trip Generation Rates

This section analyzes the trip generation rates of the businesses located within Southern Village and how they compare to ITE trip generation rates. The business survey answers the question: To what extent do the component land uses—residential, office, retail, etc., attract off-site workers and visitors?

Given that Southern Village is a relatively young TND, the businesses have not yet stabilized. Yet the survey of business managers showed reasonable results. We compared the trip generation rates of employers within Southern Village to ITE's trip generation estimates (Appendix E). Eighteen employers existed at the time of the study and their types of business, sizes, and number of employees is listed in Table 4-26. This mix of stores and businesses within Southern Village may or may not be indicative of the mix of stores and businesses within other traditional neighborhoods. Out of the top eight local businesses visited most frequently by residents of six

Austin, Texas, neighborhoods–grocery stores, drug stores, restaurants, discount stores, convenience stores, video stores, laundromats or dry cleaners, and bakeries, respectively (Handy *et al.*, 1998)—Southern Village possesses three: A grocery store, restaurant, and dry cleaners. While Southern Village may not possess an exemplary number of frequently-visited neighborhood businesses, we can compare how the trip attractions to the stores within Southern Village compare to trip attractions for stores as predicted by ITE.

Table 4-26: Southern Village employers, their size, and their number of employees

Type of Employer	Size*	Number of Employees
Retail services:		
Bookstore	1750	4.5
Grocery Store	5800	25
Public facilities:		
Church	n/a	n/a
Elementary School	606 students	89.5
Entertainment and restaurants:		
Restaurant	2000	25
Restaurant	1000	12
Theater and arcade	4 screens	13
Private services:		
Drycleaner	2500	2
Marketing/sales	1800	9
Day Spa/Salon	3000	8
Law Office	1200	3
Accounting	3500	7
Investment Company	1500	3
Development company	2000	8.5
Clinic	3000	7.5
Day Care	6000 / 86 children	22.5
Public services:		
Non-profit	1700	102
Organization	1600	78.5
Business	3500	12
Total	41850	432

*In square feet unless otherwise noted

The business survey revealed that a total of 5,105 trips ends were taken in one day of which 4,299 (84.2 percent) were by customers and the rest by employees. The ITE procedure, when applied to the businesses predicted 5,918 trip ends. This is 13.7 percent fewer trip ends than reported. Furthermore, only 5.2 percent of the 432 employees reside in Southern Village. A large majority of the employees (92.4 percent) used personal vehicles to commute to work, given the free employee parking in Southern Village. In terms of customers/visitors, an estimated 39.2 percent reside in Southern Village. According to business representatives, 77.7 percent of the customers drive, 18.1 percent walk and 4.2 percent take the bus. The results show that Southern

Village employees use passenger cars as often as employees in conventional (stand-alone) facilities, but that customers are more likely to walk.

We found that while public facilities and public service businesses attract fewer vehicular trips than estimated by ITE, entertainment and restaurants, private services, and retail services attract more vehicular trips than estimated by ITE. The difference in results among business categories leads to a somewhat inconclusive answer as to whether or not the design of Southern Village is affecting the number of automobile trips that businesses are attracting. However, it should be noted that trip ends were not measured by count; instead, they were based on the estimates of the manager or owner of each business. Overall, our findings are also not consistent with the findings of the Colorado/Wyoming Section Technical Committee (1987) of ITE who found that average trip rates for individual shops in mixed use settings were around 2.5 percent below the mean rates published in ITE's *Trip Generation* (1991) manual.

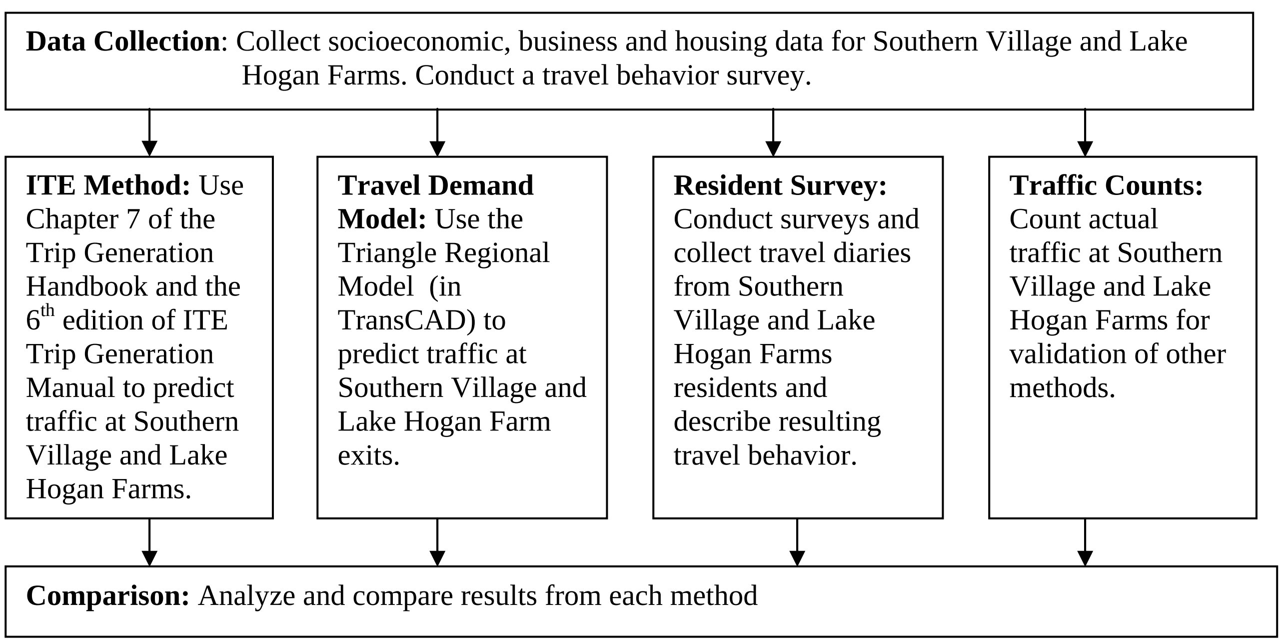
There was a relatively large difference between the reported and ITE predicted trip ends for the grocery store in Southern Village. The presence and impact of a grocery store within should be viewed in line with Handy and Clifton (2001) who identified a number of objective and subjective factors that influence a person's decision to shop at the store and how they travel there. Whereas objective factors include the size of the store, prices, ease of parking, and range of product selection, subjective factors include quality of products, crowds, atmosphere, and length of check-out lines. The significance of these factors varies for each individual and the time of day the individual chooses to shop. Accordingly, the impact of the presence of Weaver Street Market, a smaller, higher-end grocery store, within Southern Village may not be indicative of the presence of grocery stores in other traditional neighborhoods.

Chapter 5: Research Approach for Trip Generation

Introduction

This chapter describes four different methods to obtain trip generation rates and traffic estimates for the two neighborhoods, Southern Village and Lake Hogan Farms. First, ITE Manual procedures estimated trip rates and traffic estimates for the developments, which in the case of the Traditional Neighborhood Development (TND) were adjusted for internal capture and pass-by trips using the ITE Handbook. Second, local socioeconomic data and the Triangle Region travel demand model were used to estimate traffic for the developments. Third, the residents and business owners in both developments were surveyed and asked to complete travel diaries, which were then used to develop regression equations to predict total travel rates for the respective developments. Finally, results from the three approaches were compared to each other, as well as to actual traffic counts collected at all entrances and exits for the developments. A schematic figure illustrating the research approach is shown in Figure 5-1:

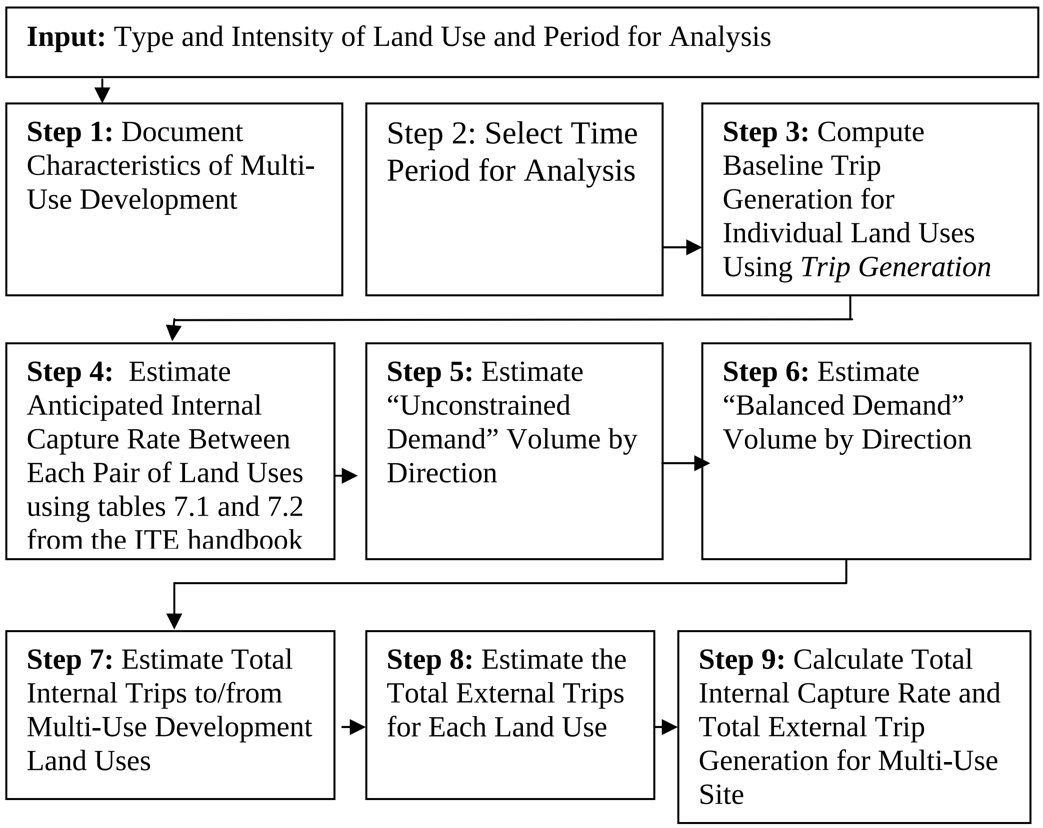
Figure 5-1: Research Approach



ITE Method

The ITE Trip Generation Handbook provides the foundation for this analysis (ITE, 2002). The Handbook uses a nine-step process for estimating trip generation at multi-use developments and involves the use of a worksheet, in Appendix L. The procedure is outlined in Figure 3-2:

Figure 5-2: ITE Trip Generation Model



Step 1: Document Characteristics of Multi-Use Development

Enter into the worksheet, (Appendix M) the development name, a description of each land use including its ITE land use code and the size of each land use corresponding to the most appropriate independent variable used in ITE's *Trip Generation Manual*. If there are two or more separate areas with the same land use, combine their areas if they are within walking distance, or treat them as two entities if they require vehicle travel (for example between two offices). If the site has multiple residential components, compute the trip generation separately but record as only a single land use on the worksheet.

Step 2: Select Time Period for Analysis

Enter the time period into the worksheet because the internal capture rates differ for each time of day: weekday midday, weekday evening peak, and weekday daily. Since internal capture rates may also differ for the day of the week, it should be noted that the rates are based on data collected on Tuesday, Wednesdays, and Thursdays and the internal capture rates may need to be adjusted for analyses on other days.

Step 3: Compute Baseline Trip Generation for Individual Land Uses

Using the land uses defined in Step 1 and the time of day information from Step 2, compute the number of entering and exiting trips using rates for the land use as found in ITE's *Trip Generation* (ITE, 1997) or use acceptable local rates. For each land use, record the baseline trip generation in the column under the "TOTAL" heading (Appendix M)

Step 4: Estimate Anticipated Internal Capture Rate Between Each Pair of Land Uses

Estimate the number of trips going between each land use pair during the selected time period using internal capture rates presented in tables 7.1 and 7.2 in the ITE Trip Generation Handbook. The ITE Handbook uses internal capture rates between land uses, collected empirically in Florida, and recommends using reliable local rates if available.

For each land use pair in the development, there are four values recorded on the worksheet that represent the maximum potential for interaction between the two land uses (unconstrained demand):

Percent trips from Land Use A going to Land Use B
Percent trips to Land Use B coming from Land Use A
Percent trips from Land Use B going to Land Use A
Percent trips to Land Use A coming from Land Use B

The four rates for each land use pair written on the worksheet are the output of Step 4.

Step 5: Estimate "Unconstrained Demand" Volume by Direction

Multiply the percentages obtained in Step 4 by the appropriate trips entering and exiting each land use obtained in Step 3. Output of this step is the "Unconstrained Demand" Volume for each direction for each land use pair and the results are written on the worksheet (Appendix M).

Step 6: Estimate "Balanced Demand" Volume by Direction

The number of calculated trips from Land Use A to Land Use B may be different than the number of trips that ended at Land Use B that came from Land Use A because of the different internal capture rates. Compare the two values in each direction for each land use pairing and select the lower value. This value should be recorded as the "balanced demand" between each pair of land uses.

Step 7: Estimate Total Internal Trips to/from Multi-Use Development Land Uses

Sum the number of internal trips going *to* other land uses and then *from* other land uses. The percent internal capture for each land use can then be calculated by dividing the internal number of trips entering and exiting a land use by the *total* number of trips entering and exiting that land use from internal or external origins. Output from this step is the number of internal trips entering and exiting each land use, and the calculated percentage of internal capture for each land use recorded on the worksheet.

Step 8: Estimate the Total External Trips for Each Land Use

Subtract the number of internal trips from the total trips to find the number of external trips for each land use. Output of this step is recorded on the worksheet for each land use, for entering and exiting traffic.

Step 9: Calculate Internal Capture Rate and Total External Trip Generation for Multi-Use Site

The number of external trips calculated in Step 8 for each land use are transcribed to the table of "net external trips" and summed to find the net external trip generation. The overall internal capture rate may be found by subtracting the ratio of calculated net external trips to total trips generated from 100 percent.

Discussion and Critique of the ITE Trip Generation Method

The Literature Review in Chapter 2 of this document discusses in detail the relative advantages and disadvantages of the ITE method including the adjustments for mixed-use developments. In summary the ITE method has the following advantages:

- The ITE Method takes types and sizes of different mixed land uses into account and calculates internal capture rates for the development to reduce the number of external trips.
- It allows and asks for variations of results with engineering judgment; professionals can distribute, assign and interpret trip generation rates.
- It is very time and cost efficient, because no expensive software is needed. Results can be obtained quickly using spreadsheet implementations.

The ITE method has the following shortcomings:

- The data for trip rates and adjustments originated in Florida from a relatively small number of TNDs. Therefore, the rates may not be transferable to nationwide applications.
- The method does not consider the location of the development relative to other competing or complimentary land uses in the region. Internal capture may be higher if no other developments are close.
- It does not account for transit accessibility and pedestrian trips, which tend to reduce the number of vehicle trips in TNDs.
- It does not consider distances between destinations, pedestrian friendliness of the network, or area type (urban/suburban).
- The internal capture rate assumes that the proportions of each land use remain relatively stable and that if enough data were available, one could predict the internal capture rate with sufficient confidence.
- Capacity, travel time and delay analysis are not included in the model. They have to be completed using other tools.

- The method does not perform trip distribution, traffic assignment, or mode split. These decisions have to be made using professional judgment.

Travel Demand Model

The North Carolina Department of Transportation developed Triangle Regional Model (TRM), uses TransCAD and predicts traffic volumes for the Triangle Region based on socioeconomic data and several different production and attraction models that vary by urban/rural locations. While the TRM is a complete travel demand model and performs all aspects of the 4-step process (Trip Generation, Distribution, Mode Split, and Traffic Assignment) this project focuses primarily on the Trip Generation portion of the model. Figure 5-3-3 shows the trip generation procedure used by the Triangle Regional Model.

Figure 5-3: TRM Trip Generation Method

Step 1: Input Socioeconomic Data for the Southern Village and Lake Hogan Farms zones into TransCAD Triangle Regional Model.

↓

Step 2: Disaggregate Households into Household Size by Income Matrix

↓

Step 3: Use Fratar Model to Balance Household Size by Income Matrix

↓

Step 4: Multiply Production Cross-Classification Matrix For Each Trip Type by Household Size by Income Matrix to Find Productions by Trip Type for Study Area

↓

Step 5: Use Attraction Regression Equations to Find Attractions Using employment and Total Dwelling Units

↓

Step 6: Verify Work Trips

↓

Step 7: Balance Productions and Attractions holding Productions Constant Except NHB Trips

Steps 1 through 3 involve separating the total number of households in the zone into categories based on size and income. This procedure was developed using the results from the Triangle

Regional Survey. For this project we are primarily concerned with the production and attraction models used in Steps 4 and 5.

Production Models

The Triangle Regional Model uses two types of trip production models: (1) a one-dimensional classification model based on a housing condition rating, which is a surrogate measure of income and associated travel; and (2) a cross-classification model based on household size and income. The trip attraction model used by the TRM is a regression model based on number of employees by five aggregate business types and the number of commercial vehicles in a zone.

Trip generation is produced for five trip purposes by the TRM: Home-Based Work (HBW), Home-Based Shopping (HBSH), Home-Based School (HBS), Home-Based Other (HBO), and Non-Home-Based (NHB). To begin the process, zonal socioeconomic data are entered into the model for each zone. Zonal data include area type (urban or rural), number of households, zone population, average household income (in 1995 dollars), average persons per household (population divided by number of households), the ratio of the average household income to the mean income for the area, number of industrial, retail, highway retail, office, and service employees, number of dwelling units, and number of university beds. Appendix N provides full table of the socioeconomic data categories, a description of each, and the data for Southern Village and Lake Hogan Farms.

The cross-classification models for estimating trip productions for each trip type in the TRM are based on the number of households stratified by household size and income group. Therefore, a disaggregation model was needed to translate the socioeconomic inputs of number of households, persons per household, and income ratio, into the number of households stratified by household size and income group. The theory underlying this model is that for any given zonal average household size, there is a specific “mix” of households for each household size. Likewise, for any given zonal average income range per household, there is a specific “mix” of households within each range. This method for determining the number of households by household size was developed by NCDOT using 1990 census data. The average household size was broken into ranges of 0.1 persons per household from 1-person households to households with 4 persons or greater. The development of the income disaggregation model followed the same approach, but used data from the 1995 Travel Behavior Survey and aggregated into five groups instead of four. Table 3-1 displays the urban trip generation rates for the Triangle Regional Model.

Table 5-1: TRM Trip Generation Urban Cross-Class Matrices

Urban HBW Trips

	Household Size (Persons/House)			
Income	**1**	**2**	**3**	**4**
Low	1.05	1.52	1.75	1.91
Low-Middle	1.05	1.88	1.88	1.91
Middle	1.12	1.92	1.92	2.39
Middle-High	1.12	2.08	2.08	2.39
High	1.12	2.08	2.08	2.39

Urban HBSH Trips

	Household Size (Persons/House)			
Income	1	2	3	4
Low	0.45	0.85	0.85	1.08
Low-Middle	0.45	0.85	0.85	1.08
Middle	0.45	0.85	0.85	1.08
Middle-High	0.45	0.86	0.86	1.38
High	0.45	0.94	0.94	1.38

Urban HBO Trips

	Household Size (Persons/House)			
Income	**1**	**2**	**3**	**4**
Low	1.2	2.37	3.76	6.97
Low-Middle	1.2	2.37	3.76	6.97
Middle	1.2	2.37	3.76	6.97
Middle-High	1.2	2.37	3.76	6.97
High	1.2	2.37	3.76	6.97

Urban NHB Trips

	Household Size (Persons/House)			
Income	**1**	**2**	**3**	**4**
Low	1.4	2.38	2.46	3.04
Low-Middle	1.74	2.38	2.46	3.04
Middle	1.74	2.74	2.84	4.11
Middle-High	1.74	2.74	2.84	4.5
High	1.74	2.74	4.63	5.43
University Beds	0.45			

Southern Village and Lake Hogan Farms are assumed to be urban areas based on their proximity to Chapel Hill. Thus, Table 3-1 trip tables were used by the TRM to determine trips for Southern Village and Lake Hogan Farms. Similar tables describe rural trip rates which are not needed in this research project.

Attraction Models

The models for trip attractions are based on regression equations that relate the trip attraction of a zone to a number of independent variables. The independent variables vary by trip purpose and include employment by type and dwelling units. The person trip attraction rates were developed by NCDOT using the Triangle Regional Survey.

The general form of the attraction equation is:

$$Attractions_{purpose}=K+a(A)+b(B)+c(C)$$

Where: K= Constant

a,b,c=coefficients

A,B,C = independent variables

Table 3-2 shows the coefficient values determined from the Triangle Regional Survey.

Table 5-2: Coefficient Values for Attraction

Regression Coefficients	HBW	HBSH	HBO	NHB
CONST	0	0	0	0
IND	1.41	0.1	0.65	1.3
RET	1.41	2.94	1.14	1.22
HWYRET	1.41	1.33	3.74	4.82
OFF	1.41	0.1	1.33	1.3
SERV	1.41	0.1	2.25	2.33
TOTDU	0	0.12	0.95	0.15

In the above table CONST = the constant, IND is industrial employment, RET is the retail employment, HWYRET is the highway retail employment (retail employment that falls into the category of fast food restaurants, service stations, etc), OFF is office employment, SERV is service employment, and TOTDU is the total number of dwelling units in the zone.

Additionally, further processing ensures that high-income jobs are not matched with low-income households in the trip distribution stage. This process is comprised of four steps:

1. Total home-based work trips are estimated for each zone using the Triangle production equations discussed previously.
2. The work trips by income group are estimated using the equation: $Trips_{inc}=TotalTrips*RegionalPercent_{inc}*Ratio_{Inc,area}$
3. The estimated trips from step 2 are balanced to equal total trips from step 1.
4. When all TAZs have been processed, work trips by income group are balanced to the regional level (from the production model).

This assures that the total attractions were estimated correctly by income level. The work attractions by income for each TAZ should sum to the total work attractions calculated for each TAZ using the total work attraction model.

Discussion and Critique of the Travel Demand Model

The Literature Review, in this document, discusses the relative advantages and disadvantages of using a Regional Travel Demand Model (TDM) for Traffic Impact Analysis. In summary the TDM method has the following advantages:

- The TDM uses information about regional land use and socioeconomic data and survey results to obtain trip generation. The model utilizes a cross-classification model to give deterministic estimates of traffic volumes throughout the region.
- It accounts for area type (urban and rural) and employment features of retail and office locations in the development.
- A regional model can incorporate effects of regional attractions and destination and assess the interaction between zones in the model.
- TND features like pass-by trips, internal capture, externally attracted traffic, and transit trips are reflected in the model.
- Capacity, travel time and delay analysis are included in the model
- The model includes internal and external trip distribution, mode split, and traffic assignment.
- Focusing and sub-area analysis techniques allow microscopic evaluation of zones containing TNDs.
- TDM methods can be integrated with micro simulations.

The TDM method has the following shortcomings with respect to site impact analysis:

- Without sub-area or micro simulation options the scale of a travel demand model is not refined enough to assess site-specific information, like the geometric layout of the neighborhood itself, and is therefore better suited for regional applications.
- The use of a regional model requires extensive training.
- Creating a regional TDM requires large amounts of data and the program comes at a significant cost.
- The socioeconomic data that is used for trip generation may be outdated and therefore may not reflect local characteristics accurately.

Components of Resident Survey

After UNC implemented the survey to residents of Southern Village and the Northern Carrboro neighborhoods, researchers developed household level trip generation models. This process is outlined in Volume 1 of this report. In chapter 5 of Volume 2 these equations will be compared to both the traffic counts taken at Southern Village and Lake Hogan Farms, and to standard ITE rates and equations.

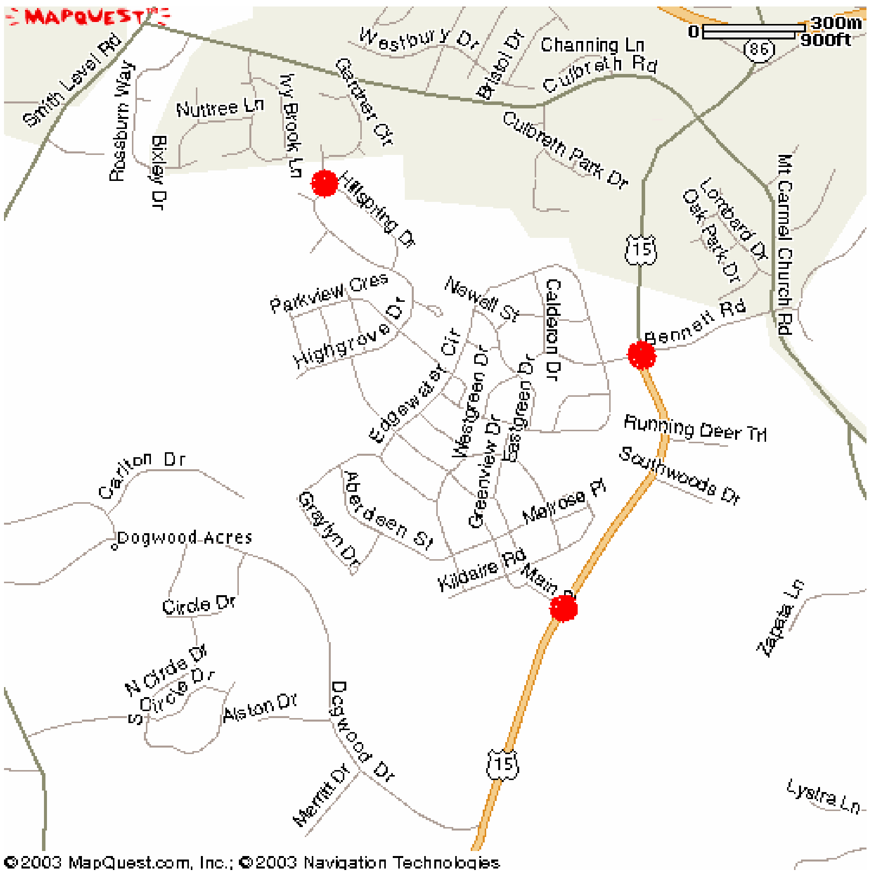
Collection of Traffic Counts

In chapter five of this report the results of the two methods of trip generation described above and the results from the residential survey performed by NCSU will be compared to actual traffic counts performed at the entrances/exits to the study neighborhood. The NCDOT traffic surveys unit performed traffic counts at all three entrances/exits to Southern Village and to the two entrances/exits to Lake Hogan Farms using pneumatic tube counters on March 18 and 19, 2003. A sample output can be found in Appendix O. The following steps outline the process.

Step 1: Determine All Entrance and Exit Points into the Study Area

Entrances and exits to the Southern Village and Lake Hogan Farms developments were determined via a site visit and using an updated map. Fortunately, both areas could be easily cordoned due the existence of only three entrances and exits to Southern Village and two to Lake Hogan Farms. Figures 3-4 and 3-5 show these entrances and exits.

Figure 5-4: Traffic Count Locations for Southern Village



Source: www.mapquest.com

Step 2: Set up Pneumatic Road Tubes for a Selected Time Period at Points Determined in Step One

NCDOT personnel set up pneumatic tubes at all three of the entrances and exits on Monday, March 17th. Data was collected on Tuesday, March 18th and Wednesday, March 19th.

Step 3: Record Data from Pneumatic Road Tubes.

Data was downloaded from the counters by NCDOT, put into spreadsheet form, and distributed to the researchers by hardcopy, and in electronic form.

Figure 5-5: Traffic Count Locations for Lake Hogan Farms

Source: http://www.ghldesign.com/lakehogan/

Discussion and Critique of Count Method

Pneumatic tube counters are a simple but accurate way of obtaining traffic counts. After installing the pneumatic tubes, no personnel are required to supervise the process. However there was a small problem at the Southern Village location. Highway construction at the southern US15-501 entrance to the development caused some drivers exiting the development to inadvertently run over the tube designated for vehicles exiting the development. NCDOT personnel determined that this would not cause significant error. The results of the traffic counts give vehicle trips entering and exiting the developments over 48 hours in 15-minute intervals. However, a shortcoming of taking counts at the entrances and exits is that internal trips are not recorded. A vehicle must enter or leave the boundaries of Southern Village to be counted as a trip. Because this project only considers external trips from the development, this issue can be ignored. However, if further research is to be done on the internal behavior of mixed-use developments (especially if they are of larger scale), other methods of analysis may be preferable.

Chapter Summary

This chapter described four different methods to obtain trip generation rates and traffic estimates for Southern Village and Lake Hogan Farms. The methods discussed in this chapter involved the ITE Manual procedures, the Triangle Regional Model, resident and business surveys, and traffic counts collected at the developments.

Chapter 6: Analysis of Case Studies

This chapter describes the results from the trip generation methods outlined in Chapter 3 applied to the two case study neighborhoods, Southern Village and Lake Hogan Farms. For a detailed description of the neighborhoods, their geographic location, and design characteristics, refer to Appendix K.

Following the trip generation development of Chapter 3, this chapter provides the ITE trip generation estimates for Southern Village and Lake Hogan Farms and applies adjustments for internal capture. Next, the results of the Triangle Regional Model are shown followed by a summary comparing all results to each other and also to the results of the resident survey. The chapter also conducts a sensitivity analysis for the ITE Method in order to better understand how changes in trip generation and internal capture rates affect level of service estimates at intersections. The chapter concludes with a proto-type micro-simulation to demonstrate state-of-the-art traffic impact analysis methods.

ITE Trip Generation

Southern Village

The method of the ITE Trip Generation Manual and the ITE Handbook was used to develop trip generation estimates, as outlined in Chapter 3. The Southern Village and Lake Hogan Farms trip generation spreadsheets can be found in Appendix M. Table 6-1 summarizes the trip generation for Southern Village (2002) before adjustments for internal capture.

Table 6-1: Southern Village ITE Trip Generation (No Internal Capture)

				Average Daily Traffic		P.M. Peak		A.M. Peak	
Code	**Land Use**	**Intensity**	**unit**	**entering**	**exiting**	**entering**	**exiting**	**entering**	**exiting**
210	Single Family Homes	510	units	2440	2440	330	185	96	287
230	Condo+Townhouses	335	units	982	982	121	60	25	122
220	Apartments	250	units	829	829	104	51	20	107
443	Theater (4scrn)	10	thou sf	390	390	58	4	0	0
832	Bistro	2	thou sf	130	130	13	9	10	9
831	Restaurant	4.5	thou sf	202	202	23	11	0	0
850	Grocery w/café	6	thou sf	335	335	35	34	12	8
814	Gift store + cleaners	2	thou sf	41	41	2	3	6	7
710	Office space	95	thou sf	523	523	24	117	130	18
560	Church	27	thou sf	123	123	10	8	10	9
565	Daycare	6	thou sf	238	238	37	42	40	36
520	Elementary school	90	thou sf	541	541	73	208	184	118
492	Swim and tennis club	3	thou sf	26	26	3	3	0	0
			Total	6800	6800	832	735	535	720

Values in Table 6-1 represent total trip generation estimates for Southern Village using the ITE Trip Generation Manual (6th edition) and 2002 land use information for the neighborhood. The ITE Trip Generation Handbook method evaluates interactions of residential, office, and retail uses and calculates external trip reductions due to internal capture between those three zone types. Table 6-2 below summarizes the results of this method for multi-use developments for Southern Village. The total number of trips are less than shown in table 6-1, because the ITE

Trip Generation Handbook method does not consider land uses other than residential, office, and retail. Internal Capture rates for other land uses (school, daycare, church, and swim & tennis club) will be considered separately and are subsequently added to the total trip estimates.

Table 6-2: Southern Village Daily Internal Capture Results

Daily Net External Trips For Multi-Use Development				
	Land Use			
Land Use Category	Residential	Office	Retail	Total
Entering Trips	4,120	490	955	5,565
Exiting Trips	4,152	469	944	5,565
Total Trips	8,271	959	1,899	**11,130**
Single-Use Estimate	8,501	1,046	2,196	**11,744**
	Interim Internal Capture			**5.23%**

Table 6-2 indicates an overall daily internal capture rate of 5.23%. However, as indicated above the trips associated with the church, elementary school, daycare, and swim and tennis club cannot be accounted for using the ITE handbook method and must therefore be added. According to officials at Mary Scroggs Elementary School 238 of their 597 students live in Southern Village. This translates into an internal capture rate of about 40% for the school. Assuming that the same trip profile and internal capture rate exists for the church, daycare, and the swim & tennis club, the estimates for those land uses will be reduced by the same percentage. The total external trip generation translates to 12,246 vehicles per day, compared to the single use trip generation of 13,600 vehicles per day. This corresponds to a daily overall internal capture rate for Southern Village of **9.96%.**

Using the 2001 ITE Handbook Method for Multi-Use Development and the ITE PM peak trip generation Table 6-3 estimates are obtained for the PM peak. The numbers are less than those given in Table 6-1, because they incorporate reductions for internal capture.

Table 6-3: Southern Village PM Peak Hour Internal Capture Results

PM Peak Hour Trip Estimates with Internal Capture				
	Land Use			
Land Use Category	Residential	Office	Retail	Total
Entering Trips	546	22	116	684
Exiting Trips	284	113	51	448
Total Trips	830	135	167	**1,132**
Single Use Estimate (from Table 4-1)	851	142	191	**1,184**
	Overall Internal Capture			**4.39%**

As for the daily calculations, the PM peak hour trips associated with the church, elementary school, daycare, and swim and tennis club must be added to the results of Table 6-3. Without internal capture the church, school, daycare, and swim & tennis club add 123 inbound and 261 outbound PM trips. With the assumed 40% internal capture the inbound and outbound PM trips are 74 and 157 respectively. Therefore, the single use trip generation estimate is 1568 vehicles in the peak hour and the net external trips are 1363 vehicles in the peak hour, resulting in an internal capture rate of **13.1%** for the p.m. peak.

The A.M. Peak Hour volumes are not analyzed because the ITE method does not account for internal capture in the AM peak.

In summary, the ITE trip generation method predicts that in November 2002, Southern Village generated approximately 12,250 vehicles daily on the surrounding network. This represents a 9.96% overall internal capture rate. In the PM peak Southern Village discharged 1363 vehicles onto the surrounding network, indicative of a 13.1% hourly internal capture rate. The findings are summarized in Table 6-4 below.

Table 6-4: Southern Village November 2002 Trip Generation

Southern Village November 2002 Trip Generation		
	Daily Traffic	**PM Peak Hour Traffic**
Trip Generation with internal capture	12250	1360
Single Use Trip Generation	13600	1568
Internal Capture Rate	9.96%	13.10%

Lake Hogan Farms

In March 2003, Lake Hogan Farms had 252 occupied single-family homes. Table 6-5 summarizes Lake Hogan Farms trip generation using the average ITE trip rates for single-family homes. There is no reduction due to internal capture, because Lake Hogan Farms is a single use, all residential development.

Table 6-5: Lake Hogan Farms March 2003 Trip Generation

Lake Hogan Farms March 2003 Trip Generation			
	Daily Traffic	**PM Peak Hour**	**PM Peak Hour**
Single Use Trip Generation (veh/time)	2419	189	254

Triangle Regional Model Trip Generation

The Triangle Regional Model uses a variety of socioeconomic data to predict trips for traffic analysis zones in the regional network. Updated data for Southern Village and Lake Hogan Farms came from a variety of sources, including the developers of each neighborhood and the surveys performed by the University of North Carolina at Chapel Hill. Using updated neighborhood socioeconomic data, the regional model determined the sum of the total daily trips entering and exiting each development (Table 6-6).

Table 6-6: TRM Trip Generation Estimates

Triangle Regional Model Daily Trip Estimates (1995 Model with 2003 S/E data)	
Southern Village (veh/day)	9610
Lake Hogan Farms (veh/day)	1884

Neighborhood Survey Trip Generation

Using responses to the surveys conducted at Southern Village and the Northern Carrboro neighborhoods, researchers at UNC Chapel Hill developed equations to describe the automobile trip generation characteristics of the residents.

Southern Village

Because Southern Village contains a variety of housing types, and because the total trips generated are different from the total external trips (because of internal capture), different rates were developed from the surveys to address specific areas of interest. The equations to develop the rates using the survey data are in the form

$$\text{Trip Rate} = \text{Coeff}_1 * (\text{Average Value}_1) + \text{Coeff}_2 * (\text{Average Value}_2) + \text{Constant}$$

The equations and coefficients used to generate the traffic estimates in the following discussion are given in the earlier sections of Chapter 3.

Table 6-7: Southern Village Resident Survey Trip Estimates (2003)

Survey Trip Generation Results for Southern Village			
Land Use Type	Rate (veh. trips/unit)	Intensity (# of units)	Daily Traffic Forecast (veh.
All Residential Households	6.29	1095	6885
Multi-Family Residential	5.90	585	3453
Single-Family Homes (SFH)	6.54	510	3335
SFH External	5.76	510	2939

Using the survey results, Table 6-7 summarizes rates for each land use type, the intensity (# of units) and the resulting daily traffic estimates. For the Single-Family Homes (SFH) category the table further shows external trips, which implies that the SFH internal capture rate is 13.5%. The SFH internal capture rate does not represent an interaction of land uses as in the ITE method and is not necessarily indicative of other residential classifications.

Lake Hogan Farms

The survey included Lake Hogan Farms and several other similar neighborhoods in Northern Carrboro. It yielded two sets of equations: one for Northern Carrboro as a whole and one specifically for Lake Hogan Farms. The following table lists results of both equations, but in each case applies only to the housing intensity in Lake Hogan Farms alone.

Table 6-8: Lake Hogan Farms Resident Survey Trip Estimates

Survey Trip Generation Results for Lake Hogan Farms			
Land Use Type	**Rate (veh. trips/unit)**	**Intensity (# of units)**	**Traffic Forecast (veh/day)**
Single-Family Homes (SFH) - "Northern Carrboro Equation"	9.42	252	2347
Single-Family Homes (SFH) - "Lake Hogan Farms Equation"	9.39	252	2365

The intensity in Table 6-8 is the number of single family homes in Lake Hogan Farms and the trips are external auto trips.

Comparative Results and Discussion

As outlined in Chapter 5, trip generation uses the ITE method, the Triangle Regional Model (TRM), and the resident survey. All methods are compared to traffic counts taken at the entrances and exits to the developments by the NCDOT Traffic Survey Unit in March 2003.

Southern Village

Table 6-9 shows the trip generation results for each method and the percent they differ from the March 2003 traffic counts. The estimates in the ITE Trip Generation column were developed using the average rates for each particular land use, and the estimates in the March 2003 traffic counts column are an average of two days.

Table 6-9: Southern Village Daily Trip Generation Comparison

	ITE Trip Generation Method (Nov 2002)	TRM Trip Generation (1995 Model w/2003 S/E Data)	March 2003 Traffic Counts
Estimated External Trips	12250	9610	12609
Percent Difference to Traffic Counts	-2.85%	-23.78%	n/a

Compared to the NCDOT traffic counts the ITE Trip Generation Manual accurately estimates the trip generation for Southern Village. The difference of 2.85% reflects an under-estimation of 359 trips. Conversely, the Triangle Regional Model under-estimates by 2999 trips over 24 hours, which is a difference of 23.78%.

Table 6-10: Southern Village PM Peak Trip Generation Comparison

	ITE Trip Generation Method (Nov 2002)	March 2003 Traffic Counts
Estimated External Trips	1363	1336
Percent Difference to Traffic Counts	2.02%	n/a

Table 6-10 shows that for the PM Peak the ITE method also performs accurately, showing a difference of 2%. Since the TRM is a 24-hour model, no peak hour trip generation figures are available.

Considering the complex travel that takes place in a neo-traditional neighborhood, and the fact that the ITE Trip Generation Manual was developed using data from single-use, individual sites, it should be somewhat inaccurate for Southern Village. Conversely, since Lake Hogan Farms is a single-use site with no mixed development, the ITE should more accurately predict the daily and PM peak traffic.

Table 6-11: Lake Hogan Farms Daily Trip Generation Comparison

	ITE Trip Generation Method (Nov 2002)	TRM Trip Generation (1995 Model w/2003 S/E data)	March 2003 Traffic Counts
Estimated External Trips	2419	1884	2732
Percent Difference to Traffic Counts	-11.46%	-31.04%	n/a

Table 6-11 indicates that the Trip Generation Manual under-predicts the total entering and exiting traffic by 313 trips (11.46%). As with Southern Village, trip generation figures were developed using the TRM, and as before, the TRM underestimated the trips entering and exiting the development. Some portions of the development were still under construction during this study, and the additional trips associated with construction traffic could explain the difference. Even though the Trip Generation Manual underestimated the total daily trips leaving Lake Hogan Farms, it does a very good job of estimating the PM peak, only missing the total by five trips, representing an under-estimation of 2.01% (Table 4-12).

Table 6-12: Lake Hogan Farms PM Peak Trip Generation Comparison

	ITE Trip Generation Method (Nov 2002)	March 2003 Traffic Counts
Estimated External Trips	254	249
Percent Difference to Traffic Counts	2.01%	n/a

The ITE Manual estimates were also compared to those of the resident survey (Table 6-13). Internal capture is not considered, because the survey equations calculated total vehicle trips generated by each household (internal and external). The only exception to this is the last row in the table below, which shows the external generation for the SFH category (includes internal capture).

Table 6-13: Comparison of Survey and ITE Trip Generation, Southern Village

	Survey Daily Traffic	ITE Trip Generation	Difference	% Difference
All Residential	6885	8501	-1616	-19.0%
Multi-Family Residential	3453	3621	-168	-4.6%
Single-Family Homes (SFH)	3335	4881	-1545	-31.7%
SFH External	2939	4748	-1809	-38.1%

The trip generation estimates from the survey equations for Southern Village are lower than those predicted by the ITE Trip Generation Manual. Most of this difference can be attributed to the single-family households. The rate developed using the surveys from Southern Village was 6.54 trips per household. The average ITE is 9.57 trips per household. The rate for Southern Village developed in the survey falls within the range given in ITE Trip Generation Manual (4.31 to 21.85 trips per household), but it is much lower than the ITE rate used in this study. As noted in Tables 6-9 and 6-10, the ITE trip generation for Southern Village closely corresponds with the traffic counts collected at the exits to the development (within 3%), so the survey result appears low.

However, the more likely case is that the ITE rates for some land uses were high, and others low, but the balance came very close to the traffic counts. If the survey data is considered to be the "truth" then the ITE rate was artificially high, but an artificially low rate for another land use made up for the discrepancy. However, this argument may be unlikely. The single-family homes have the largest single impact on the trip generation of the development. The ITE rates for several other land uses would have to be very low to make up for a 30% over prediction in single family homes. This would mean that several businesses in the development were doing much more business than average businesses.

The location of business in the development, away from a major intersection, and their relatively narrow clientele would seem to suggest that at best they were performing on average. Site visits in peak hours seem to back this statement. In conclusion, for the Southern Village case, the ITE trip generation matched traffic counts. The discrepancy between the survey rates and the ITE rates is difficult to explain. More studies should be completed with more cordon counts surrounding the different development areas (condos, apartments, single family homes, and businesses) to learn where the largest discrepancies lie between ITE and the actual trip generation characteristics of the development.

Lake Hogan Farms

Tables 6-14 to 6-16 show similar comparisons for Lake Hogan Farms. The trip generation estimates for Lake Hogan Farms using the two equations derived from the survey data are closer to the ITE trip generation estimates then traffic counts. This indicates that on the two days of counts people made more trips or the survey rates do not adequately describe the travel behavior of individuals in Lake Hogan Farms.

Table 6-14: Comparison of Survey and ITE Trip Generation, Lake Hogan Farms

	Survey Daily Traffic	ITE Trip Generation	Difference	% Difference
Single-Family Homes (SFH) - "Northern Carrboro Equation"	2374	2419	-45	-1.9%
Single-Family Homes (SFH) - "Lake Hogan Farms Equation"	2365	2419	-54	-2.2%
	Survey Daily Traffic	**Traffic Counts**	**Difference**	**% Difference**
Single-Family Homes (SFH) - "Northern Carrboro Equation"	2374	2732	-358	-13.1%
Single-Family Homes (SFH) - "Lake Hogan Farms Equation"	2365	2732	-367	-13.4%

Table 6-15: Summary of Southern Village Trip Generation

Southern Village Trip Generation Comparison						
	ITE Trip Generation		TRM Trip Gen.	Survey	Traffic Counts	
	PM Peak	Daily	Daily	Daily	Daily	PM Peak
Total Vehicle Trips	1568	13600	-	6885*	-	-
External Trips	1360	12250	9610	2939**	12609	1336
Internal Capture Trips	208	1350	-	396**	-	-
% Internal Capture	13.10%	9.96%	-	13.47%**	-	-

* Only Residential Neighborhoods
** Only Single-Family Home Residential

Table 6-16: Summary of Lake Hogan Farms Trip Generation

Lake Hogan Farms Trip Generation Comparison						
	ITE Trip Generation		TRM Trip Gen.	Survey	Traffic Counts	
	PM Peak	Daily	Daily	Daily	Daily	PM Peak
Total Vehicle Trips	254	2419	-	-	-	-
External Trips	254	2419	1884	2365*	2732	2732
Internal Capture Trips	0	0	-	-	-	-
% Internal Capture	0.00%	0.00%	-	-	-	-

* from 'Lake Hogan Farms' Equation

Sensitivity Analysis

This section summarizes a sensitivity analysis of the ITE trip generation results for the Southern Village Neighborhood Development. The results show the relative impacts of trip generation on intersection design with and without adjustments for mixed-use internal capture and the inherent variability of rates. Appendix P provides more details of the analysis including all data tables. The analysis consists of four main components:

1. Analyzing variations of trip rates within a 95% confidence interval
2. Assessing capacity and levels of service of an intersection for the 95% confidence interval and for other (hypothetical) percentages of increased traffic volumes
3. Comparing sensitivities of different land uses in the neighborhood
4. Evaluating effects of internal capture rate on intersection performance

Step 1. Trip Rate Variations in a 95% Confidence Interval

For the first step of the sensitivity analysis, the ITE trip generation method was performed three times for each land use:

- Using the mean values as listed in the ITE manual
- Using the mean values plus two standard deviations
- Using the mean values minus two standard deviations

Table 6-17 shows the trip rates for daily and peak hour traffic in a 95% confidence interval expressed as percent differences from the average rates.

Table 6-17: Variability of ITE Trip Generation Rates

Percent Difference of ITE Trip Rates for total traffic volumes in Southern Village					
Daily Traffic (# of vehicles)		**AM Peak Hour (# of vehicles)**		**PM Peak Hour (# of vehicles)**	
Entering	Exiting	Entering	Exiting	Entering	Exiting
Minus Two Standard Deviations					
-76.9%	-76.9%	-98.1%	-98.8%	-92.3%	-98.7%
Mean Values					
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Plus Two Standard Deviations					
81.2%	81.2%	186.0%	234.4%	194.0%	184.4%

Table 6-17 shows that in a 95% confidence interval, the maximum trip rate can be more than 200% greater than what the average rate suggests. The large variation in plus and minus two-sigma values is symptomatic of the wide range of U.S. locations for the data and in some cases the relatively few field data used to develop the trip rates in the ITE manual. In a real situation traffic engineers would likely adjust the average trip rates for a case study consistent with local conditions. The plus two standard deviation rates are, therefore, a high upper limit of trip rates, with actual trip rates falling somewhere in-between predicted average rates and these limits.

Step 2. Capacity Analysis for (Hypothetical) Increases in Traffic Volumes

The sensitivity analysis assessed effects of increasing PM traffic estimates on intersection levels of service. The analysis focused on the intersection of US15-501 and Main Street, the major entrance to Southern Village.

The capacity analysis of the intersection was accomplished using the HCS2000 software package. The analysis was completed with the average ITE trip generation predictions. Because the signal on the Main Street/US15-501 intersection is actuated, averages of field measurements of the actual signal times were taken to obtain average signal times for the analysis (Appendix O). The analysis was completed with the actual traffic volumes and assumed increases in traffic of 10%, 25%, 50%, 100%, 150% and two-sigma. Table 6-18 shows a summary of the capacity comparisons.

Table 6-18: Capacity Analysis for Percent Increases in Traffic Volumes

Approach	Direction	ITE forecast		SV volumes +10%		SV volumes +25%		SV volumes +50%	
		LOS	delay(s)	LOS	delay(s)	LOS	delay(s)	LOS	delay(s)
US15-501 NB	through	A	6.5	A	7.0	A	13.3	A	7.0
	left	B	10.4	B	12.8	B	7.0	B	14.3
US15-501 SB	through	B	13.1	B	17.6	B	17.6	B	17.6
	right	A	1.9	A	3.1	A	7.0	A	3.4
Main Street EB	left	D	43.6	E	64.2	E	68.2	E	79.0
	right	D	36.0	D	47.7	D	51.1	E	59.6
Intersection Totals		**B**	**16.6**	**C**	**22.9**	**C**	**24.7**	**C**	**28.8**
Approach	**Direction**	**ITE forecast**		**SV volumes +100%**		**SV volumes +150%**		**Plus Two-Sigma**	
		LOS	delay(s)	LOS	delay(s)	LOS	delay(s)	LOS	delay(s)
US15-501 NB	through	A	6.5	A	7.0	A	7.0	A	7.0
	left	B	10.4	B	16.8	C	20.0	C	29.4
US15-501 SB	through	B	13.1	B	17.6	B	17.6	B	17.6
	right	A	1.9	A	3.8	A	4.3	A	5.3
Main Street EB	left	D	43.6	F	140.1	F	249.5	F	351.5
	right	D	36.0	F	115.1	F	223.3	F	328.0
Intersection Totals		**B**	**16.6**	**D**	**51.5**	**F**	**97.1**	**F**	**140.6**

As expected, the levels of service for the intersection of Main Street and US15-501 get continuously worse with increasing traffic volumes. This analysis is interesting, however, in that the high delays are all associated with the exiting volumes from the development (the minor movements). The through movements on US15-501 remain at satisfactory levels of service even if the traffic exiting the Southern Village development increases by these large percentages. This behavior is understandable because the intersection is designed to carry large future volumes on US15-501.

Step 3. Comparison of Different Land Use Types

The analysis compares average rates predicted with the ITE method to the plus two standard deviations rates for each land use. Table 6-19 lists the percent difference between these two estimates and shows the difference in actual numbers of vehicles. A specific land use type may have little overall effects on traffic due to low intensity, despite a high standard deviation in its trip rate. Thus, this step identifies sensitive Southern Village land uses.

Table 6-19: Comparison of Different Land Use Types

Land Use Category	Intensity	% Difference From Average	Additional Vehciles from Average
Single Family Homes	510 units	77.1%	3764
Condos + Townhomes	335 units	105.5%	2070
Apartments	250 units	89.9%	1490
Office	95,000 sq.ft.	114.4%	1165
Retail	24,500 sq.ft.	138.7%	561
Church	27,000 sq.ft.	158.1%	389
Daycare	6,000 sq.ft.	53.1%	252
School	90,000 sq.ft.	116.7%	1264
Swim and Tennis Club	3,000 sq.ft.	158.6%	82
Total		**81.2%**	**11036**

Table 6-19 suggests that the most sensitive traffic predictions would probably result from the residential zones in Southern Village because of the relatively high intensity. The closest analytical attention should be paid to the traffic forecasts for residential land uses. Other land uses may have high percent differences, but they have a negligible overall effect because of relatively low intensities. Trip generation results should be treated with care, and professional judgment should be applied to verify the validity of the calculated rates for developments similar to Southern Village.

Step4: Effects of Internal Capture

The sensitivity analysis also compared the impacts of the average ITE rates predicted with rates that are adjusted for the calculated 13.1% internal capture. Table 4-20 compares the impacts of the reduced rates to the unadjusted ITE predictions.

Table 6-20: Effect of Internal Capture Rate on Capacity Analysis

Approach	Direction	without int. capture		with 13.1% Int. Capt.	
		LOS	delay(s)	LOS	delay(s)
US15-501 NB	through	A	6.5	A	6.5
	left	B	10.9	B	10.4
US15-501 SB	through	B	13.1	B	13.1
	right	A	2.0	A	1.9
Main Street EB	left	D	46.0	D	43.6
	right	D	39.2	D	36.0
Intersection Totals		**B**	**18.0**	**B**	**16.6**

Table 6-20 shows a negligible difference between levels of service and delays. The resulting improvement in overall intersection delay is 1.4 seconds for the p.m. peak hour, which suggests that impacts for other time periods of the day are even less. Furthermore, reduced Southern Village traffic due to the internal capture rate of 13.1% is distributed over all three exits/entrances. For each individual lane group this means that the actual impacts in number of vehicles are not significantly related to internal capture, and the effects on intersection capacity will be minor. Table 6-21 shows the distribution of the total traffic difference over the lane groups in the Main Street and US15-501 intersection.

Table 6-21: Volume Comparison for Main Street/US15-501

Volume Differences Between Trip Generation With and Without Internal Capture (p.m. peak hour)				
		internal capture 13.1%	**no internal capture**	**Difference in # of vehicles**
Total Volumes Predicted by ITE	Entering	723	832	**109**
	Exiting	639	735	**96**
Volume Percentages on Main Street	Entering (42%)	304	349	**46**
	Exiting (78%)	498	573	**75**
Volume Directional Splits for Turning Movements	Exiting to NB (40%)	199	229	**30**
	Exiting to SB (60%)	299	344	**45**
	Entering from NB (40%)	121	140	**18**
	Entering from SB (60%)	182	210	**27**

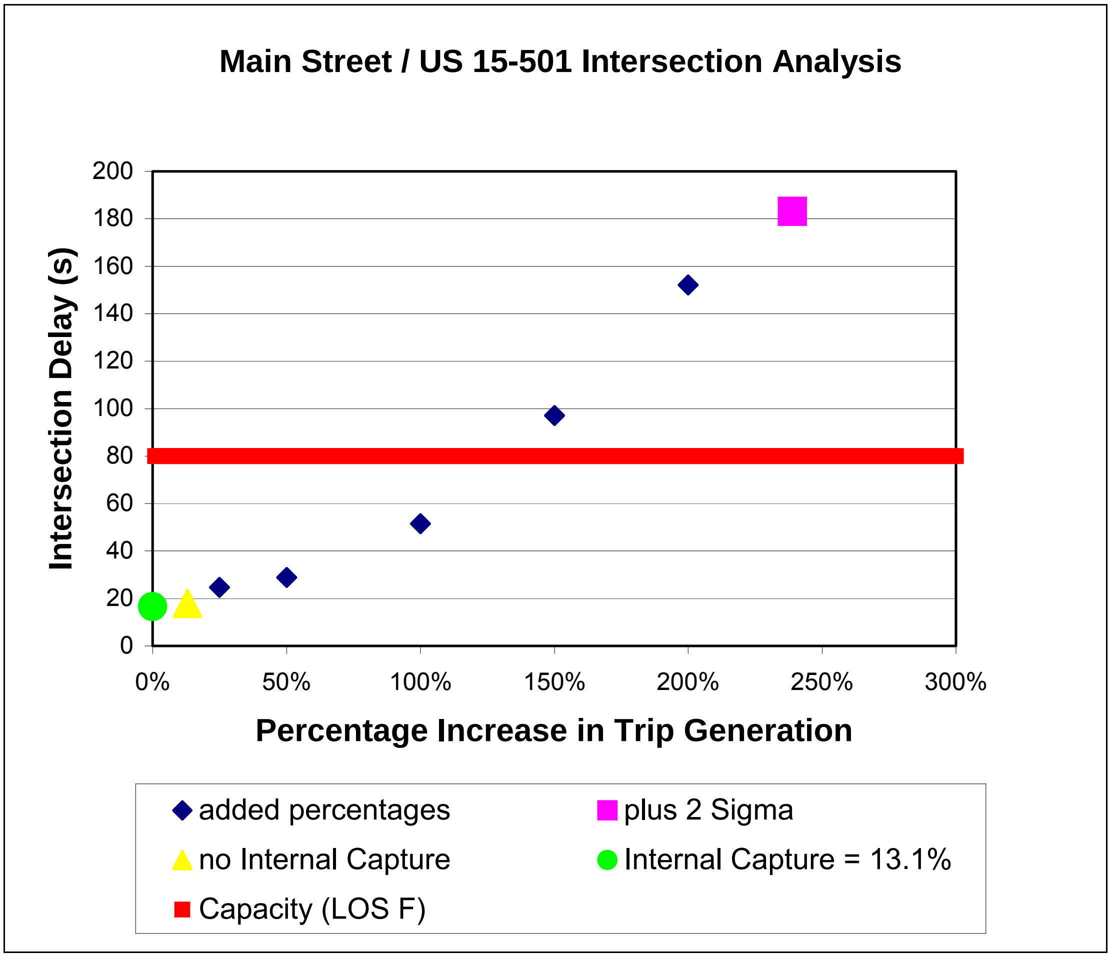
Table 6-21 shows that the internal capture rate observed for Southern Village results in less than 50 vehicles for every lane group per hour, which is less than one vehicle per minute. The impacts on Levels of Service (LOS) for the intersection are relatively insignificant. In this context it also needs to be stated that US15-501 is being widened, and that the widened roadway (which was used in this analysis) is likely designed to carry increased future traffic. The impacts on LOS may have been more significant in regions of higher density. TNDs similar to Southern Village that are located on arterials with volumes already closer to the capacity limit will likely have greater impacts on the surrounding road network. In those hypothetical cases, the impacts of 13% internal capture would then also have greater beneficial results. This case suggests that close attention needs to be paid to TNDs planned in over-capacity locations.

For cases like Southern Village, with perimeter roads that are major arterials, the sensitivity analysis suggests that it may not be necessary to calculate internal capture rates because there are only small impacts on the adjacent road network. In any event it is good practice to use the ITE handbook as a step in traffic impact analyses for traditional neighborhood developments.

Sensitivity Analysis Summary

The ITE trip generation manual can have very high standard deviations. Trip rates generated with the ITE method should compare to professional judgment and local rates. The sensitivity analysis shows that if the ITE method has underestimated traffic volumes, the levels of service on the Main Street and US15-501 intersection decrease significantly because of the intersection’s design to handle lower volumes. Figure 6-1 below summarizes the results of this sensitivity analysis in a plot of intersection delay versus percentage increase in trip generation rates.

Figure 6-1: Sensitivity Analysis Summary



The heavy line in Figure 6-1 at 80 seconds total intersection delay represents a Level of Service 'F', at which the intersection is regarded as having exceeded its capacity. The circle symbol in the bottom left represents the average ITE trip generation rates minus the reductions for internal capture. The triangle next to it refers to the delay times calculated without the adjustment. The symbols show that both delay times are well below the capacity of the intersection, and the effect of internal capture is negligible. However, at the regional scale the combined internal capture of several Traditional Neighborhood Developments along the same collector route may conceivably have a beneficial effect on traffic.

Findings of the sensitivity analysis in summary are:

- ITE Trip generation can have large variability. It should be used carefully and should be adjusted for local conditions.
- If external traffic is higher than predicted, exiting neighborhood traffic delays will likely increase and result in unsatisfactory LOS for neighborhood traffic
- LOS of mainline traffic on arterials in this case was hardly affected by increasing traffic volumes entering and exiting the neighborhood

- Highest variability and additional vehicle trips resulted from residential generators in the development. Impacts of commercial and business land uses were less significant.
- The calculated (and observed) 13% internal capture has negligible effects on intersection LOS due to distribution effects.

Feasibility of Traffic Simulation Methods

The literature review in Chapter 2 has identified time-dependent traffic simulations as a possible alternative in the assessment of traffic impacts of Traditional Neighborhood Developments. While traffic simulation relies on other methods for trip generation (like the ITE method or a regional Travel Demand Model) it allows for a visual representation of traffic impacts on the simulated section of the road network. Traffic simulations such as CORSIM or VISSIM are therefore viable alternatives to the trip distribution and capacity analysis steps of a traditional traffic impact analysis. For this report a sample network for the Southern Village TND was developed in the VISSIM software package to evaluate the software as a traffic impact analysis tool. For complete documentation of the modeling process including screenshots and records of programming time refer to Appendix R.

The experience with the VISSIM software package has shown that the programming of an accurate representation of a TND neighborhood and surrounding streets requires a significant time investment and specifically trained staff. More importantly, the successful implementation of the simulation model requires trip generation and trip distribution estimates derived from other methods. For the visual analysis of the traffic impacts of the Southern Village case, the costs in training and programming time exceed the benefits of having a dynamic, visual representation of predicted traffic flows.

However, for future traffic impact assessments and as a regional planning tool, time-dependent traffic simulation is a very powerful tool. For example, simulation software presents the unique ability to model the interaction of several TND neighborhoods along the same corridor. Traffic simulations may provide an insight into traffic impacts and road network capacity for multiple TND developments. They allow for fast and easy adjustments of traffic volumes and roadway modifications and show impacts of such changing conditions visually, as well as, in the form of delay and travel time data output.

With an anticipated simplification of programming effort in the future and decreasing time requirements for creating models, simulation methods will more and more find their place as a TIA tool in the future. They allow the addition of public transportation modes and pedestrian movements in the modeling process, which will become an ever more important issue as the number of TND neighborhoods increases.

Conclusions

The ITE Trip Generation Manual does an acceptable job of estimating the daily and PM peak volumes for Southern Village. It also estimates the trips from Lake Hogan Farms accurately.

The Triangle Regional Model falls short when estimating the daily trips entering and exiting Southern Village and Lake Hogan farms. The under-prediction of traffic is likely due to the age of the model and the general infeasibility of using a regional model for neighborhood-level traffic prediction.

The trip generation rates developed using the surveys from Southern Village are much smaller than the rates for single family homes in the ITE Trip Generation manual, but are very close to the combination of apartments and condominiums. Because the ITE trip generation is about equal to the traffic counts, either the survey rates are artificially low, or more complex land use interactions are occurring.

From the sensitivity analysis it was observed that increasing traffic volumes entering and exiting the neighborhood negligibly affected the LOS of through traffic on the adjacent arterial and that the highest variability and additional vehicle trips resulted from residential generators in the development. Impacts of commercial and business land uses were less significant. In addition, the calculated (and observed) 13% Internal Capture has negligible effects on intersection LOS due to distribution effects.

Finally, for future traffic impact assessments and as a regional planning tool, time-dependent traffic simulation may prove to be a very powerful tool. The ability to model the complex internal interactions between pedestrians and vehicles in a mixed-use development can lead to greater understanding of the impacts of such design specifically with regard to larger developments that are more integrated into the urban fabric.

Chapter 7: Summary Findings, Conclusions and Recommendations

Traveler Behavior: Trip Generation

North Carolina is experiencing rapid growth, especially in the Charlotte, Piedmont Triad, and Research Triangle areas. One way to deal with the growth is to encourage traditional neighborhood developments, which attempt to create new growth by looking at the lessons from the past. Specifically, they promote alternative modes, mixed land uses and higher densities. This study was an attempt to understand the relationships between traditional neighborhood developments and transportation. The study finds no statistically significant difference between the *total* trips made by households in the TND surveyed and the comparable conventional developments. However, TND households substitute driving trips with alternative modes, i.e., the *automobile* trip generation rate for the TND was significantly lower (by 1.25 trips per day per household) than conventional neighborhoods. In addition, empirical evidence suggests that TND households have:

- Lower vehicle miles traveled—on average, TND single-family households travel 18 miles less per day.
- Higher share of alternative modes—in the TND, 78.4 percent of the trips were by personal vehicle compared with 89.9 percent in the conventional neighborhoods.
- Lower external trips—on average TND households made 1.53 less external trips per day.

The TND examined in this study internally captured a substantial share (20.2 percent) of the total trips produced. The conventional neighborhoods internally captured a much smaller share (5.5 percent) of the total trips. Therefore the difference between the internal trip capture rates for the two development types is 14.7 percent.

Note that 1.25 fewer automobile trips per household per day translates to 1150 fewer trips per day for the entire Southern Village development (920 residences * 1.25 trips). Likewise, 1.53 fewer external trips per household per day translates to 1408 fewer external trips per day (920 residences * 1.53 trips). If we assume that 8 percent of the traffic will occur during the afternoon peak period, then this will imply 113 fewer peak period trips (1408*0.08). Given that roadway capacity is approximately 2000 passenger cars per hour per lane and assuming that all 113 trips are made in single-occupant vehicles, a relatively small network impact of Southern Village will occur. Possibly several TND developments can be clustered together, perhaps in greenfields, if a substantial impact on network performance is to be achieved. Of course it will be important to think more about which types of clustering will be most appropriate in the various North Carolina contexts.

Our findings are also consistent with the literature reviewed at the beginning of this report. For example, in line with Cervero and Kockelman (1997) and Cervero and Radisch (1996), we find that households in TNDs travel fewer vehicle miles and make more physical activity trips (TND residents made 0.42 more exercise trips per day) than households in conventionally designed neighborhoods. Even as an example of an “island of neotraditional development in a sea of freeway-oriented suburbs” (Cervero, 1996), Southern Village’s design seems to influence travel behavior by increasing alternative mode use and lowering vehicle miles traveled, which translates into fewer cars on roadways.

The results of the business survey revealed that the ITE procedure, when applied to the Southern Village businesses predicted 5,918 trip ends compared with 5,918 trip ends reported by the business managers. This is 13.7 percent fewer trip ends than reported. Furthermore, only 5.2 percent of the 432 employees reside in Southern Village and a large majority of the employees (92.4 percent) use personal vehicles to commute to work. This is not surprising given the high levels of automobile ownership in the area and free employee parking in Southern Village. A greater percentage of customers/visitors (39.2 percent) reside in Southern Village and about 18.1 percent reportedly walk to the businesses. The results show that Southern Village employees use passenger cars as often as employees in conventional (stand-alone) facilities, but that customers are more likely to walk.

Several important issues should be addressed in future studies, perhaps utilizing the same dataset or at least using this dataset and these findings as a baseline.

- Survey traditional and conventional neighborhoods that have a more diverse range of household incomes and household types. Because both the neighborhoods used in this study have relatively high incomes and housing values, we cannot refute scholars who believe that the harm in building more traditional neighborhoods is that they may backfire and actually end up generating more vehicle miles traveled: While this does not appear to be true for traditional neighborhoods that contain households with high incomes and high housing values, it may well be true for more socioeconomically diverse traditional neighborhood development. This issue clearly needs further investigation.
- There are many good reasons for children to walk or bicycle to school, e.g., it gives them the exercise they need and reduces automobile trips. By providing sidewalks and bicycling opportunities, TNDs may alleviate safety concerns and encourage parents and children to use these alternative modes. The data collected in this study allows us to quantify the use of alternative modes for children's school travel.
- With over 50 percent of the US population overweight and about 30 percent obese, the problem is costing an estimated $100 billion in healthcare costs. Part of the problem is transportation related, given the automobile dependency. Therefore, the health effects of transportation activities need investigation, e.g., do TNDs encourage more physical activity? Are people living in TNDs less likely to be overweight? Again, our data can provide at least partial answers to these questions.
- The possibility of self-selection should be thoroughly tested. While regression analysis of the responses to the attitudinal questions in this survey suggests the presence of self-selection, a longitudinal study that accounts for life-changing events is the best way to address self-selection biases.
- Finally, the Southern Village was a relatively new TND when it was surveyed. As the development matures and the diversity of businesses, land uses and residents within the development increases, it should be re-surveyed to get a sense of how residents' behavior changes over time—and if the "novelty effect" wears off. Indeed by understanding behavioral changes over time can we understand the dynamics of behavior that are so critical to reducing traffic congestion and improving air quality.

Traveler Behavior: Limitations

There are well-known limitations of survey research and this study recognizes them. Mail surveys typically have low response rates than other types of surveys, though we achieved a reasonably good response rate of 25 percent. This is consistent with other transportation surveys. Of course, non-response may introduce error. We contacted the non-respondents in the selected neighborhoods and urged them to participate, in addition to sending them reminders and assuring respondents of confidentiality. We also gave the respondents incentive coupons ($10 at the Weaver Street market) that they received upon completing the survey.

To control for non-sampling errors, a travel diary helped people note/recall daily trips. Other standard procedures, such as rechecking the data for coding errors and examining outliers were also used. Of course, we recognize that the there is a possibility of non-response errors in such surveys—though the response rates and the empirical results were reasonable and in accordance with theory and expectation.

There is evidence of self-selectivity is some of the attitudinal questions that were asked and may indicate that some people chose their residential location based at least in part on their desired travel patterns (Appendix D). Compared with residents in conventional neighborhoods, Southern Village residents are more likely to find it important to have shops and services near to their residences, believe children should have a large public play space within safe walking distance of their home, enjoy a house close to the sidewalk so they can see and interact with passerby, and to be comfortable living in close proximity to their neighbors ($p < 0.05$). They are less likely to believe that it is important for children to have a large backyard for playing.

Traveler Behavior: Recommendations

It is difficult to make general recommendations based on a study of two neighborhoods in the Chapel Hill-Carrboro area. At the same time, the study results are reasonable, they are consistent with the literature and the study was conducted using sound methodology. So we venture to make a few recommendations that flow from the results. Our findings of significantly lower automobile trips, lower vehicle miles traveled and fewer external trips in TNDs, lends empirical support to building more traditional neighborhoods as one way to encourage alternative mode use and alleviate regional traffic pressure and to improve regional air quality. While traditional neighborhoods generate fewer and shorter automobile trips than conventional neighborhoods, as pointed out in the previous section, one or two neighborhoods may not have a significant impact on traffic. So the possibly of clustering several TNDs should be considered, if a substantial impact on network performance is to be achieved.

In terms of travel demand forecasting, our findings suggest that travel behavior differs significantly between traditional and conventional neighborhoods, therefore, we recommend the use of alternative trip generation models for TNDs, such as those presented in this report.

The Statewide Planning Branch of the state government, which is responsible for preparing the North Carolina's *Statewide Multimodal Transportation Plan*, can perhaps promote TNDs by reducing impact fees for these developments, given the higher internal trip capture rates of the TND. Where appropriate, Statewide Planning may consider contributing to infrastructure expenses such as road and sidewalk construction in TNDs, targeting TND developments for public transportation funding, and expanding and improving efforts to link land use and transportation planning across the state to make TNDs more successful. In general, the site design of Southern Village follows NCDOT's *TND Street Design Guidelines*, which suggest widths of 5 feet for sidewalks, 6 feet for planter strip, 18 foot lanes, 28 foot streets, informal 'on-street' parking as well as access to transit. The empirical evidence shows that the guidelines might be sufficiently encouraging the use of alternative modes.

State and local agencies could work together to support and streamline future traditional neighborhood developments. The NCDOT Bicycle and Pedestrian Division could support TNDs as a means to further the goals outlined in *Bicycling and Walking in North Carolina: A Long-Range Transportation Plan.* In particular, by providing safe and efficient bicycle and pedestrian infrastructure that offer connections between activity centers, TNDs encourage bicycling and walking as viable transportation option and support internal non-motorized mobility needs. This study found that traditional neighborhoods can increase bicycle and walking mode shares significantly. Additionally, with their mix of housing types, TNDs promote the use of public transportation. The NCDOT Public Transportation Division could promote TNDs as a means of providing greater accessibility and choice to people.

Finally, a related purpose of the surveys was to establish a benchmark/baseline of traveler behavior in TNDs and to provide data for future comparisons and modeling efforts. Given the success of the survey and results, we recommend that Southern Village serve as a future Laboratory or Testbed for innovative transportation-land use experiments

Traffic Analysis: Trip Generation

This section presents conclusions and recommendations from the trip generation analysis of Southern Village and Lake Hogan Farms and covers three main areas: trip generation methods, traffic impacts of neo-traditional developments, and neighborhood development. The comments pertain specifically to the two case study neighborhoods and may not transfer to other TNDs.

Traffic Analysis: Methods

As demonstrated in Chapter 6, ITE trip generation rates and methods are acceptable for predicting the trip generation of both Southern Village and Lake Hogan Farms. This result helps justify the ITE method for multi-use developments as outlined in Chapter 7 of the ITE Trip Generation Handbook, as well as the trip generation rates found in the sixth edition of the ITE Trip Generation Manual.

It is also apparent from trip generation Figures 6-9 and 6-11 in Chapter 6 that the Triangle Regional Model does a poor job of estimating trips from a single development like Southern Village. This is primarily due to the aggregate nature of the model, which is satisfactory for predicting trips on a regional basis but not for estimating the entering and exiting flows for a single development. A secondary reason may be the age of the Triangle Regional Model. Some socioeconomic factors used to calibrate the model may have changed, particularly those related to the average income per capita in the Triangle Region.

At the neighborhood scale, simulation methods hold promise for analyzing the trip generation and traffic impacts of a single development, especially with a development that has complex interactions between private vehicles, pedestrians, and transit. With a simulation model, the trip generation of the development can be changed, and both the internal and external impacts can be analyzed quickly. As the collective expertise in creating simulation models grows at public agencies and private firms, simulation will play a much greater role in neighborhood traffic impact analyses.

Traffic Analysis: Impacts of Neo-Traditional Developments

The potential traffic reduction from Southern Village internal capture is less than the inherent variability in trip generation rates. As a result, access improvements for similar mixed-use developments should likely be as robust as for conventional developments.

Trip generation rates in the ITE Trip Generation Manual represent single-use sites with little or no interaction with other sites. ITE also provides special internal capture adjustments for mixed-use developments. Yet uncertainty is inherently present in the trip generation rates and the associated traffic impact analysis regardless of the type of development. In the Southern Village case the internal capture is within one standard deviation of rates published by ITE. This indicates that the internal capture traffic reduction is less than the variability in trip rates. Therefore, when attempting to predict traffic for a future development of comparable size, makeup, and location, the potential reduction in trips from internal capture may be less than the inherent variability in the traffic forecast. The relatively small amount of trip reduction compared to the trip rate variability implies that intersection access for developments comparable to Southern Village should be designed without consideration for internal capture.

A sensitivity study tested the conclusion regarding internal capture rates having little effect on access management. Trip generation and internal capture rates were varied, and the subsequent changes to the LOS at an external intersection were analyzed. The analysis indicated that the external intersection was designed to handle future increases in traffic along US 15-501 and that small traffic decreases due to internal capture did little to decrease delay at the intersection. This makes intuitive sense when considering the typical “over-design” of intersections along major highways.

Traffic Analysis: Implications for Neighborhood Development

While this study demonstrates that the traffic reduction from internal capture at Southern Village does little to affect the traffic level of service at nearby intersections, particularly in the peak periods, the ITE method indicates that external trips decrease by 10-13% based on the mix of land use. This reduction is consistent with the traveler behavior surveys. The trip reduction likely results from internal non-work trips because there are few employment opportunities in Southern Village.

Besides potential traffic benefits, neo-traditional developments are attractive to real estate developers. The neighborhoods are dense, requiring relatively little land for a large number of dwellings. However, the makeup and location of such developments should be closely analyzed. ITE indicates that retail development has the highest internal capture, both from residences and from office space. The shopping opportunities of such developments should be increased and tailored to better meet the needs of the individuals living in the development, as more realistic and practical opportunities will certainly increase the total internal capture of the development

Neo-traditional developments should also be strongly encouraged as options for re-development in urban areas. The increase in trip opportunities with a grid network has the potential to increase internal capture. If such developments are placed in a constrained network, where vehicle travel is difficult, walking and transit ridership should increase. Such increase in internal capture in an urban setting may have a greater effect on traffic impacts than at the suburban fringe. Additionally, urban settings are where simulation modeling would be the most appropriate.

Traffic Analysis: Conclusions

ITE methods and rates are acceptable for predicting the trip generation of the mixed-use development Southern Village and the single-use development Lake Hogan Farms.

The Triangle Regional Model is not acceptable for predicting the trip generation of a single development.

Simulation holds promise for analyzing the impacts of a single development and can be integrated with regional models.

Internal capture traffic reduction for mixed-use developments is less than the variability in trip rates.

Small traffic decreases due to internal capture do little to decrease delay at “over-designed” intersections along major highways.

The increased trip opportunities and network connectivity found in urban areas may greatly increase internal capture compared to mixed–use development in the suburbs.

Traffic Analysis: Recommendations

Continue to use ITE methods and rates when analyzing the traffic impacts of neo-traditional and conventional developments.

Do not use aggregate travel demand models for individual site development traffic forecasting.

Design intersection access for mixed-use developments like Southern Village without consideration for internal capture.

Increase retail opportunities and tailor them to specifically meet the needs of neighborhood residents

Encourage more mixed-use development in urban areas.

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APPENDICES

A

Appendix A: Relevant studies, their location, sample, and independent variables

Study	Location	Sample	Independent Variable		
			Density	Land Uses	Design
Cervero & Kockelman (1997)	SF Bay Area	50 neighborhoods	Yes	Yes	Yes
Ewing *et al.* (1994)	Palm Beach County, FL	6 communities	Yes	Yes	
Holtzclaw (1990)	SF Bay Area	2 communities	Yes	Yes	
Holtzclaw (1994)	California	28 communities	Yes		
Kitamura, Mokhtarian and Laidet (1997)	SF Bay Area	5 neighborhoods	Yes	Yes	Yes
Boarnet and Crane (2001)	Southern California	Areawide	Yes	Yes	Yes
Kockelman (1997)	SF Bay Area	Regional	Yes	Yes	Yes
McNally and Kulkarni (1997)	Orange County	20 neighborhoods			
Cervero (1995)	SF Bay Area	14 neighborhoods	Yes	Yes	Yes
Cervero and Radisch (1996)	SF Bay Area	2 neighborhoods	Yes	Yes	Yes
Handy and Clifton (2001)	Austin, TX	6 neighborhoods	Yes	Yes	Yes
Handy (1993)	SF Bay Area	4 communities			
Berrigan & Troiano (2002)	United States	National	Yes[1]	Yes[1]	Yes[1]
Frank and Pivo (1994)	Seattle Metro Area	Areawide	Yes	Yes	
Crane and Crepeau (1998)	San Diego County	Countywide			Yes[2]
Craig *et al.* (2002)	Canada	27 neighborhoods	Yes	Yes	Yes
Boarnet and Sarmiento (1998)	Orange County	Countywide	Yes	Yes	Yes[2]
Cervero (2002)	Montgomery County, MD	Countywide	Yes	Yes	Yes
Cervero (1996)	United States	11 MSAs	Yes	Yes	

[1]With using home age as a proxy.
[2]Just looked at street pattern.

Appendix B: Process for selecting the neighborhoods used in this study

To best represent common neighborhood types in North Carolina, we wanted to select a conventional subdivision for which to compare the travel patterns of the residents of Southern Village. A comparison between such neighborhoods would maximize the usefulness and applicability of the results of our study. Accordingly, a matrix of neighborhood attributes was developed and then used to compare various area neighborhoods to one another and to Southern Village. The aim of this matrix was to identify a neighborhood that best embodies the characteristics of a conventional subdivision.

Out of a list of dozens of Chapel Hill and Carrboro neighborhoods, we separated out neighborhoods that were roughly the same area and were approximately the same distance from the University of North Carolina campus as Southern Village (see attached map). This selection was done in order to allow us to control for various elements in our study and to help minimize the inaccurate extrapolation of our findings. Using these criteria, we selected seven neighborhoods (including Southern Village) that are listed across the X-axis of the matrix. A short description of each neighborhood is provided below with an approximate range and average of property values (which does not factor in apartment complexes). Median income of the various neighborhoods would be a better measurement than property values for which to compare the neighborhoods by, but the Census has yet to release 2000 income information for North Carolina.

- *Southern Village* is a new neighborhood, begun in the late 1990s, which was developed as Chapel Hill's first Traditionally designed neighborhood (TND). A retail/commercial/ office area is located in the southern area of the development off of the highway and is surrounded by medium- and high-density housing. Southern Village is located at the south end of Chapel Hill and is just west of US Highway 15-501. Property values range from $240,000 to $481,499 with an average of $350,365.
- *Timberlyne* is a more conventional neighborhood that was first developed several decades ago. However, some areas of the neighborhood, including a 20-unit single-family subdivision and a large apartment complex, were built in the late 1990s and a few of the single-family homes are still under construction. A retail/commercial/ office area is located in the northwest corner of the development and is surrounded by mainly high-density housing. Timberlyne is located in northern Chapel Hill at the southeast corner of Airport Road and Weaver Dairy Road. Property values range from $196,000 to $521,331 with an average of $350,878.
- *Lake Hogan Farms* is a new, conventionally developed neighborhood that is still undergoing construction. Though 100 percent of its single-family detached homes have been built, none of its single-family attached homes have been completed. Accordingly, the development is at only about 75 percent occupancy. Lake Hogan Farms is located northwest of Carrboro and to the north of Homestead Road and to the east of Old State Highway 86. Property values range from $239,271 to $875,000 with an average of $416,008.
- *Glen Lennox* was developed several decades ago and is composed of single-story garden level apartments and detached single-family homes. A retail/commercial/office area is located in the northeast corner of the development and is surrounded by the garden level apartments. Glen Lennox is located in eastern Chapel Hill at the northeast corner of the

interchange of US Highway 15-501 and State Highway 54 and is bounded on the east by Chapel Hill Country Club's golf course. No property values are available because this neighborhood is primarily composed of rental units.

- *Lake Ellen* was developed several decades ago, is composed of exclusively single-family detached homes, and includes the North Forrest Hills neighborhood. Lake Ellen is located in northern Chapel Hill to the east of Airport Road and is bounded roughly by Piney Mountain Drive. Property values in North Forrest Hills range from $175,000 to $343,648 with an average of $225,412.
- *Culbreth* includes the Cobbleridge and Southbridge developments on both sides of Culbreth Road. Most of the developments in this area were built in the 1990s and are composed of single-family detached and attached homes. Culbreth is located at the southern end of Chapel Hill and is bounded by Smith Level Road to the west and US Highway 15-501 on the east. Property values in Cobbleridge range from $240,000 to $278,500 with an average of $255,800. Property values in Southbridge range from $244,900 to $350,000 with an average of $291,466.
- *Briarcliff* was developed several decades ago and is composed exclusively of single-family detached homes. Briarcliff is located in eastern Chapel Hill to the south of Ephesus Church Road and east of US Highway 15-501. Property values range from $129,000 to $270,000 with an average of $219,722.

Along the Y-axis of the matrix, a number of neighborhood features are grouped into five major categories: "Functional," "Safety," "Aesthetics," "Destinations," and "Comparison Considerations." These features have been identified by various studies as attributes that:

1. Define a TND;
2. Influence a person's decision to walk or ride a bicycle; and/or
3. Determine how the neighborhood compares to Southern Village.

Considered carefully, each of these attributes was deemed topical to our study.

Once the attributes and their method of measurement were developed, evaluators filled in the matrix for each of the seven neighborhoods while making site visits (see attached matrix at the end of this document). Results for three of the major categories – "Functional," "Safety," and "Aesthetic" features – were summed and ranked as were the two sub-categories of "Destinations" – "Mix of Uses" and "Facilities" (Table B-1).

Table B-1: Neighborhood Evaluation Results, Ranked Scores

Feature	*Southern Village*	*Timber-lyne*	*Lake Hogan Farms*	*Glen Lennox*	*Lake Ellen*	*Culbreth*	*Briarcliff*
Functional	1 (tie)	6	4	1 (tie)	7	3	5
Safety	1	3 (tie)	6	3 (tie)	7	2	3 (tie)
Aesthetics	1	5	6	2 (tie)	7	2 (tie)	4
Mix of Uses	1	2	5 (tie)	3	5 (tie)	4	5 (tie)
Facilities	1	4	5	2	6 (tie)	3	6 (tie)
TOTAL	1	3	5	2	7	4	6

Since the total points for each category or sub-category differ, the results of the evaluation are also presented as proportions of the total points available per category, sub-category, and total in Table B-2; these are graphed in Figure B-1. The neighborhoods are positioned on a continuum in Figure B-2 based on their total proportion.

Table B-2: Neighborhood Evaluation Results, Proportionate Score

Feature	*Southern Village*	*Timber-lyne*	*Lake Hogan Farms*	*Glen Lennox*	*Lake Ellen*	*Culbreth*	*Briarcliff*
Functional	0.69	0.42	0.56	0.69	0.38	0.60	0.44
Safety	0.60	0.52	0.48	0.52	0.36	0.56	0.52
Aesthetics	0.89	0.57	0.54	0.69	0.51	0.69	0.63
Mix of Uses	1.00	0.83	0.08	0.50	0.08	0.25	0.08
Facilities	0.65	0.40	0.35	0.50	0.30	0.45	0.30
TOTAL	**0.77**	**0.55**	**0.42**	**0.60**	**0.34**	**0.53**	**0.41**

Figure B-1: Comparison of Neighborhood Features

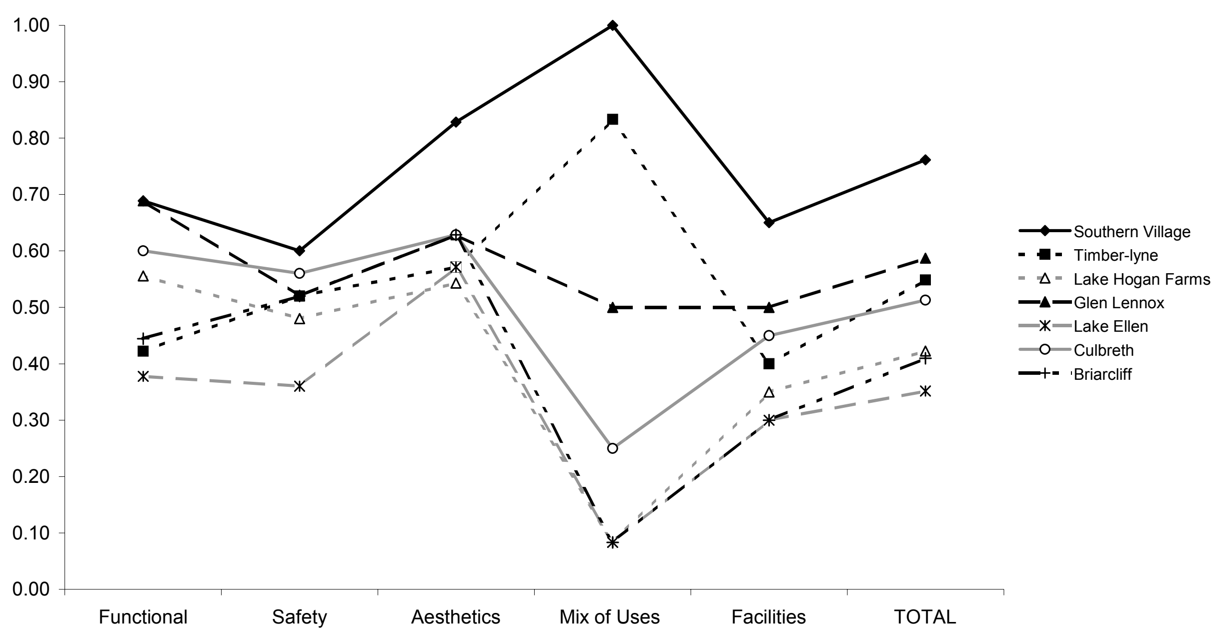
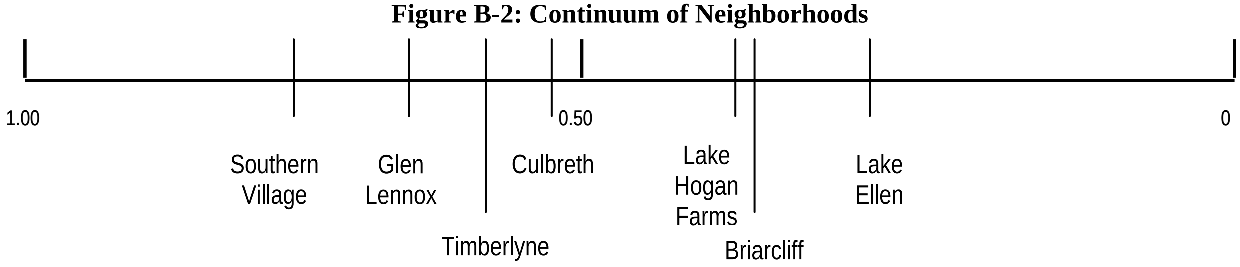


Figure B-2: Continuum of Neighborhoods



The results of our evaluation enable us to compare and contrast the features of the seven neighborhoods as they relate to our study. To visualize the meaning of the proportions in Table

B-2, assume that a score of "1" equates to being a 100-percent walkable and bikeable TND and a score of "0" equates to being a completely auto-dependent conventional neighborhood with respect to the feature being considered. Accordingly, Southern Village scored overall as being the neighborhood most like a walkable and bikeable TND. Glen Lennox, Timberlyne, and Culbreth followed respectively as second, third, and fourth, and Lake Hogan Farms, Briarcliff, and Lake Ellen followed respectively as fifth, sixth, and last. A summary of how each neighborhood compares in our evaluation follows.

- *Southern Village*, as expected, ranked first overall and ranked at the top with respect to having the most functional features, safety features, aesthetic features, mix of uses, and facilities. Relative to the other neighborhoods' scores for particular features, Southern Village scored at or near the top in most categories. However, Southern Village scored near the bottom for gradient and tree cover.
- *Glen Lennox*, ranked second overall, ranked in the top half in each of the main categories. Specifically, Glen Lennox tied for first for functional features, tied for third for safety features, tied for second for aesthetics, ranked third for mix of uses (but no schools or office space), and ranked second for facilities. Relative to the other neighborhoods' scores for particular features, Glen Lennox scored at or near the top for having no slopes, a good street design, and having numerous parks throughout the neighborhood. However, Glen Lennox scored near the bottom for having bike lanes and paths, crosswalks, and front porches facing the street.
- *Timberlyne*, ranked third overall, ranked in the top of some of the main categories, but towards the bottom in others. Specifically, Timberlyne ranked second-to-last for functional features, tied for third for safety features, ranked fifth for aesthetics, second for mix of uses (no schools present), and fourth for facilities. Relative to the other neighborhoods' scores for particular features, Timberlyne was not exceptional in any one area, except for featuring a number of land uses. Additionally, Timberlyne scored near the bottom for bike lanes and paths, front porches facing the street, and facilities for pedestrians (such as benches) and bicyclists (such as bike parking) and connected and narrower streets.
- *Culbreth*, ranked fourth overall, ranked in the top half in most of the main categories but near the bottom in others. Specifically, Culbreth ranked third for functional features, second for safety features, tied for second for aesthetics, second-to-last for mix of uses (although Culbreth does have a middle school), and third for facilities. Relative to the other neighborhoods' scores for particular features, Culbreth scored at or near the top for having good sidewalk continuity and narrow roads. However, Culbreth scored near the bottom for gradient, connected street design, and places for pedestrians to sit.
- *Lake Hogan Farms*, ranked fifth overall, ranked in the bottom half in each of the main categories. Specifically, Lake Hogan Farms ranked fourth for functional features, second-to-last for safety features, second-to-last for aesthetics, tied for last for mix of uses, and second-to-last for facilities. Relative to the other neighborhoods' scores for particular features, Lake Hogan Farms scored at or near the top for having good sidewalk continuity, interesting sights, and a number of parks throughout the neighborhood. However, Lake Hogan Farms scored near the bottom for connected street design, tree cover, setbacks, garages, facilities for pedestrians (such as benches) and bicyclists (such as bike parking), and public transportation.

- *Briarcliff*, ranked sixth overall, ranked in the bottom half in each of the main categories. Specifically, Briarcliff ranked fifth for functional features, tied for third for safety features, fourth for aesthetics, tied for last for mix of uses, and tied for last for facilities. Relative to the other neighborhoods' scores for particular features, Briarcliff scored at or near the top for having no slopes and good tree coverage. However, Briarcliff scored near the bottom for bike lanes and paths, sidewalk continuity, interesting sights, and parks.
- *Lake Ellen*, ranked last overall, ranked at the bottom in each of the main categories. Relative to the other neighborhoods' scores for particular features, Lake Ellen scored at or near the top for having good tree coverage and parks throughout the neighborhood. However, Lake Ellen scored at or near the bottom for a number of features, including sidewalks, bike lanes and paths, sidewalk continuity, on-street parking, lighting, surveillance, crosswalks, front porches facing the street, setbacks, and lot size.

Ultimately, by taking into account the results of our evaluation and other neighborhood characteristics, we chose a neighborhood which best represented a modern-day, conventional subdivision. Representative of most modern-day conventional subdivisions, three neighborhoods contain exclusively single-family detached housing: Lake Hogan Farms, Briarcliff, and Lake Ellen. However, we selected Lake Hogan Farms over Briarcliff and Lake Ellen since Lake Hogan Farms is the most recently developed (1990s and 2000s as opposed to 1960s to the 1980s), has comparable property values to Southern Village (an average of $416,008 versus Southern Village's $350,365 as opposed to $225,412 or $219,722 versus $350,365), is not well integrated with surrounding neighborhoods like most modern-day developments (see map), and does not have transit service like most modern-day developments (see map). Additionally, there are a number of similar neighborhoods (Wexford, the Highlands, Sunset Creek, and Fairoaks) that are close to Lake Hogan Farms and could be added to the study at a later date.

Figure B-3: Map of Neighborhood Candidates

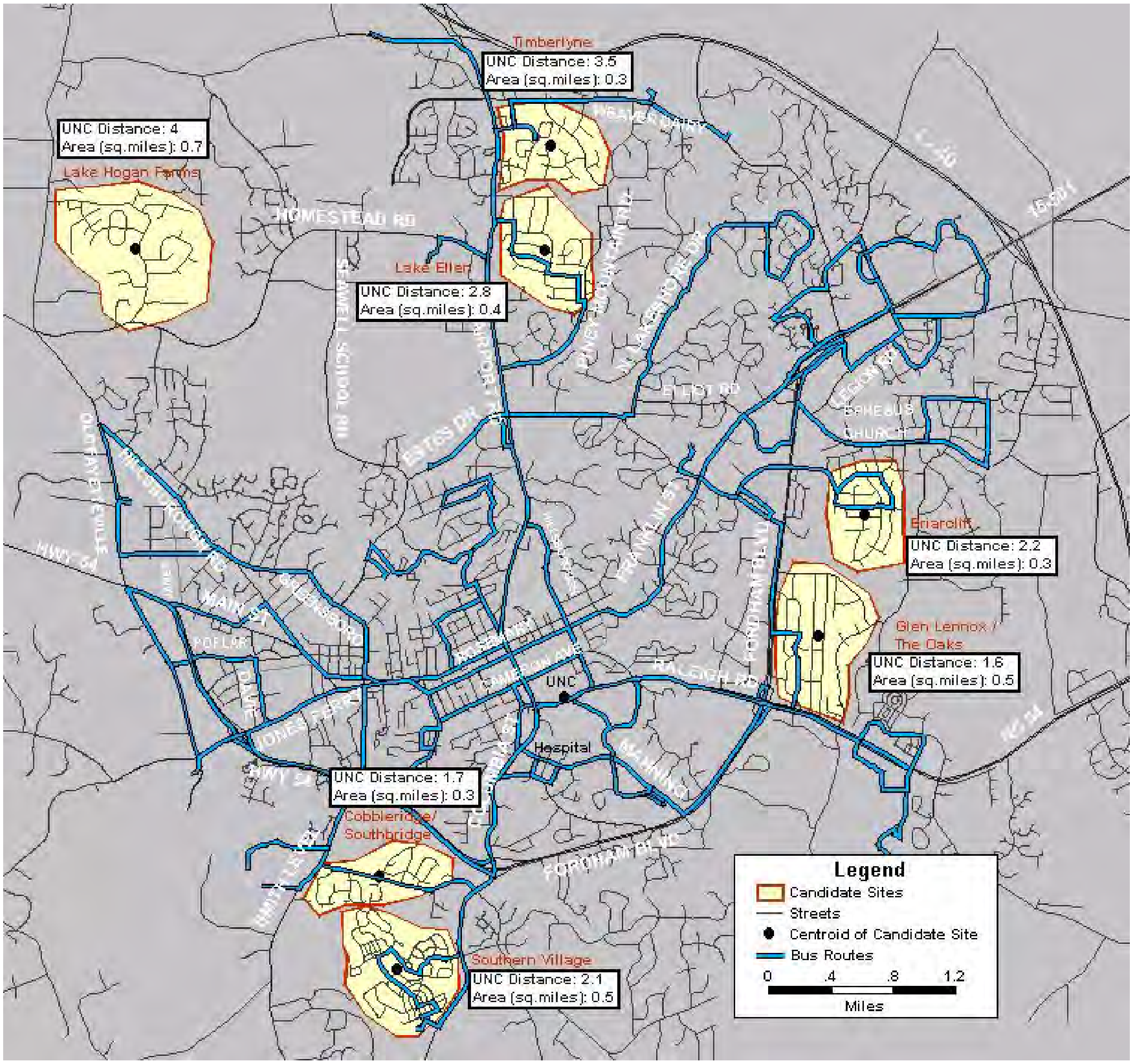


Table B-3: Neighborhood Evaluation Matrix

Feature			Southern Village	Timberlyne	Lake Hogan Farms	Glen Lennox	Lake Ellen	Culbreth	Briarcliff	Measurement
			Neighborhood/Area							
Functional	*Walking/ Cycling Surface*	Sidewalks	5	3	4	3	1	4	2	5-point scale, 1 = not present, 5 = present everywhere
		Bike Lanes/Paths/Shoulders	3	1	2	1	1	2	1	5-point scale, 1 = not present, 5 = present everywhere
		Continuity	5	3	4	3	1	4	1	5-point scale, 1 = very poor, 5 = excellent
		Gradient	2	3	3	5	3	2	4	5-point scale, 1 = very steep, 5 = flat
	Streets	Street Design	4	2	2	4	3	2	3	5-point scale, 1 = lollipop, 5 = grid
		Width	3	1	2	4	3	4	3	5-point scale, 1 = wide, 5 = narrow
		On-Street Vehicle Parking	3	2	2	4	1	3	2	5-point scale, 1 = not present, 5 = present everywhere
	Traffic	Volume	4	3	4	4	3	4	3	5-point scale, 1 = very heavy, 5 = very light
		Speed	25	25	25	25	25	25	25	Speed limit on most streets
		Management/Control Devices	2	1	2	3	1	2	1	5-point scale, 1 = not present, 5 = present everywhere
		TOTAL (minus speed)	*31*	*19*	*25*	*31*	*17*	*27*	*20*	
Safety		Lighting	3	2	2	2	1	3	3	5-point scale, 1 = not present, 5 = present everywhere
		Surveillance	4	3	3	4	1	4	3	5-point scale, 1 = very poor, 5 = excellent
		Barking Dogs	4	5	5	5	5	3	5	5-point scale, 1 = present everywhere, 5 = not present
		Crosswalks	3	2	1	1	1	3	1	5-point scale, 1 = not present, 5 = present everywhere
		Crossing Aids	1	1	1	1	1	1	1	5-point scale, 1 = not present, 5 = present everywhere
		TOTAL	*15*	*13*	*12*	*13*	*9*	*14*	*13*	
Aesthetics		Trees/Shade	2	3	2	4	4	3	4	5-point scale, 1 = not present, 5 = present everywhere
		Cleanliness (pollution, graffiti, trash)	5	4	4	3	4	4	4	5-point scale, 1 = very poor, 5 = excellent
		Sights	5	2	4	3	3	3	2	5-point scale, 1 = very poor, 5 = excellent
		Setbacks	5	3	2	4	1	4	3	5-point scale, 1 = very distant, 5 = fronts the street
		Porches	5	1	3	2	2	3	3	5-point scale, 1 = not present, 5 = present everywhere
		Garages Facing Street	5	4	1	4	2	3	3	5-point scale, 1 = present everywhere, 5 = not present
		Lot Size	4	3	3	4	2	4	3	5-point scale, 1 = large, 5 = small
		TOTAL	*31*	*20*	*19*	*24*	*18*	*24*	*22*	
Destination	*Mix of Uses*	Office	2.5	2.5	0	0	0	0	0	Yes/No (Yes = 2.5, No = 0)
		Adjacent to other uses?	2.5	2.5	0	0	0	0	0	Yes/No (Yes = 2.5, No = 0)
		Retail	2.5	2.5	0	2.5	0	0	0	Yes/No (Yes = 2.5, No = 0)
		Adjacent to other uses?	2.5	2.5	0	2.5	0	0	0	Yes/No (Yes = 2.5, No = 0)
		Low-Density Residential	2.5	2.5	2.5	2.5	2.5	2.5	2.5	Yes/No (Yes = 2.5, No = 0)
		Adjacent to other uses?	2.5	2.5	0	2.5	0	0	0	Yes/No (Yes = 2.5, No = 0)
		Medium-Density Residential	2.5	2.5	0	2.5	0	2.5	0	Yes/No (Yes = 2.5, No = 0)
		Adjacent to other uses?	2.5	2.5	0	2.5	0	0	0	Yes/No (Yes = 2.5, No = 0)
		High-Density Residential	2.5	2.5	0	0	0	0	0	Yes/No (Yes = 2.5, No = 0)
		Adjacent to other uses?	2.5	2.5	0	0	0	0	0	Yes/No (Yes = 2.5, No = 0)
		School	2.5	0	0	0	0	2.5	0	Yes/No (Yes = 2.5, No = 0)
		Adjacent to other uses?	2.5	0	0	0	0	0	0	Yes/No (Yes = 2.5, No = 0)
		TOTAL	*30*	*25*	*3*	*15*	*3*	*8*	*3*	
	Facilities	Parks	4	2	4	4	3	3	2	5-point scale, 1 = not present, 5 = present everywhere
		Benches/Places to Sit	3	1	1	2	1	1	1	5-point scale, 1 = not present, 5 = present everywhere
		Public Transport	3	4	1	3	1	3	2	5-point scale, 1 = not present, 5 = present everywhere
		Bike Parking Facilities	3	1	1	1	1	2	1	5-point scale, 1 = not present, 5 = present everywhere
		TOTAL	*13*	*8*	*7*	*10*	*6*	*9*	*6*	
Comparison Considerations		Area (approximate)	0.5	0.3	0.7	0.5	0.4	0.3	0.3	Square Miles
		Distance to UNC (approximate)	2.1	3.5	4.0	1.6	2.8	1.7	2.2	Miles
		Grocery Store	Y	Y	N	N	N	N	N	Yes/No
		Movie Theater	Y	Y	N	N	N	N	N	Yes/No
		Cleaners	Y	Y	N	N	N	N	N	Yes/No
		Daycare	Y	N	N	N	N	N	N	Yes/No
		Recreational Facilities	Y	Y	Y	Y	N	Y	Y	Yes/No
		Restaurants	Y	Y	N	Y	N	N	N	Yes/No
		Church	Y	N	N	N	N	N	N	Yes/No

Appendix C: Income Response Rates by Neighborhood

		Responding	Under $20,000	$20,000 - $30,000	$30,001 - $40,000	$40,001 - $50,000	$50,001 - $60,000	$60,001 - $80,000	$80,001 - $100,000	$100,001 - $150,000	$150,001 - $200,000	Over $200,000
Southern Village	***SV Single-Family***	**66.7%**	**4.9%**	**0.0%**	**0.0%**	**3.9%**	**5.9%**	**7.8%**	**15.7%**	**34.3%**	**19.6%**	**7.8%**
	N=153	**102**	**5**	**0**	**0**	**4**	**6**	**8**	**16**	**35**	**20**	**8**
	SV Apts	64.1%	4.0%	8.0%	0.0%	24.0%	20.0%	24.0%	8.0%	8.0%	0.0%	4.0%
	N=39	25	1	2	0	6	5	6	2	2	0	1
	SV Condos	69.2%	11.1%	16.7%	33.3%	22.2%	11.1%	0.0%	0.0%	0.0%	0.0%	5.6%
	N=26	18	2	3	6	4	2	0	0	0	0	1
	Total SV HHs	66.5%	5.5%	3.4%	4.1%	9.7%	9.0%	9.7%	12.4%	25.5%	13.8%	6.9%
	N=218	145	8	5	6	14	13	14	18	37	20	10
Conventional Neighborhoods	Lake Hogan Farms	75.9%	0.0%	2.4%	0.0%	2.4%	0.0%	4.9%	29.3%	36.6%	12.2%	12.2%
	N=54	41	0	1	0	1	0	2	12	15	5	5
	The Highlands	75.0%	0.0%	0.0%	0.0%	3.7%	3.7%	14.8%	14.8%	29.6%	18.5%	14.8%
	N=36	27	0	0	0	1	1	4	4	8	5	4
	Sunset Creek	78.9%	0.0%	0.0%	0.0%	6.7%	6.7%	0.0%	20.0%	53.3%	13.3%	0.0%
	N=19	15	0	0	0	1	1	0	3	8	2	0
	Wexford	66.0%	6.5%	0.0%	0.0%	3.2%	3.2%	6.5%	9.7%	48.4%	9.7%	12.9%
	N=47	31	2	0	0	1	1	2	3	15	3	4
	Fairoaks	93.9%	3.2%	0.0%	9.7%	3.2%	12.9%	25.8%	25.8%	16.1%	0.0%	3.2%
	N=33	31	1	0	3	1	4	8	8	5	0	1
	Total Conv. HHs	**76.7%**	**2.1%**	**0.7%**	**2.1%**	**3.4%**	**4.8%**	**11.0%**	**20.7%**	**35.2%**	**10.3%**	**9.7%**
	N=189	**145**	**3**	**1**	**3**	**5**	**7**	**16**	**30**	**51**	**15**	**14**
	TTA (Region)	84.7%	14.0%	15.7%	13.9%	11.3%	13.5%	14.3%	7.8%	5.4%	3.1%	1.0%
	N=1732	1467	205	231	204	166	198	210	114	79	45	15

Appendix D: Means of responses to attitudinal questions by neighborhood type

Topic	*Neighborhood*	*N*	*Mean*	*Sig.*
I like the flexibility that driving allows	Southern Village No. Carrboro	167 207	4.54 4.61	0.412
I enjoy walking	Southern Village No. Carrboro	168 207	4.33 4.19	0.142
I am comfortable riding a bus	Southern Village No. Carrboro	168 206	3.40 3.16	0.064
I would like to have more time for leisure	Southern Village No. Carrboro	167 206	4.34 4.32	0.789
We should raise the price of gasoline to reduce congestion and air pollution	Southern Village No. Carrboro	168 207	2.67 2.73	0.689
It’s important for children to have a large backyard for playing	Southern Village No. Carrboro	168 208	2.95 3.71	0.000
Sidewalks make walking easier in my neighborhood	Southern Village No. Carrboro	168 204	4.84 4.54	0.000
Environmental protection is an important issue	Southern Village No. Carrboro	168 208	4.51 4.50	0.988
I enjoy a house close to the sidewalk so that I can see and interact with passersby	Southern Village No. Carrboro	168 206	3.77 2.89	0.000
Too much land is consumed for new housing, stores, and offices	Southern Village No. Carrboro	167 208	3.57 3.44	0.236
I enjoy bicycling	Southern Village No. Carrboro	167 207	3.41 3.58	0.169
I can be comfortable living in close proximity to my neighbors	Southern Village No. Carrboro	168 207	4.09 3.31	0.000
Hills or other barriers in my neighborhood make walking/bicycling difficult	Southern Village No. Carrboro	167 207	2.53 2.18	0.006
My neighborhood seems safe for walking or bicycling	Southern Village No. Carrboro	168 208	4.63 4.50	0.083
Sitting in traffic aggravates me	Southern Village No. Carrboro	165 208	4.14 4.06	0.408
I prefer a lot of space between my home and the street	Southern Village No. Carrboro	168 208	2.68 3.50	0.000
Taking public transit is inconvenient	Southern Village No. Carrboro	168 207	3.32 3.68	0.004
Too many people drive alone	Southern Village No. Carrboro	167 208	3.79 3.82	0.757
Children should have a large public play space within safe walking distance of their home	Southern Village No. Carrboro	168 207	4.35 4.14	0.015
Having shops and services close by is important to me	Southern Village No. Carrboro	168 208	4.46 3.91	0.000

Appendix E: Southern Village Business Survey Report

Abstract—A goal of the study was understand the extent to which the component land uses—residential, office, retail, etc. attract off-site workers and visitors. The Business Survey was developed to assess this and understand trip attractions in Southern Village businesses/services and compare them to various business types categorized by the ITE Trip Generation Manual. The survey was conducted by interviewing business representatives directly. The comparison reveals some differences in trip generation between the businesses/land uses in Southern Village and stand-alone land uses in conventional contexts represented by ITE. The Public Facilities and Public Service businesses attracted fewer vehicular trips than those predicted by ITE. However, Entertainment and Restaurants, Private Services, and Retail Services attracted more vehicular trips than conventional contexts. Thus, when analyzed categorically this neo-traditional neighborhood development shows differences in trip generation.

Overview of Southern Village

Southern Village is a traditional neighborhood located in Chapel Hill, North Carolina. In 2003, 920 residential dwellings and nineteen businesses had been constructed and occupied. The area that was surveyed for this report was along Market Street. The street is located on the top of a small hill and ovular in shape. Businesses line the outside of the street and both a parking lot and green space are located in the center. The majority of the buildings are constructed with mottled brick standing two or three stories high. Several are mixed use buildings, meaning the first floor is office or retail space and the second floor is residential. As of 2003, there are still several vacant lots and commercial spaces available for future growth. A wide variety of businesses occupy the buildings. The vast majority are independent, small businesses that are located solely in Southern Village.

Goal of the Business Survey

The Business Survey was developed to assess trip generation in Southern Village, which will reveal the number of trips that businesses in the area attract. By comparing the results with various business types/land uses categorized by ITE, differences in trip generation patterns between Southern Village and conventional contexts will be evident. The result will show whether the goal of reducing vehicular trips in this TND is being attained. The design goals of Southern village include: interconnected streets, an extensive greenway system connecting neighborhoods to community facilities, bike paths, tree-lined sidewalks, easy access to open space, park and ride lot, and centrally located facilities to meet daily needs (food cooperative, dry-cleaning, restaurants, childcare, school, beautician, theater and arcade, playgrounds, fitness facilities, healthcare facilities).

Description of Business Survey

The North Carolina Department of Transportation, The University of North Carolina Chapel Hill Department of City and Regional Planning (DCRP), and The Department of Civil Engineering at North Carolina State University sponsored the survey as part of a Traditional Neighborhood Trip Generation Study. DCRP faculty and graduate students developed the survey’s format. The survey collects the following information:

1. Type and size of business on several axes (physical facility size, number of employees, number of customers)
2. Number of employees and estimation of customers living in Southern Village
3. Information about reasons for business location in Southern Village, plus whether that location is “good”
4. Whether or not the business requires off-site work by its employees, and if so, whether they provide cars for employee use
5. Facilities and programs available to accommodate non-automobile travel

Business Survey Process

In January and February of 2003 a graduate student surveyed existing businesses in Southern Village. Survey times ranged from eight to twenty minutes and were given to managers, owners and public administrators. Several surveys required appointments, but most were conducted on the spot.

Coding and Analyzing the Business Surveys

Upon completion of the survey, the data was coded into a spreadsheet. Answers that were given as ranges, such as the number of customers a business receives on an average day, were recorded as a range. A second column was created for the average, which was used to analyze the data. To measure employee data, two employees working part time were considered one full time employee. The businesses were broken down into the following five categories:

Retail Products:
- Market Street Books
- Weaver Street Market

Public Facilities:
- Scruggs Elementary School

Entertainment and Restaurants:
- Anna's Old Fashioned Pizza and Trattoria
- Quinn's Bistro
- Lumina Theater and Arcade

Private Services:
- Hangers Cleaner
- Forever Young Spa
- Brenner and Brenner Law Firm
- William H. Bunch Professional Accounting, Consulting and Tax
- Montgomery Development Carolina Corporation
- Plum Spring Clinic
- Chapel Hill Day Care Center
- Edward Jones Investment

Public Services:
- Active Living By Design
- IPAS
- Visiting International Faculty

Results

General results

Businesses had a wide range in the number of employees and square feet of space they occupied. Southern Village businesses employ 432 people full time (Table E-1). The average employee count was 24, while the average space occupied was 2,615 square feet. This reflects the small size of the businesses. Most cited that their reason for locating in the area was the "community feel" and convenience for customers. Several other businesses said they liked the design of the office space and/or they were looking to expand and Southern Village had the appropriate amount of space. All businesses reported that up to date, business is going as they had expected.

Table E-1: Employees per business

Name of Business	Number
Market Street Books	4.5
Anna's Old Fashioned Pizza and Trattoria	25
Weaver Street Market	25
Lumina Theater and Arcade	13
Active Living by Design	12
Hangers Cleaner	2
Tar Heel Sports Marketing	9
Forever Young Spa	8
Brenner and Brenner	3
William H Bunch	7
IPAS	102
Visiting International Faculty	78.5
Montgomery Development Company	8.5
Plum Spring Clinic	7.5
Quinn's Bistro	12
Chapel Hill Day Care Center	22.5
Scruggs Elementary School	89.5
Edward Jones Investment	3
Total:	432

Employees:

The sum of all the trip ends taken by Southern Village business' employees was reported to be 806 (Table E-2). This figure includes all offsite trips employees take during one business day and includes arriving and leaving work. The large majority, 92.4 percent, of employees used vehicles to commute to work. Only 3.5 percent of employees walked, 2.2 percent used public transit, and 1.3 percent biked. Three businesses owned vehicles for employee use. Most of the business-owned vehicles were parked off-site or were parked only temporarily in Southern Village. A parking lot centrally located to the businesses provides free parking for employees and customers.

Table E-2: Employee Trip Ends per Day

Name of Business	Number
Market Street Books	14
Anna's Old Fashioned Pizza and Trattoria	0
Weaver Street Market	70
Lumina Theater and Arcade	14
Active Living by Design	14
Hangers Cleaner	0
Tar Heel Sports Marketing	180
Forever Young Spa	0
Brenner and Brenner	80
William H Bunch	30
IPAS	154
Visiting International Faculty	72
Montgomery Development Company	64
Plum Spring Clinic	0
Quinn's Bistro	0
Chapel Hill Day Care Center	80
Scruggs Elementary School	16
Edward Jones Investment	18
Total:	806

A total of 22.5 full-time equivalent employees live and work in Southern Village (Appendix, Table E-3). Of them, only 1 person walks to work and the remaining 21.5 people either bike or use a personal vehicle for transportation.[11] Note that only 5.2 percent (22.5/432) of the people who work in Southern Village also reside in it. This low number is partly due to the relatively high living costs in Southern Village.

[11] The data provided by the survey gives the percent of the 806 Southern Village employees who walk, use a car, bike or take public transit to get to work. Since people who walk to work must work in Southern Village due to the neighborhood's relative isolation, all respondents who reported that they walk to work were assumed to live in Southern Village. After the number of people who walk to work was calculated (1 person) the total was subtracted from 22.5 (total reported living and working in SV), leaving the remainder of the people who bike, use automobile or use public transit (21.5). Since the nearest bus stop in the Southern Village is located next to the businesses, it is assumed that employees would not use the bus to reach the businesses, from their homes. Thus, there are 22.5 Southern Village residents and employees who use a car or bike to get to work.

Table E-3: Number of Employees Living in Southern Village (per Employeer)

Name of Business	Number
Market Street Books	0
Anna's Old Fashioned Pizza and Trattoria	2
Weaver Street Market	0
Lumina Theater and Arcade	3
Active Living by Design	1
Hangers Cleaner	0
Tar Heel Sports Marketing	0
Forever Young Spa	0
Brenner and Brenner	1
William H Bunch	0
IPAS	2
Visiting International Faculty	4

Combining customers and employees, a reported total of 5,105 trip ends were taken in one day, of which 4,299 were by customers.

Customers

Southern Village is able to attract a fair amount of customers from the neighborhood to its businesses. On average, 39.2 percent of business' customers are reportedly Southern Village residents (Table E-4). Conversely, 60.8 percent of the customers were off-site visitors. Tuesday's are the busiest day of the week for customer activity, although relatively all of the weekdays have approximately the same percentage ranging from 9.9 percent to 13.8 percent. On the weekend, total business activity is reduced. This is due to the fact that most private service businesses are closed.

Table E-4: Percent of Business Customers from Southern Village

Name of Business	Percent
Market Street Books	90
Anna's Old Fashioned Pizza and Trattoria	75
Weaver Street Market	60
Lumina Theater and Arcade	50
Active living by design	n/a
Hangers Cleaner	65
Tar Heel Sports Marketing	n/a
Forever Young Spa	45
Brenner and Brenner	0
William H Bunch	6
IPAS	0
Visiting International Faculty	0
Montgomery Development Company	20
Plum Spring Clinic	60
Quinn's Bistro	60
Chapel Hill Day Care Center	38
Scruggs Elementary School	33
Edward Jones Investment	25
Average:	39

The busiest time of the day is from 5-8 PM (Table E-5). The number of trip ends reported during the peak hour is displayed in Table E-6. Peak hour trip ends were calculated by taking 10 percent of all trips for the day. Most roads are designed to be wide enough for peak period traffic.

Table E-5: Customer Arrival Times

Business	7 to 9AM	9 to 11AM	11AM to 1PM	1 to 3PM	3 to 5PM	5 to 8PM	8PM to 12AM
Market Street Books	0	0	22.5	22.5	50	5	0
Anna's Old Fashioned Pizza and Trattoria	0	0	20	15	15	30	20
Weaver Street Market	5	10	20	10	10	40	5
Lumina Theater and Arcade	0	0	9	9	12	40	30
Active Living by Design	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hangers Cleaner	35	7.5	7.5	7.5	7.5	35	0
Tar Heel Sports Marketing	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Forever Young Spa	0	50	0	10	10	30	0
Brenner and Brenner	n/a	n/a	n/a	n/a	n/a	n/a	n/a
William H Bunch	n/a	n/a	n/a	n/a	n/a	n/a	n/a
IPAS	0	50	50	0	0	0	0
Visiting International Faculty	0	50	0	0	50	0	0
Montgomery Development Company	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Plum Spring Clinic	5	15	15	25	25	15	0
Quinn's Bistro	0	0	30	10	0	50	10
Chapel Hill Day Care Center	42.5	7.5	0	0	50	0	0
Scruggs Elementary School	25	25	5	25	0	0	0
Edward Jones Investment	5	20	10	50	15	0	0
Total	117.5	235	189	184	244.5	245	65
Average	6.53	13.06	10.5	10.22	13.58	13.61	3.61

Table E-6: Peak Hour Trips

Name of Business	Number
Market Street Books	8.3
Anna's Old Fashioned Pizza and Trattoria	53
Weaver Street Market	180.4
Lumina Theater and Arcade	44
Active Living by Design	3.8
Hangers Cleaner	9.4
Tar Heel Sports Marketing	19.8
Forever Young Spa	8.6
Brenner and Brenner	8.6
William H Bunch	5.1
IPAS	36.8
Visiting International Faculty	23.3
Montgomery Development Company	8.1
Plum Spring Clinic	6.5
Quinn's Bistro	15.4
Chapel Hill Day Care Center	46.5
Scruggs Elementary School	29.5
Edward Jones Investment	3.4
Total:	510.5

According to business representatives, 77.7 percent of customers use the automobile, whereas 18.1 percent of customers are reported to walk. However, it should be noted that one business responded that 100 percent of their customers walk to their business because they opened recently. Due to their infancy, they believe that the only customers they are getting are people who are from the neighborhood or stop by after visiting a nearby shop. Reporting 100 percent may have artificially inflated the average, since the sample size is small. The business expects this number will change once word spreads of their existence. The median number of customers that reportedly walk is 5.0 percent. An average 4.2 percent of businesses have customers who take the bus to reach them and no business reported that any customers bike.

Ten businesses reported having bike racks and six reported having showers for employees to use. Flextime for employees was the most common response for travel demand management options provided by businesses. Business concerns about travel demand management were infrequent bus service to the park and ride lot and limited carpooling options for employees' travel to work. The majority of businesses did not have any travel concerns for employees or customers.

Actual Vehicular Trips Versus ITE Predicted Vehicular Trips
The actual number of trip ends in Southern village was calculated by summing the number of employee trips and customer trips. Since ITE measures trip ends, which consist of entering and exiting an establishment, the employee and customer trip numbers were doubled.

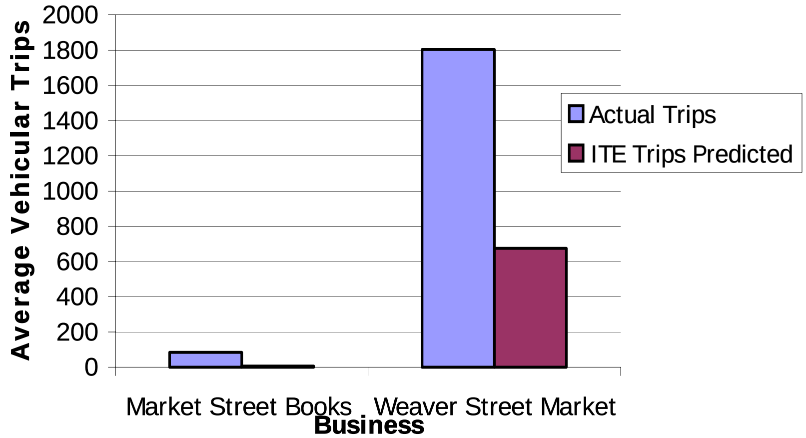
The graphs below are the same style as the graphs displayed in the ITE book. The dots represent the number of trip ends reported by each business. There are at least two dots on each graph for one business. One dot represents the actual number of trip ends that was reported in the survey. The second dot represents the predicted number of trip ends as calculated by the ITE book. The black line allows the reader to predict the number of trip ends per square foot of space or number of employees, depending on the X-axis. The Public Facility graph does not have a linear equation due to a lack of businesses in the category.

The Chapel Hill Daycare was excluded because ITE used the number of square feet of space to predict trip attraction, whereas the Private Service category used the number of employees. Similarly, Lumina Theater was excluded because ITE used the number of movie screens to predict trip attraction, whereas the Entertainment category used square feet of space.

The figures that follow represent other visual interpretations of the difference in trip attraction among Southern Village and conventional, ITE neighborhoods.

Retail Products
It is evident from Figure E-6 that the amount of actual trips far exceeds ITE's predicted number of trips.

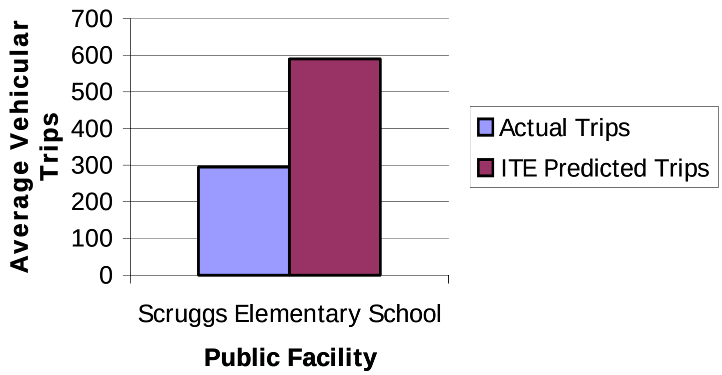
Figure E-1: Retail Products



Public Facilities:

The only public facility was Scruggs Elementary School. Figure E-7 shows that ITE predicted more trips than were actually taken. The school took 80 percent fewer trips than ITE predicted.

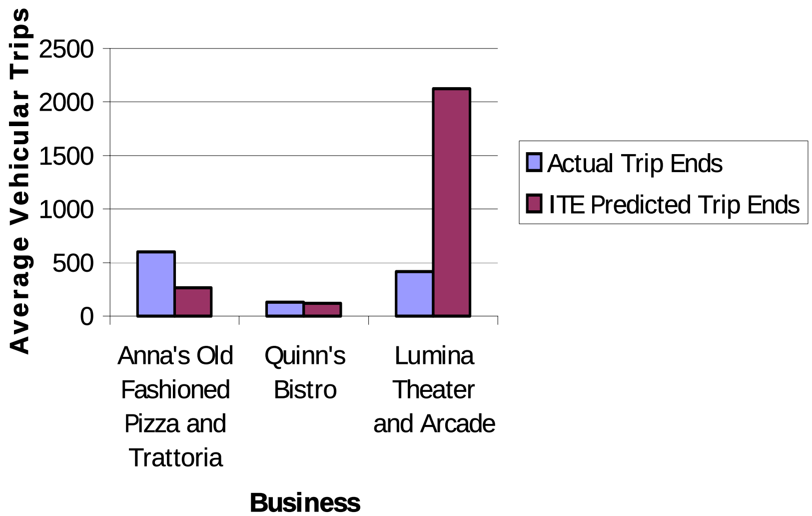
Figure E-2: Public Facilities



Entertainment and Restaurants

Both sit-down restaurants attract more automobile trips than ITE predicted. However, Lumina Theater has 81 percent fewer actual trips than ITE predicted as displayed in Figure E-8.

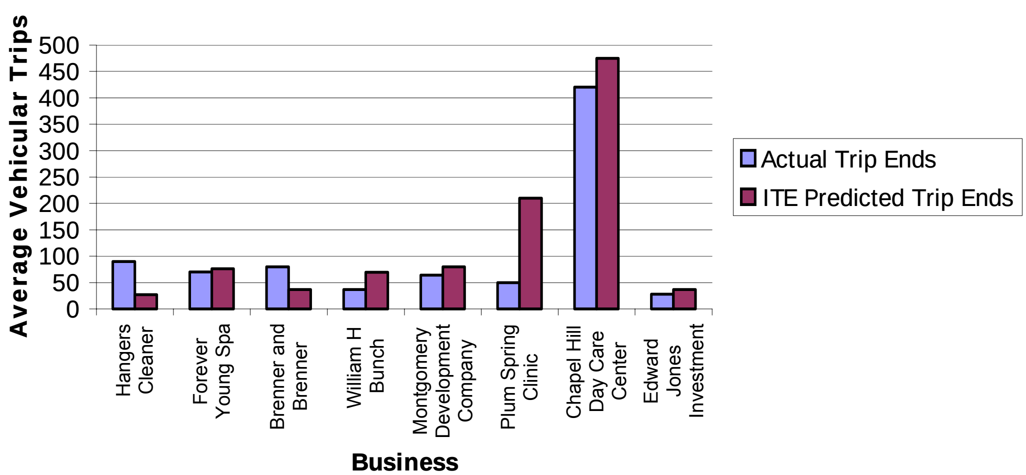
Figure E-3: Entertainment and Restaurants



Private Services

With the exception of Hangers Cleaners, Brenner and Brenner Law Firm and Plum Spring Clinic, the number of private service trip ends are similar to ITE's predicted trips (Figure E-9).

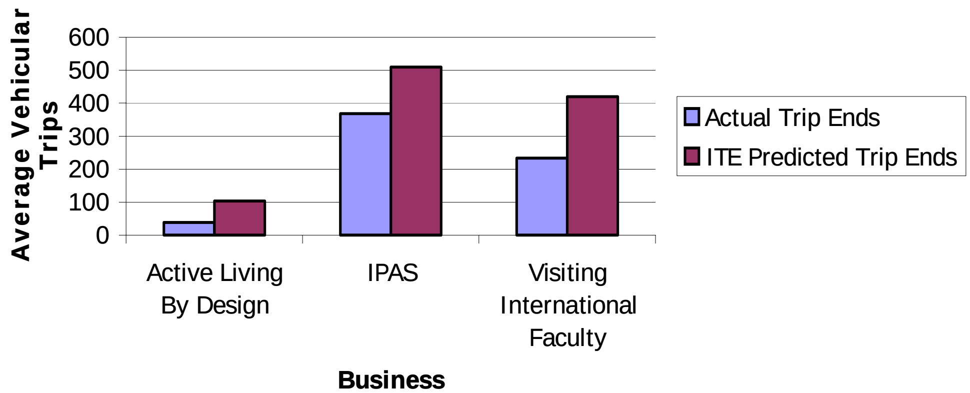
Figure E-4: Private Services



Public Services:

The Public Services in Southern Village averaged 79 percent fewer actual trips than ITE predicted (Figure E-10).

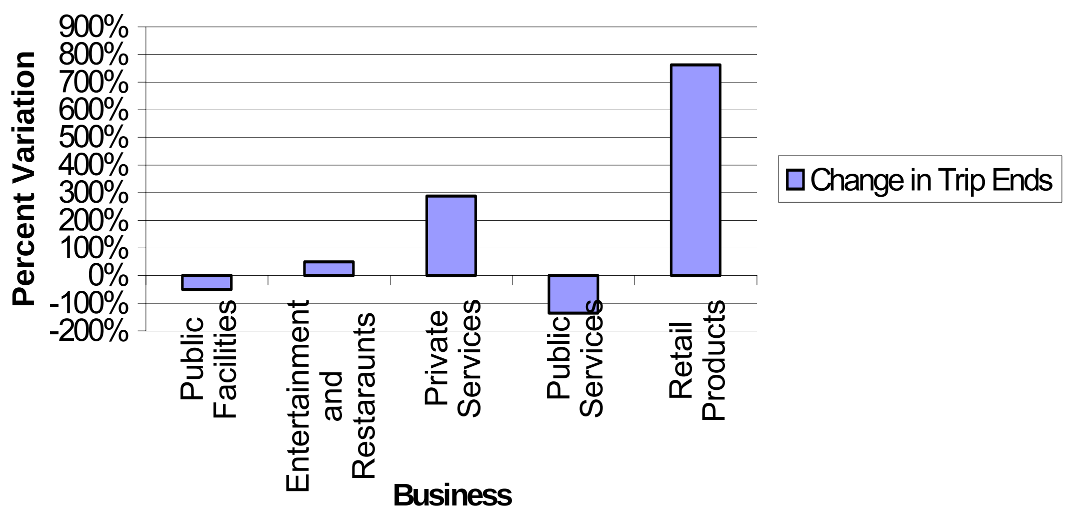
Figure E-5: Public Services



Possible Reasons for Trip Variations in Actual versus Predicted Trip Ends

The question of whether businesses are adapting to the alternative mode use goal of TNDs is unclear. Results display that certain industries are producing more automobile trips, while others are producing fewer. Figure E-11 shows the percent difference in actual trips ends versus predicted trip ends by business category. The Public Facilities and Public Service businesses are attracting fewer vehicular trips than conventional contexts. Entertainment and Restaurants, Private Services and Retail Services are attracting more vehicular trips than conventional contexts.

Figure E-6: Southern Village Trip End Variation from ITE



Due to the small sample size of businesses, it is not feasible to determine statistically if there is a relationship between the TND design of Southern Village and automobile trips. Since the evidence is inconclusive the possibility of the relationship cannot be discarded.

The age of Southern Village may be a reason for the variation in the number of automobile trips in comparison to a conventional facility forecasted by ITE. It is a relatively new development, with construction starting in the 1990s. Two businesses surveyed had been open for only one month. The newness of the businesses means that they may not have had time to maximize their client base.

Another possible reason for the variation is the fact that Southern Village residents are in the middle to upper income level. Conventional contexts, as measured by ITE, most likely include more diverse income levels. The income levels of customers who frequent Southern Village businesses may produce a different amount of trip ends.

Measurement error is another reason for variation. The survey was based on managers, owners and administrators perceptions of travel behavior. Since they are estimating employee and customer travel behavior, their responses cannot be considered fully reflective of actual travel behavior. The small sample size of both the ITE data and Southern Village businesses means that the results are less reliable than a larger sample size. Also, ITE did not consistently give a linear equation for their predicted trip ends, so several of the values are estimates based on tables printed in the ITE book.

Conclusions Regarding Business Survey

The business survey answers the question: To what extent do the component land uses—residential, office, retail, etc., attract off-site workers and visitors? Given that Southern Village is a relatively young TND, the businesses have not yet stabilized. Yet the survey of business managers showed reasonable results. A total of 5,105 trips ends were taken in one day of which 4,299 (84.2 percent) were by customers. It revealed that only 5.2 percent of the 432 employees reside in Southern Village. A large majority of the employees (92.4 percent) used personal vehicles to commute to work, given the free employee parking in Southern Village. In terms of customers/visitors, an estimated 39.2 percent reside in Southern Village. According to business representatives, 77.7 percent of the customers drive, 18.1 percent walk and 4.2 percent take the bus. The results show that Southern Village employees use passenger cars as often as employees in conventional (stand-alone) facilities, but that customers are more likely to walk.

The Southern Village business survey revealed that the Public Facilities and Public Service businesses are attracting fewer vehicular trips than those predicted by ITE for businesses located in conventional contexts. It also showed that Entertainment and Restaurants, Private Services and Retail Services are attracting more vehicular trips than conventional businesses.

Businesses Located in Southern Village

Market Street Books: A small independent bookstore www.marketstreetbooks.com

Weaver Street Market: Food cooperative selling organic and conventional goods www.weaverstreetmarket.coop

Scruggs Elementary School: Elementary School serving Chapel Hill

Anna's Old Fashioned Pizza and Trattoria: Both dine in and take out restaurant serving Italian entrees.

Quinn's Bistro: Sit down restaurant serving entrees, wine and ice cream

Lumina Theater and Arcade: An attached arcade and movie theater

Hangers Cleaner: Environmentally friendly dry cleaner

Forever Young Spa: Beauty salon and spa

Brenner and Brenner Law Firm: Law firm specializing in medical malpractice, business and civil litigation, family, employment, and federal and state criminal matters www.brennerandbrenner.com

William H. Bunch Professional Accounting, Consulting and Tax: www.WilliamHBunchCPA.com

Montgomery Development Carolina Corporation: Provides nationwide commercial general contracting services: www.montgomerydevelopment.com

Plum Spring Clinic: Integrated Medical Care www.plumspring.com

Chapel Hill Day Care Center: Day Care provider

Edward Jones Investment: Specialized in high quality, low-risk investments www.edwardjones.com

Active Living By Design: “Establishes and evaluates innovative approaches to increase physical activity through community design, public policies and communications strategies.” www.activelivingbydesign.org

Ipas: Nonprofit that protects women’s health and advances reproductive rights http://www.ipas.org/

Visiting International Faculty: A U.S. government-recognized exchange-program for teachers around the world www.vifprogram.com

Southern Village Business Survey

Date of interview____________________

Interviewer ____________________

Business Name / Address	Contact Info Name / Phone	Type of Business	Size* or X=	# of Employees Full-time / Part-time
				Full__________ Part__________

* Square feet or number of movie screens or seating capacity, depending on business type, as suggested by ITE's trip generation manual.

General Information

May we have a copy of your annual report, or other material that would help us accurately describe your organization? ________________________________

Reasons for Southern Village Location

Why did you choose to locate in Southern Village? ________________________________
Examples: Good market conditions, convenience for employees or customers, commitment to neo-traditional village concept, architecture/design. ________________________________

Is it turning out the way you expected? Yes No

Why or why not? ________________________________

Employee Travel for Work

How frequently do your employees travel off site for business? __________employees daily

__________employees weekly

Does your organization own one or more vehicles for use by employees? Yes No

If so, how many and where are they parked? ________________________________

Do you provide (free) paid parking for employees? ________________________________

How do your employees get to your business? ___% by private car ___% by transit

___% by bike ___% by walking

___% other, please specify:________

How many of your employees live in S. Village? ________________________________

How many of your customers live in S. Village? ________________________________

Business Hours and Travel Volumes

What are your hours of operation? ________________________________

Day, Average Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
% of customers on							

Hours, Average Day	7am-9am	9am-11am	11am-1pm	1pm-3pm	3pm-5pm	5pm-8pm	8pm-12am
% of customers from							

If your company does business with the public, how many customers do you get on an average day? ________________________________

How many customers enter and exit at peak hour? _______ Enter _______ Exit

How much does the average customer spend in your business? ________________________________

How do your customers get to your business? ___% by private car ___% by transit

___% by bike ___% by walking

___% other, please specify:________

Do you provide (free) paid parking for customers? ________________________________

Encouragement for Alternative Travel Modes

Do you have any facilities that make it easier for people (employees or customers) to walk or ride a bicycle to your business (bike racks, bike lockers, showers, etc.)? Yes No

If so, please describe them ______________________________

____

Do you have travel demand management programs such as car-pool support, flex-time, telecommuting, or day-care facilities? Yes No

If so, please describe them: ______________________________

____

____

Do you have any concerns about transportation for your employees or customers?

____

____

____

____

Appendix F: Targa, F. 2002. "Final Paper: Trip Generation – Land Use."

For Planning 129 Department of City and Regional Planning, University of North Carolina, Chapel Hill.

TRANSPORTATION MODELING
Trip Generation – Land Use

The project will develop regional baseline data and models for Trip Generation, Trip Distribution and Mode Choice in the Triangle region. These baselines will later be used to compare travel impacts of Southern Village to the rest of the Triangle region. These will detail the data collected, methods and computer tools used to develop baselines for comparison with Southern Village, and a discussion of how the baseline will be used to perform the comparison. This paper will address the following four questions:

- Comment on the model results in terms of parameter signs, their magnitudes and a statement about the significance of parameters and the model fit.
- What land use variables (if any) influence trip productions?
- Are your results consistent with literature you cited in the TND literature review?
- What are the implications of your findings for Southern Village?

Trip Generation This project will enlarge upon trip generation models created earlier in the semester, breaking out trip generation of Home-Based Work, Non-Home-Based, and Home-Based Other trips. Data available for this task include the 1995 Triangle Transportation Survey, the Census Transportation Planning Package, plus other data sets as available. This will require linking the trip file to the household file.

In the previous assignment for our class, we presented a model for trip generation at the household level using TTA's household survey conducted in 1995. The specification of our previous model included the traditional predictor variables for trip generation rates such as household size, number of vehicles in the household, household income level, type of home and stratum. Census data were joined to TTA's dataset in order to capture land use and accessibility measures.

Particularly, we are interested in testing the effect of density and accessibility-related measures on trip generation rates when controlling for other socio-demographic variables. The theory tells us that trip generation rates must vary with accessibility, based on utility tradeoffs between accessibility and activities (Ewing *et al*. 1996). The amount of additional trips will depend on how elastic the travel-activity demand with regard to changes in accessibility.

Therefore we expect that trip rates can be lowered by raising densities and mixing uses, at least for vehicle trips. However, our data do not allow us to differentiate between different trip purposes (e g. home-based trips, non-home-based other, and non-motorized trips). Moreover, other studies point out that the better accessibility that accompanies higher densities and mixed uses may have the opposite effect, raising vehicle trip rates rather than lowering them. All depends on the elasticities for specific trip purposes, how the substitution between non-motorized and vehicle modes plays out, and how they net up together in a measure of total trip generation rate like the one that we have in our dataset.

Table F-1: Comparison of Trip Generation Models for Different Trip Purposes

	Total Trips		**HBW**		**HBSH**				
	Coeff.	**t stat**	**Coeff.**	**t stat**	**Coeff.**	**T stat**	μ	σ^2	**Range**
HHSIZE	5.598***	23.65	-0.058*	-1.66	0.215***	5.60	2.33	1.21	6
NUMVEH	0.551*	1.75	0.017	0.36	0.000	-0.01	1.94	0.95	7
LICENSE DRIV	0.185	0.36	0.382***	5.01	0.255***	3.08	1.75	0.69	6
EMPLOYEES	0.285	0.86	0.927***	18.64	-0.274***	-5.07	1.23	0.80	5
MANAG/PROFF	0.642*	1.92	-0.015	-0.30	-0.067	-1.23	0.73	0.72	3
INCOME 20-40	0.704	0.93	0.083	0.73	0.303**	2.47	0.25	0.43	1
INCOME 40-60	1.633**	1.97	0.284**	2.30	0.453***	3.38	0.21	0.41	1
INCOME 60-80	2.097**	2.21	-0.059	-0.42	0.371**	2.41	0.12	0.33	1
INCOME 80-100	2.508**	2.27	0.052	0.32	0.755***	4.22	0.07	0.25	1
INCOME 100-150	1.596	1.30	-0.016	-0.09	0.478**	2.41	0.05	0.21	1
INCOME 150-200	-0.317	-0.21	-0.152	-0.69	0.023	0.10	0.03	0.16	1
INCOME 200+	5.735**	2.39	1.079***	3.01	0.336	0.86	0.01	0.09	1
INCOME not rep	0.469	0.55	0.091	0.72	0.320**	2.32	0.15	0.36	1
APT/CONDO	-1.193**	-1.96	0.102	1.13	-0.191*	-1.94	0.19	0.39	1
MOBILE	-2.826*	-1.73	-0.021	-0.09	-0.392	-1.48	0.02	0.14	1
STUDENT	-7.088	-1.43	0.129	0.17	-0.937	-1.17	0.00	0.04	1
OTHER	-1.386	-0.51	0.430	1.06	0.200	0.46	0.01	0.08	1
DENSITY	0.001**	2.22	0.000	1.53	0.000**	2.32	1,007	813	6,472
WHITE	0.059***	4.95	-0.002	-1.40	0.006***	2.99	72.36	20.36	98
COMMUTERS	0.047	1.61	0.009**	2.02	0.002	0.52	54.59	7.68	72
TRANSIT COM	0.224***	3.48	0.002	0.20	0.012	1.13	2.61	3.81	32
BIKE COM	0.280**	2.03	-0.017	-0.85	0.001	0.02	0.90	1.82	8
WALK	0.002	0.05	-0.001	-0.14	-0.003	-0.34	2.96	6.02	65
Constant	-7.243***	-3.76	-0.621**	-2.16	-0.343	-1.10			
N	1,667		1,667		1,667				
F statistic	63.79		35.56		8.27				
P > F	0.001		0.001		0.001				
R^2	0.472		0.332		0.104				
Adjusted R^2	0.464		0.323		0.091				
Root MSE	8.440		1.259		1.367				
Mean VIF	1.70		1.70		1.70				

Note: The mean, standard deviation, and range of TOTALTRI are 17.23, 11.48, and 77, respectively.
The mean, standard deviation, and range of HBW are 1.56, 1.53, and 10, respectively.
The mean, standard deviation, and range of HBSH are 1.21, 1.3, and 10, respectively.

*** Significant at the 99% confidence level
** Significant at the 95% confidence level
* Significant at the 90% confidence level

Table F-2: Comparison of Trip Generation Models for Different Trip Purposes (cont…)

	HBSC Coeff.	t stat	HBO Coeff.	t stat	NHB Coeff.	T stat			Range
HHSIZE	0.843***	28.48	1.275***	19.27	3.323***	18.89	2.33	1.21	6
NUMVEH	0.012	0.32	0.102	1.16	0.419*	1.79	1.94	0.95	7
LICENSE DRIV	-0.268***	-4.18	-0.100	-0.70	-0.084	-0.22	1.75	0.69	6
EMPLOYEES	-0.072*	-1.73	-0.564***	-6.05	0.268	1.08	1.23	0.80	5
MANAG/PROFF	-0.038	-0.90	0.203**	2.17	0.559**	2.25	0.73	0.72	3
INCOME 20-40	-0.356***	-3.75	0.128	0.60	0.548	0.97	0.25	0.43	1
INCOME 40-60	-0.559***	-5.39	0.137	0.59	1.318**	2.14	0.21	0.41	1
INCOME 60-80	-0.517***	-4.35	0.471*	1.77	1.831***	2.59	0.12	0.33	1
INCOME 80-100	-0.652***	-4.72	0.099	0.32	2.255***	2.75	0.07	0.25	1
INCOME 100-150	-0.293*	-1.92	0.104	0.30	1.324	1.45	0.05	0.21	1
INCOME 150-200	-0.652***	-3.53	0.316	0.77	0.148	0.14	0.03	0.16	1
INCOME 200+	-0.240	-0.80	1.000	1.49	3.560**	2.00	0.01	0.09	1
INCOME not rep	-0.568***	-5.34	0.391*	1.65	0.236	0.37	0.15	0.36	1
APT/CONDO	0.048	0.63	-0.373**	-2.20	-0.778*	-1.72	0.19	0.39	1
MOBILE	-0.204	-1.00	-0.657	-1.44	-1.552	-1.28	0.02	0.14	1
STUDENT	1.069*	1.72	-2.192	-1.58	-5.156	-1.40	0.00	0.04	1
OTHER	-0.361	-1.06	0.183	0.24	-1.837	-0.91	0.01	0.08	1
DENSITY	0.000	0.79	0.000	0.53	0.000*	1.85	1,007	813	6,472
WHITE	0.002	1.03	0.017***	5.02	0.037***	4.22	72.36	20.36	98
COMMUTERS	0.007**	2.03	-0.003	-0.33	0.031	1.43	54.59	7.68	72
TRANSIT COM	0.015*	1.82	0.063***	3.48	0.133***	2.78	2.61	3.81	32
BIKE COM	0.016	0.94	0.047	1.23	0.233**	2.27	0.90	1.82	8
WALK	0.010	1.58	0.003	0.21	-0.006	-0.18	2.96	6.02	65
Constant	-0.910***	-3.77	-1.180**	-2.19	-4.189***	-2.92			
N	1,667		1,667		1,667				
F statistic	48.46		31.94		43.74				
P > F	0.001		0.001		0.001				
R^2	0.404		0.309		0.380				
Adjusted R^2	0.396		0.299		0.371				
Root MSE	1.056		2.360		6.273				
Mean VIF	1.70		1.70		1.70				

Note: The mean, standard deviation, and range of HBSC are 0.69, 1.35, and 10, respectively.
The mean, standard deviation, and range of HBO are 2.71, 2.81, and 21, respectively.
The mean, standard deviation, and range of NHB are 11.05, 7.87, and 53, respectively.

*** Significant at the 99% confidence level
** Significant at the 95% confidence level
* Significant at the 90% confidence level

Comment on the model results in terms of parameter signs, their magnitudes and a statement about the significance of parameters and the model fit.

- The first model is the preferred model from the last assignment, which previously had 2,044 observations. However, we lost over 300 observations when we joined the TTA and Census datasets, mainly due to the fact that none of the TTA transit-enrichment households were geocoded; thus, they could not be joined with the Census dataset.
- In order to better account for density, Model 2 uses the Census block group density variable instead of TTA's stratum for urban, suburban, and rural households. Both density-related variables cannot be included in the same model due to the high degree of

collinearity between them. Although it is an average measure of the Census block group, the Census density is a more accurate variable for our model than TTA's categorical variable because it is a continuous variable that captures more variability of density in areas, while TTA's variable essentially assumed equal density within the stratum (e.g., all "urban" category observations are assumed to have an equal level of density). Although Model 2 does not improve the goodness of fit compared with Model 1, we decided to keep the density variable from the Census dataset instead of TTA's urban/suburban/rural variable in order to account for more variability in household's neighborhood density.

- In addition to using the density variable from the Census dataset instead of TTA's urban/suburban/rural variable (a land use-related measure), Model 3, our preferred model, includes proxy variables for local and regional accessibility, such as accessibility to non-motorized facilities and transit accessibility. We included an additional control for race as well. These variables are captured by proxies such as the proportion of the population who commutes to work (accounting for labor force participation), the proportion of commuters who use transit and bike, and the proportion of the population that is white. Like the Census density variable, these are averages for the Census block group.
- Poisson, negative binomial, and zero inflated negative binomial models are presented in the Appendix (available upon request). These models improved goodness of fit and prediction power compared with the OLS models presented below. However, due to the scope of this particular assignment we discuss OLS models and present in the Appendix MLE models, which for future research should be interpreted and analyzed.
- The overall significance of the three models (Table F-1) is good in terms of the F-test. The F-value of the models is higher than the F-critical; thus we can reject the hypothesis that all estimate parameters in the models are equal to zero. This means that the explanatory variables chosen for the models explain the variance in our dependent variable (TOTALTRI) to a certain degree. Indeed, the R-square for the models, and the adjusted R-square, which takes into account the number of explanatory variables introduced in the model, is higher for Model 3 than for Model 2. For example, the adjusted R-square for Model 3 indicates that 46.4 percent of the variance in the household total trip generation is explained with the explanatory or dependent variables chosen in the model. Additionally, the Root MSE for Model 3 is better than the Root MSE for Model 2. The VIF measures multi-collinearity among explanatory variables, where a mean of 4 or higher indicates a critical level. The degree of multi-collinearity decreases from Model 1 to 3 and it does not reach a critical value. However, the significance and parameter estimates of some of the variables that are correlated might be affected. The constant for Model 3 (-8.035) is significant at the 99 percent confidence level, is negative, and is large compared with to the coefficients. Though this constant is a problem for estimation, we conclude that Model 3 offers the best goodness of fit and is the preferred model. The rest of the coefficients for socioeconomic and demographic variables did not change with respect the specification model presented in the last assignment (sign and magnitude). Therefore we limit our discussion to our preferred model (Model 3) and for the coefficients of the new introduced variables.
  - The parameter estimate for density is statistically significant with a confidence level of 99 percent. Therefore, we can reject the null hypothesis that density does not affect the numbers of trips generated at the household level. The sign of the

parameter estimate is positive, meaning that the higher the density of the Census block group where the household is located, the higher the trips generated by the household. Indeed, the parameter estimate for density (0.001) indicates that for every additional person per square kilometer in the Census group block, 0.001 additional trips would be generated in two days, holding all other variables constant. This result can interpreted as an elasticity of 0.043, meaning that an increase of 100 percent in density in the Census group block is associated with an increase in 4.3 percent in the household trip generation rate.

– The parameter estimate for commuters is statistically significant with a confidence level of 90 percent. The sign of the parameter estimate is positive, meaning that the higher the proportion of commuters per Census block group (higher proportion of labor force participation), the higher the trips generated by the household. Indeed, the parameter estimate for commuters (0.0563) indicates that for an increase of one percentage point in the proportion of commuters per Census block group, 0.0563 additional trips would be generated in two days, holding all other variables constant.
– The parameter estimate for commuters who use transit is also statistically significant with a confidence level of 99 percent. The sign of the parameter estimate is positive, meaning that the higher the proportion of commuters using transit per Census block group, the higher the trips generated by the household. Indeed, the parameter estimate for transit commuters (0.253) indicates that for an increase of one percentage point in the proportion of transit commuters per Census group block, 0.253 additional trips would be generated in two days, holding all other variables constant. This result also tells us that higher accessibility to transit services or facilities is associated with higher trip generation rates. One again, we cannot make conclusions based on trip purposes because our dependent variable is for total trips. Instead, we can conclude that when all effects are netted up, the demand is elastic with regard to changes in accessibility to transit.
– The parameter estimate for commuters who bicycle to work is statistically significant with a confidence level of 99 percent. The sign of the parameter estimate is positive, meaning that the higher the proportion of commuters traveling by bicycle per Census block group, the higher the trips generated by the household. Indeed, the parameter estimate for bicycling commuters (0.359) indicates that for every additional percentage point increase in the proportion of transit commuters per Census group block, 0.359 additional trips would be generated in two days, holding all other variables constant. Similar to the proportion of transit commuters, we can conclude that higher accessibility to non-motorized transportation facilities is associated with higher trip generation rates (for all trip purposes). Instead, we can conclude that when all effects are netted up, the demand is elastic with regard to changes in accessibility to non-motorized facilities.
– Finally, the parameter estimate for white people is statistically significant with a confidence level of 99 percent. The sign of the parameter estimate is positive, meaning that the higher the proportion of white people per Census block group, the higher the trips generated by the household. The parameter estimate for white people (0.060) indicates that for an increase of one percentage point in the proportion of white people per Census group block, 0.060 additional trips would be generated in

two days, holding all other variables constant. Although this is not a land-use- or accessibility-related measure, it is control measure for race in the neighborhood.

What land use variables (if any) influence trip productions?

- According to our Models, density influences trip productions (accounting for proxy variables such as stratum or a direct measure of density at the Census block group level). Indeed we found an elasticity of 0.043, meaning that an increase of 100 percent in density in the Census group block is associated with an increase in 4.3 percent in the household trip generation rate. This elasticity is for the net effect on total trips by all purposes and we cannot generalize for specific trip purposes. Although they are not land use variables, we also found that accessibility-related measures (also related with density), such as the proportion of people who commute to work via transit and who commute to work via bicycle per Census block group, also influence trip productions. For all our results we found measures of association only; some must be influenced by self-selection issues.
-

Are the results consistent with literature you cited in the TND literature review?

Our finding that density is positively and significantly associated with trip generation is consistent with Ewing *et al*.'s theory 3 or 4 (1997). We found a positive association between density and trip generation rates. However, we cannot make conclusions based on a substitution effect among modes because of limitation issues in our data. Particularly, we cannot make conclusions about the elasticities for specific trip purposes or about the substitution between non-motorized and vehicle modes. We simply found how they netted up together in a measure of total trip generation rate.

These results match with some empirical results documented in previous studies (net total effect increases trip generation). However, it would be interesting to analyze the disaggregated elasticities for trip purposes and the substitution effects between non-motorized and vehicle modes.

Finally, the elasticity of 0.043 cannot be compared easily with the current literature because most of the studies deal with VMT elasticities.

What are the implications of the findings for Southern Village?

Since we know that Southern Village is denser than other, more conventional subdivisions in the Triangle, we hypothesize that trip generation rates for all trip purposes will be higher for households in Southern Village. More information about land use, specifically for measures of mixed use, and accessibility not only for non-motorized or transit facilities but also for local and regional accessibility to jobs, services, entertainment, and stores, would be useful. Additionally more information about trip purposes and travel contextual variables can improve the model specification.

Hypothetically, if households in Southern Village are located in denser neighborhoods with greater accessibility to transit services and non-motorized travel facilities (assuming that they can be captured by proxy variables such as people commuting to work either via transit or bicycling), then we would hypothesize that trip generation rates for all trip purposes will be higher for households in Southern Village than for households in more conventional subdivisions.

Appendix G: Survey instrument and travel diary used in this study

Chapel Hill – Carrboro Neighborhood Survey

March 1, 2003

Dear Head of Household,

The North Carolina Department of Transportation, in collaboration with the Department of City and Regional Planning at UNC-Chapel Hill and the Department of Civil Engineering at NC State, are conducting an important study about travel patterns. As part of this study, we are collecting information about how, when, and why you travel from one place to another. Your neighborhood is one of two neighborhoods that have been selected for this study. We will be mailing this survey to approximately 1800 households.

Your voluntary participation in this survey is greatly appreciated. When finished, please insert all survey items in the postage-paid envelope provided and deposit it in a mailbox. Sending in the survey is an indication of your willingness to participate in the study. If you get to a question you don't want to answer, please skip it and go on to the next one. The confidentiality of your responses is assured.

The survey is divided into two sections:

1. The first section is to be filled out only by the head of the household. In this section, you are asked to provide the first names of the people in your household. If you would like to use fictional names or initials, please do so, just be sure the same names or initials are used in the second section.
2. The second section is to be filled out by each member of your household age 16 or older. This second section is a travel diary that is used to record participant's travel behavior over a one-day period. Please have each member of your household fill out the travel diary for their trips on a Tuesday, Wednesday, or Thursday of a typical, non-Spring Break (if applicable), week as soon as possible. Please be sure the appropriate name and date is recorded in the upper portion of each travel diary.

Filling out the survey and travel diary does not take long and will improve local decision-makers' understanding of the transportation needs of area residents. To express our gratitude for your participation in this study, we will send you a $10 gift certificate to Weaver Street Market's Southern Village store upon the completion and receipt of your household's survey. In the upper right hand corner of the first page of the first section is a unique identification number that will enable us to send your household the gift certificate. If you would rather remain anonymous, feel free to cross off the number, but we will not be able to send you a gift certificate.

If you have any questions about the survey, please contact the project directors listed below. If you have any questions about your rights as a research participant, please contact Dr. Barbara Goldman, Chair of the Academic Affairs Institutional Review Board, at aa-irb-chair@unc.edu or 962-7761.

Thank you in advance,

Dr. Asad Khattak, Professor
UNC-Chapel Hill
City and Regional Planning

Dr. John Stone, Professor
NC State
Civil Engineering

Tel: 919-962-4760 Tel: 919-515-7732

Alert and Follow-up Postcards

Please Help Us By Filling Out An Important Survey That Will Be Sent To You Within The Next Couple Of Weeks

Chapel Hill - Carrboro Neighborhood Survey

The North Carolina Department of Transportation, along with the University of North Carolina and North Carolina State University, is conducting a study of travel patterns in your neighborhood. Within the next couple of weeks, a brief survey will be mailed to you. When the survey arrives, please take the time to fill it out and send it back in its enclosed postage-paid envelope.

In appreciation for receiving your completed survey, we will send you a $10 gift certificate to Weaver Street Market's Southern Village store.

Thank you for helping us improve the future of Chapel Hill and Carrboro. If you have any questions, please contact us at neighborhood_survey@unc.edu or at 962.4760.

Signed,

Asad Jan Khattak

Asad Khattak, Project Coordinator

If You Have Yet To Mail Back The Survey We Mailed You Last Week, Please Do So As Soon As Possible

Chapel Hill - Carrboro Neighborhood Survey

A few weeks ago, the North Carolina Department of Transportation, along with the University of North Carolina and North Carolina State University, mailed a survey to your household about your travel patterns. If you have not responded yet, please do so as soon as possible. If you have misplaced the survey, please contact us. If you have misplaced the postage-paid, self-addressed envelope that was enclosed with the survey, please mail the survey back to the address on the front of this postcard.

In appreciation for receiving your completed survey, we will send you a $10 gift certificate to Weaver Street Market's Southern Village store.

Thank you for helping us improve the future of Chapel Hill and Carrboro. If you have any questions, please contact us at survey@email.unc.edu or at 962.4760.

Signed,

Asad Khattak, Project Coordinator

Chapel Hill - Carrboro
Neighborhood
Survey

DATE

Dear Household Member,

Thank you for taking the time to fill out our survey. Our records show that members of your household did not complete travel diaries or did not complete them for an appropriate day. The travel diary is used to record travel behavior over a one-day period for each household member. According to the survey your head of household filled out, the name given for these people are "«name_1»" and "«name_2»".

This information is very important to our study, so please use the enclosed diaries to record you or your household member's trips on either a Tuesday, Wednesday, or Thursday by DATE and return them in the enclosed, postage-paid envelope. Please be sure the appropriate name and date is recorded in the upper portion of each travel diary and that all one-way trips over 300 feet are recorded.

If you intentionally did not fill out the travel diary and still do not wish to provide us with this information, please disregard this letter. However, your response would improve local decision-makers' understanding of the transportation needs of area residents. <u>The confidentiality of your responses is assured.</u>

If you have any questions about the survey, please contact the project directors listed below. If you have any questions about your rights as a research participant, please contact Dr. Barbara Goldman, Chair of the Academic Affairs Institutional Review Board, at aa-irb@unc.edu or 962-7761.

Thank you once again for your time,

Dr. Asad Khattak, Professor
UNC-Chapel Hill
City and Regional Planning
Tel: 919-962-4760

Dr. John Stone, Professor
NC State
Civil Engineering
Tel: 919-515-7732

SECTION ONE (ONE COPY):

TO BE FILLED OUT BY THE *HEAD OF HOUSEHOLD ONLY*

SECTION ONE – ALL RESPONSES WILL BE KEPT STRICTLY **CONFIDENTIAL**.

Chapter 1: QUESTIONS ABOUT YOUR HOUSEHOLD (TO BE FILLED OUT BY THE *HEAD OF HOUSEHOLD* ONLY)

1. What type of home do you currently live in?

- a Detached single house
- b Duplex
- c Townhouse or rowhouse
- d Apartment
- e Condominium
- f Other [Specify]________________
- g Don't know

2. Before moving here, in what type of home did you live in?

- a Detached single house
- b Duplex
- c Townhouse or rowhouse
- d Apartment
- e Condominium
- f Other [Specify]________________
- g Don't know

3. Do you rent or own your current home?

- a Own
- b Rent
- c Other [Specify]________________
- d Don't know

4. What date did you move into your current neighborhood?

a ________Year b ________Month

5. Please list the type and year of each motor vehicle in your household, for Model use the list codes provided below [Include leased, vanpool, or company-owned motorized vehicles if they are used by household members on a regular basis]

Vehicle #1: ___ Model _______ Year
Vehicle #2: ___ Model _______ Year
Vehicle #3: ___ Model _______ Year
Vehicle #4: ___ Model _______ Year
Vehicle #5: ___ Model _______ Year

<u>Codes for Model</u>
A. sedan/hatchback/convertible/station wagon/coupe
B. van [mini, cargo, passenger, conversion]
C. sports utility vehicle [explorer, land rover, jeep, etc.]
D. pickup truck
E. other truck
F. rv [recreational vehicle]
G. motorcycle
H. other

6. Please list the first name, age, and sex of each member of your household including yourself. If the member is a school-aged child (age 5 to 18), please mark how the child gets to school. Please use fictitious names or initials if you would like. [Please do <u>not</u> include anyone who usually lives somewhere else or is just visiting, if there are more than six people living in your home, please list them and their information on the previous sheet]

Your First Name: __________________ **Age**:_____

Licensed Driver? Yes No

Sex: Male Female

First Name: ______________________ **Age**:_____

Licensed Driver? Yes No

Sex: Male Female

If school-age, he/she travels to school by:

- d Walk
- b Car ride or drives to school
- e Bicycle
- c Transit (bus or school bus)
- f Other [Specify]_______________

First Name: ______________________ **Age**:_____

Licensed Driver? Yes No

Sex: Male Female

If school-age, he/she travels to school by:

- d Walk
- b Car ride or drives to school
- e Bicycle
- c Transit (bus or school bus)
- f Other [Specify]_______________

First Name: ______________________ **Age**:_____

Licensed Driver? Yes No

Sex: Male Female

If school-age, he/she travels to school by:

- d Walk
- b Car ride or drives to school
- e Bicycle
- c Transit (bus or school bus)
- f Other [Specify]_______________

First Name: ______________________ **Age**:_____

Licensed Driver? Yes No

Sex: Male Female

If school-age, he/she travels to school by:

- d Walk
- b Car ride or drives to school
- e Bicycle
- c Transit (bus or school bus)
- f Other [Specify]_______________

First Name: ______________________ **Age**:_____

Licensed Driver? Yes No

Sex: Male Female

If school-age, he/she travels to school by:

- d Walk
- b Car ride or drives to school
- e Bicycle
- c Transit (bus or school bus)
- f Other [Specify]_______________

IN THIS PART OF THE SECTION, YOU WILL BE ASKED ABOUT THE TRIPS YOU MAKE.

ONE TRIP IS CONSIDERED ANY ONE-WAY TRIP OVER 300 FEET.
ALL RESPONSES WILL BE KEPT STRICTLY CONFIDENTIAL.

Chapter 2: QUESTIONS ABOUT YOUR TRAVEL PATTERNS

1. What best describes your employment status? [Please check only one and answer the following questions accordingly]

- a Work full-time outside the home
- b Work part-time outside the home

→ **Please continue to Question 2**

- c Student → **Please skip to Question 4**

- d Work full-time at home
- e Work part-time at home
- f Unemployed (non-student)
- g Retired
- h Other [Specify]_______________

→ **Please skip to Question 6**

2. What best describes your occupation?

- a Clerical/Secretary
- b Service
- c Production/Manufacturing
- d Executive/Managerial
- e Skilled Trades
- f Retired
- g Sales/Retail
- h Computer/Technical
- i Medical/Health
- j Other[Specify]_______________

3. Do you ever telecommute/telework to work? If so, how many times per week?

a No a Yes, times per week _____

4. How much time does it typically take to travel to work or to school? [one-way travel]

a ____hours b ____minutes

5. How much do you typically spend on traveling to work or to school per week? [Include all gas, parking, or transit fares]

$_______

6. About how many miles per week do you travel by car?

________miles

7. In a typical week, Monday through Friday, how often do you make the following one-way trips:

	0 times	1	2	3	4	5	6	7+ times
Drive to work or school by car								
Outside your neighborhood								
Within your neighborhood								
Carpool to work or school by car								
Outside your neighborhood								
Within your neighborhood								
Go to work or school using public transportation								
Outside your neighborhood								
Within your neighborhood								
Walk or bicycle to work or school								
Outside your neighborhood								
Within your neighborhood								
Transport someone (pickup someone, take and wait for someone, drop someone off)								
Outside your neighborhood								
Within your neighborhood								
Go shopping/run an errand								
Outside your neighborhood								
Within your neighborhood								
Go out for recreation, entertainment, or meals (watch/play sports, movie, museum, restaurant/bar, visit friends/relatives)								
Outside your neighborhood								
Within your neighborhood								

Chapter 3: QUESTIONS ABOUT YOUR ATTITUDES

On a scale of 1 to 5, express your level of agreement with the following statements. 1= strongly disagree…. 5= strongly agree [Circle a number for each statement]

1. I like the flexibility that driving allows

   1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

2. I enjoy walking

   1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

3. I am comfortable riding a bus

   1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

4. I would like to have more time for leisure

   1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

5. We should raise the price of gasoline to reduce congestion and air pollution

   1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

6. It's important for children to have a large backyard for playing

   1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

7. Sidewalks make walking easier in my neighborhood

   1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

8. Environmental protection is an important issue

   1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

9. I enjoy a house close to the sidewalk so that I can see and interact with passersby

   1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

10. Too much land is consumed for new housing, stores, and offices

    1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

11. I enjoy bicycling

    1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

12. I can be comfortable living in close proximity to my neighbors

    1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

13. Hills or other barriers in my neighborhood make walking/bicycling difficult

    1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

14. My neighborhood seems safe for walking or bicycling

    1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

15. Sitting in traffic aggravates me

    1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

16. I prefer a lot of space between my home and the street

    1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

17. Taking public transit is inconvenient

    1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

18. Too many people drive alone

    1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

19. Children should have a large public play space within safe walking distance of their home

    1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

20. Having shops and services close by is important to me

    1 (strongly disagree) 2 3 (neutral) 4 5 (strongly agree)

21. My ideal commuting time to work or school is:

    ___Less than 5 minutes
    ___Between 5 and 15 minutes
    ___Between 15 and 30 minutes
    ___More than 30 minutes

22. The longest acceptable time for me to commute to work or school is:

    ___Less than 5 minutes
    ___Between 5 and 15 minutes
    ___Between 15 and 30 minutes
    ___Between 30 and 45 minutes
    ___Between 45 and 1 hour
    ___More than 1 hour

QUESTIONS ABOUT YOUR ACTIVITIES

1. In a usual week, do you walk for at least 10 minutes at a time for recreation or exercise?

   No __ {skip to **Question 5**} Yes ___

2. How many days per week do you walk for at least 10 minutes at a time? _____

3. On days when you walk for at least 10 minutes at a time, how much total time per day do you spend walking?

   a ____hours b ____minutes

4. Where does your walking activity for recreation and exercise take place?

   a Always in my neighborhood
   b Mostly in my neighborhood
   c Sometimes in my neighborhood and sometimes elsewhere
   d Mostly away from my neighborhood
   e Always away from my neighborhood

Now consider moderate and vigorous physical activities. Moderate activities cause *small* increases in breathing or heart rate, while vigorous activities cause *large* increases in breathing or heart rate.

5. In a usual week, do you do MODERATE physical activities for at least 10 minutes at a time, such as brisk walks, bicycling, vacuuming, gardening, or anything else that causes SMALL INCREASES in breathing or heart rate?

   No __ {skip to **Question 9**} Yes ___

6. How many days per week do you do these moderate activities for at least 10 minutes at a time? _____

7. On days when you do moderate activities for at least 10 minutes at a time, how much total time per day do you spend doing these activities?

   a ____hours b ____minutes

8. What percentage of the total time that you spend on moderate activities do you spend:

   ___% At home

   ___% Outside of my home but in my neighborhood

   ___% Outside of my neighborhood

   = 100% **TOTAL**

Now consider vigorous activities that cause *large* increases in breathing or heart rate such as jogging, swimming, or aerobics.

9. In a usual week, do you do VIGOROUS physical activities for at least 10 minutes at a time, such as running, aerobics, heavy yard work, or anything else that causes LARGE INCREASES in breathing or heart rate?

   No __ {skip to **Question 13**} Yes ___

10. How many days per week do you do these vigorous activities for at least 10 minutes at a time? _____

11. On days when you do vigorous activities for at least 10 minutes at a time, how much total time per day do you spend doing these activities?

    a ____hours b ____minutes

12. What percentage of the total time that you spend on vigorous activities do you spend:

    ___% At home

    ___% Outside of my home but in my neighborhood

    ___% Outside of my neighborhood

    = 100% **TOTAL**

13. What is your weight? _______ pounds

14. What is your height______ feet_____ inches

15. How often have you used the Internet in the past 6 months at home?

    a˜ Everyday
    b˜ Almost everyday
    c˜ Once a week
    d˜ Once a month
    e˜ Never

16. What is the highest level of education you have completed?

    a˜ Less than High School
    b˜ High School or GED
    c˜ Vocational/Technical Degree
    d˜ Some College or Associate's Degree
    e˜ Bachelor's Degree (BA,BS)
    f˜ Some graduate school, no degree
    g˜ Graduate or Professional School

17. If you work, what is your approximate household income before taxes (information is strictly confidential)?

    a Under $20,000
    b $20,000-$30,000
    c $30,001-$40,000
    d $40,001-$50,000
    e $50,001-$60,000
    f $60,001-$80,000
    g $80,001-$100,000
    h $100,001-$150,000
    i $150,001-$200,000
    j Over $200,000

SECTION TWO (FIVE COPIES):

THIS SECTION IS TO BE FILLED OUT SEPARATELY BY
EACH HOUSEHOLD MEMBER OVER THE AGE OF 15.

PLEASE DISTRIBUTE EACH IDENTICAL COPY TO EACH HOUSEHOLD MEMBER OVER THE AGE OF 15.

PLEASE FILL-IN THE DATE IN THE TOP RIGHT-HAND SPACE PROVIDED ON THE NEXT PAGE.

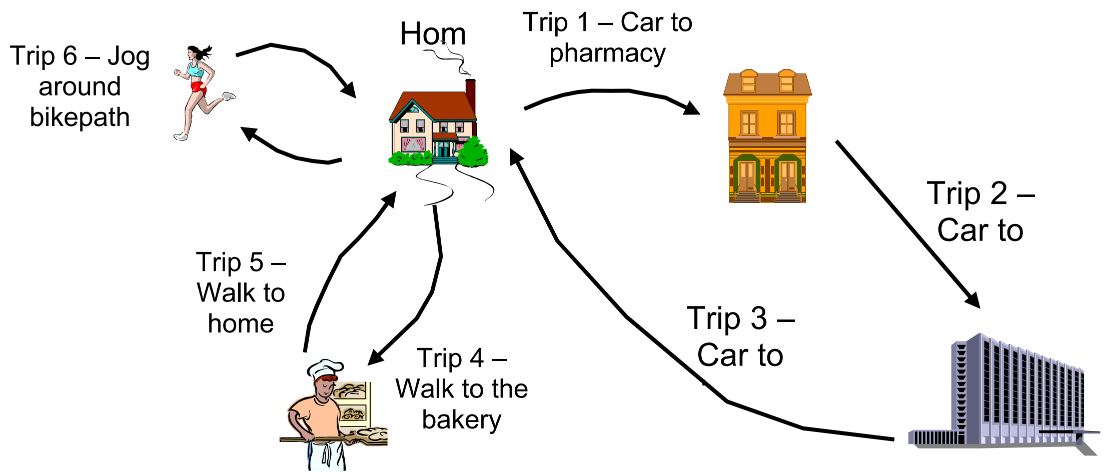
PLEASE FILL-IN THE RESPONDENT'S NAME IN THE TOP LEFT-HAND SPACE PROVIDED ON THE NEXT PAGE.
PLEASE USE THE SAME NAME YOUR HEAD OF HOUSEHOLD PROVIDED IN SECTION 1.

ALL RESPONSES WILL BE KEPT STRICTLY CONFIDENTIAL.

Instructions for completing your Travel Diary

- Use the diary on the back side of this page to record trips on your **travel day** and please record this date in the upper right hand corner of the page.
- Please fill-in your **name**, or the appropriate name your head of household provided in Section 1, in the top left-hand space provided on the back side of this page.
- The travel day starts at 4:00 a.m. and ends at 4:00 a.m. the next day.
- A **trip** is whenever you travel **from one place to another**. Use one line to record each trip. **Include:**
    - All trips you made for a specific reason, such as to go to work or school, buy gas, or drop someone off.
    - Return trips, such as coming home from work or school.
    - Walks, jogs, bike rides, and short drives. If you started and ended in the same place, list the farthest point you reached and record a return trip.
    - Trips of more than **300 feet**. These include walking for exercise, walking dogs, bike rides, etc.
    - **Do not** include stops just to change the type of transportation.
- If you made more than ten trips as part of your job (examples: a cab driver, delivery person, police officer):
    - **Don't** record the trips that were made as part of your job.
    - **Do** record the trips that got you to and from your work place.
    - **Do** record all other trips that **were not** part of your job.
- If you made more trips than will fit on the diary, record the rest on a blank sheet of paper.
- Estimate the **costs** of your travel to the best of your ability. Costs for taking the bus should only include bus fare. Costs for driving should only include parking. Costs for driving should **not** include gas, wear and tear, and ownership fees (such as insurance and depreciation) for the vehicle.

Example of Trips on a Travel Day



WHERE did you go ? (Name of place)	**WHERE** is it located? (List major cross streets)	What **TIME** did you start and end each trip? Started at:	Arrived at:	**WHY** did you go there?	**HOW** did you travel? (List route if using bus)	How **FAR** was it? (blocks or miles)	**COSTS** associated with travel (parking & transit fare only)
1. Wilson's Pharmacy	*North St/Bryant Rd*	*8:15am*	*8:25am*	*Pick up medication*	*Drive*	*1/2 mile*	*$0.50 (parking meter)*
2. St. Mary's Hospital	*Park St. / Highway 101*	*8:35am*	*8:50am*	*Work*	*Drive*	*4 miles*	*$5.00 (parking garage)*
3. Home		*4:50pm*	*5:05pm*	*End of workday*	*Drive*	*4 miles*	*none*
4. Jackie's Bakery	*High St. / 8th Ave.*	*5:15pm*	*5:30pm*	*Get some bread*	*Walk*	*3 blocks*	*none*
5. Home		*5:45pm*	*6:00pm*	*Rest*	*Walk*	*3 blocks*	*none*
6. A jog	*Loop around bikepath*	*6:30pm*	*7:00pm*	*Exercise*	*Jogged*	*3 miles*	*none*

First Name: ______________ **At the beginning of my travel day (4:00 a.m.) I was:** ☐ Home ☐ Some other place (specify)______________ **Date:**

WHERE did you go? (Name of place)	**WHERE** is it located? (List major cross streets)	What **TIME** did you start and end each trip?		**WHY** did you go there?	**HOW** did you travel? (List route if using bus)	How **FAR** was it? (blocks or miles)	**COSTS** associated with travel (parking & transit fare only)
		Started at:	Arrived at:				
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							

Appendix H: Survey Variables

Head of Household File/PA: Contents

Brief Description:
The Head of Household/PA file contains data specifically for the Head of Household and excludes other household members. Data is provided from the Household Survey, which only the Head of Household completed, as well as travel diary information for the Head of Household.

Part Zero: Head of Household File Neighborhood Data and Filters

0_1. HH_ID	household identification number
0_2. HDHH_ID (*key*)	head of household identification number
0_3. INCMPLT	travel diaries completed/not completed
0_4. FILTER1	completed/did not complete moderate and vigorous physical activity questions
0_5. FILTER2	completed moderate and vigorous physical activity questions and under 30 hours of moderate and vigorous physical activity per week
0_6. NGHB_CD	neighborhood code
0_7. TND	traditional neighborhood residence
0_8. CONV	conventional neighborhood residence
0_9. TND_SF	traditional neighborhood single-family residence
0_{10}. TND_MF	traditional neighborhood multi-family residence
0_{11}. VALUE	value of home according to Orange County
0_{12}. ADDRESS	home address
0_{13}. CITY	city
0_{14}. STATE	state
0_{15}. ZIP	zip code

Part One: Household Questions from Household Survey

1. CUR_HOME	current home type
2. PRE_HOM	previous home type
2_a. PREHO_SF	previous home type is single-family
3. OWNRENT	own vs. rent current home
3_a. OWN	homeowner
4. MOVE	date resident moved into current home (mm-dd-yyyy)
4_a. YEARS	years at current residence
5. NO_CAR	number of cars owned by the household
5_a. VEH_1ML	model of vehicle one
5_b. VEH_1YR	year of vehicle one
5_c. VEH_2ML	model of vehicle two
5_d. VEH_2YR	year of vehicle two
5_e. VEH_3ML	model of vehicle three
5_f. VEH_3YR	year of vehicle three
5_g. VEH_4ML	model of vehicle four
5_h. VEH_4YR	year of vehicle four

5_i. VEH_5ML	model of vehicle five
5_j. VEH_5YR	year of vehicle five
6. NO_HOME	number of persons in the household
6_a. UNDER_16	person is under 16 years old
6_b. NAME	person's first name
6_c. AGE	person's age
6_d. LICENSE	driver's license (yes/no)
6_e. SEX	sex (male/female)

Part Two: Travel Pattern Questions from Household Survey

1. EMPLOY	employment status (head of household)
1_a. EMP_OUT	employed outside of neighborhood dummy
1_b. STUDENT	student dummy
1_c. EMP_COM	comments (if EMPLOY is "other")
2. OCCUPA	occupation
2_a. OCC_COM	comments (if OCCUPA is "other")
3. TELECOM	telecommuting/teleworking frequency
4. TIME_1W	duration of one-way trip to work/school (decimal-hour)
5. SPEND_W	dollars spent traveling to work/school per week
6. MILES_W	miles traveled by car per week
7_{1a}. DRV_OUT	drive to work/school by car (outside neighborhood)
7_{1b}. DRV_IN	drive to work/school by car (inside neighborhood)
7_{2a}. CAR_OUT	carpool to work/school by car (outside neighborhood)
7_{2b}. CAR_IN	carpool to work/school by car (inside neighborhood)
7_{3a}. TRANOUT	travel to work/school using public transportation (outside neighborhood)
7_{3b}. TRAN_IN	travel to work/school using public transportation (inside neighborhood)
7_{4a}. WB_OUT	walk/bike to work/school (outside neighborhood)
7_{4b}. WB_IN	walk/bike to work/school (inside neighborhood)
7_{5a}. TRNSOUT	transport someone (outside neighborhood)
7_{5b}. TRNS_IN	transport someone (inside neighborhood)
7_{6a}. SHOPOUT	go shopping/run errand (outside neighborhood)
7_{6b}. SHOP_IN	go shopping/run errand (inside neighborhood)
7_{7a}. REC_OUT	go out for recreation (outside neighborhood)
7_{7b}. REC_IN	go out for recreation (inside neighborhood)

Part Three: Attitudinal Questions from Household Survey

1. FLEXDRV	flexibility of driving
2. ENJWALK	walking is enjoyable
3. COMFBUS	comfort with riding a bus
4. TMELEIS	leisure time
5. GASUP	price of gasoline
6. BACKYRD	large backyard for children
7. SIDEWLK	sidewalks in neighborhood
8. ENVIPRO	environmental protection

9. INTRACT	house proximity to sidewalk/interaction with passersby
10. LANDCON	land consumption for new housing, stores, offices
11. ENJBIKE	biking is enjoyable
12. CLOSENB	comfort with living in close proximity to neighbors
13. HILLS	hills in neighborhood
14. SAFE	safety of neighborhood for walking/biking
15. TRAFFIC	sitting in traffic
16. SPACE	space between home and street
17. PUBTRAN	public transit convenience
18. DRVALON	driving alone
19. PLAYSPC	public play space for children
20. SHOPSNB	shops and services close by
21. IDELCOM	ideal commuting time to work/school
22. ACCTCOM	longest acceptable commuting time to work/school

Part Four: Activities Questions from Household Survey

1. WALK_YN	walk at least ten minutes at a time (y/n)
2. WLK_DAY	number of days/week person walks 10+ minutes
3. WLK_TIM	total time per day spent walking (decimal-hours)
4. WALKLOC	location walking takes place
5. MOD_YN	moderate physical activities for 10+ minutes (y/n)
6. MOD_DAY	number of days/week person does moderate exercise
7. MOD_TIM	total time per day spent doing moderate exercise (decimal-hours)
8_a. MPR_HOM	percent of time spent on moderate exercise at home
8_b. MPR_NEI	percent of time spent on moderate exercise in neighborhood
8_c. MPR_OUT	percent of time spent on moderate exercise outside neighborhood
9. VIG_YN	vigorous physical activities for 10+ minutes (y/n)
10. VIG_DAY	number of days/week person does vigorous exercise
11. VIG_TIM	total time per day spent doing vigorous exercise (decimal-hours)
12_a. VPR_HOM	percent of time spent on vigorous exercise at home
12_b. VPR_NEI	percent of time spent on vigorous exercise in neighborhood
12_c. VPR_OUT	percent of time spent on vigorous exercise outside neighborhood
13. WEIGHT	respondent’s weight in pounds
14. HEIGHT	respondent’s height (decimal-feet)
14_a. HEIGHTIN	respondent’s height (inches)
14_a. BMI	respondent’s body-mass index
15. INTERNT	frequency of internet use
16. EDUCAT	highest level of education completed
16_a. COLLEGE	college education dummy
17. INCOME	household income

17$_a$. INC_MID household income (median of range)
18. MVPA duration of moderate and vigorous physical activity per week (hours)
19. MPA duration of moderate physical activity per week (hours)
20. VPA duration of vigorous physical activity per week (hours)
21. MVPA_HOM duration of home-based moderate and vigorous physical activity per week (hours)
22. MVPA_NEI duration of neighborhood-based moderate and vigorous physical activity per week (hours)
23. MVPA_OUT duration of external-based moderate and vigorous physical activity per week (hours)
24. MPA_HOM duration of home-based moderate physical activity per week (hours)
25. MPA_NEI duration of neighborhood-based moderate physical activity per week (hours)
26. MPA_OUT duration of external-based moderate physical activity per week (hours)
27. VPA_HOM duration of home-based vigorous physical activity per week (hours)
28. VPA_NEI duration of neighborhood-based vigorous physical activity per week (hours)
29. VPA_OUT duration of external-based vigorous physical activity per week (hours)
30. ACHIEVE achieves CDC recommendations for physical activity per week

Part Five: Trips from Travel Diary

1. T_TRIP total number of trips per day
2. T_TIME total travel time per day
3. T_DIST total number of miles traveled per day
4. T_CAR total number of driving trips per day
5. T_WALK total number of walking trips per day
6. T_STOP total number of stops in a tour of chain trips per day
7. T_TOUR total number of ends of the tour of chain trips per day
8. T_REG total number of regional trips per day
9. NWRKTRP total number of non-work trips per day
10. NWRKTME total travel time for non-work trips per day
11. NWRKDST total number of miles traveled for non-work trips per day
12. INT_TRP total number of trips made to destinations inside the neighborhood per day
13. EXT_TRP total number of trips made to destinations outside the neighborhood per day
14. EXT_TME total travel time to destinations outside the neighborhood per day
15. EXT_DST total number of miles traveled to destinations outside the neighborhood per day

16. EXT_CAR total number of trips made by automobile to destinations outside the neighborhood per day
17. PA_TRP number of physical activity trips
18. PA_TIM duration of physical activity trips (hours)
19. PA_DST distance of physical activity trips (miles)
20. REC_TRP number of recreational physical activity trips
21. REC _TIM duration of recreational physical activity trips (hours)
22. REC _DST distance of recreational physical activity trips (miles)
23. UTL_TRP number of utilitarian physical activity trips
24. UTL _TIM duration of utilitarian physical activity trips (hours)
25. UTL _DST distance of utilitarian physical activity trips (miles)
26. PA_TRP2 number of physical activity trips excluding four long trips
27. PA_TIM2 duration of physical activity trips excluding four long trips
28. PA_DST2 distance of physical activity trips excluding four long trips
29. REC_TRP2 number of recreational physical activity trips excluding four long trips
30. REC _TIM2 duration of recreational physical activity trips excluding four long trips
31. REC _DST2 distance of recreational physical activity trips excluding four long trips
32. UTL_TRP2 number of utilitarian physical activity trips excluding four long trips
33. UTL _TIM2 duration of utilitarian physical activity trips excluding four long trips
34. UTL _DST2 distance of utilitarian physical activity trips excluding four long trips

Head of Household File/PA: Detailed Description

Part Zero: Head of Household File Neighborhood Data and Filters

Name	Description
HH_ID	Household Identification Number
HDHH_ID	Head of Household ID
INCMPLT	Travel Diaries Completed/Not Completed

Value	Label
0	All Diaries Completed
1	Some/All Diaries Missing

FILTER1 Completed/did not complete moderate and vigorous physical activity questions

Value	Label
0	Not all moderate and vigorous physical activity questions complete
1	All moderate and vigorous physical activity questions complete

FILTER2 completed moderate and vigorous physical activity questions and under 30 hours of moderate and vigorous physical activity per week

Value	Label
0	Not all moderate and vigorous physical activity questions complete or over 30 hours of moderate and vigorous physical activity
1	All moderate and vigorous physical activity questions complete and under 30 hours of moderate and vigorous physical activity

NGHB_CD Neighborhood Code

Value	Label
1	Southern Village Households
2	Southern Village Apartments
3	Southern Village Condominiums
4	Lake Hogan Farm Households
5	Highlands Households
6	Sunset Households
7	Wexford Households
8	Fairoaks Households

TND Traditional Neighborhood Residence

Value	Label
0	Non-Traditional Neighborhood Residence
1	Traditional Neighborhood Residence

CONV

Value	Label
0	Non-Conventional Neighborhood Residence

	1	Conventional Neighborhood Residence
TND_SF	Value	Label
	0	Non-Traditional Neighborhood Single-Family Residence
	1	Traditional Neighborhood Single-Family Residence
TND_MF	Value	Label
	0	Non-Traditional Neighborhood Multi-Family Resident
	1	Traditional Neighborhood Multi-Family Resident
VALUE	Value of residence according to Orange County	
ADDRESS	Home Address	
CITY	City	
STATE	State	
ZIP	Zip Code	

Part One: Household Questions from Household Survey

CUR_HOME	Current Home Type	
	Value	Label
	1	Detached Single House
	2	Duplex
	3	Townhouse or Rowhouse
	4	Apartment
	5	Condominium
	6	Other
	7	Don't Know
PRE_HOM	Previous Home Type	
	Value	Label
	1	Detached Single House
	2	Duplex
	3	Townhouse or Rowhouse
	4	Apartment
	5	Condominium
	6	Other
	7	Don't Know
PREHO_SF	Previous Home Type is Single-Family Residence	
	Value	Label
	0	Not a Single-Family Residence
	1	Single-Family Residence
OWNRENT	Own vs. Rent Current Home	
	Value	Label

	1	Own
	2	Rent
	3	Other
	4	Don't Know

OWN — Homeowner

Value	Label
0	Does not own home
1	Homeowner

MOVE — Date resident moved into current home (mm-dd-yyyy)

YEARS — Number of years resident has lived at current home

NO_CAR — Number of cars owned by the household

VEH_1ML — Model of Vehicle One

Value	Label
1	Sedan/Hatchback/Convertible/Station Wagon/Coupe
2	Van (Mini, Cargo, Passenger, Conversion)
3	Sports Utility Vehicle
4	Pickup Truck
5	Other Truck
6	Recreational Vehicle
7	Motorcycle
8	Other

VEH_1YR — Year of Vehicle One

VEH_2ML — Model of Vehicle Two

Value	Label
1	Sedan/Hatchback/Convertible/Station Wagon/Coupe
2	Van (Mini, Cargo, Passenger, Conversion)
3	Sports Utility Vehicle
4	Pickup Truck
5	Other Truck
6	Recreational Vehicle
7	Motorcycle
8	Other

VEH_2YR — Year of Vehicle Two

VEH_3ML — Model of Vehicle Three

Value	Label

	1	Sedan/Hatchback/Convertible/Station Wagon/Coupe
	2	Van (Mini, Cargo, Passenger, Conversion)
	3	Sports Utility Vehicle
	4	Pickup Truck
	5	Other Truck
	6	Recreational Vehicle
	7	Motorcycle
	8	Other

VEH_3YR — Year of Vehicle Three

VEH_4ML — Model of Vehicle Four

Value	Label
1	Sedan/Hatchback/Convertible/Station Wagon/Coupe
2	Van (Mini, Cargo, Passenger, Conversion)
3	Sports Utility Vehicle
4	Pickup Truck
5	Other Truck
6	Recreational Vehicle
7	Motorcycle
8	Other

VEH_4YR — Year of Vehicle Four

VEH_5ML — Model of Vehicle Five

Value	Label
1	Sedan/Hatchback/Convertible/Station Wagon/Coupe
2	Van (Mini, Cargo, Passenger, Conversion)
3	Sports Utility Vehicle
4	Pickup Truck
5	Other Truck
6	Recreational Vehicle
7	Motorcycle
8	Other

VEH_5YR — Year of Vehicle Five

NO_HOME — Number of Persons in the Household

UNDER_16 — Number of Persons in the Household Under 16 Years Old

NAME — Person's First Name

AGE — Person's Age

LICENSE — Licensed Driver

Value	Label

	0	Does not have a driver's license
	1	Has a driver's license
SEX	Person's Sex	
	Value	Label
	0	Female
	1	Male

Part Two: Travel Pattern Questions from Household Survey

EMPLOY	Employment Status (Head of Household)	
	Value	Label
	1	Work Full-Time Outside the Home
	2	Work Part-Time Outside the Home
	3	Student
	4	Work Full-Time at Home
	5	Work Part-Time at Home
	6	Unemployed
	7	Retired
	8	Other
EMP_OUT	Head of Household is Employed Outside of the Home	
	Value	Label
	0	Not Employed Outside the Home
	1	Employed Outside the Home
STUDENT	Household Head is a Student	
	Value	Label
	0	Not a Student
	1	Student
EMP_COM	Comments (if EMPLOY is "Other")	
OCCUPA	Occupation	
	Value	Label
	1	Clerical/Secretary
	2	Service
	3	Production/Manufacturing
	4	Executive/Managerial
	5	Skilled Trades
	6	Retired
	7	Sales/Retail
	8	Computer/Technical
	9	Medical/Health
	10	Other
OCC_COM	Comments (if OCCUPA is "Other")	
TELECOM	Times per week head of household telecommutes/teleworks to work	

TIME_1W	Duration of a typical one-way trip to work or school (in decimal-hours)
SPEND_W	Dollars spent traveling to work/school per week (includes gas, parking, and transit fares)
MILES_W	Number of miles traveled by car per week
DRV_OUT	How often resident drives to work or school by car, Monday – Friday (outside neighborhood)
DRV_IN	How often resident drives to work or school by car, Monday – Friday (inside neighborhood)
CAR_OUT	How often resident carpools to work or school by car, Monday – Friday (outside neighborhood)
CAR_IN	How often resident carpools to work or school by car, Monday – Friday (inside neighborhood)
TRANOUT	How often resident travels to work or school using public transportation, Monday – Friday (outside neighborhood)
TRAN_IN	How often resident travels to work or school using public transportation, Monday – Friday (inside neighborhood)
WB_OUT	How often Resident Walks or Bicycles to Work or School, Monday – Friday (outside Neighborhood)
WB_IN	How often resident walks or bicycles to work or school, Monday – Friday (inside neighborhood)
TRNSOUT	How often resident transports someone, Monday – Friday (outside neighborhood)
TRNS_IN	How often resident transports someone, Monday – Friday, (inside neighborhood)
SHOPOUT	How often resident shops/runs an errand, Monday – Friday (outside neighborhood)
SHOP_IN	How often resident shops/runs an errand, Monday – Friday (inside neighborhood)
REC_OUT	How often resident goes out for recreation, entertainment, or meals, Monday – Friday (outside neighborhood)
REC_IN	How often resident goes out for recreation, entertainment, or meals, Monday – Friday (inside neighborhood)

Part Three: Attitudinal Questions from Household Survey

FLEXDRV — I like the flexibility that driving allows

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

ENJWALK — I enjoy walking

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

COMFBUS — I am comfortable riding a bus

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

TMELEIS — I would like to have more time for leisure

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

GASUP — We should raise the price of gasoline to reduce congestion and air pollution

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

BACKYRD — It’s important for children to have a large backyard for playing

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

SIDEWLK — Sidewalks make walking easier in my neighborhood

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral

4	Agree
5	Strongly Agree

ENVIPRO — Environmental protection is an important issue

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

INTRACT — I enjoy a house close to the sidewalk so that I can see and interact with passersby

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

LANDCON — Too much land is consumed for new housing, stores, and offices

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

ENJBIKE — I enjoy bicycling

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

CLOSENB — I can be comfortable living in close proximity to my neighbors

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral

	4	Agree
	5	Strongly Agree
HILLS	Hills or other barriers in my neighborhood make walking/bicycling difficult	
	Value	Label
	1	Strongly Disagree
	2	Disagree
	3	Neutral
	4	Agree
	5	Strongly Agree
SAFE	My neighborhood seems safe for walking or bicycling	
	Value	Label
	1	Strongly Disagree
	2	Disagree
	3	Neutral
	4	Agree
	5	Strongly Agree
TRAFFIC	Sitting in traffic aggravates me	
	Value	Label
	1	Strongly Disagree
	2	Disagree
	3	Neutral
	4	Agree
	5	Strongly Agree
SPACE	I prefer a lot of space between my home and the street	
	Value	Label
	1	Strongly Disagree
	2	Disagree
	3	Neutral
	4	Agree
	5	Strongly Agree
PUBTRAN	Taking public transit is inconvenient	
	Value	Label
	1	Strongly Disagree
	2	Disagree
	3	Neutral
	4	Agree
	5	Strongly Agree
DRVALON	Too many people drive alone	
	Value	Label
	1	Strongly Disagree
	2	Disagree
	3	Neutral
	4	Agree

		5	Strongly Agree
PLAYSPC	Children should have a large public play space within safe walking distance of their home		
		Value	Label
		1	Strongly Disagree
		2	Disagree
		3	Neutral
		4	Agree
		5	Strongly Agree
SHOPSNB	Having shops and services close by is important to me		
		Value	Label
		1	Strongly Disagree
		2	Disagree
		3	Neutral
		4	Agree
		5	Strongly Agree
IDELCOM	Ideal Commuting Time to Work or School		
		Value	Label
		1	Less than 5 minutes
		2	Between 5 and 15 minutes
		3	Between 15 and 30 minutes
		4	More than 30 minutes
ACCTCOM	Longest Acceptable Commuting Time to Work or School		
		Value	Label
		1	Less than 5 minutes
		2	Between 5 and 15 minutes
		3	Between 15 and 30 minutes
		4	Between 30 and 45 minutes
		5	Between 45 minutes and 1 hour
		6	More than one hour

Part Four: Activities Questions from Household Survey

WALK_YN	In a usual week, do you walk for at least 10 minutes at a time for recreation or exercise? Value / Label 0 No 1 Yes
WLK_DAY	Number of days per week respondent walks for a least 10 minutes at a time
WLK_TIM	Total time per day spent walking (decimal-hours)
WALKLOC	Location recreational/exercise walking takes place Value / Label 1 Always in neighborhood 2 Mostly in neighborhood 3 Sometimes in neighborhood, sometimes elsewhere 4 Mostly away from neighborhood 5 Always away from neighborhood
MOD_YN	In a usual week, do you do moderate physical activities for at least 10 minutes at a time? Value / Label 0 No 1 Yes
MOD_DAY	Number of days per week respondent does moderate activities for a least 10 minutes at a time
MOD_TIM	Total time per day spent doing moderate activities (decimal-hours)
MPR_HOM	Percent of total time spent on moderate activities spent at home
MPR_NEI	Percent of total time spent on moderate activities spent outside the home but in neighborhood
MPR_OUT	Percent of total time spent on moderate activities spent outside neighborhood
VIG_YN	In a usual week, do you do vigorous physical activities for at least 10 minutes at a time? Value / Label 0 No 1 Yes
VIG_DAY	Number of days per week respondent does vigorous activities for a least 10 minutes at a time
VIG_TIM	Total time per day spent doing vigorous activities (decimal-hours)

VPR_HOM	Percent of total time spent on vigorous activities spent at home
VPR_NEI	Percent of total time spent on vigorous activities spent outside the home but in neighborhood
VPR_OUT	Percent of total time spent on vigorous activities spent outside neighborhood
WEIGHT	Respondent's weight in pounds
HEIGHT	Respondent's height in decimal-feet
HEIGHTIN	Respondent's height in inches
BMI	Body-Mass Index
INTERNT	How often respondent used the Internet at home over the past 6 months

Value	Label
1	Everyday
2	Almost everyday
3	Once a week
4	Once a month
5	Never

EDUCAT — Highest level of education completed by respondent

Value	Label
1	Less than High School
2	High School or GED
3	Vocational/Technical Degree
4	Some College or Associate's Degree
5	Bachelor's Degree (BA, BS)
6	Some graduate school, no degree
7	Graduate or Professional School

COLLEGE — Highest level of education completed by respondent

Value	Label
0	Less than college
1	College

INCOME — Household income before taxes

Value	Label
1	Under $20,000
2	$20,000 - $30,000
3	$30,001 - $40,000
4	$40,001 – $50,000
5	$50,001 – $60,000
6	$60,001 – $80,000
7	$80,001 – $100,000
8	$100,001 – $150,000

9	$150,001 – $200,000
10	Over $200,000

INC_MID — Household income before taxes (midpoint of range)

Value	Label
1	$10,000
2	$25,000
3	$35,000
4	$45,000
5	$55,000
6	$70,000
7	$90,000
8	$125,000
9	$175,000
10	$200,000

MVPA — Duration of moderate and vigorous physical activity per week (hours)

MPA — Duration of moderate physical activity per week (hours)

VPA — Duration of vigorous physical activity per week (hours)

MVPA_HOM — Duration of home-based moderate and vigorous physical activity per week (hours)

MVPA_NEI — Duration of neighborhood-based moderate and vigorous physical activity per week (hours)

MVPA_OUT — Duration of external-based moderate and vigorous physical activity per week (hours)

MPA_HOM — Duration of home-based moderate physical activity per week (hours)

MPA_NEI — Duration of neighborhood-based moderate physical activity per week (hours)

MPA_OUT — Duration of external-based moderate physical activity per week (hours)

VPA_HOM — Duration of home-based vigorous physical activity per week (hours)

VPA_NEI — Duration of neighborhood-based vigorous physical activity per week (hours)

VPA_OUT — Duration of external-based vigorous physical activity per week (hours)

ACHIEVE — Achieves CDC recommendations for physical activity per week

Part Five: Trips from Travel Diary

T_TRIP — Total number of trips per day

T_TIME — Total travel time per day

T_DIST — Total number of miles traveled per day

T_CAR — Total number of driving trips per day

T_WALK — Total number of walking trips per day

T_STOP	Total number of stops in a tour of chain trips per day
T_TOUR	Total number of ends of the tour of chain trips per day
T_REG	Total number of regional trips per day
NWRKTRIP	Total number of non-work trips per day
NWRKTIME	Total travel time for non-work trips per day
NWRKDIST	Total number of miles traveled for non-work trips per day
INT_TRIP	Total number of trips made to destinations inside the neighborhood per day
EXT_TRIP	Total number of trips made to destinations outside the neighborhood per day
EXT_TIME	Total travel time to destinations outside the neighborhood per day
EXT_DIST	Total number of miles traveled to destinations outside the neighborhood per day
EXT_CAR	Total number of trips made by automobile to destinations outside the neighborhood per day
PA_TRP	Number of physical activity trips
PA_TIM	Duration of physical activity trips
PA_DST	Distance of physical activity trips
REC_TRP	Number of recreational physical activity trips
REC _TIM	Duration of recreational physical activity trips
REC _DST	Distance of recreational physical activity trips
UTL_TRP	Number of utilitarian physical activity trips
UTL _TIM	Duration of utilitarian physical activity trips
UTL _DST	Distance of utilitarian physical activity trips
PA_TRP2	Number of physical activity trips excluding four long trips
PA_TIM2	Duration of physical activity trips excluding four long trips
PA_DST2	Distance of physical activity trips excluding four long trips
REC_TRP2	Number of recreational physical activity trips excluding four long trips
REC _TIM2	Duration of recreational physical activity trips excluding four long trips
REC _DST2	Distance of recreational physical activity trips excluding four long trips
UTL_TRP2	Number of utilitarian physical activity trips excluding four long trips
UTL _TIM2	Duration of utilitarian physical activity trips excluding four long trips
UTL _DST2	Distance of utilitarian physical activity trips excluding four long trips

Household File: Contents

Brief Description:
The Household File contains data at the household level, meaning that individual data is aggregated to the household level. Data is provided from the Household Survey and the travel diary. Some household members did not complete a travel diary, even if they were eligible to do so. The 'missing' people were assigned the mean of each travel behavior attribute and then were linked at the household level. No new households were created in instances where every eligible person in that household failed to complete a travel diary.

Part Zero: Head of Household File Neighborhood Data and Filters

0_1. HH_ID (*key*) household identification number
0_2. HDHH_ID person identification number
0_3. DIARIES travel diaries completed/not completed
0_4. FILTER1 completed/did not complete moderate and vigorous physical activity questions
0_5. FILTER2 completed moderate and vigorous physical activity questions and under 30 hours of moderate and vigorous physical activity per week
0_6. NGHB_CD neighborhood code
0_7. TND traditional neighborhood development
0_8. CONV conventional residence
0_9. TND_SF traditional neighborhood single-family
0_{10}. TND_MF traditional neighborhood multi-family
0_{11}. LHF Lake Hogan Farms residence
0_{12}. OTHER conventional residence (excluding Lake Hogan Farms)
0_{13}. VALUE value of home according to Orange County
0_{14}. ADDRESS home address
0_{15}. CITY city
0_{16}. STATE state
0_{17}. ZIP zip code

Part One: Household Questions from Household Survey

1. CUR_HOME current home type
2. PRE_HOM previous home type
2_a. PREHO_SF previous home type is single-family
3. OWNRENT own vs. rent current home
3_a. OWN homeowner
4. MOVE date resident moved into current home (mm-dd-yyyy)
4_a. YEARS years at current residence
5. NO_CAR number of cars owned by the household
5_a. VEH_1ML model of vehicle one
5_b. VEH_1YR year of vehicle one
5_c. VEH_2ML model of vehicle two
5_d. VEH_2YR year of vehicle two
5_e. VEH_3ML model of vehicle three
5_f. VEH_3YR year of vehicle three

5_g. VEH_4ML	model of vehicle four
5_h. VEH_4YR	year of vehicle four
5_i. VEH_5ML	model of vehicle five
5_j. VEH_5YR	year of vehicle five
6. NO_HOME	number of persons in the household
6_a. UNDER_16	person is under 16 years old
6_b. NAME	person’s first name
6_c. AGE	person’s age
6_d. LICENSE	driver’s license (yes/no)
6_e. SEX	sex (male/female)

Part Two: Travel Patterns Questions from Household Survey

1. EMPLOY	employment status (head of household)
1_a. EMP_OUT	employed outside of neighborhood dummy
1_b. STUDENT	student dummy
1_c. EMP_COM	comments (if EMPLOY is “other”)
2. OCCUPA	occupation
2_a. OCC_COM	comments (if OCCUPA is “other”)
3. TELECOM	telecommuting/teleworking frequency
4. TIME_1W	duration of one-way trip to work/school (decimal-hour)
5. SPEND_W	dollars spent traveling to work/school per week
6. MILES_W	miles traveled by car per week
7_{1a}. DRV_OUT	drive to work/school by car (outside neighborhood)
7_{1b}. DRV_IN	drive to work/school by car (inside neighborhood)
7_{2a}. CAR_OUT	carpool to work/school by car (outside neighborhood)
7_{2b}. CAR_IN	carpool to work/school by car (inside neighborhood)
7_{3a}. TRANOUT	travel to work/school using public transportation (outside neighborhood)
7_{3b}. TRAN_IN	travel to work/school using public transportation (inside neighborhood)
7_{4a}. WB_OUT	walk/bike to work/school (outside neighborhood)
7_{4b}. WB_IN	walk/bike to work/school (inside neighborhood)
7_{5a}. TRNSOUT	transport someone (outside neighborhood)
7_{5b}. TRNS_IN	transport someone (inside neighborhood)
7_{6a}. SHOPOUT	go shopping/run errand (outside neighborhood)
7_{6b}. SHOP_IN	go shopping/run errand (inside neighborhood)
7_{7a}. REC_OUT	go out for recreation (outside neighborhood)
7_{7b}. REC_IN	go out for recreation (inside neighborhood)

Part Three: Attitudes Questions from Household Survey

1. FLEXDRV	flexibility of driving
2. ENJWALK	walking is enjoyable
3. COMFBUS	comfort with riding a bus
4. TMELEIS	leisure time
5. GASUP	price of gasoline

6. BACKYRD	large backyard for children
7. SIDEWLK	sidewalks in neighborhood
8. ENVIPRO	environmental protection
9. INTRACT	house proximity to sidewalk/interaction with passersby
10. LANDCON	land consumption for new housing, stores, offices
11. ENJBIKE	biking is enjoyable
12. CLOSENB	comfort with living in close proximity to neighbors
13. HILLS	hills in neighborhood
14. SAFE	safety of neighborhood for walking/biking
15. TRAFFIC	sitting in traffic
16. SPACE	space between home and street
17. PUBTRAN	public transit convenience
18. DRVALON	driving alone
19. PLAYSPC	public play space for children
20. SHOPSNB	shops and services close by
21. IDELCOM	ideal commuting time to work/school
22. ACCTCOM	longest acceptable commuting time to work/school

Part Four: Activities Questions from Household Survey

1. WALK_YN	walk at least ten minutes at a time (y/n)
2. WLK_DAY	number of days/week person walks 10+ minutes
3. WLK_TIM	total time per day spent walking (decimal-hours)
4. WALKLOC	location walking takes place
5. MOD_YN	moderate physical activities for 10+ minutes (y/n)
6. MOD_DAY	number of days/week person does moderate exercise
7. MOD_TIM	total time per day spent doing moderate exercise (decimal-hours)
8_a. MPR_HOM	percent of time spent on moderate exercise at home
8_b. MPR_NEI	percent of time spent on moderate exercise in neighborhood
8_c. MPR_OUT	percent of time spent on moderate exercise outside neighborhood
9. VIG_YN	vigorous physical activities for 10+ minutes (y/n)
10. VIG_DAY	number of days/week person does vigorous exercise
11. VIG_TIM	total time per day spent doing vigorous exercise (decimal-hours)
12_a. VPR_HOM	percent of time spent on vigorous exercise at home
12_b. VPR_NEI	percent of time spent on vigorous exercise in neighborhood
12_c. VPR_OUT	percent of time spent on vigorous exercise outside neighborhood
13. WEIGHT	respondent’s weight in pounds
14. HEIGHT	respondent’s height (decimal-feet)
14_a. HEIGHTIN	respondent’s height (inches)
14_a. BMI	respondent’s body-mass index
15. INTERNT	frequency of internet use

16. EDUCAT	highest level of education completed
16_a. COLLEGE	college education dummy
17. INCOME	household income
17_a. INC_MID	household income (midpoint of range)
17_b. INC_1	household income is under $20,000
17_c. INC_2	household income is $20,001 to $30,000
17_d. INC_3	household income is $30,001 to $40,000
17_e. INC_4	household income is $40,001 to $50,000
17_f. INC_5	household income is $50,001 to $60,000
17_g. INC_6	household income is $60,001 to $80,000
17_h. INC_7	household income is $80,001 to $100,000
17_i. INC_8	household income is $100,001 to $150,000
17_j. INC_9	household income is $150,001 to $200,000
17_k. INC_10	household income is over $200,000

Part Five: Household Trips from Travel Diary

1_a. T_TRIP	total number of trips per household per day
1_b. T_TRIP2	total number of trips per household per day (corrected*)
2_a. HB_WORK	home-based work trips per household
2_b. HB_WORK2	home-based work trips per household (corrected*)
2_c. HB_SHOP	home-based shopping trips per household
2_d. HB_SHOP2	home-base shopping trips per household (corrected*)
2_e. HB_SCH	home-based school trips per household
2_f. HB_SCH2	home-based school trips per household (corrected*)
2_g. HB_OTH	home-based other trips per household
2_h. HB_OTH2	home-based other trips per household (corrected*)
2_i. NON_HB	non-home based trips per household
2_j. NON_HB2	non-home based trips per household (corrected*)
3_a. T_TIME	total travel time per household per day
3_b. T_TIME2	total travel time per household per day (corrected*)
4_a. T_DIST	total number of miles traveled per household per day
4_b. T_DIST2	total number of miles traveled per household per day (corrected*)
5_a. T_CAR	total number of driving trips per household per day
5_b. T_CAR2	total number of driving trips per household per day (corrected*)
6_a. T_WALK	total number of walking trips per household per day
6_b. T_WALK2	total number of walking trips per household per day (corrected*)
7_a. T_STOP	total number of stops in a tour of chain trips per household per day
7_b. T_STOP2	total number of stops in a tour of chain trips per household per day (corrected*)
8_a. T_TOUR	total number of ends of the tour of chain trips per household per day

8_b. T_TOUR2 total number of ends of the tour of chain trips per household per day (corrected*)
9_a. STP_TR total number stops per tour per household
9_b. STP_TR2 total number of stops per tour per household (corrected*)
10_a. T_REG total number of regional trips per household per day
10_b. T_REG2 total number of regional trips per household per day (corrected*)
11_a. NWRKTRP total number of non-work trips per household per day
11_b. NWRKTRP2 total number of non-work trips per household per day (corrected*)
12_a. NWRKTME total travel time for non-work trips per household per day
12_b. NWRKTME2 total travel time for non-work trips per household per day (corrected*)
13_a. NWRKDST total number of miles traveled for non-work trips per household per day
13_b. NWRKDST2 total number of miles traveled for non-work trips per household per day (corrected*)
14_a. INT_TRP total number of trips made to destinations inside the neighborhood per household per day
14_b. INT_TRP2 total number of trips made to destinations inside the neighborhood per household per day (corrected*)
15_a. EXT_TRP total number of trips made to destinations outside the neighborhood per household per day
15_b. EXT_TRP2 total number of trips made to destinations outside the neighborhood per household per day (corrected*)
16_a. EXT_TME total travel time to destinations outside the neighborhood per household per day
16_b. EXT_TME2 total travel time to destinations outside the neighborhood per household per day (corrected*)
17_a. EXT_DST total number of miles traveled to destinations outside the neighborhood per household per day
17_b. EXT_DST2 total number of miles traveled to destinations outside the neighborhood per household per day (corrected*)
18_a. EXT_CAR total number of trips made by automobile to destinations outside the neighborhood per household per day
18_b. EXT_CAR2 total number of trips made by automobile to destinations outside the neighborhood per household per day (corrected*)
19. PA_TRP number of physical activity trips per household
20. PA_TIM duration of physical activity trips per household (hours)
21. PA_DST distance of physical activity trips per household (miles)
22. REC_TRP number of recreational physical activity trips per household
23. REC _TIM duration of recreational physical activity trips per household (hours)

24. REC _DST distance of recreational physical activity trips per household (miles)
25. UTL_TRP number of utilitarian physical activity trips per household
26. UTL _TIM duration of utilitarian physical activity trips per household (hours)
27. UTL _DST distance of utilitarian physical activity trips per household (miles)
28. MVPA duration of moderate and vigorous physical activity per week (hours)
29. MPA duration of moderate physical activity per week (hours)
30. VPA duration of vigorous physical activity per week (hours)
31. MVPA_HOM duration of home-based moderate and vigorous physical activity per week (hours)
32. MVPA_NEI duration of neighborhood-based moderate and vigorous physical activity per week (hours)
33. MVPA_OUT duration of external-based moderate and vigorous physical activity per week (hours)
34. MPA_HOM duration of home-based moderate physical activity per week (hours)
35. MPA_NEI duration of neighborhood-based moderate physical activity per week (hours)
36. MPA_OUT duration of external-based moderate physical activity per week (hours)
37. VPA_HOM duration of home-based vigorous physical activity per week (hours)
38. VPA_NEI duration of neighborhood-based vigorous physical activity per week (hours)
39. VPA_OUT duration of external-based vigorous physical activity per week (hours)
40. ACHIEVE achieves CDC recommendations for physical activity per week

* Accounts for ‘missing’ trip data, where one or more eligible people did not complete a travel diary. The ‘missing’ people were assigned the mean of each travel behavior attribute and then were aggregated at the household level. No households were created in instances were each eligible person in that household failed to complete a travel diary. The inclusion of this missing data provides a more accurate picture of household travel behavior that can be compared to the TTA regional data.

Household File: Variable Description

Name	Description	
HH_ID	Household Identification Number	
HDHH_ID	Head of Household ID	
DIARIES	Travel Diaries Completed/Not Completed	
	Value	Label
	0	Some/All Diaries Missing
	1	All Diaries Completed
FILTER1	Completed/did not complete moderate and vigorous physical activity questions	
	Value	Label
	0	Not all moderate and vigorous physical activity questions complete
	1	All moderate and vigorous physical activity questions complete
FILTER2	Completed moderate and vigorous physical activity questions and under 30 hours of moderate and vigorous physical activity per week	
	Value	Label
	0	Not all moderate and vigorous physical activity questions complete or over 30 hours of moderate and vigorous physical activity
	1	All moderate and vigorous physical activity questions complete and under 30 hours of moderate and vigorous physical activity
NGHB_CD	Neighborhood Code	
	Value	Label
	1	Southern Village Households
	2	Southern Village Apartments
	3	Southern Village Condominiums
	4	Lake Hogan Farm Households
	5	Highlands Households
	6	Sunset Households
	7	Wexford Households
	8	Fairoaks Households
TND	Traditional Neighborhood Residence	
	Value	Label
	0	Non-Traditional Neighborhood Residence
	1	Traditional Neighborhood Residence
CONV	Value	Label
	0	Non-Conventional Neighborhood Residence

	1	Conventional Neighborhood Residence
TND_SF	Value	Label
	0	Non-Traditional Neighborhood Single-Family Resident
	1	Traditional Neighborhood Single-Family Resident
TND_MF	Value	Label
	0	Non-Traditional Neighborhood Multi-Family Resident
	1	Traditional Neighborhood Multi-Family Resident
LHF	Value	Label
	0	Non-Lake Hogan Farms Residence
	1	Lake Hogan Farms Residence
OTHER	Value	Label
	0	Non-Lake Hogan Farms Conv. Residence
	1	Lake Hogan Farms Conventional Residence
ADDRESS	Home Address	
CITY	City	
STATE	State	
ZIP	Zip Code	
CUR_HOME	Current Home Type	
	Value	Label
	1	Detached Single House
	2	Duplex
	3	Townhouse or Rowhouse
	4	Apartment
	5	Condominium
	6	Other
	7	Don’t Know
PRE_HOM	Previous Home Type	
	Value	Label
	1	Detached Single House
	2	Duplex
	3	Townhouse or Rowhouse
	4	Apartment
	5	Condominium
	6	Other
	7	Don’t Know
PREHO_SF	Previous Home Type is Single-Family Residence	
	Value	Label

	0	Not a Single-Family Residence
	1	Single-Family Residence
OWNRENT	Own vs. Rent Current Home	
	<u>Value</u>	<u>Label</u>
	1	Own
	2	Rent
	3	Other
	4	Don't Know
OWN	Homeowner	
	<u>Value</u>	<u>Label</u>
	0	Does not own home
	1	Homeowner
MOVE	Date resident moved into current home (mm-dd-yyyy)	
YEARS	Number of years resident has lived at current home	
NO_CAR	Number of cars owned by the household	
VEH_1ML	Model of Vehicle One	
	<u>Value</u>	<u>Label</u>
	1	Sedan/Hatchback/Convertible/Station Wagon/Coupe
	2	Van (Mini, Cargo, Passenger, Conversion)
	3	Sports Utility Vehicle
	4	Pickup Truck
	5	Other Truck
	6	Recreational Vehicle
	7	Motorcycle
	8	Other
VEH_1YR	Year of Vehicle One	
VEH_2ML	Model of Vehicle Two	
	<u>Value</u>	<u>Label</u>
	1	Sedan/Hatchback/Convertible/Station Wagon/Coupe
	2	Van (Mini, Cargo, Passenger, Conversion)
	3	Sports Utility Vehicle
	4	Pickup Truck
	5	Other Truck
	6	Recreational Vehicle
	7	Motorcycle
	8	Other
VEH_2YR	Year of Vehicle Two	
VEH_3ML	Model of Vehicle Three	
	<u>Value</u>	<u>Label</u>

Value	Label
1	Sedan/Hatchback/Convertible/Station Wagon/Coupe
2	Van (Mini, Cargo, Passenger, Conversion)
3	Sports Utility Vehicle
4	Pickup Truck
5	Other Truck
6	Recreational Vehicle
7	Motorcycle
8	Other

VEH_3YR — Year of Vehicle Three

VEH_4ML — Model of Vehicle Four

Value	Label
1	Sedan/Hatchback/Convertible/Station Wagon/Coupe
2	Van (Mini, Cargo, Passenger, Conversion)
3	Sports Utility Vehicle
4	Pickup Truck
5	Other Truck
6	Recreational Vehicle
7	Motorcycle
8	Other

VEH_4YR — Year of Vehicle Four

VEH_5ML — Model of Vehicle Five

Value	Label
1	Sedan/Hatchback/Convertible/Station Wagon/Coupe
2	Van (Mini, Cargo, Passenger, Conversion)
3	Sports Utility Vehicle
4	Pickup Truck
5	Other Truck
6	Recreational Vehicle
7	Motorcycle
8	Other

VEH_5YR — Year of Vehicle Five

NO_HOME — Number of Persons in the Household

UNDER_16 — Number of Persons in the Household Under 16 Years Old

NAME — Person’s First Name

AGE — Person’s Age

LICENSE — Licensed Driver

Value	Label

0	Does not have a driver's license
1	Has a driver's license

SEX — Person's Sex

Value	Label
0	Female
1	Male

EMPLOY — Employment Status (Head of Household)

Value	Label
1	Work Full-Time Outside the Home
2	Work Part-Time Outside the Home
3	Student
4	Work Full-Time at Home
5	Work Part-Time at Home
6	Unemployed
7	Retired
8	Other

EMP_OUT — Head of Household is Employed Outside of the Home

Value	Label
0	Not Employed Outside the Home
1	Employed Outside the Home

STUDENT — Household Head is a Student

Value	Label
0	Not a Student
1	Student

EMP_COM — Comments (if EMPLOY is "Other")

OCCUPA — Occupation

Value	Label
1	Clerical/Secretary
2	Service
3	Production/Manufacturing
4	Executive/Managerial
5	Skilled Trades
6	Retired
7	Sales/Retail
8	Computer/Technical
9	Medical/Health
10	Other

OCC_COM — Comments (if OCCUPA is "Other")

TELECOM — Times per week head of household telecommutes/teleworks to work

TIME_1W — Duration of a typical one-way trip to work or school (in decimal-hours)

SPEND_W	Dollars spent traveling to work/school per week (includes gas, parking, and transit fares)
MILES_W	Number of miles traveled by car per week
DRV_OUT	How often resident drives to work or school by car, Monday – Friday (outside neighborhood)
DRV_IN	How often resident drives to work or school by car, Monday – Friday (inside neighborhood)
CAR_OUT	How often resident carpools to work or school by car, Monday – Friday (outside neighborhood)
CAR_IN	How often resident carpools to work or school by car, Monday – Friday (inside neighborhood)
TRANOUT	How often resident travels to work or school using public transportation, Monday – Friday (outside neighborhood)
TRAN_IN	How often resident travels to work or school using public transportation, Monday – Friday (inside neighborhood)
WB_OUT	How often Resident Walks or Bicycles to Work or School, Monday – Friday (outside Neighborhood)
WB_IN	How often resident walks or bicycles to work or school, Monday – Friday (inside neighborhood)
TRNSOUT	How often resident transports someone, Monday – Friday (outside neighborhood)
TRNS_IN	How often resident transports someone, Monday – Friday, (inside neighborhood)
SHOPOUT	How often resident shops/runs an errand, Monday – Friday (outside neighborhood)
SHOP_IN	How often resident shops/runs an errand, Monday – Friday (inside neighborhood)
REC_OUT	How often resident goes out for recreation, entertainment, or meals, Monday – Friday (outside neighborhood)
REC_IN	How often resident goes out for recreation, entertainment, or meals, Monday – Friday (inside neighborhood)
FLEXDRV	I like the flexibility that driving allows

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

ENJWALK — I enjoy walking

Value	Label

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

COMFBUS — I am comfortable riding a bus

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

TMELEIS — I would like to have more time for leisure

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

GASUP — We should raise the price of gasoline to reduce congestion and air pollution

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

BACKYRD — It’s important for children to have a large backyard for playing

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

SIDEWLK — Sidewalks make walking easier in my neighborhood

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

ENVIPRO — Environmental protection is an important issue

Value	Label

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

INTRACT — I enjoy a house close to the sidewalk so that I can see and interact with passersby

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

LANDCON — Too much land is consumed for new housing, stores, and offices

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

ENJBIKE — I enjoy bicycling

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

CLOSENB — I can be comfortable living in close proximity to my neighbors

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

HILLS — Hills or other barriers in my neighborhood make walking/bicycling difficult

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

SAFE — My neighborhood seems safe for walking or bicycling

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

TRAFFIC — Sitting in traffic aggravates me

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

SPACE — I prefer a lot of space between my home and the street

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

PUBTRAN — Taking public transit is inconvenient

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

DRVALON — Too many people drive alone

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

PLAYSPC — Children should have a large public play space within safe walking distance of their home

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

SHOPSNB — Having shops and services close by is important to me

Value	Label
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

IDELCOM — Ideal Commuting Time to Work or School

Value	Label
1	Less than 5 minutes
2	Between 5 and 15 minutes
3	Between 15 and 30 minutes
4	More than 30 minutes

ACCTCOM — Longest Acceptable Commuting Time to Work or School

Value	Label
1	Less than 5 minutes
2	Between 5 and 15 minutes
3	Between 15 and 30 minutes
4	Between 30 and 45 minutes
5	Between 45 minutes and 1 hour
6	More than 1 hour

WALK_YN — In a usual week, do you walk for at least 10 minutes at a time for recreation or exercise?

Value	Label
0	No
1	Yes

WLK_DAY — Number of days per week respondent walks for a least 10 minutes at a time

WLK_TIM — Total time per day spent walking (decimal-hours)

WALKLOC — Location recreational/exercise walking takes place

Value	Label

	1	Always in neighborhood
	2	Mostly in neighborhood
	3	Sometimes in neighborhood, sometimes elsewhere
	4	Mostly away from neighborhood
	5	Always away from neighborhood

MOD_YN — In a usual week, do you do moderate physical activities for at least 10 minutes at a time?

Value	Label
0	No
1	No

MOD_DAY — Number of days per week respondent does moderate activities for a least 10 minutes at a time

MOD_TIM — Total time per day spent doing moderate activities (decimal-hours)

MPR_HOM — Percent of total time spent on moderate activities spent at home

MPR_NEI — Percent of total time spent on moderate activities spent outside the home but in neighborhood

MPR_OUT — Percent of total time spent on moderate activities spent outside neighborhood

VIG_YN — In a usual week, do you do vigorous physical activities for at least 10 minutes at a time?

Value	Label
0	No
1	No

VIG_DAY — Number of days per week respondent does vigorous activities for a least 10 minutes at a time

VIG_TIM — Total time per day spent doing vigorous activities (decimal-hours)

VPR_HOM — Percent of total time spent on vigorous activities spent at home

VPR_NEI — Percent of total time spent on vigorous activities spent outside the home but in neighborhood

VPR_OUT — Percent of total time spent on vigorous activities spent outside neighborhood

WEIGHT — Respondent’s weight in pounds

HEIGHT — Respondent’s height in decimal-feet

HEIGHTIN — Respondent’s height in inches

BMI — Body-Mass Index

Variable	Description
INTERNT	How often respondent used the Internet at home over the past 6 months

Value	Label
1	Everyday
2	Almost everyday
3	Once a week
4	Once a month
5	Never

Variable	Description
EDUCAT	Highest level of education completed by respondent

Value	Label
1	Less than High School
2	High School or GED
3	Vocational/Technical Degree
4	Some College or Associate’s Degree
5	Bachelor’s Degree (BA, BS)
6	Some graduate school, no degree
7	Graduate or Professional School

Variable	Description
COLLEGE	Highest level of education completed by respondent

Value	Label
0	Less than college
1	College

Variable	Description
INCOME	Household income before taxes

Value	Label
1	Under $20,000
2	$20,000 - $30,000
3	$30,001 - $40,000
4	$40,001 – $50,000
5	$50,001 – $60,000
6	$60,001 – $80,000
7	$80,001 – $100,000
8	$100,001 – $150,000
9	$150,001 – $200,000
10	Over $200,000

INC_MID Household income before taxes (midpoint of range)

Value	Label
1	$10,000
2	$25,000
3	$35,000
4	$45,000
5	$55,000
6	$70,000
7	$90,000
8	$125,000
9	$175,000
10	$200,000

INC_1 Household income under $20,000

Value	Label
0	Household income is not under $20,000
1	Household income is under $20,000

INC_2 Household income between $20,001 – $30,000

Value	Label
0	Household income is not between $20,001 – $30,000
1	Household income is between $20,001 – $30,000

INC_3 Household income between $30,001 – $40,000

Value	Label
0	Household income is not between $30,001 – $40,000
1	Household income is between $30,001 – $40,000

INC_4 Household income between $40,001 – $50,000

Value	Label
0	Household income is not between $40,001 – $50,000
1	Household income is between $40,001 - $50,000

INC_5 Household income between $50,001 – $60,000

Value	Label
0	Household income is not between $50,001 – $60,000
1	Household income is between $50,001 – $60,000

INC_6	Household income between $60,001 – $80,000		
		Value	Label
		0	Household income is not between $60,001 – $80,000
		1	Household income is between $60,001 - $80,000
INC_7	Household income between $80,001 – $100,000		
		Value	Label
		0	Household income is not between $80,001 – $100,000
		1	Household income is between $80,001 – $100,000
INC_8	Household income between $100,001 – $150,000		
		Value	Label
		0	Household income is not between $100,001 – $150,000
		1	Household income is between $100,001 – $150,000
INC_9	Household income between $150,001 – $200,000		
		Value	Label
		0	Household income is not between $150,001 – $200,000
		1	Household income is between $150,001 – $200,000
INC_10	Household income above $200,000		
		Value	Label
		0	Household income is not over $200,000
		1	Household income is over $200,000
T_TRIP	Total number of trips per household per day		
T_TRIP2	Total number of trips per household per day (corrected*)		
HB_WORK	Home-based work trips		
HB_WORK2	Home-based work trips (corrected*)		
HB_SHOP	Home-based shopping trips		
HB_SHOP2	Home-base shopping trips (corrected*)		
HB_SCH	Home-based school trips		
HB_SCH2	Home-based school trips (corrected*)		
HB_OTH	Home-based other trips		
HB_OTH2	Home-based other trips (corrected*)		
NON_HB	Non-home based trips		
NON_HB2	Non-home based trips (corrected*)		
T_TIME	Total travel time per household per day		
T_TIME2	Total travel time per household per day (corrected*)		
T_DIST	Total number of miles traveled per household per day		

T_DIST2 (corrected*)	Total number of miles traveled per household per day
T_CAR	Total number of driving trips per household per day
T_CAR2	Total number of driving trips per household per day (corrected*)
T_WALK	Total number of walking trips per household per day
T_WALK2	Total number of walking trips per household per day (corrected*)
T_STOP	Total number of stops in a tour of chain trips per household per day
T_STOP2	Total number of stops in a tour of chain trips per household per day (corrected*)
T_TOUR	Total number of ends of the tour of chain trips per household per day
T_TOUR2	Total number of ends of the tour of chain trips per household per day (corrected*)
STP_TR	Total number of stops per tour
STP_TR2	Total number of stops per tour (corrected*)
T_REG	Total number of regional trips per household per day
T_REG2	Total number of regional trips per household per day (corrected*)
NWRKTRP	Total number of non-work trips per household per day
NWRKTRP2	Total number of non-work trips per household per day (corrected*)
NWRKTME	Total travel time for non-work trips per household per day
NWRKTME2	Total travel time for non-work trips per household per day (corrected*)
NWRKDST	Total number of miles traveled for non-work trips per household per day
NWRKDST2	Total number of miles traveled for non-work trips per household per day (corrected*)
INT_TRP	Total number of trips made to destinations inside the neighborhood per household per day
INT_TRP2	Total number of trips made to destinations inside the neighborhood per household per day (corrected*)
EXT_TRP	Total number of trips made to destinations outside the neighborhood per household per day
EXT_TRP2	Total number of trips made to destinations outside the neighborhood per household per day (corrected*)
EXT_TIM	Total travel time to destinations outside the neighborhood per household per day

EXT_TIM2	Total travel time to destinations outside the neighborhood per household per day (corrected*)
EXT_DST	Total number of miles traveled to destinations outside the neighborhood per household per day
EXT_DST2	Total number of miles traveled to destinations outside the neighborhood per household per day (corrected*)
EXT_CAR	Total number of trips made by automobile to destinations outside the neighborhood per household per day
EXT_CAR2	Total number of trips made by automobile to destinations outside the neighborhood per household per day (corrected*)
PA_TRP	Number of physical activity trips per household per day
PA_TIM	Duration of physical activity trips (hours) per household per day
PA_DST	Distance of physical activity trips (miles) per household per day
REC_TRP	Number of recreational physical activity trips per household per day
REC _TIM	Duration of recreational physical activity trips (hours) per household per day
REC _DST	Distance of recreational physical activity trips (miles) per household per day
UTL_TRP	Number of utilitarian physical activity trips per household per day
UTL _TIM	Duration of utilitarian physical activity trips (hours) per household per day
UTL _DST	Distance of utilitarian physical activity trips (miles) per household per day
MVPA	Duration of moderate and vigorous physical activity per week (hours)
MPA	Duration of moderate physical activity per week (hours)
VPA	Duration of vigorous physical activity per week (hours)
MVPA_HOM	Duration of home-based moderate and vigorous physical activity per week (hours)
MVPA_NEI	Duration of neighborhood-based moderate and vigorous physical activity per week (hours)
MVPA_OUT	Duration of external-based moderate and vigorous physical activity per week (hours)
MPA_HOM	Duration of home-based moderate physical activity per week (hours)
MPA_NEI	Duration of neighborhood-based moderate physical activity per week (hours)
MPA_OUT	Duration of external-based moderate physical activity per week (hours)
VPA_HOM	Duration of home-based vigorous physical activity per week (hours)

VPA_NEI Duration of neighborhood-based vigorous physical activity per week (hours)
VPA_OUT Duration of external-based vigorous physical activity per week (hours)
ACHIEVE Achieves CDC recommendations for physical activity per week

* Accounts for ‘missing’ trip data, where one or more eligible people did not complete a travel diary. This occurred in 63 households. If these individuals were left unaccounted for, our analysis at the household level might misrepresent travel behavior. The ‘missing’ people were assigned the mean of each travel behavior attribute and then were aggregated at the household level. No households were created in instances were each eligible person in that household failed to complete a travel diary. The inclusion of this missing data provides a more accurate picture of household travel behavior that can be compared to the TTA regional data.

Trip File: Contents

Brief Description:
Contains unaggregated data from the travel diary.

1. HH_ID	household identification number
2. DIARIES	travel diaries completed/not completed
3. NGHB_CD	neighborhood code
4. TND	traditional neighborhood development residence
5. PERSNUM	person number
6. PER_ID	household identification number plus person number
7. NAME	person's first name
8. DATE	date travel diary was completed
9. DAY	day of the week travel diary was completed
10. TRIP	signifies that a trip was made
11. ACT_NO	activity number
12. ACT_ID (*key*)	person identification number plus activity number
13. DPARTLO	departure location
14. NMEDEST	name of destination
15. ARIVELO	arrival location
16. BEG_TIME	time trip began
17. HOUR	approximate hour trip began
18. END_TIME	time trip ended
19. TOT_TIME	total duration of trip
20. REASON	reason for trip
21. TYPE	type of trip
21_a. HB_WORK	home-based work trip
21_b. HB_SHOP	home-based shopping trip
21_c. HB_SCH	home-based school trip
21_d. HB_OTH	home-based other trip
21_e. NON_HB	non-home-based trip
22. MODE	mode used for trip
23. WALK	walking trip
24. DRIVE	driving trip in private vehicle
25. STOP	a stop in a tour of chain trips
26. TOUR	end of the tour of chain trips or a trip with no stops
27. DIST_MIL	distance of the trip
28. REGION	regional trip
29. INTERNAL	trip took place in neighborhood
30. BUSACCPR	mode used to access park and ride bus (ns route)
31. PA_TRP	trip mode was walking or bicycling
32. PA_REC	trip mode was walk/bike for recreational purposes
33. PA_UTL	trip mode was walk/bike for utilitarian purposes
34. BUS_RTE	bus route used
35. COST	cost of trip
36. NWRKTRP	non-work trip
37. ENTERER	data enterer

Trip File: Variable Description

Name	Description
HH_ID	Household Identification Number
DIARIES	Travel Diaries Completed/Not Completed Value / Label 0 Some/All Diaries Missing 1 All Diaries Completed
NGHB_CD	Neighborhood Code Value / Label 1 Southern Village Households 2 Southern Village Apartments 3 Southern Village Condominiums 4 Lake Hogan Farm Households 5 Highlands Households 6 Sunset Households 7 Wexford Households 8 Fairoaks Households
TND	Traditional Neighborhood Residence Value / Label 0 Conventional Residence 1 Southern Village Residence
PERSNUM	Person Number (for persons 16 years and older)
PER_ID	Household Identification Number with Person Number added as last two digits
NAME	Person's first name or initials
DATE	Date travel diary was completed
DAY	Day of the week travel diary was completed Value / Label 1 Monday 2 Tuesday 3 Wednesday 4 Thursday 5 Friday 6 Saturday 7 Sunday
TRIP	"1" signifies that a trip was made
ACT_NO	Activity Number
ACT_ID	Household Identification Number with Activity Number added as last two digits
DPARTLO	Departure location (often described by the intersection of two major roads)
NMEDEST	Name of destination

ARIVELO	Arrival location (often described by the intersection of two major roads)
BEG_TIM	Time trip began (military decimal-hours)
HOUR	Approximate hour trip began (rounded to nearest hour, military time)
END_TIM	Time trip ended (military decimal-hours)
TOT_TIM	Total duration of trip (decimal-hours)
REASON	Reason trip was made, as specified by respondent
TYPE	Type of trip

Value	Label
1	Home-Based Work
2	Home-Based Shop
3	Home-Based School
4	Home-Based Other
5	Non-Home-Based

HB_WORK — Home-based work trip

Value	Label
0	Non- Home-based work Trip
1	Home-based work Trip

HB_SHOP — Home-based shopping trip

Value	Label
0	Non- Home-based shopping Trip
1	Home-based shopping Trip

HB_SCH — Home-based school trip

Value	Label
0	Non- Home-based school Trip
1	Home-based school Trip

HB_OTH — Home-based other trip

Value	Label
0	Non- Home-based other Trip
1	Home-based other Trip

NON_HB — Non-home based trip

Value	Label
0	Not a non-home based trip
1	Non-home based trip

MODE — Mode used for trip

	Value	Label
	1	Private Vehicle
	2	Bus
	3	Walk
	4	Bike
	5	Other
WALK	Walking trip	
	Value	Label
	0	Non-Walking Trip
	1	Walking Trip
DRIVE	Driving trip in private vehicle	
	Value	Label
	0	Non-Driving Trip
	1	Driving Trip
STOP	A stop in a tour of chain trips	
	Value	Label
	0	Not a stop in a tour of chain trips
	1	A stop in a tour of chain trips
TOUR	End of a tour of chain trips or a trip with no stops	
	Value	Label
	0	Not the end of a tour of chain trips or a trip with no stops
	1	End of a tour of chain trips or a trip with no stops
DIST_MIL	Distance of the trip (in decimal-miles)	
REGION	Regional trip	
	Value	Label
	0	Trip was ≤10 miles
	1	Trip was >10 miles
INTERNAL	Trip took place in neighborhood	
	Value	Label
	0	Trip took place outside neighborhood
	1	Trip took place in neighborhood
BUSACCPR	Mode used to access park and ride bus (NS Route)	
	Value	Label
	1	Private Vehicle
	2	Bus
	3	Walk
	4	Bike
	5	Other

PA_TRP	The mode choice was walking or bicycling		
		Value	Label
		0	Mode choice was not walking or bicycling
		1	Mode choice was walking or bicycling
PA_REC	The walking or bicycling trip was for recreational purposes		
		Value	Label
		0	Trip was not for recreational purposes
		1	Trip was for recreational purposes
PA_UTL	The walking or bicycling trip was for utilitarian purposes		
		Value	Label
		0	Trip was not for utilitarian purposes
		1	Trip was for utilitarian purposes
BUS_RTE	Bus Route Used		
COST	Cost of Trip (includes transit fares and parking fees)		
ENTERER	Data Enterer		
		Value	Label
		1	Ben
		2	Steve
		3	Helen
		4	Sarah
		5	Jennifer
		6	David

Trips Per Person File: Contents

Brief Description:
Contains data from the travel diary and is aggregated to the person level.

HH_ID	household identification number
PER_ID*(key)*	person identification number
NGHB_CD	neighborhood code
TND	traditional neighborhood development
TND_SF	traditional neighborhood single-family residence
TND_MF	traditional neighborhood multi-family residence
DIARIES	travel diaries completed/not completed
VALUE	value of residence according to Orange County
CUR_HOME	current home type
PRE_HOM	previous home type
PREHO_SF	previous home type is single-family
OWNRENT	own vs. rent current home
OWN	homeowner
MOVE	date resident moved into current home (mm-dd-yyyy)
YEARS	years at current residence
NO_CAR	number of cars owned by the household
NO_HOME	number of persons in the household
NAME	person's name
AGE	person's age
LICENSE	driver's license (yes/no)
SEX	sex (male/female)
INCOME	household income
INC_MID	midpoint of income level range
INC_MID2	midpoint of income level range, missing values coded at mean
T_TRIP	total number of trips per household per day
T_TIME	total travel time per household per day
T_DIST	total number of miles traveled per day
T_CAR	total number of driving trips per day
T_WALK	total number of walking trips per day
T_STOP	total number of stops in a tour of chain trips per day
T_TOUR	total number of ends of the tour of chain trips per day
STP_TR	total number of stops per tour per day
T_REG	total number of regional trips per day
NWRKTRP	total number of non-work trips per day
NWRKTIM	total travel time for non-work trips per day
NWRKDST	total number of miles traveled for non-work trips per day
INT_TIP	total number of trips made to destinations inside the neighborhood per day
EXT_TRP	total number of trips made to destinations outside the neighborhood per day

EXT_TIM	total travel time to destinations outside the neighborhood per day
EXT_DST	total number of miles traveled to destinations outside the neighborhood per day
EXT_CAR	total number of trips made by automobile to destinations outside the neighborhood per day
PA_TRP	number of physical activity trips
PA_TIM	duration of physical activity trips
PA_DST	distance of physical activity trips
REC_TRP	number of recreational physical activity trips
REC _TIM	duration of recreational physical activity trips
REC _DST	distance of recreational physical activity trips
UTL_TRP	number of utilitarian physical activity trips
UTL _TIM	duration of utilitarian physical activity trips
UTL _DST	distance of utilitarian physical activity trips
PA_TRP2	number of physical activity trips*
PA_TIM2	duration of physical activity trips*
PA_DST2	distance of physical activity trips *
REC_TRP2	number of recreational physical activity trips*
REC _TIM2	duration of recreational physical activity trips*
REC _DST2	distance of recreational physical activity trips*
UTL_TRP2	number of utilitarian physical activity trips*
UTL _TIM2	duration of utilitarian physical activity trips*
UTL _DST2	distance of utilitarian physical activity trips*

* excludes four long bicycle rides

Trips per Person File: Variable Description

Name	Description
HH_ID	Household Identification Number
PER_ID	Person Identification Number
NGHB_CD	Neighborhood Code

Value	Label
1	Southern Village Households
2	Southern Village Apartments
3	Southern Village Condominiums
4	Lake Hogan Farm Households
5	Highlands Households
6	Sunset Households
7	Wexford Households
8	Fairoaks Households

TND — Traditional Neighborhood Development

Value	Label
0	Not a Southern Village Residence
1	Southern Village Residence

TND_SF — Traditional Neighborhood Single Family Home

Value	Label
0	Not a Traditional Neighborhood Single Family Home
1	Traditional Neighborhood Single Family Home

TND_MF — Traditional Neighborhood Multi-Family Home

Value	Label
0	Non-Traditional Neighborhood Multi-Family Home
1	Traditional Neighborhood Multi-Family Home

DIARIES — Travel Diaries Completed/Not Completed

Value	Label
0	Some/All Diaries Missing
1	All Diaries Completed

VALUE — Value of residence according to Orange County

CUR_HOME — Current Home Type

Value	Label
1	Detached Single House
2	Duplex
3	Townhouse or Rowhouse
4	Apartment
5	Condominium
6	Other

	7	Don't Know
PRE_HOM	Previous Home Type	
	Value	Label
	1	Detached Single House
	2	Duplex
	3	Townhouse or Rowhouse
	4	Apartment
	5	Condominium
	6	Other
	9	Don't Know
PREHO_SF	Previous Home Type is Single-Family Residence	
	Value	Label
	0	Not a Single-Family Residence
	1	Single-Family Residence
OWNRENT	Own vs. Rent Current Home	
	Value	Label
	1	Own
	2	Rent
	3	Other
	4	Don't Know
OWN	Homeowner	
	Value	Label
	0	Does not own home
	1	Homeowner
MOVE	Date resident moved into current home (mm-dd-yyyy)	
YEARS	Number of years resident has lived at current home	
NO_CAR	Number of cars owned by the household	
NO_HOME	Number of persons in the household	
PER_NUM	person number	
NAME	Person's First Name	
AGE	Person's Age	
LICENSE	Licensed Driver (Yes or No)	
	Value	Label
	0	Does not have a driver's license
	1	Has a driver's license
SEX	Person's Sex (male or female)	
	Value	Label
	0	Female
	1	Male
INCOME	Household income before taxes	
	Value	Label
	1	Under $20,000

	2	$20,000 - $30,000
	3	$30,001 - $40,000
	4	$40,001 – $50,000
	5	$50,001 – $60,000
	6	$60,001 – $80,000
	7	$80,001 – $100,000
	8	$100,001 – $150,000
	9	$150,001 – $200,000
	10	Over $200,000

INC_MID — Household income before taxes (midpoint of range)

Value	Label
1	$10,000
2	$25,000
3	$35,000
4	$45,000
5	$55,000
6	$70,000
7	$90,000
8	$125,000
9	$175,000
10	$200,000

INC_MID2 — Household income before taxes (midpoint of range), missing values coded at the mean

Value	Label
1	$10,000
2	$25,000
3	$35,000
4	$45,000
5	$55,000
6	$70,000
7	$90,000
8	$125,000
9	$175,000
10	$200,000

T_TRIP	Total number of trips per day
T_TIME	Total travel time per day
T_DIST	Total number of miles traveled per day
T_CAR	Total number of driving trips per day
T_WALK	Total number of walking trips per day
T_STOP	Total number of stops in a tour of chain trips per day
T_TOUR	Total number of ends of the tour of chain trips per day
STP_TR	Total number of stops per tour per day
T_REG	Total number of regional trips per day
NWRKTRP	Total number of non-work trips per day

NWRKTIM	Total travel time for non-work trips per day
NWRKDST	Total number of miles traveled for non-work trips per day
INT_TRP	Total number of trips made to destinations inside the neighborhood per day
EXT_TRP	Total number of trips made to destinations outside the neighborhood per day
EXT_TIM	Total travel time to destinations outside the neighborhood per day
EXT_DST	Total number of miles traveled to destinations outside the neighborhood per day
EXT_CAR	Total number of trips made by automobile to destinations outside the neighborhood per day
PA_TRP	Number of physical activity trips
PA_TIM	Duration of physical activity trips (hours)
PA_DST	Distance of physical activity trips (miles)
REC_TRP	Number of recreational physical activity trips
REC _TIM	Duration of recreational physical activity trips (hours)
REC _DST	Distance of recreational physical activity trips (miles)
UTL_TRP	Number of utilitarian physical activity trips
UTL _TIM	Duration of utilitarian physical activity trips (hours)
UTL _DST	Distance of utilitarian physical activity trips (miles)
PA_TRP2	Number of physical activity trips*
PA_TIM2	Duration of physical activity trips (hours)*
PA_DST2	Distance of physical activity trips (miles)*
REC_TRP2	Number of recreational physical activity trips*
REC _TIM2	Duration of recreational physical activity trips (hours)*
REC _DST2	Distance of recreational physical activity trips (miles)*
UTL_TRP2	Number of utilitarian physical activity trips*
UTL _TIM2	Duration of utilitarian physical activity trips (hours)*
UTL _DST2	Distance of utilitarian physical activity trips (miles)*

* excluding four long bicycle rides

Person File: Contents

Brief Description:
Contains data for those individuals reported in the Household Survey.

1. HH_ID	household identification number
2. NGHB_CD	neighborhood code
3. DIARIES	diaries completed/not completed
4. VALUE	value of home according to Orange County
5. CUR_HOME	current home type
6. PRE_HOM	previous home type
7. OWNRENT	own vs. rent current home
8. MOVE	date resident moved into current home
9. NO_CAR	number of cars owned by the household
10. NO_HOME	number of persons in the household
11. PERSNUM	person number
12. PER_ID (*key*)	household identification number plus person number
13. NAME	person's first name
14. AGE	person's age
15. LICENSE	driver's license (yes/no)
16. SEX	sex (male/female)
17. SCHL_MD	mode by which person travels to school
18. INCOME	household income

Person File: Variable Description

Name	Description	
HH_ID	Household Identification Number	
NGHB_CD	Neighborhood Code	
	Value	Label
	1	Southern Village Households
	2	Southern Village Apartments
	3	Southern Village Condominiums
	4	Lake Hogan Farm Households
	5	Highlands Households
	6	Sunset Households
	7	Wexford Households
	8	Fairoaks Households
DIARIES	Diaries Completed/Not Completed	
	Value	Label
	0	Some/All Household Travel Diaries Missing
	1	All Household Travel Diaries Completed

VALUE	Value of residence according to Orange County
CUR_HOME	Current Home Type

Value	Label
1	Detached Single House
2	Duplex
3	Townhouse or Rowhouse
4	Apartment
5	Condominium
6	Other
7	Don’t Know

PRE_HOM	Previous Home Type

Value	Label
1	Detached Single House
2	Duplex
3	Townhouse or Rowhouse
4	Apartment
5	Condominium
6	Other
7	Don’t Know

OWNRENT	Own vs. Rent Current Home

Value	Label
1	Own
2	Rent
3	Other
4	Don’t Know

MOVE	Date resident moved into current home (mm-dd-yyyy)
NO_CAR	Number of cars owned by the household
NO_HOME	Number of persons in the household
PERSNUM	Person Number (for persons 16 years and older)
PER_ID	Household Identification Number with Person Number added as last two digits
NAME	Person’s First Name
AGE	Person’s Age
LICENSE	Licensed Driver (Yes or No)

Value	Label
0	Does not have a driver’s license
1	Has a driver’s license

SEX	Person's Sex (male or female)		
		<u>Value</u>	<u>Label</u>
		0	Female
		1	Male
SCHL_MD	Mode by which person travels to school		
		<u>Value</u>	<u>Label</u>
		1	Car Ride or Drives to School
		2	Transit (Bus or School Bus)
		3	Walk
		4	Bicycle
		5	Other
		6	Combination of modes
INCOME	Household income before taxes		
		<u>Value</u>	<u>Label</u>
		1	Under $20,000
		2	$20,000 - $30,000
		3	$30,001 - $40,000
		4	$40,001 – $50,000
		5	$50,001 – $60,000
		6	$60,001 – $80,000
		7	$80,001 – $100,000
		8	$100,001 – $150,000
		9	$150,001 – $200,000
		10	Over $200,000

Appendix I: Selected Modeling Results

Table I-1: Regression models for total trips

a. OLS (not accounting for missing data)

	Coeff.	T stat
Constant	2.02***	2.73
Size of Household	1.08***	6.33
Number of Vehicles	2.16***	6.52
Southern Village	0.09	0.21
Mean of Dep. Var	9.180	
N	405	
F statistic	56.79***	
R-square	0.298	
Adjusted R-square	0.293	

b. OLS (accounting for missing data)

	Coeff.	T stat
Constant	1.95***	2.76
Size of Household	1.26***	7.74
Number of Vehicles	2.37***	7.49
Southern Village	0.00	0.01
Mean of Dep. Var	10.000	
N	405	
F statistic	80.90***	
R-square	0.377	
Adjusted R-square	0.372	

c. Negative Binomial

	Coeff.	Z stat
Constant	1.44***	19.65
Size of Household	0.13***	8.54
Number of Vehicles	0.24***	8.07
Southern Village	-0.01	-0.17
Alpha	0.03	(p=0.00)
N	405	
Psuedo-R^2	0.086	
LR χ^2(var)	201.93	
Prob > χ^2	0.000	
Log likelihood	-1067.566	

*** Significant at the 99% confidence level
** Significant at the 95% confidence level
* Significant at the 90% confidence level

d. Marginal Effects

	Mean	Coeff.	Z
Size of Household	2.80	1.27	8.60
Number of Vehicles	1.90	2.30	8.12
Southern Village	0.54	-0.06	-0.17

Table I-2: Regression models for external trips

a. OLS (not accounting for missing data)

	Coeff.	T stat
Constant	2.45***	3.59
Size of Household	0.81***	5.120
Number of Vehicles	2.12***	6.930
Southern Village	-1.32***	-3.490
Mean of Dep. Var	8.02	
N	406	
F statistic	68.210	
R-square	0.337	
Adjusted R-square	0.332	

b. OLS (accounting for missing data)

	Coeff.	T stat
Constant	2.51***	3.780
Size of Household	0.96***	6.3
Number of Vehicles	2.30***	7.72
Southern Village	-1.53***	-4.15
Mean of Dep. Var	8.74	
N	406	
F statistic	92.900	
R-square	0.409	
Adjusted R-square	0.405	

c. Negative Binomial

	Coeff.	Z stat
Constant	1.38***	17.670
Size of Household	0.12***	7.260
Number of Vehicles	0.26***	8.390
Southern Village	-0.18***	-4.380
Alpha	0.03	(p=0.00)
N	406	
Psuedo-R^2	0.098	
LR χ^2(var)	226.31	
Prob > χ^2	0.000	
Log likelihood	-1037.544	

*** Significant at the 99% confidence level

** Significant at the 95% confidence level

* Significant at the 90% confidence level

d. Marginal Effects

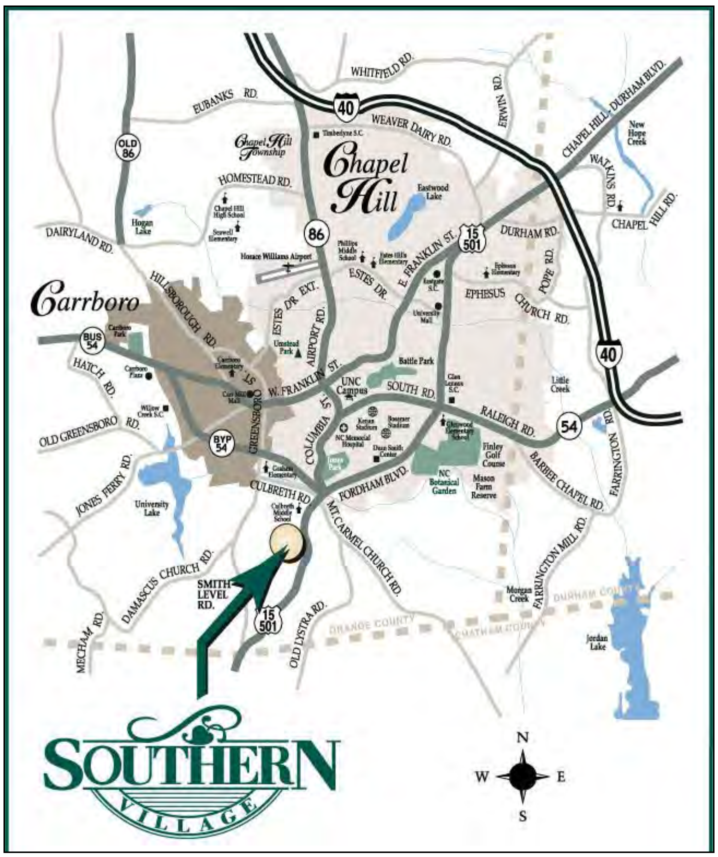
	Mean	Coeff.	Z
Size of Household	2.80	0.99	7.31
Number of Vehicles	1.90	2.18	8.44
Southern Village	0.54	-1.50	-4.34

Appendix J: Neighborhood Descriptions

Southern Village:

Southern Village is located south of Chapel Hill, North Carolina just south of the NC 54 bypass. It is located on US15-501, a major north/south arterial that leads into downtown Chapel Hill to the campus of the University of North Carolina and UNC hospital. US15-501 is currently being widened to a four lane, undivided facility. To the North, Culbreth Road, a two-lane east-west collector street, borders Southern Village (see Figure A1-1).

Figure J-1: Southern Village Location



Source: www.southernvillage.com

Southern Village is a Neotraditional Neighborhood Development as it contains several different land uses, including a central commercial and retail core. Housing types include detached single-family homes, condominiums, townhouses, and apartments. All residential housing is convenient to a swim/tennis club and to various businesses within the neighborhood. The 120,000 square feet central business core contains office and retail space, including a grocery store, movie theater, church, daycare, and an elementary school. Table A1-1 summaries the different land uses in the neighborhood.

Table J-1: Southern Village Land Use Intensities

Land Use	Intensity	unit	Code
Single Family Homes	510	units	210
Condo+Townhouses	335	units	230
Apartments	250	units	220
Theater (4scrn)	10	thousand square feet	443
Bistro	2	thousand square feet	832
Italian Rest	4.5	thousand square feet	831
grocery w/cafe	6	thousand square feet	850
gift store + dry cleaners	2	thousand square feet	814
office space	95	thousand square feet	710
church	27	thousand square feet	560
daycare	6	thousand square feet	565
elementary sch	90	thousand square feet	520
swim and tennis club	3	thousand square feet	492

Two bus lines serve the development and provide residents with access to downtown Chapel Hill and the university. There are three entrances to Southern Village; two along US 15-501 and one in the northwest corner of the development, just north of the Highgrove neighborhood connecting to Culbreth Road (Figure A1-2).

Figure J-2: Southern Village Interior Layout

Source: www.southernvillage.com

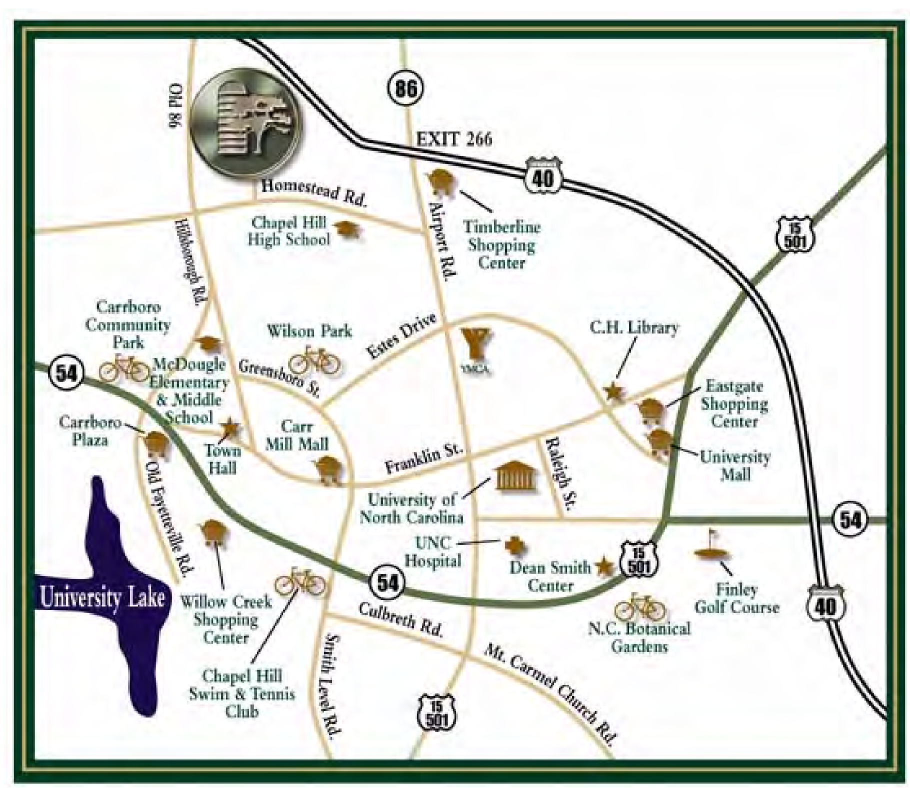
ITE defines a multi use development as one that "is typically a single real-estate project that consists of two or more ITE land use classifications between which trips can be made without using the off-site road system" (2001 ITE Trip Generation Handbook). Southern Village fits this description by having multiple land uses and a vast network of sidewalks and greenways. Consistent with Neotraditional Neighborhoods Development guidelines the street layout is a grid system intended to increase internal route choice. Furthermore, most building properties are elongated rectangles with the short side facing the street. This in combination with grid layout and pleasant sidewalks is encouraged to promote walking and bike use and thus decreasing vehicular traffic. The commercial village core offers a desirable destination for shopping and recreational use. Overall, neotraditional neighborhood design intends to capture a significant number of trips within the development, thus decreasing vehicular impacts on the surrounding road network. Figure A1-3 shows a typical building front in Southern Village, characterized by sidewalks, street trees, narrow houses, and short building setback.

Figure J-3: Southern Village Streetscape

Lake Hogan Farms:

Lake Hogan Farms is located north of Chapel Hill along Homestead Rd. It is approximately 10 miles north of the Southern Village neighborhood, but approximately equidistant to downtown Chapel Hill and the university (Figure

Figure J-4: Lake Hogan Farms Location



Source: http://www.ghldesign.com/lakehogan

Lake Hogan Farms is a conventional, single use development consisting of 252 single-family dwellings. Two entrances serve this development. The main entrance is south of the development along Homestead Rd. A secondary entrance is located to the west of the development, along Old NC 86. All of the homes are fairly expensive and most are on half-ace lots. The development has a swimming and tennis club. There are some shopping and biking trails, however, not to the extent found in Southern Village. Lake Hogan Farms does not have shopping venues or other such amenities. Figure A1-4 shows a map of the interior layout of Lake Hogan Farms.

Figure J-5: Lake Hogan Farms Interior Layout

Source: http://www.ghldesign.com/lakehogan

The map above shows that the Lake Hogan Farms neighborhood does not have the same grid layout as can be found in Southern Village. Consistent with suburban neighborhood design principles, the development is characterized by large lots and cul-de-sacs to increase a feeling of privacy. It is clearly visible which roads serve as the main collectors and are intended to move traffic in and out of the neighborhood. The lack of shopping venues and other desirable destinations within the development minimizes internal traffic and conceptually results in a greater relative impact on the surrounding road network. Figure A1-5 below shows a photo of the Lake Hogan Farms neighborhood.

Figure J-6: Lake Hogan Farms Streetscape

FEATURE	NEO TRADITIONAL DEVELOPMENT (NTD)	CONVENTIONAL SUBURBAN DEVELOPMENT (CSD)
Basic Layout	Interconnected network of streets dispersing trips	Hierarchical layout designed to collect and channelize trips
Driveways	Garages and driveways located behind the buildings for pleasing streetscape	Driveways, garages prominent in the front
Building setback	Typically no minimum setback, houses located close to street with front porches that promote neighborhood feeling	Typically 15 feet setback or more from street, deep yards make neighborhood conversationdifficult; few and narrow porches; large areas to maintain.
Architecture	Houses mostly long and narrow, mixed architectural styles and varying sizes that are affordable to people at different stages of life	Houses oftentimes square, all houses and houseplans of similar size and price; uniform appearance of development
Street Design	Street arranged in grid pattern, creates great route choice and distributes traffic, also designed to slow traffic flow	Collector roads with cul-de-sacs, create congestion; all traffic enters/exits at few locations
Use of Alleys	Encouraged to accommodate narrower lots and fewer driveways on local streets, which allow for narrower streets	Often discouraged, especially in residential areas
Design Speed	Typically 20 mph or even less, with design elements to assure design speed equal to travel speed	Typically 25-30 mph minimum, designed to recognize 85th percentile rate of travel
Street Width	Typically narrow street to encourage slow travel speeds, delay from slo passing maneuvers and obstacles is desirable	Wide Street to allow safe vehicle movements in two directions, while still accounting for possible obstacles on the side of the road
Curb Radii	Selected considering impacts on pedestrian street crossing times and types of vehicles expected or desired to generally use the street	Generally selected to ensure in-lane turning movements for all types of vehicles
Intersection geometry	civic buildings and safety, unsignalized possible, hypthetically more efficient turning movements, as more and un-signalized intersections	Designed for efficiency, speed of vehicular traffic, cost of operation and safety
Street trees and landscaping	Encouraged to form part of the street space; larger sizes and small clearances desirable	Where allowed, strictly controlled as to size and location according to Intersection and Stopping Sight Distance Specifications
Street Lighting	more and smaller streetlights of lesser wattage and scale	Few, large, high and efficient luminaires
Sidewalks	Sidewalks lined with trees transform streets into “public rooms” and promote walking	Oftentimes no sidewalks; if existing, usually not lined with trees and not as pleasing
Sidewalk Width and location	5-foot minimum, generally within right-of-way and parallel with the street	Typically 4 foot minimum, in parts of the country encouraged outside the right-of-way or to undulate
Construction Centerline not always coincing with design	Encouraged where it serves to form vista terminations	not permitted
Parking	On-Street encouraged and counted toward minimum parking requirements; off-street generally located midblock or to the rear of buildings	Off-Street preferred, but often located between buildings and the adjacent street (driveways)
Trip Generation	greater in-project opportunities for "captured trips"; hypothetically reduced internal vehicle miles traveled	Developed from a sum of the users; few captured trips
Traffic Flow	Uninterrupted flow more likely, as more and un-signalized intersections; hypothetically grid network has higher capacity; possibility of real-time route decisions	All flow towards main collector out of development; congestion at entrance/exit likely

Figure J-7: Park & Ride Lot, Southern Village

Figure J-8: Chapel Hill Transit Service, Southern Village

Figure J-9: Proximity of homes in Southern Village

Figure J-10: Green Way in Southern Village

Appendix K: Sample ITE Trip Generation Spreadsheets

ITE MULTI-USE PROJECT INTERNAL CAPTURE

(Source: Chapter 7, ITE *Trip Generation Handbook*, October 1998)

Land Use A: None

ITE Land Use

Size:

	Total	Internal	External
Enter	0	0	0
Exit	0	0	0
Total	0	0	0
%			

Enter from	0
Exit to	0

Demand	0.0%	0
Balanced	0	
Demand	0.0%	0

0.0%	0	Demand
0	Balanced	
0.0%	0	Demand

Demand	0.0%	0
Balanced	0	
Demand	0.0%	0

Land Use B:

ITE Land Use

Size:

	Total	Internal	External
Enter	0	0	0
Exit	0	0	0
Total	0	0	0
%			

Demand	0.0%	0
	0	Balanced
0.0%	0	Demand

Enter from	0
Exit to	0

0.0%	0	Demand
0	Balanced	
0.0%	0	Demand

Demand	0.0%	0
Balanced	0	
Demand	0.0%	0

Demand	0.0%	0
Balanced	0	
Demand	0.0%	0

Land Use C:

ITE Land Use

Size:

	Total	Internal	External
Enter	0	0	0
Exit	0	0	0
Total	0	0	0
%			

Enter from	0
Exit to	0

Project Number:
Project Name:
Scenario:
Analysis Period: PM Peak
Analyst:

Land Use A: None

ITE Land Use Code			
Size:			
	Total	Internal	External
Enter	0	0	0
Exit	0	0	0
Total	0	0	0
%			

0.0%	0	Demand
	0	Balanced
0.0%	0	Demand

Demand	0.0%	0
Balanced		0
Demand	0.0%	0

Demand	0.0%	0
Balanced		0
Demand	0.0%	0

Land Use D: None

ITE Land Use Code			
Size:			
	Total	Internal	External
Enter	0	0	0
Exit	0	0	0
Total	0	0	0
%			

Demand	0.0%	0
Balanced		0
Demand	0.0%	0

Demand	0.0%	0
Balanced		0
Demand	0.0%	0

Demand	0.0%	0
Balanced		0
Demand	0.0%	0

Enter from External:	0
Exit to External:	0

0.0%	0	Demand
	0	Balanced
0.0%	0	Demand

Land Use C: None

ITE Land Use Code			
Size:			
	Total	Internal	External
Enter	0	0	0
Exit	0	0	0
Total	0	0	0
%			

NET EXTERNAL TRIPS FOR MULTI-USE DEVELOPMENT

	Land Use				
Category	A	B	C	D	Total
Enter	0	0	0	0	0
Exit	0	0	0	0	0
Total	0	0	0	0	**0**
Single Use Trip Gen Estimate	0	0	0	0	**0**

Overall Internal Capture =

Table 7.1 Unconstrained Internal Capture Rates for Trip Origins within a Multi-Use Development

		WEEKDAY		
		MIDDAY PEAK HOUR	P.M. PEAK HOUR OF ADJACENT STREET TRAFFIC	DAILY
from OFFICE	to Office	2%	1%	2%
	to Retail	20%	23%	22%
	to Residential	0%	2%	2%
from RETAIL	to Office	3%	3%	3%
	to Retail	29%	20%	30%
	to Residential	7%	12%	11%
from RESIDENTIAL	to Office	0%	0%	0%
	to Retail	34%	53%	38%
	to Residential	0%	0%	0%

Table 7.2 Unconstrained Internal Capture Rates for Trip Destinations within a Multi-Use Development

		WEEKDAY		
		MIDDAY PEAK HOUR	P.M. PEAK HOUR OF ADJACENT STREET TRAFFIC	DAILY
to OFFICE	from Office	6%	6%	2%
	from Retail	38%	31%	15%
	from Residential	0%	0%	0%
to RETAIL	from Office	4%	2%	4%
	from Retail	31%	20%	28%
	from Residential	5%	9%	9%
to RESIDENTIAL	from Office	0%	2%	3%
	from Retail	37%	31%	33%
	from Residential	0%	0%	0%

Appendix L: Southern Village ITE Trip Generation

Code	Land Use	Intensity	unit	ADT rate	ADT	%ent	%exit	enter	exit	AM Rate	AM gen	%ent	%exit	enter	exit	PM rate
210	Single Family Homes	510	units	9.57	4880.7	50	50	2440.35	2440.35	0.75	382.5	25	75	95.625	286.875	1.01
230	Condo+Townhouses	335	units	5.86	1963.1	50	50	981.55	981.55	0.44	147.4	17	83	25.058	122.342	0.54
220	Apartments	250	units	6.63	1657.5	50	50	828.75	828.75	0.51	127.5	16	84	20.4	107.1	0.62
443	Theater (4scrn)	10	thou sf	78.06	780.6	50	50	390.3	390.3	0.22	2.2			0	0	6.16
832	Bistro	2	thou sf	130.34	260.68	50	50	130.34	130.34	9.27	18.54	52	48	9.6408	8.8992	10.86
831	Italian Rest	4.5	thou sf	89.95	404.775	50	50	202.3875	202.3875	0.81	3.645			0	0	7.49
850	grocery w/cafe	6	thou sf	111.51	669.06	50	50	334.53	334.53	3.25	19.5	61	39	11.895	7.605	11.51
814	gift store + dry cleaners	2	thou sf	40.67	81.34	50	50	40.67	40.67	6.41	12.82	48	52	6.1536	6.6664	2.59
710	office space	95	thou sf	11.01	1045.95	50	50	522.975	522.975	1.56	148.2	88	12	130.416	17.784	1.49
560	church	27	thou sf	9.11	245.97	50	50	122.985	122.985	0.72	19.44	54	46	10.4976	8.9424	0.66
565	daycare	6	thou sf	79.26	475.56	50	50	237.78	237.78	12.71	76.26	53	47	40.4178	35.8422	13.2
520	elementary sch	90	thou sf	12.03	1082.7	50	50	541.35	541.35	3.36	302.4	61	39	184.464	117.936	
492	swim and tennis club	3	thou sf	17.14	51.42	50	50	25.71	25.71	1.46	4.38			0	0	1.83
	Total							**6799.678**	**6799.678**					**534.5678**	**719.9922**	

Residential

Code	Land Use	Intensity	unit	ADT rate	ADT	%ent	%exit	enter	exit	AM Rate	AM gen	%ent	%exit	enter	exit	PM rate
210	Single Family Homes	510	units	9.57	4880.7	50	50	2440.35	2440.35	0.75	382.5	25	75	95.625	286.875	1.01
233	Condo+Townhouses	335	units	5.86	1963.1	50	50	981.55	981.55	0.44	147.4	17	83	25.058	122.342	0.54
220	Apartments	250	units	6.63	1657.5	50	50	828.75	828.75	0.51	127.5	16	84	20.4	107.1	0.62
443	Theater (4scrn)	10	thou sf	78.06	780.6	50	50	390.3	390.3	0.22	2.2			0	0	6.16

Office

Code	Land Use	Intensity	unit	ADT rate	ADT	%ent	%exit	enter	exit	AM Rate	AM gen	%ent	%exit	enter	exit	PM rate
710	office space	95	thou sf	11.01	1045.95	50	50	522.975	522.975	1.56	148.2	88	12	130.416	17.784	1.49

Retail

Code	Land Use	Intensity	unit	ADT rate	ADT	%ent	%exit	enter	exit	AM Rate	AM gen	%ent	%exit	enter	exit	PM rate
443	Theater (4scrn)	10	thou sf	78.06	780.6	50	50	390.3	390.3	0.22	2.2			0	0	6.16
832	Bistro	2	thou sf	130.34	260.68	50	50	130.34	130.34	9.27	18.54	52	48	9.6408	8.8992	10.86
831	Italian Rest	4.5	thou sf	89.95	404.775	50	50	202.3875	202.3875	0.81	3.645			0	0	7.49
850	grocery w/cafe	6	thou sf	111.51	669.06	50	50	334.53	334.53	3.25	19.5	61	39	11.895	7.605	11.51
814	gift store + dry cleaners	2	thou sf	40.67	81.34	50	50	40.67	40.67	6.41	12.82	48	52	6.1536	6.6664	2.59

ITE MULTI-USE PROJECT INTERNAL CAPTURE WORKSHEET
(Source: Chapter 7, ITE Trip Generation Handbook, October 1998)

Project Number:
Project Name: SV Tripgen Nov 2002
Scenario:
Analysis Period: Daily
Analyst:

Land Use A: Residential (All Residential)
ITE Land Use Code
Size: 210sf 233cond/twnh 220apt

	Total	Internal	External
Enter	4,251	131	4,120
Exit	4,251	99	4,152
Total	8,501	230	8,271
%	100%	**3%**	97%

Enter from External: 4,120
Exit to External: 4,152

Land Use B: Office (Office)
ITE Land Use Code 710
Size: 95thousf

	Total	Internal	External
Enter	522.975	33	489.975
Exit	522.975	54	468.975
Total	1045.95	87	958.95
%	100%	**8%**	92%

Enter from External: 490
Exit to External: 469

Land Use C: Retail (All Retail)
ITE Land Use Code
Size: theat bistro ital groc drycl gift s

	Total	Internal	External
Enter	1098.228	143	955.228
Exit	1098.228	154	944.228
Total	2196.456	297	1899.456
%	100%	**14%**	86%

Enter from External: 955
Exit to External: 944

Land Use D: None
ITE Land Use Code
Size:

	Total	Internal	External
Enter	0	0	0
Exit	0	0	0
Total	0	0	0
%			

Enter from External: 0
Exit to External: 0

A–B:
Demand 0.0% 0
Balanced 0
Demand 0.0% 0

B–A:
3.0% 128 Demand
10 Balanced
2.0% 10 Demand

A–C:
Demand 38.0% 1615
Balanced 99
Demand 9.0% 99

C–A:
Demand 33.0% 1403
Balanced 121
Demand 11.0% 121

A–D:
0.0% 0 Demand
0 Balanced
0.0% 0 Demand

D–A:
Demand 0.0% 0
Balanced 0
Demand 0.0% 0

B–D:
Demand 0.0% 0
Balanced 0
Demand 0.0% 0

D–B:
Demand 0.0% 0
0 Balanced
0.0% 0 Demand

B–C:
15.0% 78 Demand
33 Balanced
3.0% 33 Demand

C–B:
Demand 22.0% 115
Balanced 44
Demand 4.0% 44

C–D:
Demand 0.0% 0
Balanced 0
Demand 0.0% 0

D–C:
0.0% 0 Demand
0 Balanced
0.0% 0 Demand

NET EXTERNAL TRIPS FOR MULTI-USE DEVELOPMENT

Category	Land Use A	Land Use B	Land Use C	Land Use D	Total
Enter	4,120	490	955	0	5,565
Exit	4,152	469	944	0	5,565
Total	8,271	959	1,899	0	**11,130**
Single Use Trip Gen Estimate	8,501	1,046	2,196	0	**11,744**

Overall Internal Capture = 0.052283

ITE MULTI-USE PROJECT INTERNAL CAPTURE WORKSHEET
(Source: Chapter 7, ITE Trip Generation Handbook, October 1998)

Project Number:
Project Name: SV Tripgen Nov 2002
Scenario:
Analysis Period: PM Peak
Analyst:

Land Use A: Residential (All Residential)

ITE Land Use Code
Size: 210sf 233cond/twnh 220apt

	Total	Internal	External
Enter	555	9	546
Exit	296	12	284
Total	851	21	830
%	100%	**2%**	98%

Enter from External: 546
Exit to External: 284

Demand 0.0% 0
Balanced 0
Demand 0.0% 0

2.0% 11 Demand
2 Balanced
2.0% 2 Demand

Demand 53.0% 157
Balanced 12
Demand 9.0% 12

0.0% 0 Demand
0 Balanced
0.0% 0 Demand

Demand 0.0% 0
Balanced 0
Demand 0.0% 0

Land Use B: Office (Office)

ITE Land Use Code 710
Size: 95thousf

	Total	Internal	External
Enter	24.0635	2	22.0635
Exit	117.4865	5	112.4865
Total	141.55	7	134.55
%	100%	**5%**	95%

Enter from External: 22
Exit to External: 112

Demand 0.0% 0
0 Balanced
0.0% 0 Demand

Demand 0.0% 0
Balanced 0
Demand 0.0% 0

Land Use D: None

ITE Land Use Code
Size:

	Total	Internal	External
Enter	0	0	0
Exit	0	0	0
Total	0	0	0
%			

Enter from External: 0
Exit to External: 0

31.0% 7 Demand
2 Balanced
3.0% 2 Demand

Demand 31.0% 172
Balanced 7
Demand 12.0% 7

Demand 0.0% 0
Balanced 0
Demand 0.0% 0

Demand 23.0% 27
Balanced 3
Demand 2.0% 3

0.0% 0 Demand
0 Balanced
0.0% 0 Demand

Land Use C: Retail (All Retail)

ITE Land Use Code
Size: theat bistro ital groc drycl gift s

	Total	Internal	External
Enter	130.9664	15	115.9664
Exit	60.29865	9	51.29865
Total	191.265	24	167.265
%	100%	**13%**	87%

Enter from External: 116
Exit to External: 51

NET EXTERNAL TRIPS FOR MULTI-USE DEVELOPMENT

Category	Land Use A	Land Use B	Land Use C	Land Use D	Total
Enter	546	22	116	0	684
Exit	284	112	51	0	448
Total	830	135	167	0	**1,132**
Single Use Trip Gen Estimate	851	142	191	0	**1,184**

Overall Internal Capture = 0.043926

Appendix M: Triangle Regional Model Socio-economic Data

DEM 95 Field	Description	SV value	LHF Value	Source
TAZ	TAZ of zone (1-2471)	1382	1720	GIS Layer
ATYPE	Area Type	1 (urban)	1 (urban)	Both are Urban
HH	Number of Households	1095	252	Real Estate Sources
POP	Population	2716	784	Surveys
INC	Average income in zone	105000	123386	Surveys
Avghh	Average household size	2.48	3.11	Pop/#of HH
INCRATIO	Median Income for study area / INC – this is calculated by the model	2.706	3.18	TAZ Income/Average Area Income
IND	Industrial Employment	0	0	Visits to Businesses
RET	Retail Employment	52	0	Visits to Businesses
HWY	Highway Employment	0	0	Visits to Businesses
OFF	Office Employment	118	0	Visits to Businesses
SER	Service Employment	181	0	Visits to Businesses
DWELLUNIT	Dwelling Units	1095	252	Visits to Businesses
UNIV	University	0	0	Visits to Businesses
AIRPORT	Airport	0	0	No Airports Present
HOSP	Hospital Beds	0	0	No Hospitals Present
UBEDS	University Beds	0	0	No Dormitories Present
[%AUTOEE]	Percent Auto External-External traffic	0	0	Zones are not external stations
[%CVEE]	Percent CV External-External traffic	0	0	Zones are not external stations
TERMTIME	Terminal time – from termtime.prn	1	2	Previously programmed in model
PARKCOST	Parking Cost – from parking.prn	0	0	Previously programmed in model
SHUTTLE	Whether shuttle service is provided	0	0	Previously programmed in model
DOORSTEP	Door step service	0	0	Previously programmed in model
CBDWALK	Designation of CBD Walk	1	0	Previously programmed in model
CCWALKDIST	Distance from centroid to walk network	0	0	Previously programmed in model
STOPSPACE	Stop spacing	0.7952	2.5341	Previously programmed in model
ZONEAREA	Zonal area	0.3708	0	Previously programmed in model
GISDIST	Distance from centroid to nearest stop	1	1	Previously programmed in model
SHORTWALK	Percent short walk	48	0	Previously programmed in model
LONGWALK	Percent long walk	52	0	Previously programmed in model
DISTGROUP	Dist group	6	6	Previously programmed in model

Appendix N: Signal Timing and Traffic Counts

This appendix contains signal timing data collected by NCSU researchers and traffic count data collected by the NCDOT Traffic Survey Unit.

Intersection Analysis Southern Village

Main Street / US15-501

PM PEAK	29-Jul-03

	Phase Description						
	Left/Right out		protected Left in		Through		
Cycle #	Green	Y/AR	Green	Y/AR	Green	Y/AR	**Cycle Length**
1	20	4	0	0	50	4	**78**
1	25	4	0	0	50	4	**83**
2	15	4	0	0	75	4	**98**
2	13	4	0	0	75	4	**96**
3	31	4	0	0	90	4	**129**
3	30	4	0	0	90	4	**128**
4	20	4	0	0	35	4	**63**
4	13	4	0	0	35	4	**56**
5	11	4	0	0	50	4	**69**
5	10	4	0	0	52	4	**70**
6	30	4	0	0	50	4	**88**
6	32	4	0	0	54	4	**94**
7	17	4	0	0	60	4	**85**
7	18	4	0	0	65	4	**91**
8	30	4	6	3	60	4	**107**
8	32	4	5	4	58	4	**107**
9	16	4	0	0	45	4	**69**
9	13	4	0	0	45	4	**66**
10	17	4	0	0	80	4	**105**
10	17	4	0	0	82	4	**107**
11	21	4	0	0	75	4	**104**
11	21	4	0	0	75	4	**104**
12	31	4	0	0	52	4	**91**
12	31	4	0	0	50	4	**89**
AVERAGE:	**21.42**	**4.00**	**0.46**	**0.29**	**60.54**	**4.00**	**90.71**

all numbers given in secons

Summary Intersection Timing for Main Street and US15-501

Road	**Movement**	**avg.green (s)**	**Y/AR**
US 15-501	through	60.5	4.0
US 15-502	protected left	21.4	4.0
Main Street	left/right	0.5	4.0
Average cycle length (s)		**90.7**	

Traffic Survey Unit
North Carolina Department of Transportation

HRP 2003-13
Traffic Data Collection

Prepared by K. Taylor
24-Mar-03

Station	Location	Status
1	US 15-501 South of Main Street	Not Collected Due to Construction
2	Main Street West of US 15-501	Collected
3	US 15-501 North of Main Street	Collected
4	US 15-501 South of Arlen Park Drive	Not Collected Due to Construction
5	Arlen Park Drive West of US 15-501	Collected
6	US 15-501 North of Arlen Park Drive	Collected
7	Highgrove Drive South of Gardner Street	Collected
8	Culbreth Road (SR 1994) East of Weyer Road	Collected
9	Culbreth Road (SR 1994) West of Weyer Road	Collected
10	Homestead Road (SR 1777) East of Lake Hogan Farm Road	Collected
11	Lake Hogan Farm Road North of Homestead Road (SR 1777)	Collected
12	Homestead Road (SR 1777) West of Lake Hogan Farm Road	Equipment Failure WB, EB Data Only
13	Old NC 86 (SR 1009) South of Hogan Ridge Court	Collected
14	Hogan Ridge Court East of Old NC 86 (SR 1009)	Collected
15	Old NC 86 (SR 1009) North of Hogan Ridge Court	Collected

Summary of Trip Generator Driveways

Southern Village

March 18, 2003

Location	Entering	Exiting	Total
Station 2	3274	4005	7279
Station 5	1413	1254	2667
Station 7	1327	1067	2394
Total	6014	6326	12340

March 19, 2003

Location	Entering	Exiting	Total
Station 2	3472	4237	7709
Station 5	1560	1284	2844
Station 7	1044	1299	2343
Total	6076	6820	12896

Hogan Farms

March 18, 2003

Location	Entering	Exiting	Total
Station 11	1120	1091	2211
Station 14	152	246	398
Total	1272	1337	2609

March 19, 2003

Location	Entering	Exiting	Total
Station 11	1286	1126	2412
Station 14	193	249	442
Total	1479	1375	2854

Traffic Survey Unit/NCDOT
Volume Counts

Location: Main Street West of US 15-501
County: Orange

Date: March 18, 2003

15 Min Counts				Sliding Hourly Totals			
Start	Direction		15 Min	Start	Direction		Hour
Time	EB	WB	Total	Time	EB	WB	Total
0:00	4	0	4	0:00	9	7	16
0:15	3	4	7	0:15	5	8	13
0:30	1	2	3	0:30	2	4	6
0:45	1	1	2	0:45	3	5	8
1:00	0	1	1	1:00	4	4	8
1:15	0	0	0	1:15	4	3	7
1:30	2	3	5	1:30	4	6	10
1:45	2	0	2	1:45	3	4	7
2:00	0	0	0	2:00	1	4	5
2:15	0	3	3	2:15	1	5	6
2:30	1	1	2	2:30	1	5	6
2:45	0	0	0	2:45	0	4	4
3:00	0	1	1	3:00	0	4	4
3:15	0	3	3	3:15	0	3	3
3:30	0	0	0	3:30	3	1	4
3:45	0	0	0	3:45	3	1	4
4:00	0	0	0	4:00	5	1	6
4:15	3	1	4	4:15	5	1	6
4:30	0	0	0	4:30	3	2	5
4:45	2	0	2	4:45	6	6	12
5:00	0	0	0	5:00	10	18	28
5:15	1	2	3	5:15	16	21	37
5:30	3	4	7	5:30	25	39	64
5:45	6	12	18	5:45	36	63	99
6:00	6	3	9	6:00	49	96	145
6:15	10	20	30	6:15	69	156	225
6:30	14	28	42	6:30	90	258	348
6:45	19	45	64	6:45	163	419	582
7:00	26	63	89	7:00	312	500	812
7:15	31	122	153	7:15	392	523	915
7:30	87	189	276	7:30	453	497	950
7:45	168	126	294	7:45	423	398	821
8:00	106	86	192	8:00	333	342	675
8:15	92	96	188	8:15	282	337	619
8:30	57	90	147	8:30	230	309	539
8:45	78	70	148	8:45	233	259	492
9:00	55	81	136	9:00	214	234	448
9:15	40	68	108	9:15	212	193	405
9:30	60	40	100	9:30	209	174	383
9:45	59	45	104	9:45	199	168	367
10:00	53	40	93	10:00	184	158	342
10:15	37	49	86	10:15	160	147	307
10:30	50	34	84	10:30	170	135	305
10:45	44	35	79	10:45	182	132	314
11:00	29	29	58	11:00	208	143	351
11:15	47	37	84	11:15	221	150	371
11:30	62	31	93	11:30	225	150	375
11:45	70	46	116	11:45	230	164	394
12:00	42	36	78	12:00	214	154	368
12:15	51	37	88	12:15	220	157	377
12:30	67	45	112	12:30	227	156	383
12:45	54	36	90	12:45	219	154	373
13:00	48	39	87	13:00	215	159	374
13:15	58	36	94	13:15	204	155	359
13:30	59	43	102	13:30	187	185	372
13:45	50	41	91	13:45	197	214	411
14:00	37	35	72	14:00	240	209	449
14:15	41	66	107	14:15	285	209	494
14:30	69	72	141	14:30	286	184	470
14:45	93	36	129	14:45	302	156	458
15:00	82	35	117	15:00	271	162	433
15:15	42	41	83	15:15	258	164	422
15:30	85	44	129	15:30	302	176	478
15:45	62	42	104	15:45	309	168	477
16:00	69	37	106	16:00	359	188	547
16:15	86	53	139	16:15	435	203	638
16:30	92	36	128	16:30	490	230	720
16:45	112	62	174	16:45	579	269	848
17:00	145	52	197	17:00	571	251	822
17:15	141	80	221	17:15	512	239	751
17:30	181	75	256	17:30	443	209	652
17:45	104	44	148	17:45	321	201	522
18:00	86	40	126	18:00	278	217	495
18:15	72	50	122	18:15	242	230	472
18:30	59	67	126	18:30	241	230	471
18:45	61	60	121	18:45	227	195	422
19:00	50	53	103	19:00	205	174	379
19:15	71	50	121	19:15	198	150	348
19:30	45	32	77	19:30	150	129	279
19:45	39	39	78	19:45	143	124	267
20:00	43	29	72	20:00	114	102	216
20:15	23	29	52	20:15	96	90	186
20:30	38	27	65	20:30	104	77	181
20:45	10	17	27	20:45	114	67	181
21:00	25	17	42	21:00	119	57	176
21:15	31	16	47	21:15	110	56	166
21:30	48	17	65	21:30	95	55	150
21:45	15	7	22	21:45	51	43	94
22:00	16	16	32	22:00	46	46	92
22:15	16	15	31	22:15	34	39	73
22:30	4	5	9	22:30	24	35	59
22:45	10	10	20	22:45	36	49	85
23:00	4	9	13	23:00	44	44	88
23:15	6	11	17				
23:30	16	19	35				
23:45	18	5	23				
Total	4005	3274	7279				

Date: March 19, 2003

15 Min Counts				Sliding Hourly Totals			
Start	Direction		15 Min	Start	Direction		Hour
Time	EB	WB	Total	Time	EB	WB	Total
0:00	4	6	10	0:00	14	13	27
0:15	6	3	9	0:15	12	7	19
0:30	4	3	7	0:30	6	4	10
0:45	0	1	1	0:45	2	2	4
1:00	2	0	2	1:00	4	3	7
1:15	0	0	0	1:15	2	3	5
1:30	0	1	1	1:30	3	5	8
1:45	2	2	4	1:45	3	5	8
2:00	0	0	0	2:00	1	4	5
2:15	1	2	3	2:15	1	4	5
2:30	0	1	1	2:30	0	2	2
2:45	0	1	1	2:45	0	1	1
3:00	0	0	0	3:00	0	0	0
3:15	0	0	0	3:15	0	0	0
3:30	0	0	0	3:30	0	0	0
3:45	0	0	0	3:45	1	0	1
4:00	0	0	0	4:00	1	0	1
4:15	0	0	0	4:15	1	0	1
4:30	1	0	1	4:30	3	2	5
4:45	0	0	0	4:45	5	5	10
5:00	0	0	0	5:00	12	16	28
5:15	2	2	4	5:15	18	26	44
5:30	3	3	6	5:30	24	51	75
5:45	7	11	18	5:45	33	64	97
6:00	6	10	16	6:00	42	97	139
6:15	8	27	35	6:15	74	133	207
6:30	12	16	28	6:30	116	238	354
6:45	16	44	60	6:45	189	421	610
7:00	38	46	84	7:00	344	517	861
7:15	50	132	182	7:15	390	588	978
7:30	85	199	284	7:30	424	555	979
7:45	171	140	311	7:45	399	422	821
8:00	84	117	201	8:00	315	373	688
8:15	84	99	183	8:15	282	338	620
8:30	60	66	126	8:30	267	306	573
8:45	87	91	178	8:45	288	302	590
9:00	51	82	133	9:00	249	275	524
9:15	69	67	136	9:15	250	240	490
9:30	81	62	143	9:30	217	216	433
9:45	48	64	112	9:45	189	188	377
10:00	52	47	99	10:00	197	165	362
10:15	36	43	79	10:15	193	163	356
10:30	53	34	87	10:30	221	150	371
10:45	56	41	97	10:45	238	150	388
11:00	48	45	93	11:00	253	152	405
11:15	64	30	94	11:15	271	148	419
11:30	70	34	104	11:30	288	178	466
11:45	71	43	114	11:45	275	181	456
12:00	66	41	107	12:00	257	199	456
12:15	81	60	141	12:15	278	199	477
12:30	57	37	94	12:30	258	197	455
12:45	53	61	114	12:45	277	209	486
13:00	87	41	128	13:00	271	200	471
13:15	61	58	119	13:15	232	208	440
13:30	76	49	125	13:30	224	208	432
13:45	47	52	99	13:45	233	210	443
14:00	48	49	97	14:00	283	218	501
14:15	53	58	111	14:15	303	209	512
14:30	85	51	136	14:30	323	179	502
14:45	97	60	157	14:45	318	158	476
15:00	68	40	108	15:00	294	148	442
15:15	73	28	101	15:15	325	155	480
15:30	80	30	110	15:30	346	181	527
15:45	73	50	123	15:45	383	206	589
16:00	99	47	146	16:00	424	220	644
16:15	94	54	148	16:15	447	243	690
16:30	117	55	172	16:30	480	272	752
16:45	114	64	178	16:45	520	306	826
17:00	122	70	192	17:00	529	301	830
17:15	127	83	210	17:15	495	284	779
17:30	157	89	246	17:30	449	254	703
17:45	123	59	182	17:45	343	223	566
18:00	88	53	141	18:00	297	219	516
18:15	81	53	134	18:15	285	213	498
18:30	51	58	109	18:30	250	198	448
18:45	77	55	132	18:45	243	167	410
19:00	76	47	123	19:00	201	147	348
19:15	46	38	84	19:15	159	125	284
19:30	44	27	71	19:30	140	111	251
19:45	35	35	70	19:45	123	97	220
20:00	34	25	59	20:00	119	82	201
20:15	27	24	51	20:15	101	73	174
20:30	27	13	40	20:30	94	73	167
20:45	31	20	51	20:45	88	77	165
21:00	16	16	32	21:00	70	68	138
21:15	20	24	44	21:15	64	63	127
21:30	21	17	38	21:30	55	47	102
21:45	13	11	24	21:45	46	38	84
22:00	10	11	21	22:00	40	33	73
22:15	11	8	19	22:15	31	31	62
22:30	12	8	20	22:30	30	28	58
22:45	7	6	13	22:45	21	22	43
23:00	1	9	10	23:00	20	22	42
23:15	10	5	15				
23:30	3	2	5				
23:45	6	6	12				
Total	4237	3472	7709				

Appendix O: - Sensitivity Analysis Discussion

This appendix presents the sensitivity analysis of the ITE trip generation results for the Southern Village Neighborhood Development in more detail. The complete spreadsheets used for this analysis are given in Appendix M.

Chapter 6 has shown that the ITE trip generation method with adjustments for internal capture results in fairly accurate estimates of peak hour traffic volumes for the Southern Village neighborhood. These results suggest that the ITE method, which combines ITE manual and handbook, is a good choice for forecasting traffic generated by Traditional Neighborhood Developments similar to Southern Village. However, some trip rates for specific land uses (residential, recreational and commercial) that are given in the ITE trip generation manual are based on small sample sizes. As a result, some of the trip rates have relatively high standard deviations and have to be treated with care. The following sensitivity analysis assessed what variations in the traffic forecasts are possible based on variability of the trip rates. Furthermore, it evaluated the effects of such variations on the levels of service of the adjacent intersection of Main Street and US 15-501 at Southern Village. The analysis consists of four main components:

5. Analyzing variations of trip rates within a 95% confidence interval
6. Assessing capacity and levels of service of an intersection for the 95% confidence interval and for other (hypothetical) percentages of increased traffic volumes
7. Comparing sensitivities of different land uses in the neighborhood
8. Evaluating effects of internal capture rate on intersection performance

The first step of this sensitivity analysis uses the 95% confidence interval for ITE trip rates for the different land uses, which is equivalent to two standard deviations of the average rates listed in the ITE manual. This method represents a common method of data analysis used in statistics, and is performed here for that reason. Trip rates increased by two standard deviations (two-sigma) should result in very high traffic estimates and unacceptable operational levels of service of intersections in Southern Village and may not be very useful in real life. The two standard deviation estimate does, however, present a good starting point for this analysis.

In the second step, the traffic volumes generated in the first step are used to predict the levels of service of the intersection of Main Street and US15-501 under two-sigma conditions. The traffic volumes entering and exiting Southern Village are increased by specific percentages below the two-sigma level. This step allows developing a sense of how much of an increase in traffic volumes the particular intersection can handle and at what percent increase in traffic the intersection delays become unacceptable. In a practical context, this worst-case percent increase can be interpreted as resulting from an erroneous or extreme prediction of trip rates. If the trip rate forecast were excessive compared to reality, then the actual traffic would be less than predicted and the intersection would be over-designed. Conversely, if the trip rate prediction were too low, the actual higher traffic volumes would result in worse levels of service than expected.

The third step of the analysis looks at each land use type in Southern Village individually and assesses its sensitivity for increases in traffic volumes. The average rate and the two-sigma rate for each land use are evaluated in terms of percent difference and difference in actual numbers of vehicles for each land use. This section shows which of the land uses would be most likely to have large impacts on overall traffic in the case of a wrong estimate, assuming constant land use intensity.

In the last step the analysis concentrates on very specific characteristics of the Main Street/ US15-501 intersection in Southern Village. While the first three steps of the sensitivity analysis represent hypothetical scenarios that might result from high trip rates predictions, the fourth step focuses on the actual situation in the neighborhood. This step of the analysis therefore includes the issues that are most practical and may be most interesting to professionals, as they represent actual applications and practical implications of the ITE trip generation method.

Step 1. Trip Rate Variations in a 95% Confidence Interval

For the first step of the sensitivity analysis, the ITE trip generation method was performed for each land use three times:

- Using the mean values as listed in the ITE manual
- Using the mean values plus two standard deviations
- Using the mean values minus two standard deviations

A range of plus and minus two standard deviations from the average corresponds to a 95% confidence interval, according to statistical theory. It is common practice in statistics to calculate this 95% confidence interval, in order to gain an understanding of the precision and variability of the results. Table O-1 below presents the overall trip rates for daily and peak hour traffic, measured in number of vehicles, for the entire neighborhood. Table O-2 shows the same numbers expressed as percent differences from the average rates.

Table O-1: Trip Rate Variations (number of vehicles)

Trip Volumes generated with ITE trip generation method for total number of vehicles in Southern Village					
Daily Traffic (# of vehicles)		**AM Peak Hour (# of vehicles)**		**PM Peak Hour (# of vehicles)**	
Entering	Exiting	Entering	Exiting	Entering	Exiting
Minus Two Standard Deviations					
1571.7	1571.7	10.5	8.9	64.0	9.5
Mean Values					
6799.7	6799.7	542.6	722.2	832.3	734.8
Plus Two Standard Deviations					
12317.8	12317.8	1551.8	2415.1	2447.1	2089.7

Table O-2: Trip Rate Variations (Percent Difference)

Percent Difference of ITE Trip Rates for total traffic volumes in Southern Village					
Daily Traffic (# of vehicles)		**AM Peak Hour (# of vehicles)**		**PM Peak Hour (# of vehicles)**	
Entering	Exiting	Entering	Exiting	Entering	Exiting
Minus Two Standard Deviations					
-76.9%	-76.9%	-98.1%	-98.8%	-92.3%	-98.7%
Mean Values					
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Plus Two Standard Deviations					
81.2%	81.2%	186.0%	234.4%	194.0%	184.4%

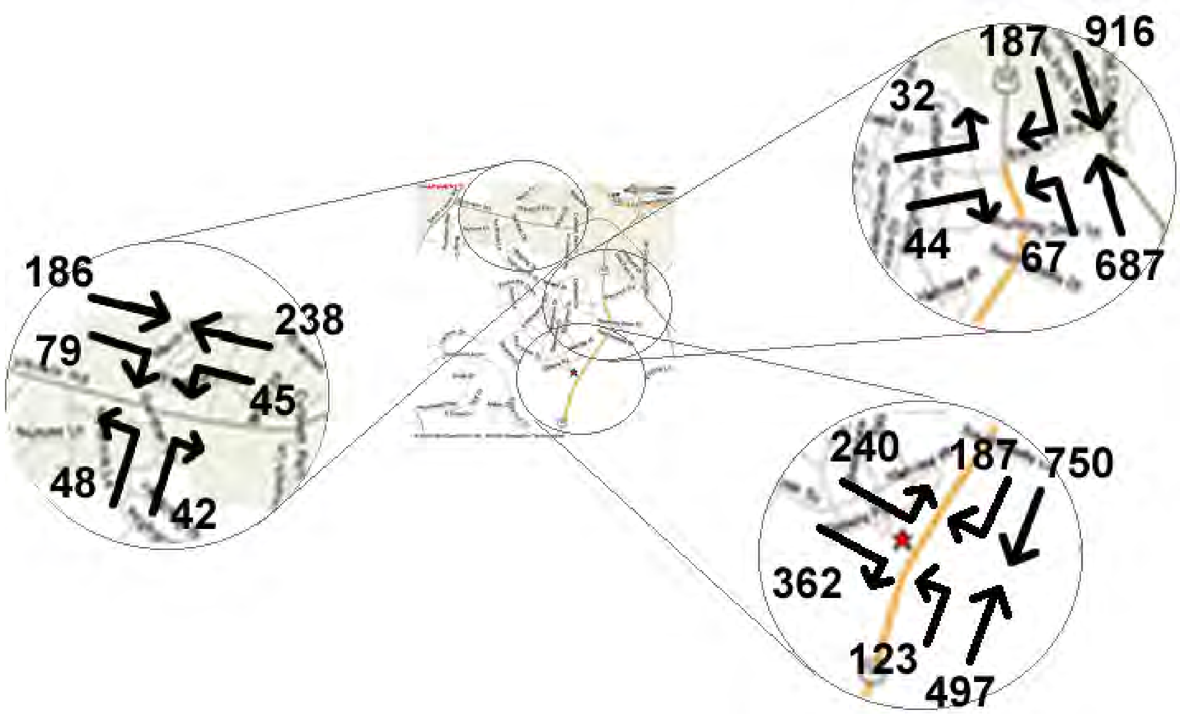
Results in Table O-2 show that the trip rates obtained with the ITE trip generation methods may vary greatly. The tables show that in a 95% confidence interval, the maximum trip rate can be more than 200% greater than what the average rate suggests. In summary the use of a variation of two standard deviations resulted in extremely different traffic volumes. The large variation in plus and minus two-sigma values is symptomatic of the relatively few field data used to develop the trip rates in the ITE manual. In a real situation it is unlikely that such large differences would occur between trip generation forecasts and actual trip rates. Traffic engineers would likely adjust the average trip rates for a case study consistent with local conditions. The plus two standard deviation rates are, therefore, a high upper limit of trip rates, with actual trip rates falling somewhere in-between predicted average rates and these limits.

The following section shows what effects such high traffic estimates can have and how the levels of service of an intersection adjacent to Southern Village change under conditions at the upper limits of the 95% confidence interval. The section then analyzes the same intersection for other percent increases of entering and exiting traffic volumes that may be more likely to occur in a real situation.

Step 2. Capacity Analysis for (Hypothetical) Increases in Traffic Volumes

The sensitivity analysis of intersection levels of service in response to traffic estimates focused on the main entrance to Southern Village - the intersection of US15-501 and Main Street. Actual traffic counts at the entrances and exits to the neighborhood presented in Appendix O show that this is indeed the main entrance because it has the highest entering and exiting volumes compared to the other two entrances at the a.m. and p.m. peak hours. Thus, the Main Street and US 15-501 intersection would likely experience congestion impacts first and would be a reasonable choice for a sensitivity analysis. Figure O-1 below shows a map of the neighborhood with the current p.m. peak hour traffic volumes obtained by NCDOT counts..

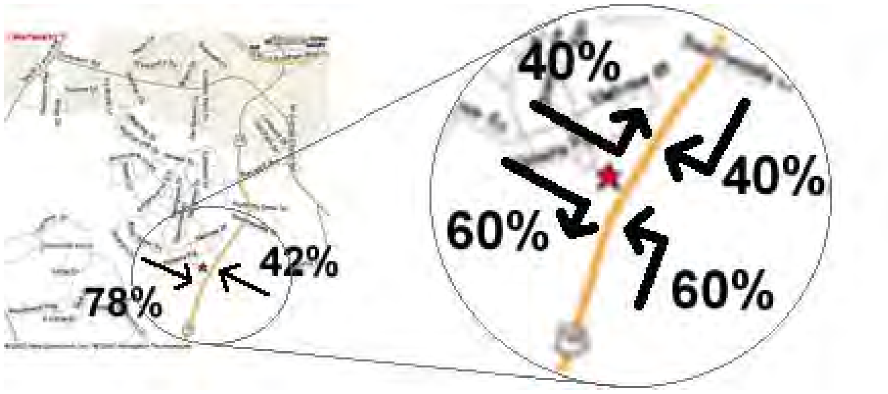
Figure O-1: Traffic Volumes in Southern Village, p.m. peak hour (vehicles/hour)



The analysis concentrated on the p.m. peak hour, as that represents the highest traffic volume in the area and typically has the highest likelihood of congestion. The analysis of the intersection assumes current traffic volumes on all streets external to the Southern Village neighborhood. The entering and exiting volumes were then calculated from the two standard deviation estimates and by other percent increases. The two-sigma category represents the highest trip rates and depending on the land use intensity may represent flows that are unreasonable for this intersection. The resulting flows surpass capacity constraints of the intersection and are worst-case scenarios. The other percent increases fall below the two-sigma rates and represent a broad range of possible traffic increases. These flows can be used to estimate at what hypothetical percent increase in traffic, the intersection will experience significant delays and at what point capacity is reached.

Values shown in Figure O-1 represent total entering and exiting volumes for the entire development. To obtain traffic volumes for the intersection of interest only, the percentage distribution of traffic between the three exits was assumed to be the same as it is in the actual traffic counts. The distribution for directional splits was done in the same manner. The percentage of total traffic volumes of the development on Main Street is 42% of entering and 78% of exiting vehicles. The outbound directional split of Main Street is 40% northbound and 60% southbound. The inbound directional split is 40% from the northbound approach and 60% from the southbound approach. The percentages are shown in Figure O-2 below.

Figure O-2: Turn Percentages in Southern Village



The capacity analysis of the intersection was accomplished using the HCS2000 software package. The analysis was completed with the average ITE trip generation predictions. Because the signal on the Main Street/US15-501 intersection is actuated, averages of field measurements of the actual signal times were taken to obtain average signal times for the analysis (Table O-3).

Table O-3: Actual Signal Times Main Street/US15-501

Green Times for Main Street and US15-501			
Road	**Movement**	**avg.green (s)**	**Y/AR**
US 15-501	through	60.5	4.0
US 15-501	protected left	5.5 / 0.0*	4.0
Main Street	left/right	21.4	4.0
Average cycle length (s)		**90.7**	

Table O-3 shows average green times for the signal and yellow/all red (Y/AR) times as provided in the signal-timing plan. The timing analysis was conducted on a Tuesday between the hours of 5 and 6 p.m. The measured green times were averaged for each phase over the entire count period. The asterisk next to the protected left movement from US 15-501 onto Main Street indicates that while the counts were conducted, this particular phase only appeared twice. At all other times, the left turning volumes were low enough that all vehicles were able to turn during the phase for the through movement and the protected left turn phase therefore wasn't actuated. The average green time for the two occurrences of the protected left phase was 5.5 seconds, while the average distributed over the entire count period was close to zero seconds. In the following intersection analysis, green and Y/AR for this phase were therefore assumed to be zero during the p.m. peak hour.

The analysis was then repeated with the trip rates plus two standard deviations. For this step, the maximum green times from the signal-timing plan were assumed, because it is reasonable to assume that the signal has reached maximum capacity under these high volume conditions. Green times in an actuated signal will increase with higher traffic volumes, because the detector in the roads are triggered more frequently with higher flows. Although it is not exactly known to what degree the green times will increase, it is a reasonable assumption that they have reached the maximum allowable with volumes as high as in this case. All other variables, such as geometry factors, vehicle types, yellow and all-red times were kept constant throughout the analysis. Table O-4 below shows the summary of the capacity comparison.

Table O-4: Capacity Analysis for Plus Two Standard Deviations

Approach	Direction	Average ITE Rates		Plu Two-Sigma	
		LOS	delay(s)	LOS	delay(s)
US15-501 NB	through	A	6.5	A	7.0
	left	B	10.4	C	29.4
US15-501 SB	through	B	13.1	B	17.6
	right	A	1.9	A	5.3
Main Street EB	left	D	43.6	F	351.5
	right	D	36.0	F	328.0
Intersection Totals		**B**	**16.6**	**F**	**140.6**

The table shows that the intersection levels of service were significantly reduced in the second scenario. If indeed the ITE trip rate predictions had been underestimating the impacts by two standard deviations, the effects on the Main Street/US15-501 intersection would be detrimental. Therefore, the level of service of the main entrance, within a 95% confidence interval, is estimated to be between LOS B and F. In practice this means, that even if the ITE prediction was appropriate in the case of Southern Village, it may under or over predict in other cases. Engineers and consultants should therefore always be aware that there is a range of trip rates possible, and the most professional judgment should be used to validate the results.

In order to gain a better understanding of the capacity threshold of the intersection, further adjustments were made. The main question in this context was at what point the intersection would be over capacity and require additional lanes. As discussed in the previous paragraphs, it is possible that the ITE trip generation method indeed under-predicted the effects of a traditional neighborhood development. The next step of the sensitivity analysis, therefore repeated the HCS2000 capacity analysis assuming that actual traffic volumes are higher than predicted by set percentages. Tables O-5.1 and O-5.2 below show the levels of service and delays per lane group for assumed volumes that are 10%, 25%, 50%, 100%, and 150% over the volumes predicted by ITE.

Table O-5.1: Capacity Analysis for Percent Increase in Traffic Volumes

Approach	**Direction**	**ITE forecast**		**SV volumes +10%**		**SV volumes +25%**		**SV volumes +50%**	
		LOS	delay(s)	LOS	delay(s)	LOS	delay(s)	LOS	delay(s)
US15-501 NB	through	A	6.5	A	7.0	A	13.3	A	7.0
	left	B	10.4	B	12.8	B	7.0	B	14.3
US15-501 SB	through	B	13.1	B	17.6	B	17.6	B	17.6
	right	A	1.9	A	3.1	A	7.0	A	3.4
Main Street EB	left	D	43.6	E	64.2	E	68.2	E	79.0
	right	D	36.0	D	47.7	D	51.1	E	59.6
Intersection Totals		**B**	**16.6**	**C**	**22.9**	**C**	**24.7**	**C**	**28.8**

Table O-5.2: Capacity Analysis for Percent Increase in Traffic Volumes (contd.)

Approach	Direction	ITE forecast		SV volumes +100%		SV volumes +150%		SV volumes +200%	
		LOS	delay(s)	LOS	delay(s)	LOS	delay(s)	LOS	delay(s)
US15-501 NB	through	A	6.5	A	7.0	A	7.0	A	7.0
	left	B	10.4	B	16.8	C	20.0	C	24.6
US15-501 SB	through	B	13.1	B	17.6	B	17.6	B	17.6
	right	A	1.9	A	3.8	A	4.3	A	4.8
Main Street EB	left	D	43.6	F	140.1	F	249.5	F	369.7
	right	D	36.0	F	115.1	F	223.3	F	341.6
Intersection Totals		**B**	**16.6**	**D**	**51.5**	**F**	**97.1**	**F**	**152.1**

As tables O-5.1 and O-5.2 above show, the consequences of inappropriate trip rates can have significant effects on the levels of service of adjacent intersections in the development. As expected, the levels of service for the intersection of Main Street and US15-501 get continuously worse with increasing traffic volumes. This analysis is interesting, however, in that the high delays are all associated with the exiting volumes from the development (the minor movements). The through movements on US15-501 remain at satisfactory levels of service even if the traffic exiting the Southern Village development were to increase by these large percentages. This means that even if the developer had underestimated the impacts of the new neighborhood, the effects on the regional network would be almost negligible.

Step 3. Comparison of Different Land Use Types

The first two sections of the sensitivity analysis show that significant increases in predicted traffic volumes, compared to original TND estimates, could result from variations in the ITE trip rates. As discussed it is unlikely that an error in the magnitude of plus two standard deviations would occur, however, it is very well possible that the forecast volumes resulting from ITE trip generation do not match local conditions. In this context it is interesting to know, which land uses in Southern Village are most sensitive to changes, i.e. have the highest variability in the research results underlying the published trip rates.

This section of the analysis, therefore, looks at each land use in the Southern Village separately. The average rates predicted from the ITE method are compared to the plus two standard deviations rates listed in section 1. For each land use, those two rates are compared and the percent difference between the two is calculated. Furthermore, the differences in actual numbers of vehicles are listed. This is done because a specific land use type may have little overall effects on traffic due to low intensity, despite a high standard deviation in its trip rate. Table O-6 summaries the findings.

Table O-6: Comparison of Different Land Use Types

Land Use Category	Intensity	% Difference From Average	Additional Vehciles from Average
Single Family Homes	510 units	77.1%	3764
Condos + Townhomes	335 units	105.5%	2070
Apartments	250 units	89.9%	1490
Office	95,000 sq.ft.	114.4%	1165
Retail	24,500 sq.ft.	138.7%	561
Church	27,000 sq.ft.	158.1%	389
Daycare	6,000 sq.ft.	53.1%	252
School	90,000 sq.ft.	116.7%	1264
Swim and Tennis Club	3,000 sq.ft.	158.6%	82
Total		**81.2%**	**11036**

As the table above shows, there are significant differences between the average rates and the plus two standard deviations rates. The largest percent differences occur for the Swim Club, the Church and Retail Stores. All of these, however, result in relatively small increases in the number of vehicles. Also, it is unlikely that predictions for the church will be so much larger for the p.m. peak hour, as most church traffic occurs on Sunday mornings. The largest increases in number of vehicles result from all three residential land use types and the school. For the school, a similar argument applies as mentioned for the church, as increases in the given magnitude are very doubtful for the p.m. peak period.

In summary the results suggest that the most significant increases in traffic predictions would probably result from the residential zones in Southern Village. It is therefore suggested that the closest attention be paid to the traffic forecasts for these three land uses. Trip generation results should be questioned and professional judgment be applied to verify the validity of the calculated rates for development similar to Southern Village.

4. Effects of Internal Capture

The final step of the sensitivity analysis compared the impacts of the average ITE rates predicted using the ITE manual with those rates that were adjusted for internal capture. The ITE trip generation handbook suggests that due to the mixed land use of traditional neighborhood developments a significant percentage of trips are captured within the development. The results of the Southern Village traffic impact analysis indicated a 13.1% capture rate because of significant internal trips to schools, daycare, restaurants, and shopping venues. The sensitivity analysis compared the impacts of these reduced rates to the unadjusted ITE predictions. Again, the distribution of traffic volumes among the three exits and among turn movements was done consistent with the percentages from the actual counts (see Figure O-2). The results of the analysis are shown in Table O-7 below.

Table O-7: Capacity Analysis With and Without Internal Capture

Approach	Direction	without int. capture		with 13.1% Int. Capt.	
		LOS	delay(s)	LOS	delay(s)
US15-501 NB	through	A	6.5	A	6.5
	left	B	10.9	B	10.4
US15-501 SB	through	B	13.1	B	13.1
	right	A	2.0	A	1.9
Main Street EB	left	D	46.0	D	43.6
	right	D	39.2	D	36.0
Intersection Totals		**B**	**18.0**	**B**	**16.6**

Table O-7 shows that the difference between levels of service and delays for the two cases is negligible. The resulting improvement in overall intersection delay is merely 1.4 seconds for the p.m. peak hour, which suggests that impacts for other time periods of the day are even less. Furthermore, reduced Southern Village traffic due to the internal capture rate of 13.1% is distributed over all three exits/entrances and then for the directional turning split of each intersection. For each individual lane group this means that the actual impacts in number of vehicles are not significant and the effects on intersection capacity will, therefore, be minor. Table O-8 shows the distribution of the total traffic difference over the lane groups in the Main Street and US15-501 intersection.

Table O-8: Volume Comparison for Main Street/US15-501

Volume Differences Between Trip Generation With and Without Internal Capture (p.m. peak hour)				
		internal capture 13.1%	**no internal capture**	**Difference in # of vehicles**
Total Volumes Predicted by ITE	Entering	723	832	**109**
	Exiting	639	735	**96**
Volume Percentages on Main Street	Entering (42%)	304	349	**46**
	Exiting (78%)	498	573	**75**
Volume Directional Splits for Turning Movements	Exiting to NB (40%)	199	229	**30**
	Exiting to SB (60%)	299	344	**45**
	Entering from NB (40%)	121	140	**18**
	Entering from SB (60%)	182	210	**27**

The table shows that the internal capture rate observed for Southern Village only results in less than 50 vehicles for every lane group per hour, which is significantly less than one vehicle per minute. With this in mind it is understandable that the impacts on Levels of Service for the intersection are relatively insignificant. In this context it also needs to be stated that US15-501 is currently being widened, and that the widened roadway (which was used in this analysis) was likely designed to carry significant increases in future traffic. The minor impacts on LOS on US15-501 shown here, may have resulted in more severe impacts in more dense areas. TNDs similar to Southern Village that are located on arterials with volumes already closer to the capacity limit, will likely have greater impacts on the surrounding road network. In those hypothetical cases, the impacts of 13% internal capture would then also have more significant results, theoretically. This case suggests that close attention needs to be paid to TNDs planned in over-capacity locations. Effects of internal capture from amenities can then be attractive for marketing of the product, even if traffic impacts are not clearly predictable.

For this particular case, with perimeter roads that are major arterials, these results suggest that it may not be necessary to calculate internal capture rates for the development at all, as there is virtually no difference in impacts on the adjacent road network. However, since our analysis has shown that the calculated rates with internal capture were extremely close to the actual counts, it is good practice to use the ITE handbook as a step in traffic impact analyses for traditional neighborhood developments.

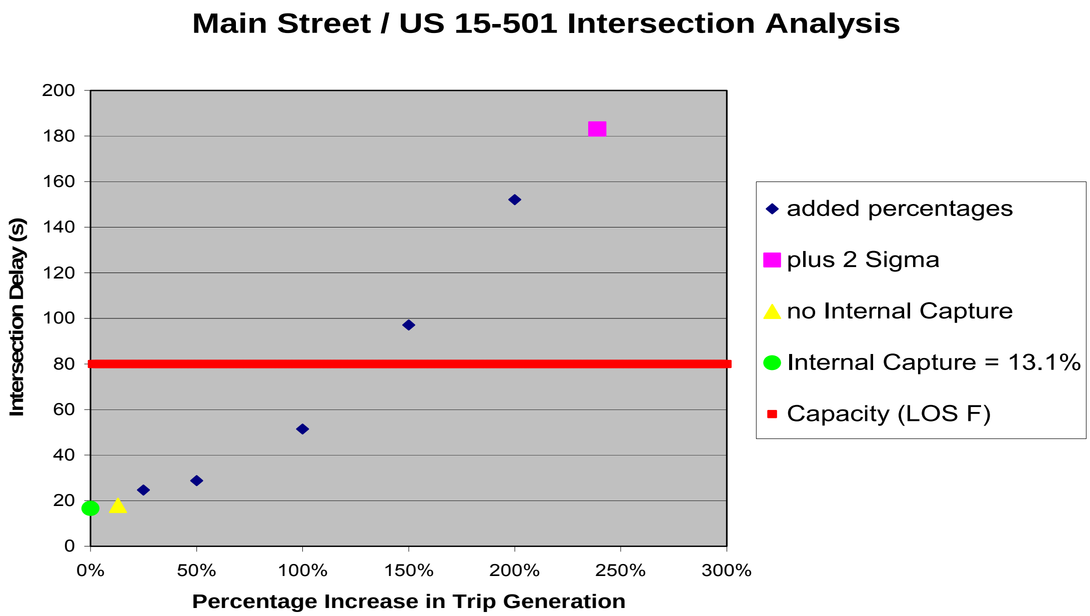
Sensitivity Analysis Summary

The ITE trip generation manual can have very high standard deviations and trip rates generated with the ITE method should be validated by professional judgment. The sensitivity analysis showed that if the ITE method had indeed underestimated traffic volumes, the levels of service on the Main Street and US15-501 intersection would have been decreased significantly. The analysis was done first using plus two standard deviation rates and second using rates that were increased by certain percentages below the 95% confidence upper limit. While the plus two standard deviation rates expectedly put the studied intersection over capacity, increases of lower percentages still resulted in significant increases in intersection delays.

The analysis further showed that in the assessment of a neighborhood similar to Southern Village, the results of the ITE trip generation should be regarded with care, even if the estimate was fairly accurate for this case. In particular, the rates predicting residential volumes can be subject to high variability and would have resulted in the largest increases in numbers of vehicles in the case of Southern Village.

In the final step, the sensitivity analysis evaluated effects of internal capture on the Main Street/US15-501 intersection. The results showed, that the calculated 13.1% internal capture rate for Southern Village had negligible effects on delays and levels of service for the studied intersection. This outcome was explained by the fact that the total reduction of trips by 13.1% in reality is divided up among the three exits/entrances and then split into the different turning directions. Also, the intersection has a high design year intended to carry high future traffic volumes on the major thoroughfare US15-501. In this sense, the total internal capture of 109 vehicles in the p.m. peak hour only results in increases below 50 vehicles per lane group per hour, which has virtually no effect on the performance of the studied intersection. Figure O-3 below summarizes the results of this sensitivity analysis in a plot of intersection delay versus percentage increase in trip generation rates.

Figure O-3: Sensitivity Analysis Summary



In Figure O-3 the heavy line at 80 seconds total intersection delay represents a Level of Service 'F', at which the intersection is regarded as having exceeded its capacity. The circle symbol in the bottom left represents the average ITE trip generation rates minus the reductions for internal capture. The triangle next to it refers to the delay times calculated without the adjustment. The plot then shows that both delay times are well below the capacity of the intersection. The effect of internal capture may therefore be considered negligible, if only one TND neighborhood is assessed. However, imagining regional effects of this reduction through internal capture, for a number of TNDs along the same collector road, the results of a similar capacity analysis would likely be different. The combined internal capture of several Traditional Neighborhood Developments, conceivably will have a significant effect on the performance of the regional road network.

Findings of the sensitivity analysis in summary are:

- ITE forecasts can have high deviations and predictions should be validated with professional judgment
- If traffic is higher than predicted, the delays of exiting traffic on adjacent intersections will likely increase and result in unsatisfactory LOS for neighborhood traffic
- LOS of through traffic on adjacent arterial in this case was hardly affected by increasing traffic volumes entering and exiting the neighborhood
- Highest variability and additional vehicle trips resulted from residential generators in the development. Impacts of commercial and business land uses were less significant.
- The calculated (and observed) 13% Internal Capture has negligible effects on intersection LOS due to distribution effects

Appendix P: Sensitivity Analysis Tables

US15-501/Main Street
Traffic Volumes - Forecasts

Annual Growth Rate 1%

		actual counts 2003	Forecast 5 years at 1% growth	Forecast 10 years at 1% growth	Forecast 20 years at 1% growth	Forecast 30 years at 1% growth
NB	through	497	522	549	606	670
	left	123	129	136	150	166
	Total	620	652	685	757	836
SB	through	750	788	828	915	1011
	right	187	197	207	228	252
	Total	937	985	1035	1143	1263
EB	left	240	252	265	293	323
	right	362	380	400	442	488
	Total	602	633	665	735	811

Annual Growth Rate 2%

		actual counts 2003	Forecast 5 years at 2% growth	Forecast 10 years at 2% growth	Forecast 20 years at 2% growth	Forecast 30 years at 2% growth
NB	through	497	549	606	739	900
	left	123	136	150	183	223
	Total	620	685	756	921	1123
SB	through	750	828	914	1114	1359
	right	187	206	228	278	339
	Total	937	1035	1142	1392	1697
EB	left	240	265	293	357	435
	right	362	400	441	538	656
	Total	602	665	734	895	1090

Annual Growth Rate 3%

		actual counts 2003	Forecast 5 years at 3% growth	Forecast 10 years at 3% growth	Forecast 20 years at 3% growth	Forecast 30 years at 3% growth
NB	through	497	576	668	898	1206
	left	123	143	165	222	299
	Total	620	719	833	1120	1505
SB	through	750	869	1008	1355	1820
	right	187	217	251	338	454
	Total	937	1086	1259	1692	2274
EB	left	240	278	323	433	583
	right	362	420	486	654	879
	Total	602	698	809	1087	1461

US15-501/Main Street
Volumes/LOS/Delays - Forecasts

		actual counts 2003			Forecast 5 years at 1% growth			Forecast 10 years at 1% growth			Forecast 20 years at 1% growth			Forecast 30 years at 1% growth		
		vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)
NB	through	497	A	7.0	522	A	7.1	549	A	7.2	606	A	7.3	670	A	7.5
	left	123	B	12.5	129	B	13.3	136	B	14.3	150	B	16.9	166	C	20.7
	Total	620	A	8.1	652	A	8.3	685	A	8.6	757	A	9.2	836	B	10.1
SB	through	750	B	17.6	788	B	17.9	828	B	18.2	915	B	18.9	1011	B	19.7
	right	187	A	3.1	197	A	3.1	207	A	3.2	228	A	3.2	252	A	3.3
	Total	937	B	14.7	985	B	14.9	1035	B	15.2	1143	B	15.8	1263	B	16.5
EB	left	240	E	66.9	252	E	68.7	265	E	70.9	293	E	77.3	323	F	87.7
	right	362	D	50.1	380	D	51.6	400	D	53.5	442	E	58.7	488	E	67.4
	Total	602	E	56.8	633	E	58.4	665	E	60.5	735	E	66.1	811	E	75.5
Intersection Totals		**2159**	**C**	**24.5**	**2269**	**C**	**25.2**	**2385**	**C**	**25.9**	**2634**	**C**	**27.9**	**2910**	**C**	**31.1**

		actual counts 2003			Forecast 5 years at 2% growth			Forecast 10 years at 2% growth			Forecast 20 years at 2% growth			Forecast 30 years at 2% growth		
		vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)
NB	through	497	A	7.0	549	A	7.2	606	A	7.3	739	A	7.7	900	A	8.3
	left	123	B	12.5	136	B	14.3	150	B	16.9	183	C	26.3	223	D	47.9
	Total	620	A	8.1	685	A	8.6	756	A	9.2	921	B	11.4	1123	B	16.1
SB	through	750	B	17.6	828	B	18.2	914	B	18.9	1114	C	20.7	1359	C	23.7
	right	187	A	3.1	206	A	3.1	228	A	3.2	278	A	3.4	339	A	3.7
	Total	937	B	14.7	1035	B	15.2	1142	B	15.8	1392	B	17.3	1697	B	19.7
EB	left	240	E	66.9	265	E	70.9	293	E	77.3	357	F	106.7	435	F	177.8
	right	362	D	50.1	400	D	53.5	441	E	58.5	538	F	84.0	656	F	154.4
	Total	602	E	56.8	665	E	60.5	734	E	66.0	895	F	93.0	1090	F	163.7
Intersection Totals		**2159**	**C**	**24.5**	**2384**	**C**	**25.9**	**2632**	**C**	**27.9**	**3208**	**D**	**36.7**	**3911**	**E**	**58.8**

		actual counts 2003			Forecast 5 years at 3% growth			Forecast 10 years at 3% growth			Forecast 20 years at 3% growth			Forecast 30 years at 3% growth		
		vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)
NB	through	497	A	7.0	576	A	7.2	668	A	7.5	898	A	8.3	1206	A	9.5
	left	123	B	12.5	143	B	15.5	165	C	20.5	222	D	47.5	299	F	109.3
	Total	620	A	8.1	719	A	8.9	833	B	10.1	1120	B	16.0	1505	C	29.3
SB	through	750	B	17.6	869	B	18.5	1008	B	19.7	1355	C	23.6	1820	C	34.3
	right	187	A	3.1	217	A	3.2	251	A	3.3	338	A	3.7	454	A	4.2
	Total	937	B	14.7	1086	B	15.5	1259	B	16.4	1692	B	19.6	2274	C	28.3
EB	left	240	E	66.9	278	E	73.6	323	F	87.7	433	F	175.7	583	F	351.5
	right	362	D	50.1	420	E	55.8	486	E	66.9	654	F	152.9	879	F	328.0
	Total	602	E	56.8	698	E	62.9	809	E	75.2	1087	F	162.0	1461	F	337.3
Intersection Totals		**2159**	**C**	**24.5**	**2503**	**C**	**26.8**	**2902**	**C**	**31.0**	**3899**	**E**	**58.3**	**5240**	**F**	**114.8**

US15-501/Main Street - PM peak
Volumes/LOS/Delays - with +2Std from ITE-TG

Total ITE-TG prediction in:	832
Total ITE-TG prediction out:	735

Total Volume in:	2447.15
Total Volume out:	2089.69

Main Street Directional Split:	OUT to NB:	40%	IN from NB:	40%
	OUT to SB:	60%	IN from SB:	60%

Percentage on Main Street in:	42%
Percentage on Main Street out:	78%

								Volumes with +2STD from ITE trip generation					
		actual counts 2003 with measured green times			ITE trip generation predictions with measured green times (without internal capture)			max. greens on Main and measured green times on other approaches			max. green times on all approaches		
		vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)
NB	through	497	A	7.0	497	A	6.5	497	A	9.5	497	A	7.0
	left	123	B	12.5	140	B	10.9	411	D	41.9	411	C	29.4
	Total	620	A	8.1	637	A	7.5	908	C	24.2	908	B	17.2
SB	through	750	B	17.6	750	B	13.1	750	B	17.1	750	B	17.6
	right	187	A	3.1	210	A	2.0	617	A	3.4	617	A	5.3
	Total	937	B	14.7	960	B	10.7	1367	B	10.9	1367	B	12.1
EB	left	240	E	66.9	229	D	46.0	652	F	148.5	652	F	351.5
	right	362	D	50.1	344	D	39.2	978	F	256.0	978	F	328.0
	Total	602	E	56.8	573	D	41.9	1630	F	213.1	1630	F	337.3
Intersection Totals		**2159**	**C**	**24.5**	**2170**	**B**	**18.0**	**3905**	**F**	**93.2**	**3905**	**F**	**140.6**

Average Rates		
	In	Out
	832	735
on Main	350	573
40%	140	229
60%	210	344

plus 2 Std. Dev.		
	In	Out
	2447	2090
on Main	1028	1630
40%	411	652
60%	617	978

		Average ITE Rates		Plus two St.Dev.	
Approach	Direction	LOS	delay(s)	LOS	delay(s)
NB	through	A	6.5	A	7.0
	left	B	10.9	C	29.4
SB	through	B	13.1	B	17.6
	right	A	2.0	A	5.3
EB	left	D	46.0	F	351.5
	right	D	39.2	F	328.0
Intersection Totals		**B**	**18.0**	**F**	**140.6**

Volume Distribution with and without internal capture

with internal capture 13.1%			**without internal capture**		
	In	Out		In	Out
Total	723	639	Total	832	735
on Main	304	498	on Main	350	573
40%	122	199	40%	140	229
60%	182	299	60%	210	344

Volume Differences Between Trip Generation With and Without Internal Capture

		internal capture 13.1%	**no internal capture**	**Difference in # of vehicles**
Total Volumes Predicted by ITE	Entering	723	832	**109**
	Exiting	639	735	**96**
Volume Percentages on Main Street	Entering (42%)	304	349	**46**
	Exiting (78%)	498	573	**75**
Volume Directional Splits for Turning Movements	Exiting to NB (40%)	199	229	**30**
	Exiting to SB (60%)	299	344	**45**
	Entering from NB (40%)	121	140	**18**
	Entering from SB (60%)	182	210	**27**

US15-501/Main Street - PM peak
Volumes/LOS/Delays - with/without internal capture

	IC 13.1%	no IC
Total ITE-TG prediction in:	723	832
Total ITE-TG prediction out:	639	735

Plus 2 Std. Dev.	
Total Volume in:	2447.15
Total Volume out:	2089.69

Main Street Directional Split:				
	OUT to NB:	40%	IN from NB:	40%
	OUT to SB:	60%	IN from SB:	60%

Percentage on Main Street in:	42%
Percentage on Main Street out:	78%

		ITE trip generation predictions with measured green times - **with internal capture 13.1%**			ITE trip generation predictions with measured green times - **without internal capture**			Volumes with +2STD from ITE trip generation: max. greens on Main and measured green times on other approaches			Volumes with +2STD from ITE trip generation: max. green times on all approaches		
		vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)
NB	through	497	A	6.5	497	A	6.5	497	A	9.5	497	A	7.0
	left	122	B	10.4	140	B	10.9	411	D	41.9	411	C	29.4
	Total	619	A	7.3	637	A	7.5	908	C	24.2	908	B	17.2
SB	through	750	B	13.1	750	B	13.1	750	B	17.1	750	B	17.6
	right	182	A	1.9	210	A	2.0	617	A	3.4	617	A	5.3
	Total	932	B	10.9	960	B	10.7	1367	B	10.9	1367	B	12.1
EB	left	199	D	43.6	229	D	46.0	652	F	148.5	652	F	351.5
	right	299	D	36.0	344	D	39.2	978	F	256.0	978	F	328.0
	Total	498	D	38.9	573	D	41.9	1630	F	213.1	1630	F	337.3
Intersection Totals		**2049**	**B**	**16.6**	**2170**	**B**	**18.0**	**3905**	**F**	**93.2**	**3905**	**F**	**140.6**

with internal capture 13.1%			**without internal capture**			**+2 STD Volumes**		
	In	Out		In	Out		In	Out
Total	723	639	Total	832	735		2447	2090
on Main	304	498	on Main	350	573	on Main	1028	1630
40%	122	199	40%	140	229	40%	411	652
60%	182	299	60%	210	344	60%	617	978

Approach	Direction	without int. capture LOS	without int. capture delay(s)	with int.capt. 13.1% LOS	with int.capt. 13.1% delay(s)	Plus two St.Dev. LOS	Plus two St.Dev. delay(s)
NB	through	A	6.5	A	6.5	A	7.0
	left	B	10.9	B	10.4	C	29.4
SB	through	B	13.1	B	13.1	B	17.6
	right	A	2.0	A	1.9	A	5.3
EB	left	D	46.0	D	43.6	F	351.5
	right	D	39.2	D	36.0	F	328.0
Intersection Totals		**B**	**18.0**	**B**	**16.6**	**F**	**140.6**

US15-501/Main Street - PM peak
Volumes/LOS/Delays - percentages added for possible underprediction

	IC 13.1%	no IC
Total ITE-TG prediction in:	723	832
Total ITE-TG prediction out:	639	735

Main Street Directional Split:				
	OUT to NB:	40%	IN from NB:	40%
	OUT to SB:	60%	IN from SB:	60%

		ITE trip generation predictions with measured green times - **without internal capture**			ITE trip generation predictions with measured green times - **with internal capture 13.1%**			ITE trip generation predictions - with internal capture 13.1% - **SV volumes +50%**			ITE trip generation predictions - with internal capture13.1% - **SV volumes +100%**			ITE trip generation predictions - with internal capture 13.1% - **SV volumes +150%**		
		vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)	vph	LOS	delay(s)
NB	through	497	A	6.5	497	A	6.5	497	A	7.0	497	A	7.0	497	A	7.0
	left	140	B	10.9	122	B	10.4	182	B	14.3	243	B	16.8	304	C	20.0
	Total	637	A	7.5	619	A	7.3	679	A	9.0	740	B	10.2	801	B	12.0
SB	through	750	B	13.1	750	B	13.1	750	B	17.6	750	B	17.6	750	B	17.6
	right	210	A	2.0	182	A	1.9	273	A	3.4	365	A	3.8	456	A	4.3
	Total	960	B	10.7	932	B	10.9	1023	B	13.8	1115	B	13.1	1206	B	12.6
EB	left	229	D	46.0	199	D	43.6	299	E	79.0	398	F	140.1	498	F	249.5
	right	344	D	39.2	299	D	36.0	448	E	59.6	598	F	115.1	747	F	223.3
	Total	573	D	41.9	498	D	38.9	747	E	67.4	996	F	125.1	1245	F	233.8
Intersection Totals		**2170**	**B**	**18.0**	**2049**	**B**	**16.6**	**2449**	**C**	**28.8**	**2851**	**D**	**51.5**	**3252**	**F**	**97.1**

without internal capture			**with internal capture 13.1%**			**volumes plus 50%**			**volumes plus 50%**			**volumes plus 150%**		
	In	Out		In	Out		In	Out		In	Out		In	Out
Total	832	735	Total	723	639	Total	1085	958	Total	1447	1277	Total	1808	1596
on Main	350	573	on Main	304	498	on Main	456	747	on Main	608	996	on Main	759	1245
40%	140	229	40%	122	199	40%	182	299	40%	243	398	40%	304	498
60%	210	344	60%	182	299	60%	273	448	60%	365	598	60%	456	747

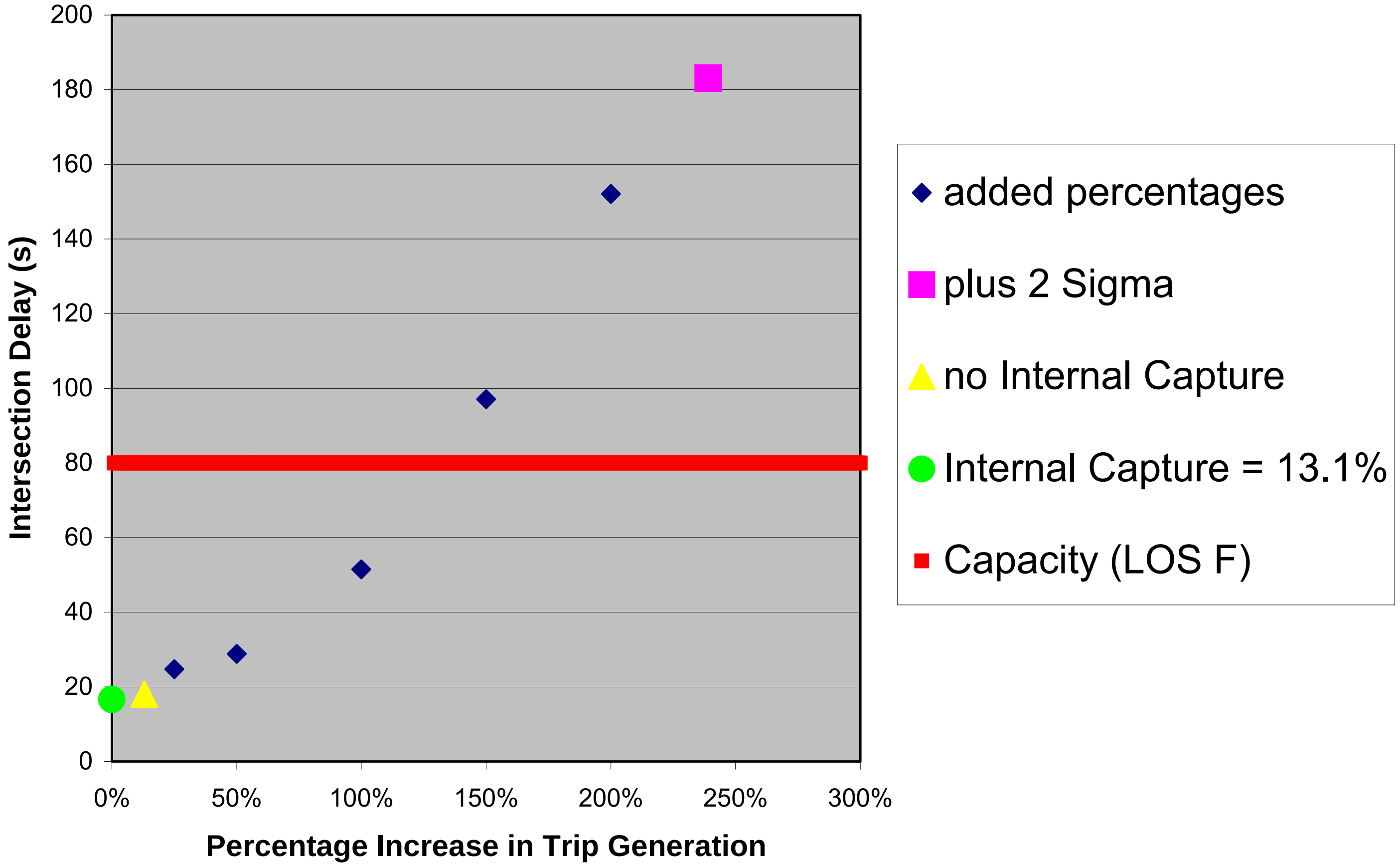
		ITE forecast		**SV volumes +10%**		**SV volumes +25%**		**SV volumes +50%**	
Approach	**Direction**	LOS	delay(s)	LOS	delay(s)	LOS	delay(s)	LOS	delay(s)
US15-501 NB	through	A	6.5	A	7.0	A	13.3	A	7.0
	left	B	10.4	B	12.8	B	7.0	B	14.3
US15-501 SB	through	B	13.1	B	17.6	B	17.6	B	17.6
	right	A	1.9	A	3.1	A	7.0	A	3.4
Main Street EB	left	D	43.6	E	64.2	E	68.2	E	79.0
	right	D	36.0	D	47.7	D	51.1	E	59.6
Intersection Totals		**B**	**16.6**	**C**	**22.9**	**C**	**24.7**	**C**	**28.8**

		ITE forecast		**SV volumes +100%**		**SV volumes +150%**		**SV volumes +200%**	
Approach	**Direction**	LOS	delay(s)	LOS	delay(s)	LOS	delay(s)	LOS	delay(s)
US15-501 NB	through	A	6.5	A	7.0	A	7.0	A	7.0
	left	B	10.4	B	16.8	C	20.0	C	24.6
US15-501 SB	through	B	13.1	B	17.6	B	17.6	B	17.6
	right	A	1.9	A	3.8	A	4.3	A	4.8
Main Street EB	left	D	43.6	F	140.1	F	249.5	F	369.7
	right	D	36.0	F	115.1	F	223.3	F	341.6
Intersection Totals		**B**	**16.6**	**D**	**51.5**	**F**	**97.1**	**F**	**152.1**

		without int. capture		**with 13.1% Int. Capt.**	
Approach	**Direction**	LOS	delay(s)	LOS	delay(s)
US15-501 NB	through	A	6.5	A	6.5
	left	B	10.9	B	10.4
US15-501 SB	through	B	13.1	B	13.1
	right	A	2.0	A	1.9
Main Street EB	left	D	46.0	D	43.6
	right	D	39.2	D	36.0
Intersection Totals		**B**	**18.0**	**B**	**16.6**

max. g measured
vph
497
411
908
750
617
1367
652
978
1630
3905

Main Street / US 15-501 Intersection Analysis



Appendix Q: Resident Survey

This Appendix presents a summary of the resident survey conducted by the research team of the Department of City and Regional Planning at the University of North Carolina at Chapel Hill. The following data tables and equations are those used for comparison with other trip generation methods used in this report.

Southern Village:

Southern Village contains a variety of housing types including single-family homes, apartments, condominiums and townhouses. The results from the resident survey were used to develop equations for the different residential land uses in the broad categories of single-family and multifamily residential. These equations can then be used in combination with land use intensities to estimate rates for generated traffic of each land use. The equations developed from the survey are all given in the following form:

$$\textit{Trip Rate} = \textit{Coeff}_1 * (\textit{Average Value}_1) + \textit{Coeff}_2 * (\textit{Average Value}_2) + \textit{Constant}$$

The two main variables in the equation were “Size of Household” and “Number of Vehicles”. For each of the variables an average value was calculated that remained constant across all calculations for Southern Village. In addition coefficients were calculated for each land use classification.

Residential land uses in Southern Village were divided in the classifications “All Households”, “Multi-Family Residential”, and “Single-Family Homes”. The survey produced separate equations for each of these categories that described the amount of total traffic generated. In addition, a fourth equation describes external traffic only for the “Single-Family Homes” category, which allows for a rough estimate of internal for that land use.

Table Q-1 below summarizes the calculated coefficients for the “All household” category

Table Q-1 Village Trip Generation "All Housholds"

	All Households				
	Coeff	**Average Val**			
Constant	0.586	1	0.586		
Size of Household	1.212	2.28	2.76336		
Number of Vehicles	1.781	1.65	2.93865	**Intensity**	**ADT**
		Rate	6.28801	1095	6885.371

Using the coefficients listed in table Q-1 the equation to describe the trip rate for all residential households is as follows:

Trip Rate (All Households) = 1.212*(2.28) + 1.781*(1.65) + 0.586
= 6.28801 trips/resid.unit/day

Multiplying the calculated rate with the overall intensity of residential housing in Southern Village yields the total number of average daily traffic generated from residential land uses. The resident survey therefore estimates 6885 trips per day estimated from all residences in Southern Village.

Similar to the example above, coefficient were developed for "Multi-Family" and "Single-Family" residential units separately. "Multi-Family" residential includes apartments, condominiums, and town homes in Southern Village. Tables Q-2 and Q-3 below summarize obtained coefficients. The equations used to calculate the rates are provided following each table.

Table Q-2: Southern Village Trip Generation "Multi-Family Households"

	Multi-Family				
	Coeff	**Average Val**			
Constant	0.288	1	0.288		
Size of Household	1.29	2.28	2.9412		
Number of Vehicles	1.62	1.65	2.673	**Intensity**	**ADT**
		Rate	5.9022	585	3452.787

Trip Rate (Multi-Family) = 1.29*(2.28) + 1.62*(1.65) + 0.288
= 5.9022 trips/resid.unit/day

Table Q-3: Southern Village Trip Generation "Single-Family Households"

	Single Family				
	Coeff	**Average Val**			
Constant	1.377	1	1.377		
Size of Household	1.111	2.28	2.53308		
Number of Vehicles	1.594	1.65	2.6301	**Intensity**	**ADT**
		Rate	6.54018	510	3335.492

Trip Rate (Single-Family) = 1.111*(2.28) + 1.594*(1.65) + 1.377
= 6.54018 trips/resid.unit/day

Finally, the survey derived coefficients for external trips only of single-family residential units. Table Q-4 shows coefficients and the equation used to calculate estimated vehicle from single-family homes that leave the development.

Table Q-4: Southern Village Trip Generation "Single-Family External"

	S/F External				
	Coeff	**Average Val**			
Constant	0.851	1	0.851		
Size of Household	0.833	2.28	1.89924		
Number of Vehicles	1.826	1.65	3.0129	**Intensity**	**ADT**
		Rate	5.76314	510	2939.201

Trip Rate (S/F External) = 0.833*(2.28) + 1.826*(1.65) + 0.851
= 5.76314 trips/resid.unit/day

Table Q-5: Southern Village Resident Survey Trip Estimates Summary

Survey Trip Generation Results for Southern Village			
Land Use Type	**Rate (veh. trips/unit)**	**Intensity (# of units)**	**Daily Traffic Forecast (veh.**
All Residential Households	6.29	1095	6885
Multi-Family Residential	5.90	585	3453
Single-Family Homes (SFH)	6.54	510	3335
SFH External	5.76	510	2939

Summarizing the survey results, Table Q-5 shows rates for each land use type, the intensity and the resulting daily traffic estimates. For the Single-Family homes category the table further shows external trips only. From the two SFH the internal capture rate then is calculated to be 11.9%. It is important to note that this internal capture rate only corresponds to Single Family homes and was obtained only from responses given in the resident survey. It therefore does not represent an interaction of land uses as in the ITE method and is not necessarily indicative of other residential classifications.

Lake Hogan Farms

In order to obtain a sufficient sample size of responses to the resident surveys, several neighborhoods in close proximity to Lake Hogan Farms were administered the same questionnaire. In the evaluation of the survey results two separate equations were developed one for Lake Hogan Farms alone, and a second one for all surveyed "Northern Carrboro" neighborhoods. The equations were developed in the same form as discussed above for Southern Village The following tables list the coefficients, average values and the completed equations for both data sets. In each case only the housing intensity for Lake Hogan Farms was applied.

Table Q-6: Lake Hogan Farms Trip Generation "Northern Carrboro Equation"

	Coeff.	**Average Val**			
Constant	1.457	1	1.457		
Size of Household	0.997	3.26	3.25022		
Number of Vehicles	2.234	2.11	4.71374	**Intensity**	**ADT**
		Rate	9.42096	252	2374.082

Trip Rate (Northern Carrboro) = 0.997*(3.26) + 2.234*(2.11) + 1.457
= 9.42096 *trips/resid.unit/day*

Table Q-7: Lake Hogan Farms Trip Generation "Lake Hogan Farms Equation"

	Coeff.	Average Val			
Constant	3.378	1	3.378		
Size of Household	1.166	3.26	3.80116		
Number of Vehicles	1.046	2.11	2.20706	**Intensity**	**ADT**
		Rate	9.38622	252	2365.327

Trip Rate (Lake Hogan Farms) = 1.166*(3.26) + 1.046*(2.11) + 3.378
= 9.38622 *trips/resid.unit/day*

The intensity in the above tables is the number of single family homes in Lake Hogan Farms. The calculated trips are average daily traffic estimates for the Lake Hogan Farms development. All trips can be considered external, because there is no internal capture in a single-land-use development. Table Q-8 below summarizes the results of the resident survey calculations for Lake Hogan Farms.

Table Q-8: Lake Hogan Farms Resident Survey Trip Estimates Summary

Survey Trip Generation Results for Lake Hogan Farms			
Land Use Type	Rate (veh. trips/unit)	Intensity (# of units)	Daily Traffic Forecast (veh.
Single-Family Homes (SFH) - "Northern Carrboro Equation"	9.42	252	2347
Single-Family Homes (SFH) - "Lake Hogan Farms Equation"	9.39	252	2365

Appendix R: Simulation

Why Simulation?

The literature review in Chapter 2 has identified time-dependent traffic simulations as a possible alternative in the assessment of traffic impacts of Traditional Neighborhood Developments (TND). To further assess the feasibility of using traffic simulations for Traffic Impact Analysis (TIA) applications, the scope of this report included creating a sample simulation model and evaluate its benefits versus time effort and cost.

While traffic simulations rely on other methods for trip generation (like the ITE method or a regional Travel Demand Model) it allows for a visual representation of traffic impacts on the simulated section of the road network. Traffic simulations such as CORSIM, SIMTRAFFIC or VISSIM may therefore become viable alternatives to the trip distribution and capacity analysis steps of a TIA. In recent years, consultants have used simulation models increasingly, because of their ability to represent and analyze system-wide traffic behavior. Furthermore, simulations have become a strong political tool, as they are relatively easy to follow visually and enable professionals to better convey traffic engineering concepts and findings to a broad public audience.

This appendix summarizes the process of constructing a simulation model of the Southern Village neighborhood in the VISSIM software package, developed by PT-Vision and the University of Karlsruhe, Germany. The VISSIM model was chosen over other models such as CORSIM or SIMTRAFFIC because its program code includes a “dynamic assignment” routine, which could feasibly be used to model internal travel behavior in the neighborhoods. Also, VISSIM includes a three-dimensional visualization of traffic, which increases its political marketability. For a more detailed discussion of benefits and drawbacks of traffic simulation models over other TIA methods please refer to the Literature Review in Chapter 2 of this report.

Objectives

For this project, only the Southern Village neighborhood was included in the simulation analysis. Southern Village is bigger than the Lake Hogan Farms development and was believed to be more interesting in a modeling application, as the interaction of different land uses leads to a significant amount of internal traffic (internal capture). The model developed includes the major roads within the neighborhood and collectors and arterials adjacent to the neighborhood.

Developing a simulation model of Southern Village had the following objectives:

- Built a model showing all major internal and external roads to the neighborhood
- Represent external traffic consistent with traffic counts taken at the entrances and exits to the development
- Incorporate internally generated traffic as predicted from the ITE trip generation method
- Evaluate traffic flow in the model visually

- Compare costs of developing the model with potential benefits for TIA application and make recommendations for future use

Method

Before programming a simulation model in VISSIM it is helpful to decide on assumptions for the model. In some cases values predefined in VISSIM may not be applicable for the region and need to be adapted accordingly to let the model behave accurately. Having decided on necessary data parameters in advance greatly facilitates data input and also assures consistency for the model. Table R-1 lists of assumptions was used for the Southern Village model:

Table R-1: List of Assumptions for VISSIM Model

Assumptions of VISSIM Model		
Turn curvature (Spline):	6 curve points for left, 4 for right turns, 2 for straight	
Priority rules:	Consistent with traffic rules	
Traffic Composition:	Assumed defaults	
Turning Movements:	All left turns into left lane (where applicable)	
	All right turns into right lane (where applicable)	
Signals:	Assume fixed-time signals	
	Assume field measurements for green allocation	
Speed Distribution:	Assume ± 4 mph of posted speed limit	
Ped. Speed Distribution:	Desired speed between 3.0 and 4.0 mph [3.0, 4.0] mph	
Speed Reductions:	Left Turns:	Cars [18.6, 24.9] mph
		HGV [15.5, 18.6] mph
	Right Turns:	Cars [15.5, 18.6] mph
		HGV [12.4, 15.5] mph
	Merge:	NONE
	Major Approaches:	NONE
	Minor Approaches:	Cars [18.6, 24.9] mph
		HGV [15.5, 18.6] mph
Gap acceptance:	Right Turn:	min. gap = 3.0 sec
		min. headway = 16.4ft (5m)
	Left Turn:	min. gap = 5.0 sec
		min. headway = 32.8ft (10m)
	Through:	min. gap = 5.0 sec
		min. headway = 32.8ft (10m)

The following steps were taken to complete the simulation model in the VISSIM software package.

1. Obtain an aerial photograph of the study area in the “Bitmap” file format (.bmp) with sufficient resolution to identify road features and building layouts. The availability of a GIS file containing an aerial photo layer, as well as, road centerlines and property lines may facilitate programming (the file still needs to be exported as a bitmap).

Then determine the scale of the photo file by identifying known features and providing the software with an accurate distance measurement between two landmarks.

2. Layout the road network as desired by following road alignments visible in the aerial photo or centerlines in a converted GIS file.
3. Join roads with left turn and right turn connectors. It may be desirable to decide on a fixed number of “curve points” (Spline) for consistency.
4. Configure Speed Distributions to be used by vehicles in zones of a certain speed limit (in this case for 25mph, 35mph, and 45mph). Also configure speed distribution for pedestrians.
5. Input traffic compositions for regular traffic (% trucks) and pedestrian traffic
6. Enter vehicle generators into the network with traffic volumes and time distribution of traffic (US15-501 NB and SB; Mt. Carmel Church Rd NB; Culbreth Rd. EB; Internal Generators)
7. Specify desired speed distributions (speed limits) following traffic generator points and at locations where speed limit changes
8. Insert speed reduction zones at intersections (turning movements and throughs)
9. Program Routing Decisions following generator points and at the three entrance points to the development
10. Place stop signs where applicable
11. Enter necessary priority rules at all unsignalized intersections
12. Program signal timings for signalized intersection and add priority rules where necessary

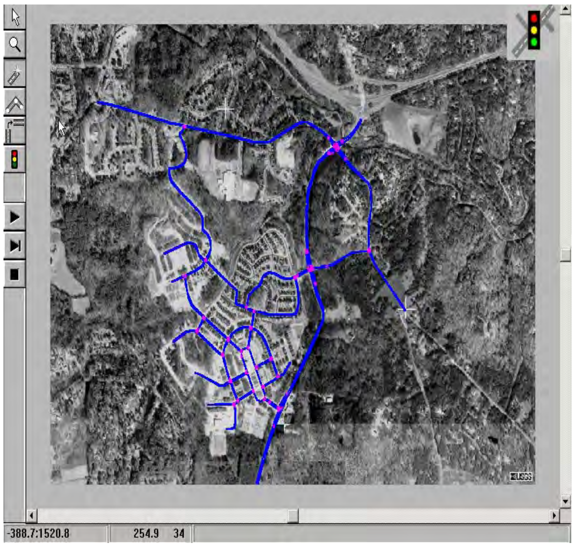
Table R-2 summarizes the method and includes estimates of working hours spent for each step.

Table R-2: VISSIM Programming Time

VISSIM Time Sheet		
	Taks	**Time**
1	Aerial photo	4.0
2	Road Network	9.5
3	Draw Connectors	5.0
4	Speed Distributions	1.0
5	Traffic Compositions	1.0
6	Traffic Generators	12.0
7	Speed Limits	1.0
8	Speed Reductions	3.0
9	Routing Decisions	15.0
10	Stop Signs	1.0
11	Priority Rules	6.0
12	Signal Timing	4.5
13	Operations	10.0
14	Tutoral	27.0
15	Other	30.5
	TOTAL	**130.5**

In the following several screenshots of the completed simulation model are shown. Figure R-1 shows the aerial photograph and the entire superimposed VISSIM model. The aerial photo was taken before the entire neighborhood was completed, but included sufficient detail to allow for programming.

Figure R-1: Overview of VISSIM model



The next two images show close-ups of two intersections modeled in the VISSIM simulation of Southern Village. Figure R-2 shows the intersection of Main Street and US15-501, the main entrance and exit into the development. In the background the one-way loop in the commercial village center of Southern Village is visible. The parking lot inside the loop serves as a traffic attractor and generator. The image is provided in the three-dimensional view featured in the VISSIM software.

Figure R-2: Intersection of US15-501 and Main Street

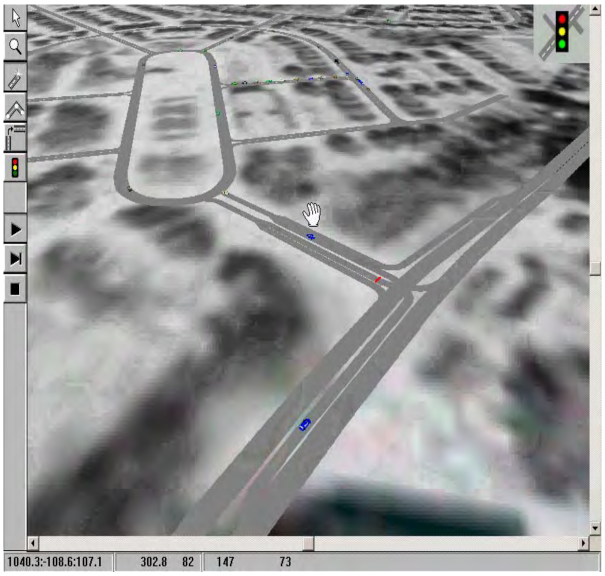
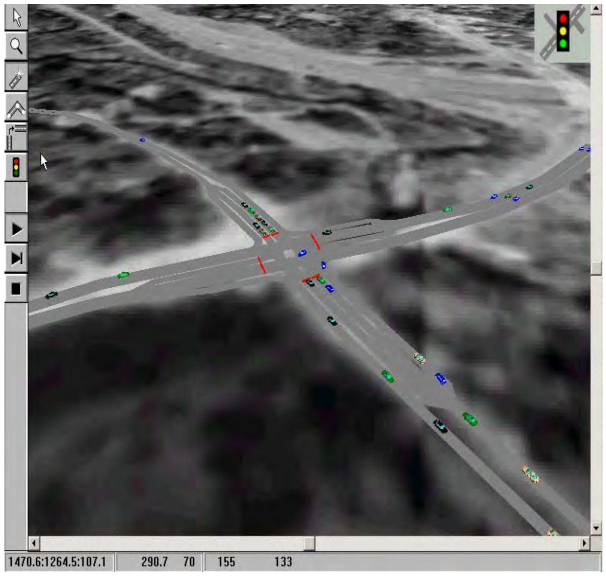


Figure R-3 shows the intersection of US15-501 and Culbreth Rd. located to the north of the neighborhood. The latter intersection is most likely to be affected by traffic generated by the development.

Figure R-3: Intersection of US15-501 and Culbreth Road



Discussion

The experience with the VISSIM software package has shown that the programming of an accurate representation of a TND neighborhood and surrounding streets requires a significant time input and specifically trained staff. More importantly the successful implementation of the simulation model requires trip generation and trip distribution estimates derived from other methods. For the visual analysis of the traffic impacts of one isolated neighborhood as was done here with Southern Village, the costs in training and programming time therefore exceed the benefits of having a dynamic, optical representation of predicted traffic flows.

However, for future traffic impact assessments and as a regional planning tool, time-dependent traffic simulation may prove to be a very powerful tool. Simulation software represents the unique ability to model the interaction of several TND neighborhoods along the same corridor for example. Traffic Simulations may therefore provide an insight in traffic impacts and road network capacity for multiple TND developments. They allow for a fast and easy adjustment of traffic volumes and roadway modification and show impacts of such changing conditions visually, as well as, in the form of delay and travel time data output.

With an anticipated simplification of programming effort in the future and decreasing time requirements for creating models, simulation methods are likely to find their place as a TIA tool in the future. They allow the addition of public transportation modes and pedestrian movements in the modeling process, which will become an ever more important issue as the number of TND neighborhoods increases.

As discussed in Chapter 2, it may also become feasible in the future to integrate traffic simulations with regional travel demand model, which would greatly facilitate the required amount of data input. Such methodology would possibly allow using regional traffic generation data for overall network analyses and inserting simulation models in specific areas that require a more focused assessment.

Transportation Planning for Heartland Town Square-

A Major Regional Mixed-Use Project

Brentwood, NY

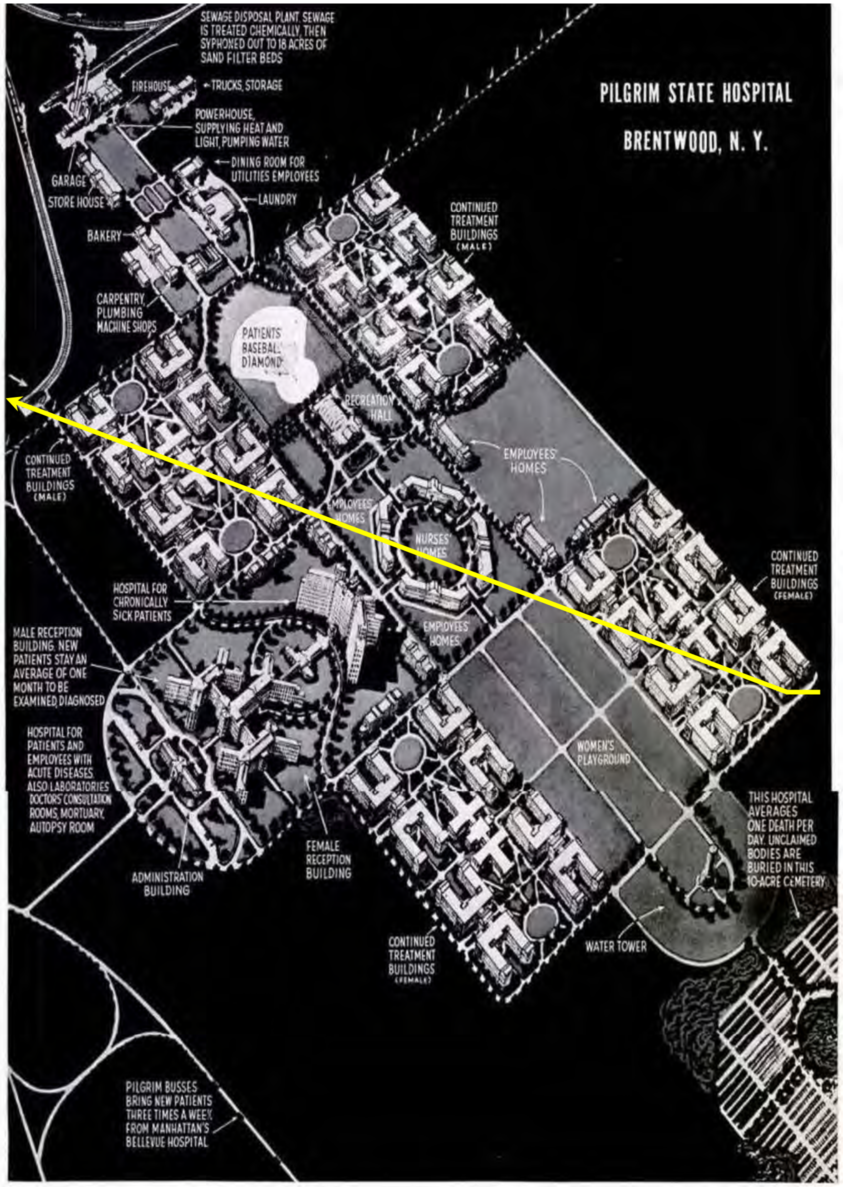
Presented to:
ITE 2011 Northeastern District Meeting

Presented by:
Robert M. Eschbacher, PE
VHB Engineering, Surveying & Landscape Architecture, P.C.

May 26, 2011

The Story

- Downtowns are the key to reversing troubling trends
- Nassau County has virtually nowhere left to build, and Suffolk's open space could be gone within a decade
- **Young adults move away**
- Smart Growth at Heartland Town Square (HTS)
  - Residents live close to work
  - Shops, other businesses and civic uses merge in an integrated neighborhood environment
  - Minimizes the need for single occupancy vehicles



The History

- Pilgrim State Hospital was named after Dr. Charles W. Pilgrim, Commissioner of Mental Health in the early 1900s
- When it was built, Pilgrim was the largest facility of its kind in the world

TRAIN STATION

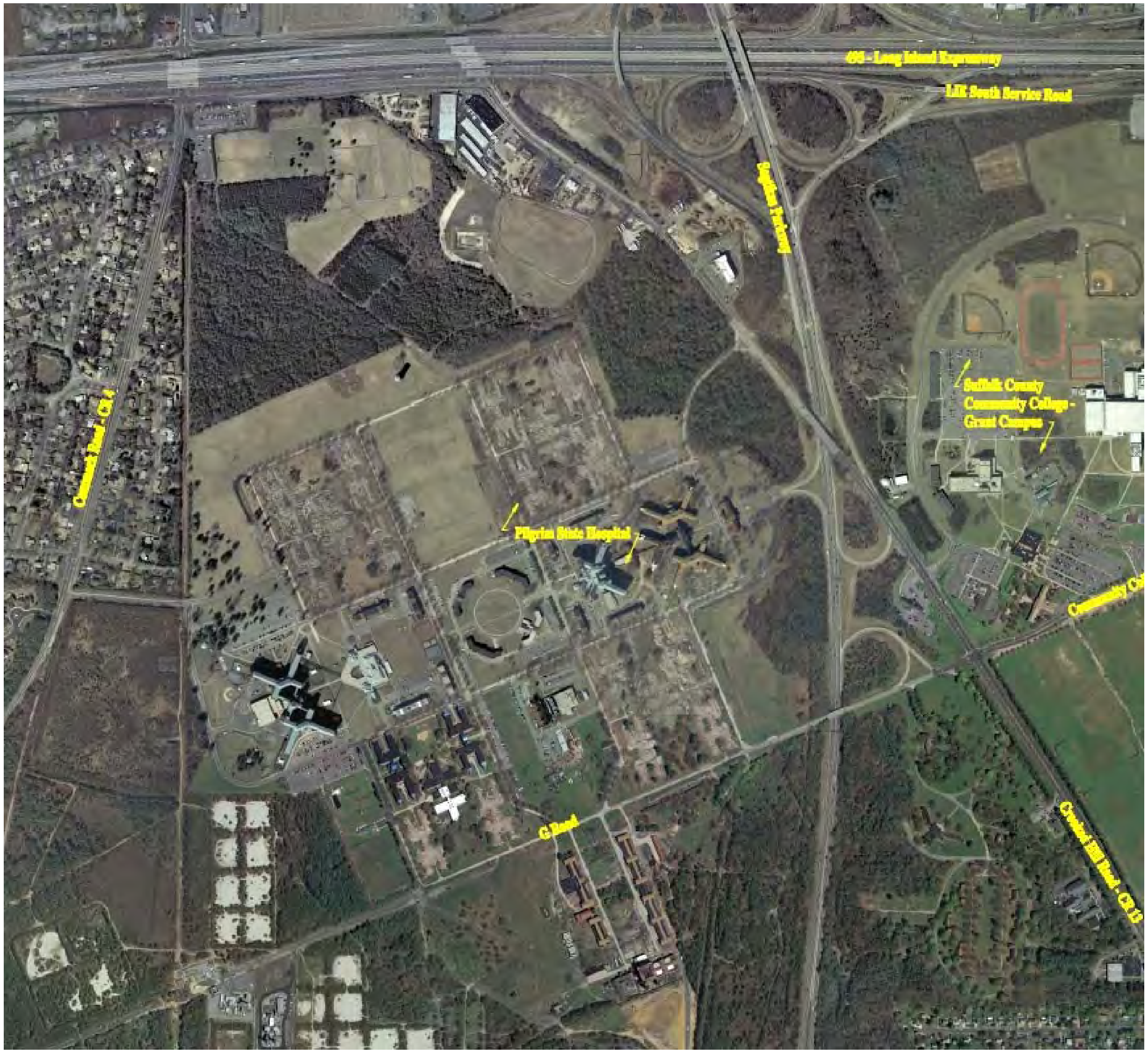
The History

- NYS bought approx. 1,000 acres of land in Brentwood and began construction of Pilgrim in 1930
- Opened in 1931, Pilgrim had its own LIRR station, fire and police departments, power plant, potters field, swine farm, church, water tower, and staff housing
- Underground tunnels were used for transporting food as well as carrying steam pipes
- The number of patients peaked in 1954 with 13,875

The Present

- As patients were discharged and services became available in the community, the need for large facilities to treat the mentally ill diminished
- Today, Pilgrim reflects the history and best practices for care and treatment and has become a modern healthcare delivery system serving the mentally ill adults of Long Island

The Present



495 - Long Island Expressway
LIE South Service Road
Suffolk County
Community College -
Grant Campus
Pilgrim State Hospital
G Road
Crooked Hill Road - CR 13

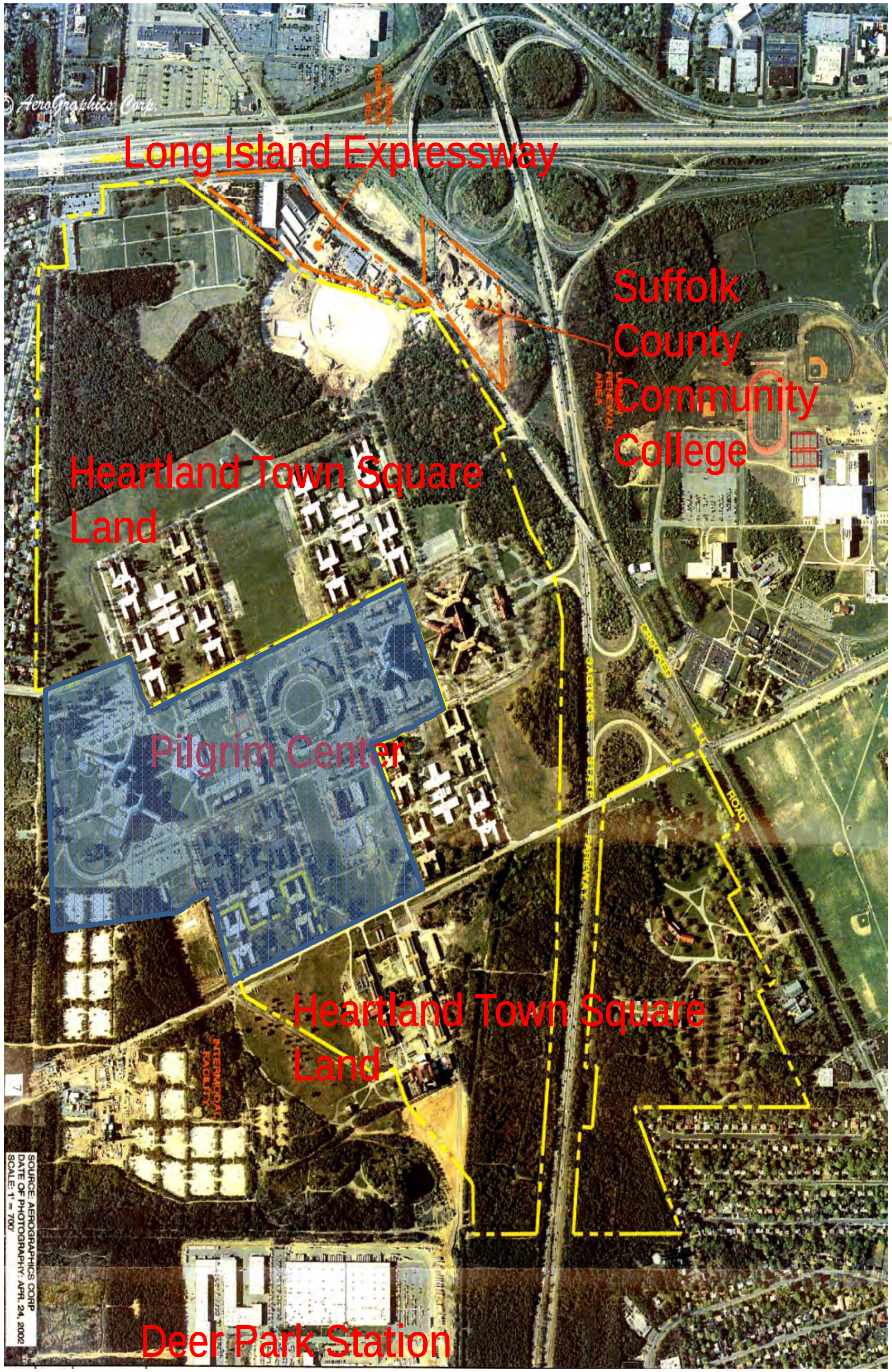
The Future

Table of Uses by Phase

Use	Phase I	Phase II	Phase III	TOTAL
Residential (units)	3,500	3,500	2,000	9,000
Office (SF)	625,000	1,600,000	1,125,000	3,350,000
Civic (SF)	210,500	5,000	0	215,500
Retail (SF)	560,000	390,000	50,000	1,000,000

Trips Generated and Reduced by Internal Capture

	AM Weekday	PM Weekday	Saturday Midday
Full Build (unadjusted)	6,041	9,252	7,003
Full Build (adjusted)	5,184	7,440	5,395
Internal capture rate	14%	20%	23%



The Future

- The Planned Redevelopment District occupies 476 acres of land decommissioned by the State
- It is strategically located close to LIRR at the junction of the Long Island Expressway and the Sagtikos Parkway at the midpoint of Long Island