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TRAFFIC IMPACT ANALYSIS FOR HIDDEN LAKES, McKINNEY, TEXAS

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TRAFFIC IMPACT ANALYSIS
FOR HIDDEN LAKES,
McKINNEY, TEXAS

by

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ABSTRACT

TRAFFIC IMPACT ANALYSIS

FOR HIDDEN LAKES,

McKINNEY, TEXAS

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Approximately 27 acres of undeveloped property located in McKinney, Texas is to be developed with two commercial pads along US 380 and the remaining land to be used for single-family homes. There are four steps to a Traffic Impact Analysis: trip generation, trip distribution, mode choice, and trip assignment. Trip generation is a function of household size, vehicles per home, employees, age, income, land use, and size of building. Trip distribution takes into account the information from trip generation and the travel time from the new development to other zones. Mode choice analyzes different alternatives of transportation based on travel time and cost. Finally, trip assignment predicts the route a vehicle will take based on road capacity and travel time.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Land development projects differ from each other depending on land use desired by the client and by location. Hidden Lakes is mainly a residential neighborhood to be designed with single-family dwelling units and two commercial pads on the north end of the site. Its location is south of US 380, a regional freeway, and west of Custer Road, a major north/south arterial in McKinney, Texas. This 27-acre site is located between Wal-Mart on the east and Aero Country Airport and a lake on the west. South of the development is an existing neighborhood by the name of Virginia Hills. This development consists of homes with property values predicted to range from $100,000 to $200,000. Figure 1.1 and 1.2 show a map and an aerial of the location of the site.

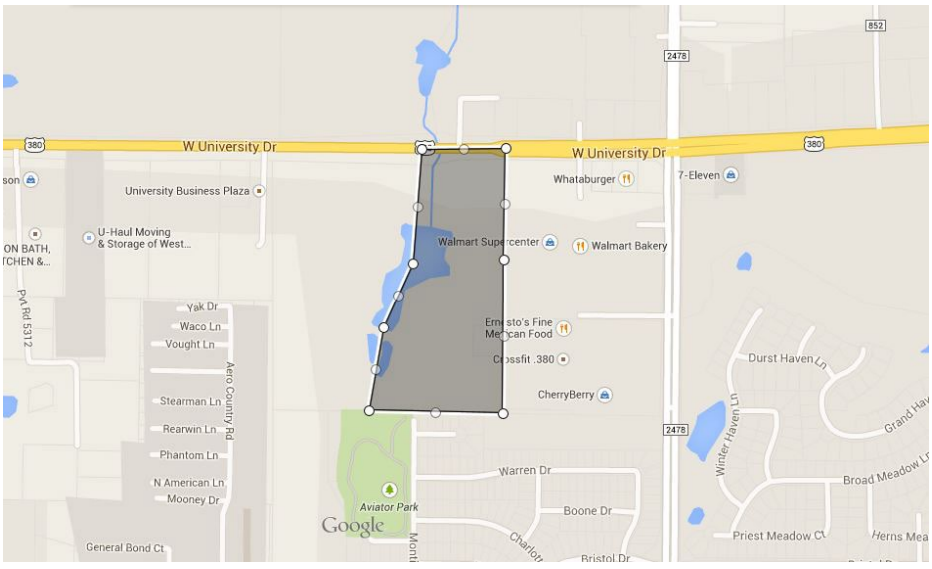

Figure 1.1: Location of Hidden Lakes Development from Google Maps

Figure 1.2: Aerial View of Project Site

1.1.1 Project Design

Hidden Lakes is designed with 56 single-family property lots of minimum width and depth of 70 feet and 120 feet, respectively. There will be five roads in the new subdivision, with one of two main roads connecting to an existing neighborhood south of the new development. The commercial pads must be at a minimum of 250 feet deep from the right-of-way (ROW) of US 380. The collector ROW through the commercial area is to be 60 feet and reduced to a 50 feet ROW upon entering the residential development. The size of the roads will affect the flow and capacity of traffic; therefore, it will affect the Traffic Impact Analysis and the Traffic Control Plan. Figure 1.3 shows the layout of the lots and streets in the new development.

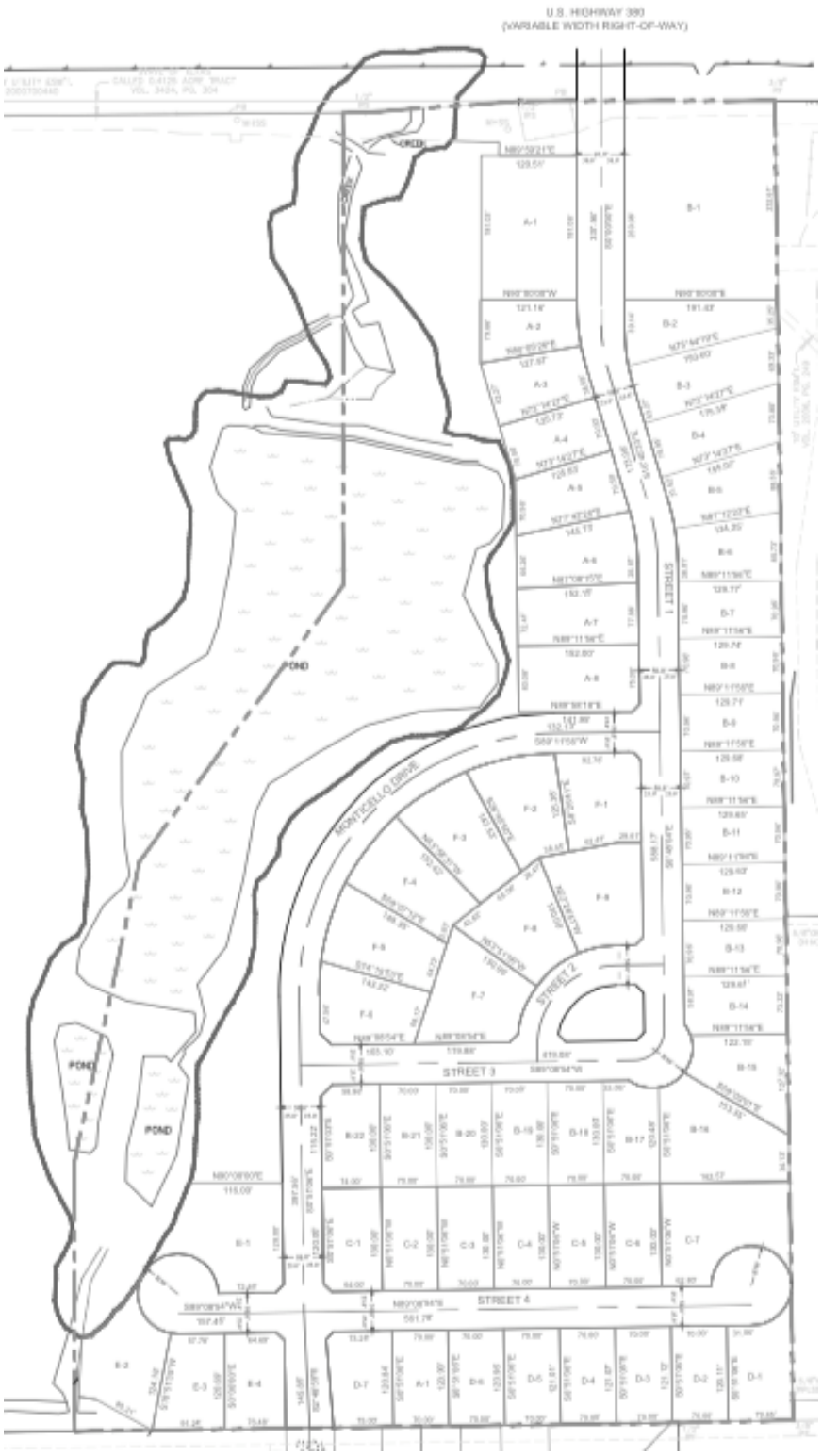

Figure 1.3: Lot Layout of Hidden Lakes

1.1.2 Street Design

The residential streets (R2U) must be at a minimum of 50 feet ROW and 26 feet F-F (or 27 feet B-B). The design speed is 30 mph, thus the minimum stopping sight distance is 200 feet. The minimum allowed horizontal curve radius is 250 feet for an R2U classification street. To find the minimum length of a vertical curve, the equation L=KA can be used. A is the grade difference, with the minimum and maximum street grades 0.6% and 8.0%, respectively, for an R2U street. The minimum K value for a crest vertical curve and a sag vertical curve are 19 and 37, respectively. A block cannot be longer than 1200 feet through a residential neighborhood to prevent racing.

Each street in the proposed residential development will have two driving lanes and one parking lane on each side of the street. The driving lanes in the 60' ROW are 18.5 feet wide and lanes are 13.5 feet wide in the 50' ROW. The parking lanes are all 11.5 feet wide.

1.2 Project Objectives

A Traffic Impact Analysis (TIA) is required for a new development when it is adjacent to and takes access from a TxDOT roadway. The project Hidden Lakes is developed directly south of US 380, a major freeway in McKinney. The TIA consists of a four-step traffic forecasting process – trip generation, trip distribution, mode choice, and, finally, trip assignment. A map defining the site and the area boundaries is shown on page 3. Other Traffic Analysis Maps required for a TIA are given in Appendix A.

1.2.1 Trip Generation

Trip Generation for a residential development predicts the number of trips produced from a residential zone and the attraction to another zone. Travel demand is

categorized into Home-Based Work (HBW) trips, Home-Based Non-Work (HBN) trips, and Non-Home (NH) trips. HBW trips are trips from home to work and work to home. HBN trips are home to/from non-work trips. NH trips are trips where the origin and the destination are not home-based (CrimeStat). In trip generation, the trip production and the trip attraction for each zone is modeled. Traffic Analysis Zones (TAZ) are analyzed to determine the number of productions and attractions for each zone.

1.2.2 Trip Distribution

Trip distribution models the number of trips from the origin zone to the destination zone. The Gravity Model applies Newton's Theory of Gravity to model this attraction of one zone to another. The difference between trip generation and trip distribution is that trip generation calculates the number of trip ends in each zone, but trip distribution connects the trip ends to for trip interchanges (T_{ij}) (Fricker 206).

1.2.3 Mode Choice

Using a *multinomial logit* (MNL) *model*, the mode choice will be predicted. "The MNL model incorporates the notion that a traveler with a choice tends to choose the travel mode that has the greatest *utility* to him/her, but it also recognizes that (a) the utility may be difficult for the modeler to measure and (b) individual travelers may perceive the same mode choice alternatives in different ways" (Fricker 217).

1.2.4 Trip Assignment

Trip assignment is the last step of the four-step traffic modeling process. It is assumed that trip makers will choose the origin-destination path that has the shortest travel time (Fricker 228). The capacity of the road, free-flow travel time, speed, and cost

affect the flow rate of the routes. A graphic representation plots Travel Time vs. Vehicle Flow Rate using *user equilibrium*.

CHAPTER 2

TRIP GENERATION

In this chapter, the first step of the four-step modeling process will be presented. Hidden Lakes is a residential development; therefore, the Home-Based Work (HBW) model and the Home-Based School (HBS) model are used to produce the estimations for trip generation. Home-based trips are trips that leave and return to the homes in a certain Traffic Analysis Zone (TAZ). Home-end trips (trips that have the home as beginning and end of a total trip) are a function of number of housing units, household size, age, income, and number of vehicles owned. In trip generation, there are two sub-models – trip productions and trip attractions. A residential zone produces trips, while a non-residential zone attracts trips. A higher productions and attractions for the zones generates a higher number of trips, which will directly affect Trip Distribution (Chapter 3) and Trip Assignment (Chapter 5).

2.1 Trip Purpose

Every trip has a beginning (the origin) and a destination. These trips are categorized into different purposes that affect the destination. The trip purpose affects the travel distance, the travel time, and the time of day of travel. Two factors that largely control Trip Purpose are age and gender. Gender and age determine what types of activities are more favorable or whether the person works or goes to school. According to the 2010 census, McKinney is 50.9% female, 47.9% of McKinney's population is between the ages of 18 and 65, and 32.0% are under 18 (McKinney).

The three types of trips that are going to be considered in this traffic impact analysis are home-based work (HBW), home-based other (HBO), and non-home-based (NHB).

2.2 Trip Productions and Attractions

The home ends of home-based trips are defined as productions. The number of trip productions for Hidden Lakes, a single-family residential zone, is based on the number of households in the zone. According to the NCHRP Report 365, the origin can be both the production end and the attraction end, if the trip-maker is returning home to the origin (Martin). Rates and equations will be taken from the ITE Trip Generation Handbook and from the NCHRP Reports 365 and 716.

2.2.1 Census Data Obtained

Hidden Lakes residential development will have 56 single-family dwelling units. According to City-Data.com, zip code 75071, where Hidden Lakes is located, has a median household income of $107,257 and the median house/condo value is $243,573 (City-Data). Based on these numbers, it can be assumed that each household for the new development will have at least one working member. The average household size is 2.91 (non-family households) and the average family size is 3.94 (McKinney). To be conservative, the average number of people per home in Hidden Lakes will be 3.94.

2.2.2 Traffiz Analysis Zones

Four traffic analysis zones were chosen, two small and two large.

Zone 1: Hidden Lakes

Zone 2: Wal-Mart and other businesses

Zone 3: Plano

Zone 4: Frisco

These TAZs were chosen because the existing Wal-Mart and commercial area to the east draws in a lot of traffic, based on the AADT along US 380 (Table 5.1). The average work travel time is 28.5 minutes for residents of McKinney. Zones that were within the average work travel time were also desirable, thus the large TAZs of Plano and Frisco were chosen.

2.2.3 Trip Productions and Attractions

The trip rates shown in Table 2.1 and 2.2 are from the ITE *Trip Generation Manual, 9th Edition*. The Trip Generation Manual is used to determine the trip productions (leaving) and the trip attractions (entering) for the Hidden Lakes development, which includes single-family dwelling units and commercial area (Zone 1), and for the commercial area east of the new development (Zone 2). Since the commercial lots have yet to be developed, the square footage of each business for these lots are assumed to be 15, 000 square feet (SF).

ITE Code	Anticipated Land Use	Unit	Average Rate	Entering	Leaving	Trips
210	Single Family Dwelling Unit	DU	10	50%	50%	10
826	Specialty Store	1000 S.F.	44.32	50%	50%	T = 52.78X +37.66

Table 2.1: Trip Rates for Hidden Lakes (Zone 1) (ITE)

The existing commercial area has a Wal-Mart, one fast food restaurants with a drive-thru, three fast food restaurants without a drive-thru, two sit-down restaurants, three retail shops, and one drive-in bank. To calculate the trips, square footage of each type of

usage is required. The square-footage of these businesses was determined based off the companies' respective reports of average square footage. For the two non-major chain restaurants and for the retail businesses, the average square footage of similar restaurants was used. For Zone 2, the following average square footages are used:

- 24-hour convenience store = 182,000 SF (Walmart)
- Three existing retail clothing stores = 8,000 SF each (Heschmeyer)
- One fast-food with drive-thru = 2700 SF (Average)
- Three fast-food without drive-thru = 2000 SF each (Chopped)
- Two sit-down restaurants = 5000 SF each (Huebsch)
- One drive-thru bank = 1500 SF (White)

The following table tabulates the average trip rates and the percentage entering and leaving.

ITE Code	Anticipated Land Use	Unit	Average Rate	Entering	Leaving	Trips
851	24-hour Convenience Store	1000 S.F.	737.99	50%	50%	T = 42.78X +37.66
932	Sit Down Restaurant	1000 S.F.	127.15	50%	50%	Not Given
933	Fast Food w/o Drive Thru	1000 S.F.	716	50%	50%	Not Given
934	Fast Food w/ Drive Thru	1000 S.F.	496.12	50%	50%	Not Given
912	Drive-In Bank	1000 S.F.	148.15	50%	50%	Not Given
826	Specialty Retail	1000 S.F.	44.32	50%	50%	T = 52.78X +37.66

Table 2.2: Trip Rates for Existing Commercial to the East (Zone 2) (ITE)

Unlike the first two zones, Zones 3 and 4 trip production and attraction will be based on households and employment, with rates obtained from the NCHRP Reports 716 (for trip production) and 365 (for trip attraction). The ITE *Trip Generation Manual* cannot be used to determine trip productions and attractions for zones 3 and 4 since it is nearly impossible to number each and every type of business in each city for the scope of this development and project. For Plano and Frisco, the number of households in the cities was obtained from the 2010 census for each respective city. The total employment percentage in retail, service, and other employment were obtained from (Sperling).

In Table 2.3, the average income and the number of household for Plano and Frsico are provided, along with the production rates for home-based work (HBW), home-based other (HBO), and non-home based (NHB) trips. These production rates are obtained from NCHRP Report 716 (Tables B.1, B.2, and B.3) and are based on the income and number of households for the zone.

Zone	Income	Household	HBW	HBO	NHB
Plano	$82,484	80,875	2.1	5.3	3.3
Frisco	$109,956	50,500	2.6	5.3	4.7

Table 2.3: Trip Production Rates for Plano and Frisco (Zones 3 and 4) (NCHRP)

The following two tables are the rates used to find the trip attractions in zones 3 and 4. The trip attraction rates in Table 2.4 are from the NCHRP Report 365 (Table B.4). The employment percentages in Table 2.5 are from Sperling, which gives the percentages of different types of employment for each city.

Trip Type	# of HH	Retail	Service	Other	Total
HBW	0	0	0	0	1.45
HBO	0.9	9	1.7	0.5	0
NHB	0.5	4.1	1.2	0.5	0

Table 2.4: Trip Attraction Rates for Plano and Frisco (Zones 3 and 4) (NCHRP)

Zone	Retail (%)	Service (%)	Other (%)	Total (%)
Plano	30.09	22.12	47.79	100
Frisco	29.96	22.01	48.03	100

Table 2.5: Employment Percentages in Plano and Frisco (Sperling)

Trip productions for each zone are found using the average square footage and/or number of households. The spreadsheets are shown in Appendix C. To find the trip productions in Zones 1 and 2, first find the average trip rate in the zone. For a weekday, each land usage has a 50% entering and 50% leaving rate. 50% of the average weekday trip rate will be trip production. Since Zones 3 and 4 are much larger than zones 1 and 2, a different approach is used to find trip production. The trip productions are calculated from trip production rates for HBW, HBO, and NHB trips based on number of household and the average income for each zone.

Zone 1 has a total trip production of 723, Zone 2 had a production of 285,037, Zone 3 had a production of 865,363, and Zone 4 had a production of 636,300. Recall that Zones 3 and 4 are whole cities, therefore, their trip productions are much greater the trip productions from Zones 1 and 2. The trip productions are shown in Table 2.6 to compare with trip attractions.

Similar to trip production, the trip attraction is calculated from the number of households, the square footage of businesses, and/or the employment of the respective zones. 50% of average weekday trips are the trip attractions for Zones 1 and 2. The trip attraction for Zone 1 is 1099, for Zone 2 is 10,739, for Zone 3 is 1,920,311, and for Zone 4 is 958,932.

2.3 Trip Generation Results

Zone 1 has significantly lower productions and attractions because it is a small zone with only 56 single-family dwelling units and two commercial lots. Zone 2 is purely retail and commercial; thus the productions and attractions are higher than Zone 1. Zones 3 and 4 are whole cities, therefore, the trip productions and attractions are much greater. Frisco is a smaller city; therefore, its trip productions and attractions are lower than Plano.

Zones	Productions	Attractions
1 (Hidden Lakes)	723	723
2 (Existing Commercial)	72,465	72,465
3 (Plano)	865,363	1,920,311
4 (Frisco)	636,300	958,932
Total	1,575,073	2,952,653

Table 2.6: Summary of Trip Productions and Trip Attraction

Notice that Zones 1 and 2 have equal trip productions and trip attractions because, on a weekday, 50% of the average weekday trips enter and 50% leave the zone. Zones 3 and 4 do not have equal productions and attractions because they are calculated using trip rates exclusive to each trip model. The trip productions and attractions in Zone 1, the

focal point of the TIA, yields reasonable numbers for 27 acres of a largely residential area and two commercial lots.

CHAPTER 3

TRIP DISTRIBUTION

In this chapter, the second step of the four-step modeling process is presented. In the trip generation step, only the trips in each trip end were calculated. In the second step, the trip ends are connected and number of trips between the two ends is calculated. The number of trips produced in Zone i and attracted to Zone j is called *trip interchanges*. The Gravity Model will be used calculate the trip interchanges. As the name suggests, it is much like Newton's Theory of Gravity. The Gravity Model assumes that the attraction of a zone is proportional to the productions of another zone and inversely proportional to the total attractions of all the Traffic Analysis Zones (TAZ). The Gravity Model has two principal assumptions (Fricker 207):

(1) Trips produced in Zone i is most likely going to be attracted to a Zone j with higher attractions.

(2) Trips produced in Zone i is most likely going to be attracted to a Zone j with lower travel time.

3.1 Trip Distribution Calculations

The Gravity Model uses an equation similar to Newton's gravity equation. The equation is a function of travel time and the trip productions and attractions at each trip end. The equation is based on Newton's gravity equation and on the two principal assumptions stated above.

$$T_{ij} = \frac{P_i A_j F_{ij}}{\sum_{j=1}^{n} A_j F_{ij}}$$

Where

$T_{ij} = trip\ interchanges$

$P_i = production\ in\ Zone\ i$

$A_j = attraction\ in\ Zone\ j$

$F_{ij} = t_{ij}^{-2} = friction\ factor\ (travel\ time\ factor)$

$t_{ij} = travel\ time\ between\ zone\ i\ and\ zone\ j$

Using the results produced from trip generation and the average travel times between zones, the trip demand can be found. The average travel times were determined by averaging travel times between zones through various times of the day based on Google Maps. Recall that Zones 3 and 4 were chosen based on McKinney's average work travel time of 28.5 minutes. Looking at Table 3.1, t_{11}, t_{22}, t_{33}, and t_{44} are all equal to zero (0) minutes. Since the trip ends are the same zone, the travel time is zero (0).

Travel Time, t_{ij}		Destinations, j			
		Zone 1	Zone 2	Zone 3	Zone 4
Origin, i	Zone 1	0	5	16	36
	Zone 2	5	0	28	28
	Zone 3	14	26	0	20
	Zone 4	32	30	20	0

Table 3.1: Travel Times Between Zone i and Zone j

Using Table 2.6 and Table 3.1, the equation above is used to determine the trip interchanges between zone i and zone j.

3.2 Trip Matrix

The trip interchanges between each zone are tabulated below. Notice, in Table 3.2, that the trip interchanges between Zones 3 and 4 are very high, which is reasonable since Zone 3 is Plano and Zone 4 is Frisco. The trip interchanges between Zones 2 and 3 may not be reasonable because the businesses in Zone 2 are very common in almost all large cities. Zone 2 consists of a Wal-Mart, Chase Bank, McDonald's, Whataburger, Subway, and other businesses. Since Zone 1 is the main focus of the Traffic Impact Analysis, the focus of the trip interchanges will be placed there.

Trip Interchange, T_{ij}		Destination, j			
Origin, i		Zone 1	Zone 2	Zone 3	Zone 4
	Zone 1	0	337	172	436
	Zone 2	62,906	0	4,077,059	2,035,931
	Zone 3	18,340	4,077,059	0	47,652,603
	Zone 4	70,454	1,176,822	70,167,233	0

Table 3.2: Trip Interchanges Between Zone i and Zone j

CHAPTER 4

MODE CHOICE

In this chapter, the third step of the four-step modeling process is presented. Mode choice is the process in which transportation choices are determined. There are three groups of transportation – auto, transit, and non-motorized. The factors that affect mode choice vary with the type of transportation mode. Calculations were done using rates and equations obtained from the North Central Texas Council of Governments (NCTCOG). The Multinomial Logit (MNL) Mode Choice Model is used to determine mode choice. This model takes into account that a trip-maker with a choice of transportation mode will choose the mode with the greatest benefit, or utility.

4.1 Mode Choice Calculations

In the Dallas-Fort Worth Metroplex, the percentage of people driving is much greater than the number of people who take public transportation. If the average work travel time is 28.5 minutes by car, then by transit it would be much longer thus highly undesirable. For the sake of this development, the mode choice will be determined between driving alone, carpooling with two people, and carpooling with three or more people per car. The use of transit in McKinney will also be neglected for the sake of this TIA for this development. Each of mode choice percentages will be calculated individually for home-based work, home-based other, and non-home-based trips. Table 4.1 compiles the rates needed to perform mode choice and are obtained from the

NCTCOG Mode Choice Model Documentation. The utility functions required are also taken from NCTCOG's documentation. After the utility functions for each trip interchange is found, the mode choice probability is:

$$P_i = \frac{e^{V_i}}{\sum e^{V_j}}$$

Where V_i is the utility of one trip interchange and V_j are all the utilities of each trip interchange.

4.1.1 Utility Functions

There are several factors that affect a trip-maker's decision about which mode of transportation to take for the trip. Cost and travel time are two essential variables that will influence a trip-maker's mode choice decision (Fricker 217).

	HBW	HBO	NHB
AUTO2	-3.457	-0.992	-0.992
AUTO3	-5.116	-4.464	-4.464
AUTOIVTT	-0.052	-0.016	-0.016
AUTOCOST	-0.77	-0.194	-0.194
AULTPER	1.197	0.935	—
LOWINC	0.439	—	—
MEDINC	—	-0.099	—
HIGHINC	-0.372	-0.23	—
HHSIZE (2)	—	0.099	—
HHSIZE (3+)	—	1.111	—
CBD	—	-0.447	-0.447

Table 4.1: Utility Function Constants (NCHRP)

Where

AUTO2 = two occupants per vehicle

AUTO3 = three or more occupants per vehicle

AUTOIVTT = auto travel time in minutes

AUTOCOST = total auto cost (operating and parking costs) in dollars

AULTPER = 1 if fewer autos in household than persons, 0 otherwise

LOWINC = 1 if household income is less than $30,000, 0 otherwise

MEDINC = 1 if household income is between than $30,000 and $75,000, 0 otherwise

HIGHINC = 1 if household income is greater than $75,000, 0 otherwise

HHSIZE = number of persons in household

McKinney average household size = 3.99

Plano average household size = 3.18

Frisco average household size = 3.13 (Census)

CBD = attraction zone is CBD (Central Business District) area type

The final utility functions are based on the type trip made and the mode of transportation (drive alone, 2 people carpool, or 3+ people carpool, for this TIA). From the "NCTCOG Mode Choice Model Estimation", the utility equations used for this third step of the modeling process are as follows, using the rates above in Table 4.1.

Home-Based Work Utility Functions:

Drive alone utility = – 0.052*(AUTOIVTT) – 0.77*(AUTOCOST)

Auto 2 person utility = – 0.052*(AUTOIVTT) – 0.77*(AUTOCOST)
+ 1.197*(AULTPER) + 0.439*(LOWINC) – 0.372*(HIGHINC) – 3.457

Auto 3+ person utility = – 0.052*(AUTOIVTT) – 0.77*(AUTOCOST)
+ 1.197*(AULTPER) + 0.439*(LOWINC) – 0.372*(HIGHINC) – 5.116

Home-Based Other Utility Functions:

Drive alone utility = – 0.016*(AUTOIVTT) – 0.194*(AUTOCOST)

Auto 2 person utility = – 0.016*(AUTOIVTT) – 0.194*(AUTOCOST)
+ 0.935*(AULTPER) – 0.099*(MEDINC) – 0.230*(HIGHINC)
+ 0.099*(HHSIZE) – 0.447*(CBD) – 0.992

Auto 3+ person utility = – 0.016*(AUTOIVTT) – 0.194*(AUTOCOST)
+ 0.935*(AULTPER) – 0.099*(MEDINC) – 0.230*(HIGHINC)
+ 1.111*(HHSIZE) – 0.447*(CBD) – 4.464

Non-Home Based Utility Functions:

Drive alone utility = – 0.011*(AUTOIVTT) – 0.200*(AUTOCOST)

Auto 2 person utility = – 0.011*(AUTOIVTT) – 0.200*(AUTOCOST) –
– 0.754*(CBD) – 0.902

Auto 3+ person utility = – 0.011*(AUTOIVTT) – 0.200*(AUTOCOST) –
– 0.754*(CBD) – 1.178

For out-of-pocket cost, the cheapest gas price of Dallas was used for the calculations. Let the gas price be $2.35.

4.1.2 Mode Choice Results

Zone 1 is the focal point of the TIA, therefore, mode choice calculations were performed where zone 1 was the production or the attraction. Once the utility functions

V_i are calculated, use $P_i = \frac{e^{V_i}}{\sum e^{V_j}}$ to find the mode choice probability for each mode of transportation.

For trips to and from Zone 1, based on the mode choice calculations, 74.9% of the trip-makers will drive alone, while 25.1% will carpool. 16.8% of the carpoolers will travel with two people in the car, while 8.3% of the carpoolers will travel with three or more people per car.

4.1.2.1 Mode Choice Comparison

From the United States Census Bureau, McKinney, from the 2010 census, has 80.5% of trip-makers driving alone, 13.2% carpooling, 0.4% taking the public transit, and 5.9% making other types of trips (walking, biking, worked from home, or other means of transportation). Although the results of Zone 1 are slightly lower than that of McKinney's 2010 census, the calculations yielded reasonable results.

CHAPTER 5

TRIP ASSIGNMENT

In this chapter, the fourth and final step of the four-step modeling process is presented. In trip assignment, assumptions are made on what route or path a trip-make will take to get from Zone i to Zone j. Most route choice models are based on the assumption that trip-makers will choose the path with the shortest travel time (Fricker 228). Other factors that will affect the route choice are, but not limited to, distance, out-of-pocket cost, number of traffic signals, and road capacity depending on time of day, available routes, and/or location of destination.

5.1 Possible Routes

The possible routes shown below in Figure 5.1 detail the main arterials and/or TxDOT roadways that could be used to get to a specific zone from Hidden Lakes. Between Zone 1 and Zone 2, the travel time is roughly 5 minutes by foot along US 380. From Zone 1 to Zone 3 (Plano), there are two possible routes, one along a major freeway and one taking a major arterial. Factors affecting the trip-maker's decision will most likely be the time of day of travel and whether one wants to avoid traffic signals or sitting in traffic jams on US-75. From Zone 1 to Zone 4 (Frisco), there are two possible routes, one with toll and one without. The cost, along with travel time and distance, will definitely be a factor in determining the route or a path an individual trip-maker will take. Refer to Figure 5.2 for the map showing the routes.

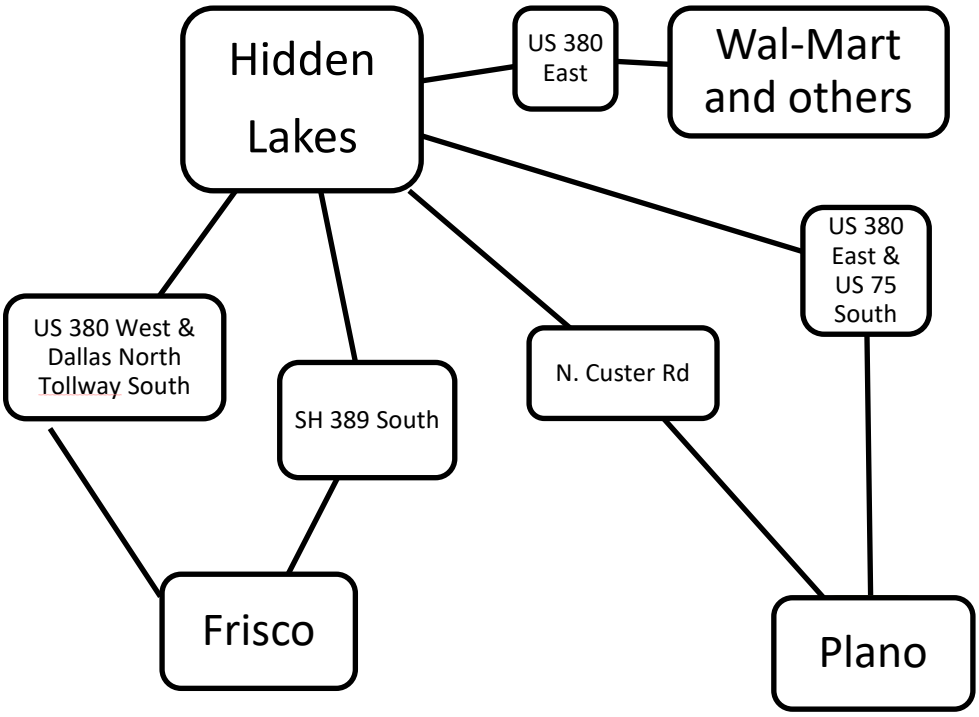

Figure 5.1: Rough Sketch of Possible Routes Taken from Zone 1 to other Zones

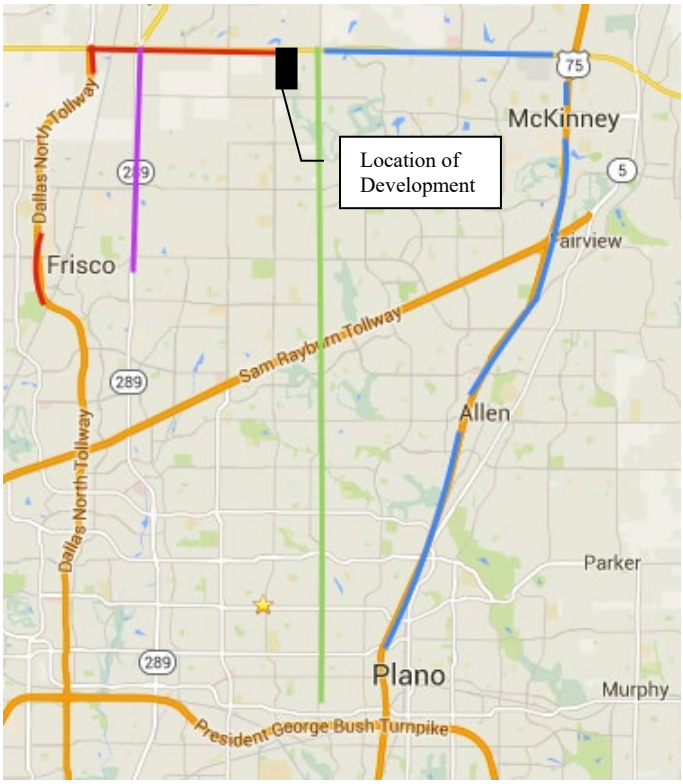

Figure 5.2: Possible Routes from Zone 1 to other Zones

5.1.1 Current Road Volumes

Using the Texas Department of Transportation (TxDOT) Statewide Planning Map, the 2013 AADT (Average Annual Daily Trips) is obtained for the roads shown in Figure 5.1. The AADT is only taken from Traffic Count Stations in between Hidden Lakes and the other zones. If there are multiple count stations, the average was taken and tabulated below in Table 5.1. During the trip generation step, the trip production of Hidden Lakes is 723 trips. This is a considerable increase in traffic volume. A Traffic Control Plan is needed.

Volume	2013 AADT
US 380	26,984
US 75	261,522
SH 389	56,265
Dallas North Tollway	86,497
N. Custer Rd.	24,135

Table 5.1: 2013 AADT (Statewide)

CHAPTER 6

CONCLUSION

The trip production for Hidden Lakes (Zone 1) is 723, which is 50% of the predicted average trips for Zone 1. Hypothetically, if 723 trips are divided evenly amongst all the major and principle arterials, the number of trips per roadway, except US-380, will be approximately 181. The reason US-380 is excluded is because one of Hidden Lakes access points connects to US-380. The majority, if not all, of the trips leaving the development will not be taking the roads through the Virginia Hills neighborhood to the south.

Using the Traffic Impact Analysis (TIA), a Traffic Control Plan (TCP) can be developed. With the 723 trips produced from Hidden Lakes, the traffic along US 380 will be impacted. Looking at Figures 6.1 and 6.2, one can see that traffic going east along US 380 will have a hard time turning right into the Hidden Lakes development. Those traveling west along US 380 could use the middle turn lanes.

Figure 6.1: View of Hidden Lakes Entrance from US 380 East

Figure 6.2: View of Hidden Lakes Entrance from US 380 West

Further analysis is required to determine whether a traffic signal is required for this intersection. Although the westbound traffic could enter and leave Hidden Lakes using the middle turn lane, if traffic increased along US 380 in the future, yielding (i.e., no traffic signals) and using the middle turn lane could be hazardous.

US Customary (ft)			**Metric (m)**		
Speed	Speed Differential*		Speed	Speed Differential*	
(mph)	15 mph	20 mph	(km/h)	20 km/h	25km/h
30	110	75	50	40	35
35	160	110	60	60	50
40	215	160	70	75	65
45	275	215	80	95	85
50	345	275	90	115	105
55	425	345			
* Speed differential = the difference between a turning vehicle when it clears the through traffic lane and speed of following through traffic. Clearance is considered to have occurred when the turning vehicle has moved laterally a sufficient distance (10 ft. [3m]) so that a following through vehicle can pass without encroaching upon the adjacent through lane.					

Table 6.1: Deceleration Lengths for Speed Differentials Greater than 10 mph (Roadway)

A right-turn deceleration lane is required. The speed limit of US 380 at this location is 55 MPH. This can be a hazard if a driver is not paying attention and rear-ends the right-turn driver. The length of the deceleration lane is chosen based on the TxDOT *Roadway Design Manual*. The table from the manual is shown below in Table 6.1.

In conclusion, based off the results of the TIA, a Traffic Control Plan will be required. The volume of traffic entering and exiting the residential and commercial areas will impact the existing traffic a great deal. For safety, design of a right-turn deceleration lane and a left-turn deceleration lane will be required. Further analysis and calculations will be needed to determine the need for traffic signals and, if signals are required, then the timing of the lights based on various hours of the day.

APPENDIX A

TABLES, GRAPHS, AND CHART

Table A.1: Home-Based Work Trip Production Rates (NCHRP 716)

	Household Size					
Income Group	**1**	**2**	**3**	**4**	**5+**	**Average**
Low (Less than $25,000)	0.5	1.4	1.4	1.4	2.7	*0.8*
Middle ($25,000–$99,999)	1.3	1.9	2.1	2.3	2.7	*1.9*
High ($100,000 or more)	1.0	1.9	2.6	2.5	2.1	*2.2*
Average	*1.1*	*1.9*	*2.2*	*2.4*	*2.5*	*1.8*

Table A.2: Home-Based Non-Work (Other) Trip Production Rates (NCHRP 716)

	Household Size					
Income Group	**1**	**2**	**3**	**4**	**5+**	**Average**
Low (Less than $25,000)	1.5	2.6	5.4	5.5	5.6	*2.2*
Middle ($25,000–$99,999)	1.7	3.6	5.3	8.3	11.6	*4.9*
High ($100,000 or more)	1.9	3.2	5.3	10.5	11.6	*6.2*
Average	*1.6*	*3.4*	*5.3*	*9.2*	*11.5*	*4.9*

Table A.3: Non-Home Based Trip Production Rates (NCHRP 716)

	Household Size					
Income Group	**1**	**2**	**3**	**4**	**5+**	**Average**
Low (Less than $25,000)	0.9	0.9	3.3	3.1	3.1	*1.1*
Middle ($25,000–$99,999)	1.5	2.8	3.3	4.0	3.8	*2.8*
High ($100,000 or more)	2.5	3.5	4.7	5.1	6.3	*4.4*
Average	*1.4*	*2.9*	*3.7*	*4.5*	*4.6*	*3.0*

Table A.4: Trip Attraction Rates (NCHRP 365)

To estimate trip attractions for an analysis area, use[1]

HBW Attractions = 1.45 × *Total Employment*

HBO Attractions CBD = 2.00 × *CBD RE* + 1.7 × *SE* = 0.5 × *OE* + 0.9 × *HH*

HBO Attractions NBD = 9.00 × *NCBD RE* + 1.7 × *SE* + 0.5 × *OE* + 0.9 × *HH*

NHB Attractions CBD = 1.40 × *DBD RE* + 1.2 × *SE* + 0.5 × *OE* + 0.5 × *HH*

NHB Attractions NCBD = 4.10 × *NCBD RE* + 1.2 × SE + 0.5 × OE + 0.5 × *HH*

where

CBD RE	= Retail Employment in Central Business District Zones,
NCBD RE	= Retail Employment in Non-Central Business District Zones,
SE	= Service Employment,
OE	= Other Employment (Basic and Government), and
HH	= Households.

[1] Note: The coefficients for these equations were derived from a variety of trip attraction models for urban area studies and represent a consensus of these models.

APPENDIX B

TRAFFIC IMPACT ANALYSIS CALCULATIONS

TRIP GENERATION EXCEL

Hidden Lakes		Weekday			
		Avg Rate	Entering	Leaving	Trips
210 Single Family (DU)	Rate/Equation	10	50%	50%	10
	Number	560	280	280	560
826 Specialty Store (1000 sq. ft.)	Rate/Equation	44.32	50%	50%	T=42.78X + 37.66
	Number	1330	665	665	1064
		Total:	945	945	

Wal-Mart & Others		Weekday			
		Avg Rate	Entering	Leaving	Trips
851 Convenience (24 hrs)(KSF)	Rate/Equation	737.99	50%	50%	T=42.78X + 37.66
	Number	134314	67157	67157	7824
826 Specialty Store (1000 sq. ft.)	Rate/Equation	44.32	50%	50%	T=52.78X + 37.66
	Number	3191	1596	1596	1064
934 Fast Food w/ Drive Thru (KSF)	Rate/Equation	496.12	50%	50%	Not Given
	Number	1340	670	670	--
933 Fast Food w/o Drive Thru (KSF)	Rate/Equation	716	50%	50%	Not Given
	Number	4296	2148	2148	--
932 Sit Down Restaurant (KSF)	Rate/Equation	127.15	50%	50%	Not Given
	Number	1272	636	636	--
912 Drive-In Bank (KSF)	Rate/Equation	148.15	50%	50%	Not Given
	Number	519	259	259	--
		Total:	72465	72465	

Production for Zones 3 & 4

Zone	Income	Household	HBW	HBO	NHB
Plano	82484	80875	2.1	5.3	3.3
Frisco	109956	50500	2.6	5.3	4.7

Zone	HBW	HBO	NHB	Total
3	169838	428638	266888	865362.5
4	131300	267650	237350	636300

Attraction for Zones 3 & 4

Zone 3
Pop 274409
Zone 4
Pop 136791

Trip Type	# of HH	Retail	Service	Other	Total
HBW	0	0	0	0	1.45
HBO	0.9	9	1.7	0.5	0
NHB	0.5	4.1	1.2	0.5	0

Zone	# of HH	Retail (%)	Service (%)	Other (%)	Total (%)
3	--	0.306	0.2212	0.4779	1
4	--	0.2996	0.2201	0.4803	1

Zone	# of HH	Retail	Service	Other	Total
3	80875	83969	60699	131140	275808
4	50500	40983	30108	65701	136791

Zone	HBW	HBO	NHB	Total
3	399922.3046	997269	523120.1869	1920311.168
4	198346.95	498327	262258.1903	958931.8399

TRIP DISTRIBUTION EXCEL

	P_i	A_j	F_{ij}	$A_j F_{ij}$	Tij
T_{12}	945	72465.3845	0.04	2898.62	337
T_{13}	945	1,920,311	0.00077	1481.72	172
T_{14}	945	958,932	0.00391	3745.83	436
T_{41}	636300	945	0.00510	4.82	70454
T_{31}	865363	945	0.00098	0.92	18340
T_{21}	72465	945	0.04	37.79	62906
T_{23}	72465	1920311	0.00128	2449.38	4077059
T_{24}	72465	958932	0.00128	1223.13	2035931
T_{32}	865363	72465	0.00148	107.20	2130800
T_{34}	865363	958932	0.00250	2397.33	47652603
T_{42}	636300	72465	0.00111	80.52	1176822
T_{43}	636300	1920311	0.00250	4800.78	70167233

ZONES	1	2	3	4
1	0	337	172	436
2	62906	0	4077059	2035931
3	18340	4077059	0	47652603
4	70454	1176822	70167233	0

MODE CHOICE EXCEL

HOME-BASED WORK

Column1	COEFFICIENT	VALUE 12	VALUE 13	VALUE 14	VALUE 21	VALUE 31	VALUE 41
AUTO2	-3.457	--	--	--	--	--	--
AUTO3	-5.116	--	--	--	--	--	--
AUTOIVTT	-0.052	5	16	36	5	14	32
AUTOCOST	-0.77	0.47	22.56	49.115	0.47	25.38	49.35
AULTPER	1.197	0	0	0	0	0	0
LOWINC	0.439	0	0	0	0	0	0
HIGHINC	-0.372	1	1	1	1	1	1

Column1	V_{12}	V_{13}	V_{14}	V_{21}	V_{31}	V_{41}
Drive Alone	-0.6219	-18.20	-39.69	-0.6219	-20.27	-39.66
Auto 2 Person	-4.4509	-22.03	-43.52	-4.4509	-24.10	-43.49
Auto 3+ Person	-6.1099	-23.69	-45.18	-6.1099	-25.76	-45.15

HOME BASED WORK

Column1	ZONE 1,3	ZONE 1,4	ZONE 3,1	ZONE 4,1	Average
$P_{drive\ alone}$	0.975	0.975	0.975	0.975	0.975
$P_{auto\ 2\ person}$	0.021	0.021	0.021	0.021	0.021
$P_{auto\ 3\ person}$	0.004	0.004	0.004	0.004	0.004

HOME-BASED NON WORK

Column1	COEFFICIENT	VALUE 12	VALUE 13	VALUE 14	VALUE 21	VALUE 31	VALUE 41
AUTO2	-0.992	--	--	--	--	--	--
AUTO3	-4.464	--	--	--	--	--	--
AUTOIVTT	-0.016	5	16	36	5	14	32
AUTOCOST	-0.194	0.47	9.36	20.37	0.19	10.53	20.47
AULTPER	0.935	0	0	0	0	0	0
MEDINC	-0.099	0	0	0	0	0	0
HIGHINC	-0.23	1	1	1	1	1	1
HHSIZE (2)	0.099	3.99	3.99	3.99	0	3.18	3.13
HHSIZE (3+)	1.111	3.99	3.99	3.99	0	3.18	3.13
CBD	-0.447	0	0	0	0	0	0

Column1	V_{12}	V_{13}	V_{14}	V_{21}	V_{31}	V_{41}

Drive Alone	-0.17	-2.07	-4.53	-0.12	-2.27	-4.48
Auto 2 Person	-1.00	-2.90	-5.36	-1.34	-3.17	-5.40
Auto 3+ Person	-0.43	-2.33	-4.79	-4.81	-3.43	-5.70

HOME BASED NON WORK

	ZONE 1,2	ZONE 1,3	ZONE 1,4	ZONE 2,1	ZONE 3,1	ZONE 4,1	Average
$P_{drive\ alone}$	0.453	0.453	0.453	0.767	0.582	0.589	0.550
$P_{auto\ 2\ person}$	0.198	0.198	0.198	0.226	0.235	0.237	0.215
$P_{auto\ 3\ person}$	0.349	0.349	0.349	0.007	0.182	0.174	0.235

<u>NON HOME-BASED WORK</u>

Column1	COEFFICIENT	VALUE 12	VALUE 13	VALUE 14	VALUE 21	VALUE 31	VALUE 41
AUTO2	-0.992	--	--	--	--	--	--
AUTO3	-4.464	--	--	--	--	--	--
AUTOIVTT	-0.016	5	16	36	5	14	32
AUTOCOST	-0.194	0.47	4.35	9.47	0.09	4.89	9.51
CBD	-0.447	0	0	0	0	0	0

Column1	V_{12}	V_{13}	V_{14}	V_{21}	V_{31}	V_{41}
Drive Alone	-0.17	-1.10	-2.41	-0.10	-1.17	-2.36
Auto 2 Person	-1.16	-2.09	-3.40	-1.09	-2.17	-3.35
Auto 3+ Person	-4.64	-5.56	-6.88	-4.56	-5.64	-6.82

NON HOME BASED WORK

	ZONE 1,2	ZONE 1,3	ZONE 1,4	ZONE 2,1	ZONE 3,1	ZONE 4,1	Average
$P_{drive\ alone}$	0.723	0.723	0.723	0.723	0.723	0.723	0.723
$P_{auto\ 2\ person}$	0.268	0.268	0.268	0.268	0.268	0.268	0.268
$P_{auto\ 3\ person}$	0.008	0.008	0.008	0.008	0.008	0.008	0.008

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BIOGRAPHICAL INFORMATION

Thuy-Nhu Nguyen will receive an Honors Bachelor of Science in Civil Engineering in May 2015. Throughout her undergraduate degree, she has been involved with the American Society of Civil Engineers (ASCE), Tau Beta Pi (Engineering Honor Society), and Chi Epsilon (Civil Engineering Honor Society) where she served as Vice President for one semester and as President for another semester. Thuy-Nhu is interested Structural Engineering and plans to continue at the University of Texas at Arlington to study for a Master of Engineering degree. Her ultimate goal is to become a licensed engineer. Thuy-Nhu Nguyen is interested in both land development and high-rise structures.