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## Assessing School Neighborhood Walkability: A Targeted Approach to Safe Routes to School Programming

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# Assessing School Neighborhood Walkability: A Targeted Approach to Safe Routes to School Programming

A Thesis

Submitted to the Graduate Faculty of the  
University of New Orleans  
in partial fulfillment of the  
requirements for the degree of

Master of Urban and Regional Planning  
Specialization: Transportation/ Land Use

by

Chelsea O. Shelling

B.A. Howard University, 2008

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## Abstract

This thesis intends to demonstrate how capital infrastructure investments can be targeted objectively, using the “Safe Routes to School” (SRTS) program for context. SRTS impacts physical activity, a determinant of childhood obesity by encouraging children’s regular active transportation use. This thesis supports the widespread implementation of SRTS and has developed the “Shelling Model” to objectively identify schools for programming. Accordingly, the “Shelling Model” aims to objectively identify physical and socio-economic environment variables impacting HISD-E middle school neighborhoods’ walkability. The “Shelling Model” is a first step in creating a walkability index for which pedestrian orientation levels can be identified and schools targeted. This model facilitates the identification of variables, providing insight into neighborhood walkability levels. Revealed by statistically significant variables, in combination with Walkscore and Catchment regression models’ respective 45.5 and 13.6 Adjusted R-Square values, the “Shelling” archetype proves a useful tool for investigating the walkability of HISD-E middle school neighborhoods.

*Keywords* Walkability, Obesity Intervention, Active Commuting/Active Transportation, Geographic Information Systems, HISD-E middle schools

## Chapter 1: Introduction

Over the past 30 years, the prevalence of overweight and/or obesity in children has become a significant public health concern. For decades public health researchers have sought, in earnest, ways to address the rising epidemic, embracing obesity interventions within the school environment as a means to that end. Motivating these efforts are the negative health outcomes associated with obesity such as hypertension, diabetes and cardiovascular disease (Must & Strauss, 1999). However, to the detriment of such interventions' effectiveness in lowering obesity prevalence long term, school-based interventions have not regularly recognized factors beyond this environment which may counter mediation efforts. This inconsistent recognition has a marked impact on interventions aimed at increasing children's physical activity through active transportation (i.e. walking) use for school commutes. Accordingly, barriers to walking such as distance to school and potentially hazardous road conditions have gone unaddressed in interventions staged within the school environment. Just as children may be provided with opportunities for physical activity within the school environment they should also be afforded opportunities for physical activity (i.e. walking for school commutes) beyond this setting.

The "*Safe Routes to School*" (SRTS) program, which encourages walking and biking to school, is a national program actively addressing the impact of the built environment on children's opportunities for physical activity (Pedroso & Ping, 2009). The SRTS program, serving in part as an obesity intervention, recognizes that in addition to school siting policies which have contributed to children's increased commuting distances, the design of the built environment has informed children's mode share for school commutes. As noted by McMillan, smart growth supporters identify "increased block lengths, street widths and the decreased presence of sidewalks as some physical design elements which have contributed to the shift from active transportation to automobile use for school commutes (McMillan, 2005, p.440). The program recognizes that as children's opportunities have decreased, with physical education and athletic program funding cuts in schools throughout the United States, it is imperative that other avenues for physical activity are provided for youth. "Safe Routes to School" funds pathway, sidewalk and safe crossing construction, bike and pedestrian safety education and advocates for state policies



supporting walkability. SRTS seeks to make children's school commutes safe by impacting the physical design of communities in a way that promotes physical activity through active transportation use (Pedroso & Ping, 2009).

Part of the "Safe Routes to School" implementation success in installing programs is attributed to its understanding that a change in neighborhood design from pre-WWII to post-WWII has occurred. "Walkable" pre-WWII neighborhood design enabling residents to reach destinations, including schools, government services, etc. (Sallis & Glanz, 2006) by walking has been out popularized by "unwalkable" post-WWII neighborhood design favoring the automobile as the primary mode of transport. It has been generally accepted in planning that this shift from active transportation use (not just for school commutes) to employing automobiles for transport occurred with the shift from pre-WWII walkable neighborhood design to post-WWII auto dependent layouts.

Despite SRTS success in installation, participation has been limited to those schools with the mobilized administrator, community and parent organization support to submit an application, and sustain program activities. Program participation by self-selection threatens to exclude communities lacking such support, but which are still in need of the benefits conferred by "Safe Routes to School." As demonstrated by this method of program implementation, SRTS has not adopted an objective approach to targeting schools for investments. However, the SRTS program's subjective method of program installation is not unlike the manner in which municipalities regularly identify areas for program investments, from capital improvements to economic development initiatives. Investments are often targeted where a mobilization of resources to support such investments already exists.

This research, using SRTS for context, demonstrates how capital infrastructure program investments can be targeted objectively. Utilizing SRTS's partial focus on altering the physical design of neighborhoods, this thesis proposes a model, the "Shelling Model" for targeting schools based on neighborhoods' conduciveness to walking for school commutes. Accordingly, the focus of this thesis is to demonstrate how the impact of physical and socio-economic environment variables on Houston Independent School District-E middle school neighborhoods' walkability can be determined. Based on this proposed model's predictive ability as determined through a regression analysis, "Safe Routes to School" administrators

may create an objective walkability index with which schools may be targeted for SRTS programming. This research is the first step in creating a walkability index; identifying a mix of physical and socio-economic variables which predict, through regression models, variations in walkability,

### **Research Questions (RQ)**

The two questions central to this thesis seek to evaluate Houston Independent School District middle school neighborhoods' conduciveness to walking for school commutes as well as how such a determination can be used in part, to target SRTS program investments. While RQ1 is answered through the findings of this research, RQ2 is answered in research findings, as well as in the Chapter 2 review of literature.

RQ1. What level of walkability exists in Houston Independent School District (HISD) middle school neighborhoods?

RQ2. How can an analysis of middle school neighborhoods' walkability be employed to objectively target schools for "Safe Routes to School" programming?

### **Contents**

This thesis is comprised of six chapters. Chapter 1, the Introduction, provides an overview of the topics explored in this research as well as the research questions anchoring this research. Chapter 2 describes why an assessment of school neighborhood walkability is important, highlighting: the rise of childhood obesity in the United States, public research intervention strategies, and planning efforts' analysis of built environment factors contributing to decreased access to physical activity opportunities.

Chapter 3 introduces the Houston Independent School District in Houston, Texas as the study area of this thesis. Thereafter, Chapter 4 describes how a Geographic Information System and a multiple regression analysis, using Statistical Package for the Social Sciences (SPSS) software, can be utilized to determine the level of walkability existing in Houston Independent School District middle school neighborhoods. Chapter 4 also outlines how the methodology employed in the University of Western Australia TREK project served as the inspiration for the methodology attempted in this thesis.

Chapter 5 reveals findings of the multiple regression analysis employed in Chapter 4, while Chapter 6 synthesizes the findings of this study, revisiting research questions, describing limitations, policy implications and recommendations for future research arising from this thesis.

## Chapter 2: A Call for Increased Access to Opportunities for Physical Activity

### Overview

Chapter 2 reviews the literature supporting children's increased access to opportunities for physical activity and in particular, their improved ability to walk for school commutes. This review provides the rationale for the methodology described in Chapter 4.

First, the impact of the obesity epidemic on American youth and, in particular, Houston youth will be examined. Thereafter, interventions' regular omission of post mediation follow-ups from their research designs is discussed. In addition, the gap this omission creates in the knowledge of mediation efforts' impact on long term obesity prevalence will be considered. A discussion of how the "Safe Routes to School" (SRTS) program holds promise in serving as a potential long term obesity intervention, and the SRTS State Network Partnership's strategy in seeking state policies supporting SRTS efforts to alter the built environment will follow. Urban form's impact on active transportation use among children will then be reviewed, followed by a case study demonstrating how through state law, one school district was able to integrate smart growth principles into its education facility siting practices; resulting in children's increased access to walking for school commutes.

### **Obesity as a rising epidemic.**

Based on studies conducted by the United States Centers for Disease Control, the prevalence of people who are overweight and obese has been steadily increasing over the last 30 years. This rise in overweight or obese individuals, especially children, has heightened the risk of developing health conditions which pose an imminent threat to their present and future quality of life.

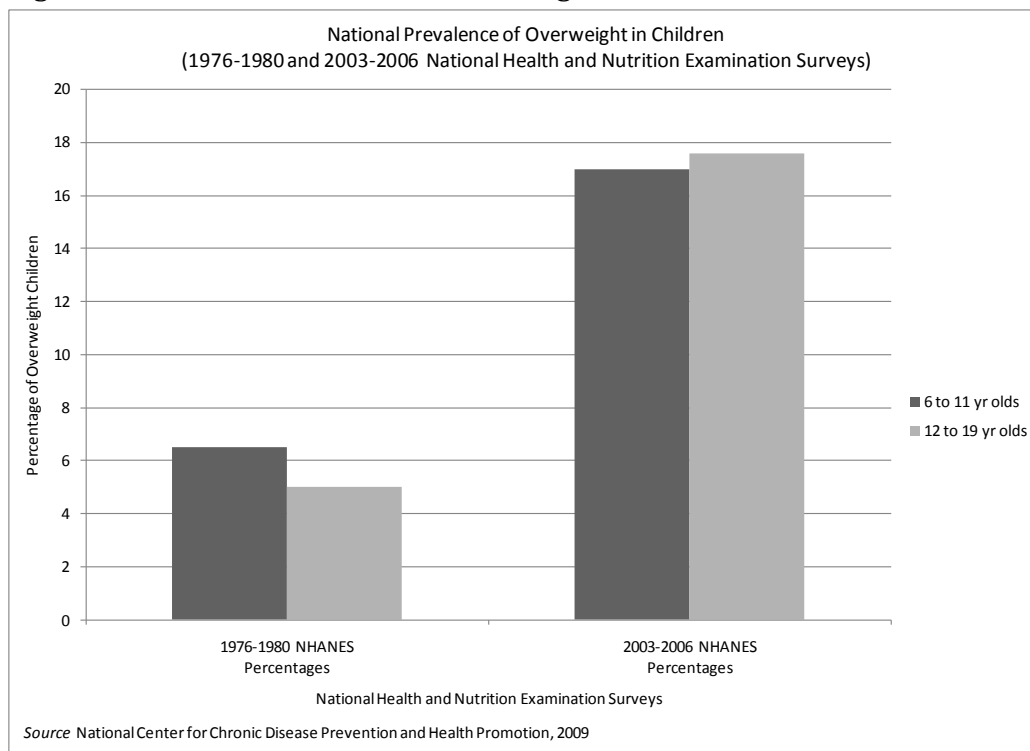
It should be noted that the Houston Department of Health and Human Services asserts that "for children, overweight is defined by the Youth Risk Behavior Survey (YRBS) as at or above the 95<sup>th</sup> percentile for Body Mass Index age and sex. Thus, the term "overweight" includes weights that would be termed 'overweight and obese' in adults"

(2007, p. 36). Therefore, childhood overweight and obesity will be used interchangeably throughout this study.

In consideration of this definition, Mexican American and Non-Hispanic black adolescents exceed national averages for childhood obesity. According to the 2003-2006 National Health and Nutrition Examination Survey (NHANES), 17 percent of 6 to 11 year olds and 17.6 percent of 12 to 19 year olds are overweight.

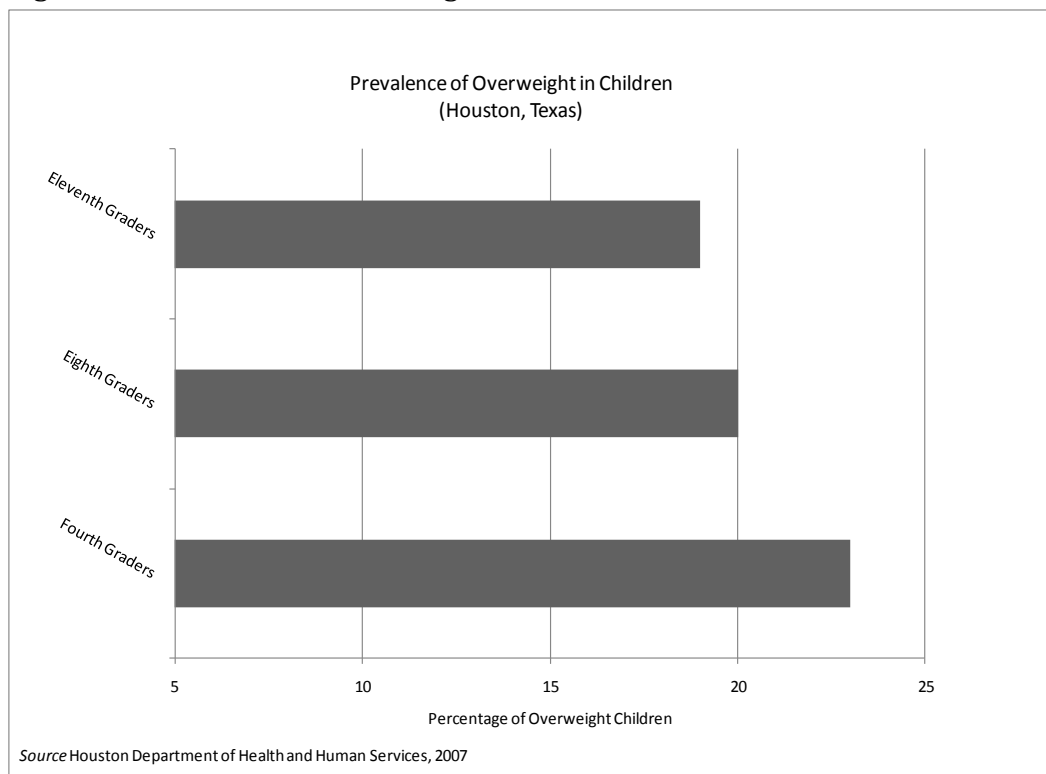
These statistics show a significant increase in the prevalence of obese children nationally when compared to the 1976-1980 NHANES in which, 6.5 percent of 6 to 11 year olds and 5 percent of 12 to 19 year olds were overweight (National Center for Chronic Disease Prevention and Health Promotion, 2009). Overall, between the 1976-1980 NHANES and the 2003-2006 NHANES there was an increase in the prevalence of overweight and obesity of 10.5 percent for 6 to 11 year olds and a 12.6 percent increase for 12 to 19 year olds. See Figure 1.

Figure I. National Prevalence of Overweight in Children



In examining the prevalence of childhood obesity in Houston, figures echo NHANES trends as 23 percent of fourth graders, 20 percent of eighth graders, and 19 percent of eleventh graders in the city are identified as overweight (Houston Department of Health and Human Services, 2007, p. 36). See Figure II. With respective 11.5 and 12.6 percent increases in overweight in 6 to 19 year olds nationally, public researchers and planners alike have sought ways to reduce this epidemic's prevalence. Driving these efforts are the adverse health conditions associated with obesity.

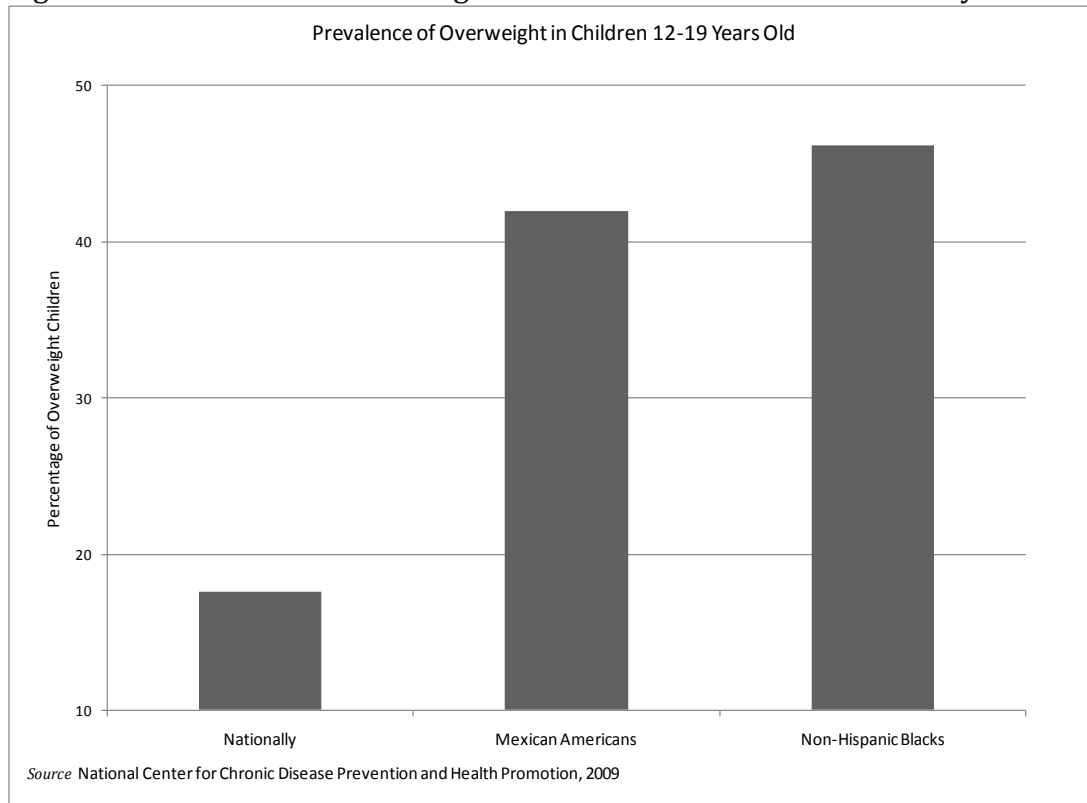
Figure II. Prevalence of Overweight in Children in Houston, TX



Obese children confront a multitude of health conditions which may compound in adulthood if obesity prevalence is not reduced. Must and Strauss note that “25-50% of individuals who are obese in childhood remain obese in adulthood” (1999, p. 121). Obesity affects orthopedic, neurological, pulmonary, gastroenterological, and endocrine functions. As a result, such health conditions as “the presence of unfused growth plates and softer cartilaginous bones,” asthma, the development of gallstones, sleep apnea, menstrual abnormalities in girls, high cholesterol, high blood pressure, cardiovascular disease and

diabetes are potential health concerns confronting individuals facing persistent obesity from childhood to adulthood (Must & Strauss, 2007, p. 122). It is the prevalence of such health conditions traditionally impacting adults, such as high blood pressure, high cholesterol and diabetes, becoming common in children which elevate childhood obesity to epidemic proportions.

Figure III. Prevalence of Overweight in Children 12-19 Years Nationally



The prevention of these health conditions is especially important for minority populations that experience levels of childhood obesity exceeding national averages. The Centers for Disease Control cites an elevated prevalence of obesity among Mexican Americans and non-Hispanic black adolescents in particular. This elevated prevalence places these groups at increased risk of the aforementioned adverse health conditions. According to the 2003-2006 National Health and Nutrition Examination Survey (NHANES) 46.2 percent of non-Hispanic blacks ages 12 to 19 years old and 42 percent of Mexican Americans ages 12 to 19 years old nationally are identified as obese by the Centers for Disease Control (National Center for Chronic Disease Prevention and Health Promotions,

2009). See Figure III. This means that the prevalence of overweight in 12 to 19 year old Non-Hispanic blacks and Mexican Americans is three and four times the national average respectively. These statistics maintain special relevance to the Houston Independent School District as 61.1 percent and 27.8 percent of the district's 200,225 student population are Hispanic and African American respectively ("Facts and Figures 2008-2009," n.d.).<sup>1</sup>

Therefore, with a significant proportion of American adolescents, and particularly HISD students at risk of obesity and subsequent life altering health conditions, a reduction in prevalence has become an important mission within the health profession. This concern further compels efforts which seek to understand and impact environmental and socio-demographic factors contributing to America's increased obesity prevalence.

### **Obesity interventions.**

Poor dietary nutrition and physical inactivity emerge as two recurring determinant behaviors in childhood obesity research (Sharma, 2006). In an effort to understand the relationship between these determinant behaviors and prevalence, obesity interventions have been staged by public health researchers. An obesity intervention is a strategy in which a decreased prevalence of obesity is attempted through behavior modification; with efforts aimed at increasing physical activity or nutrition depending on the intervention's design (Boon & Clydesdale, 2005). Such interventions do show potential for negatively impacting the prevalence of obesity. However, their irregular integration of post mediation follow-ups into research designs has lead to a gap in knowledge regarding the long term impacts of school-based interventions on obesity prevalence. In addition, how environments outside of school fare as settings for interventions is left unknown due to these omissions.

Obesity interventions have been primarily school-based and employ either single component or multi component strategies (Boon & Clydesdale, 2005). The school environment is used to stage obesity interventions to the extent that children may be: encouraged to increase physical activity; introduced to healthy eating through

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<sup>1</sup> Of the 848,113 Hispanic and Latino population of any race in Houston, between 75 percent and 77 percent are Mexican ("2005-2007 American Community Survey," n.d.).



improvements in food offerings and educated regarding a nutritious diet and exercise (Boon & Clydesdale, 2005, p. 512). Single component interventions focus on individual behavior changes such as increased physical activity or decreased television viewing, while multi- component interventions encourage multiple behavior changes within a single mediation effort (2005). For example, a multi-component obesity intervention may seek to simultaneously increase physical activity, decrease television viewing, and increase the intake of fruits and vegetables.

Though singular and multi-component interventions have yielded reductions in obesity prevalence, Gittelsohn and Kumar suggest these outcomes may be “modest and of questionable clinical significance” individually (2007, p. 56). Gittelsohn and Kumar assert that impacts on obesity prevalence are unclear as intervention outcomes are generally incomparable due to differing research designs<sup>2</sup> (Campbell, Waters, O’Meara & Summerbell, 2001, p. 150; Gittelsohn & Kumar 2007). For example, neither long term<sup>3</sup> maintenance of intervention outcomes (i.e. follow-ups) nor consideration of elements in the built environment is a regular feature of obesity intervention research designs.

Therefore, it is unclear whether positive results yielded by obesity interventions are maintained long term or whether recidivism prevails. Through the studies which have charted outcomes following the end of an intervention, it is clear that long term behavior modification is a difficult goal to achieve and recidivism is a threat to reducing the prevalence of obesity. Recidivism poses a particular threat to positive outcomes gained through school-based interventions as those outcomes may be “undermined by opposing influences outside the school” (Gittelsohn & Kumar, 2007, p. 26).

A study conducted by the Georgia Prevention Institute demonstrates this challenge as the study reveals how initial intervention outcomes may not be maintained. In the study, seventy 7 to 11 year old obese children participated in a four month physical training program with their progress being compared to a control group. For five days a week, physical training program participants “completed 20 minutes of machine exercise and 20

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<sup>2</sup> This study looks to the built environment outside of school as the intervention environment. As this study supports children’s increased physical activity opportunities through its exploration of HISD-E middle school neighborhoods’ conduciveness to children’s use of walking for school commutes, this study can be viewed within the framework of a single component intervention.

<sup>3</sup> This study refers to long term maintenance of intervention outcomes as outcomes which have been maintained after an intervention has ended, into adulthood.

minutes of playing games” (as cited in Clydesdale and Boon, 2005, p. 519). By the physical training program’s end, the physical training group displayed an overall “1.6% decrease in body fat” (519). However, when 35 of the physical training program participants were “examined at a four month follow-up” their body fat measurements had increased to between “ the baseline and post-intervention measures” (519). As demonstrated in this study, the presence of an intervention follow-up in a research design may reveal whether intervention outcomes are maintained.

The importance of the post intervention follow-up is further highlighted by a Japanese obesity intervention which yielded greater initial outcomes than the Georgia study. The two year study of 40 Japanese children implemented 100 minutes of running throughout the school week. After the first year of a two year intervention, collectively, female participants displayed a decrease in body fat of 31% while male participants displayed a decrease in body fat of 40%. Although modest, decreases in body fat continued through the second year of the study (519).

Despite the Japanese study’s initial positive impact on obesity prevalence, the study’s omission of a post intervention follow-up highlights the gap in knowledge created regarding the impacts of obesity interventions on a long term reduction in obesity prevalence. If there is any need for a post intervention follow-up, it is most needed for those interventions displaying a great decrease in obesity prevalence initially. Moreover, if recidivism did prevail in the Japanese study as it did in the Georgia study, then such outcomes highlight the need to explore environments beyond the school which facilitate recidivism.

As Gittelsohn and Kumar cite, more than 90 percent of children’s total calories are consumed outside the school environment with a majority of consumption occurring between home and restaurants (Gittelsohn & Kumar, 2007, p. 66). Accordingly, if a school-based intervention seeks only to encourage healthy eating habits through altering food offerings within schools, then an opportunity for long term change in children’s dietary behavior is missed. Consequently, access to healthy food within the environments in which children consume most of their calories is not addressed. Similarly, school-based interventions aimed at increasing children’s physical activity may miss an opportunity for

long term change in that determinant behavior when the built environment beyond the education setting, where pupils spend a majority of their time, is not considered.

This study acknowledges a single-component intervention strategy, seizing on the opportunity to encourage increased long term changes in children's physical activity levels. It supports "Safe Routes to School's" emphasis on modifying the built environment in a manner supportive of children walking and biking to school. As "Safe Routes to School" mandates that the built environment, where children spend a majority of their time, be assessed for its conduciveness to safe walking and biking, the program provides a sense of how settings outside the school fare as sites of intervention. By exploring the impact of physical and socio-economic environment variables on the walkability of HISD-E middle school neighborhoods, this thesis attempts to gain similar insight; showing the conduciveness of the built environ for children walking to school. Based on research suggesting habits learned in childhood are continued in adulthood, this study assumes that if children increase their activity levels in childhood, then there is a likelihood that increased physical activity levels may be maintained through adulthood (Steinbeck, 2001; Mota, Gomez, Almeida, Ribeiro, Carvalho, & Santos, 2007).

### **Appropriate levels of physical activity.**

In neither childhood nor adulthood do inconsistent and limited occasions of physical activity translate into a "consistent increase" in regular (i.e. daily) physical activity (Steinbeck, 2001, p. 120). Therefore, if a child does not engage in at least the recommended 30 minutes of daily physical activity consistently, they will not reap the overall health benefits accompanying an "active" lifestyle (McMillan, 2005, p. 443). Accordingly, some efforts aimed at reducing obesity prevalence seek to promote "active living"<sup>4</sup> (Shephard, 2008, p. 752) by encouraging regular engagement in physical activity. Shephard suggests active transportation use for school and work commutes as one way to incorporate consistent physical activity into normal daily life as "it is difficult to forget work or schooling (in contrast to the ease of missing attendance at a scheduled exercise class)" (752). The "Safe Routes to School" program is one such obesity intervention which

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<sup>4</sup> Shephard defines "active living" as "the incorporation of the needed physical activity into normal daily life" (2008, p. 120).

has internalized this assertion and through its encouragement of children's use of walk and/or biking for school commutes, it is promoting active living by promoting children's participation in regular/habitual physical activity (Mota et al, 2007).

Although the national "Safe Routes to School" program does not regularly study its impact on the prevalence of obesity among participants, one public health organization in Texas is assisting SRTS with this effort. The Texas SRTS network has partnered with Live Smart Texas to examine the impacts the SRTS program as well as the WIC Food Access and Availability Project have on the prevalence of childhood obesity in Texas (Pedroso & Ping, 2009). Therefore, with this effort, SRTS in Texas holds promise as a long term intervention which encourages regular physical activity and is backed by research detailing its impact on childhood obesity.

The potential exhibited by Texas SRTS magnifies the need for determining the existing 'levels of walkability' in HISD-E middle school neighborhoods and the variables impacting that pedestrian orientation. With SRTS's objective targeting strategy, a larger installation of programs throughout the state may result. This would result in a larger study group for the Live Smart Texas study. Furthermore, a larger study group may result in a greater cross section of schools participating in the study, assuming that those self-selected schools currently participating in the program share similar health and walkability profiles. Even more, with the larger and more varied study group, Live Smart Texas and SRTS administrators may use the obesity prevalence in schools as a criterion for future program installations in addition to the determination of walkability.

Once again, SRTS does hold promise in impacting obesity prevalence. When children engage in what Shephard defines as "active living", they are in turn impacting one of the determinant behaviors of obesity, sedentary behavior, thus contributing to the reduced prevalence of childhood corpulence. The lifestyle behaviors children learn at a young age lay the foundation for the lifestyle habits they adopt as adults. Therefore, the engagement in an active lifestyle in childhood increases the likelihood of a continued pursuit of an active lifestyle in adulthood with the potential for long term decreased obesity prevalence (Steinbeck, 2001).

### **“Safe Routes to School” program.**

The aim of the “Safe Routes to School” program is to support a national reduction in the prevalence of obesity. It pursues this goal by “creating the environment, policy, and behavioral changes” (Pedroso & Ping, 2009, p. 5) necessary to get individuals engaged in regular physical activity, especially children, through walking and biking for school commutes. Safe Routes to School’s funding focuses primarily on improvements to the built environment which impede children’s safe walking and biking to school. However, with approximately 60 percent of middle and elementary school students nationally living more than two miles from school (Pedroso & Ping, 2009, p. 5); the program has been confronted with broader issues of school siting policies. Such policies complicate the program’s already strong emphasis on the modification of the built environment. In response to this challenge and as a way to address broader policy issues challenging the implementation of Safe Routes programs the SRTS National Partnership was created.

One major function of the Partnership is to provide guidance to states in addressing broader policies crucial to the implementation of SRTS programs. According to the Safe Routes to School State Network Project final report for 2007-2009 the policies of focus are: state SRTS implementation, neighborhood schools, school wellness policies, traffic safety curriculum and training, SRTS-related legislation, complete streets, fine-based funding mechanisms, and state highway safety plans (Pedroso & Ping, 2009, p. 12). Of these policies, neighborhood schools and complete streets policies are most relevant to this study as they address the broader urban design of communities impacting school siting as well as the provision of pedestrian and bicyclist facilities accommodating children’s safe travel to school.

In support of neighborhood schools, state network partners advocated for these community-centered schools by educating key decision makers on the communal benefits attributable to such schools (13). Neighborhood schools supported policies are important because as Pedroso and Ping suggest, the proportion of students living within “walking or bicycling distance of their school (i.e. 2 miles)” can be attributed to state sponsored guidelines. For example, guidelines regarding school siting, campus acreage, facility rehabilitation, and joint facility use versus new construction are state policies which have generally been in conflict with the existence of neighborhood schools (13). Additionally,

“open access” admissions policies enable children’s attendance at schools beyond their neighborhood. Complementary to neighborhood schools policies, complete streets policies further address children’s access to walking and biking for school commutes through addressing the need for pedestrian, bicyclist and transit user facilities. In sum, while neighborhood policies may ultimately address the proximity of students’ homes to their schools, complete streets policy further addresses particular design elements of the built environment, such as the presence of sidewalks and crosswalks which improve children’s access to walking or biking for school commutes.

These concepts are prevalent in the discussion of children’s access to walking and biking for school commutes as active transportation research and policy work has emphasized the implementation of such schools. Research exploring walkability has focused on identifying those elements within the built environment impeding active transportation. Meanwhile, smart growth has emerged as a policy tool appropriate for implementing neighborhood schools throughout the United States.

### **The built environment and active transportation for school commutes.**

#### ***Neighborhood design pre-WWII and post-WWII.***

In step with the emerging overweight and obesity epidemic in America, over the past 50 years the United States has undergone a transformation from a country committed to pedestrian oriented development, to a country whose growth centers on the automobile. This bias toward auto dependence has hinged primarily on the rise of the automobile’s popularity in the United States which grew considerably pre-WWII. As previously stated, a change in neighborhood design from pre-WWII to post-WWII has occurred. “Walkable” pre-WWII neighborhood design enabling residents to reach destinations, including schools, government services, etc. (Sallis & Glanz, 2006) by active transportation has been out popularized by “unwalkable” post-WWII layouts favoring the automobile as the primary mode of transport. During this transition Federal Government programs expanded highway building by encouraging homeowners’ relocation to new suburban developments (Bauman, Biles & Szylvain, 2000, p. 163). More specifically, in the 1950s, Federal Housing Administration and Department of Veteran Affairs mortgage programs offered low down payments and longer termed mortgages, making homeownership available to a wider

spectrum of Americans (165). These programs are in part responsible for the significant proportion of Americans living in suburban developments today. As highway construction occurred, residential developments arose near exit ramps along these corridors, and sprawled developments gained popularity.

According to Sallis and Glanz, neighborhood design preceding suburbia was characterized as “traditional,” with elements such as mixed land uses and connected streets considered pedestrian oriented due to the proximity of “homes, stores, employment centers and government services” to each other (92). However, following WWII, zoning codes separated land uses, increasing residents’ proximity to amenities (92). As a result, the previously traditional neighborhood design is generally described as “walkable” (92) while post-WWII suburban development is generally “described as unwalkable (93).

In consideration of the changing walkability of neighborhoods pre-WWII to post-WWII active transportation researchers have sought to better understand specific changes in the elements of the environment following this era and their impact on people’s ability to walk to destinations.

#### ***Active transportation for school commutes.***

*Active transportation* research does not regularly study the travel behavior of children (Sallis & Glanz, 2006). Furthermore, the research has not definitively revealed the relationship between the built environment and decreases in children’s use of active transportation for school commutes (McMillan, 2005; Ewing, Forinash, & Schroer, 2005). Clearly defining this relationship is complicated in part by the many social factors which impact a child’s decision to walk to school, regardless of the supportiveness of the built environment for such activity. Despite the inability to definitively tie elements of the built environment with increases or decreases in walking for school commutes, researchers have made progress in identifying key elements of the built and social settings which impact the conduciveness of environs for walking and pose as barriers to children’s active transportation use.

In regard to elements of the built environment, McMillan asserts that smart growth supporters contend that physical design elements such as “increased block lengths, street widths and the decreased presence of sidewalks” are contributing to children’s shift from active transportation for school commutes to automobile use (McMillan, 2005, p. 440).

While this contention is merely a hypothesis, it has gained credibility as the Safe Routes to School program is cited as a direct “policy reaction” to this hypothesis (p. 443). As inferred from SRTS’s funding dedication to infrastructure improvements (Pedroso & Ping, 2009, p. 3), SRTS does recognize the impact of urban form on children’s access to walking for school commutes.

Various active transportation studies have yielded results supporting smart growth supporters’ hypothesis, showing that “longer distances from home to school and lack of sidewalks” do impact children’s access to walking for school commutes (Lee & Tudor-Locke, 2005, p. 213; Schlossberg, Greene, Paulsen-Phillips, Johnson & Parker, 2006, p. 338). In the 2002 Health Styles Survey conducted by the Centers for Disease Control, of the 611 household respondents with children participating in the survey, 55% cited long distances as a barrier to walking or biking to school (“Barriers to Children Walking,”2002).

Studies have revealed elements of the environment which individuals perceive as barriers to walking. However, the removal of those barriers does not guarantee an increase in walking. For example, despite the constant citing of distance as a major barrier to children actively commuting to school, “only 31% of U.S. children living within one mile of school walk” (Nelson, Foley, O’Gorman, Moyna, & Woods, 2008). The reporting of increases in walking following SRTS funded infrastructure improvements in one school neighborhood further emphasizes the importance of recognizing the difficulties in attributing increases or decreases in walking to specific elements of the built environment. In an evaluation of one California Safe Routes to School program in which more street crossings and sidewalks were added, there was a 64 percent and 114 percent increase in walking and cycling respectively (Sallis & Glanz, 2006, p. 94). However, the reporting does not acknowledge that a number of factors, including the educational aspects of the “Safe Routes to School” program may have had an impact on parent’s willingness to allow their children to walk to school and this also resulted in an increase of walking.

There is limited empirical evidence showing that the increases are attributed to singular improvements within the built environment. As researchers have sought to understand all factors impacting a child’s decision to walk to school, active transportation studies has revealed and acknowledged that beyond the observed elements of the physical environment hindering walking, external factors beyond the built environment such as



parental decision making and perceived safety impact children's access to walking for school commutes.

In the same Health Styles Survey in which 55% of 611 household respondents with children cited long distances as a barrier to children walking to school, 40% identified traffic danger, 24% indicated weather conditions, 18% reported crime danger and 7% noted opposing school policy as impediments ("Barriers to Walking," 2002). For the remaining 16% of respondents reporting no barriers to walking 85% reported using walking or biking for school commutes "at least once a week in the preceding month" (2002, p.702). The barriers articulated in the Health Styles Survey are a testament to the myriad of impediments to walking. These barriers recur throughout active transportation research. Studies conducted by Schlossberg et al and Lee & Tudor-Lock are examples of analyses exposing the importance of external social factors, in addition to elements of the built environment which impact children's access to walking for school commutes.

In Schlossberg et al's study between urban form, distance and active transportation for school commutes among middle school students, a survey gathering information on pupils' mode of transportation for commutes deployed. The survey was sent to 287 middle school students' households (Schlossberg et al., 2006, p. 338). The survey also obtained middle school students' addresses so that distance to and from school could be determined. This study revealed that middle school students who lived less than 1 mile from school were the most likely to walk to school than students who lived 1 to 2 miles away from school (341). The study also revealed that despite a majority of middle school students arriving at school by car or bus, a percentage of this population using motorized transportation for arrivals used active transport to return home. In Schlossberg et al's study, "84% of children surveyed primarily traveled to school by car or bus, while nearly 75% returned home by these modes"(341). Furthermore, while 15% of children surveyed traveled to school primarily by walking or biking, about 25% used these active transportation modes to travel home (341). This shift from motorized to non-motorized transportation from school arrival to school dismissal further affirms the existence of factors beyond distance which may impact children's decision to actively commute.

In Lee & Tudor-Locke's study, 87 sixth grade students were surveyed concerning modes of transportation to school. Also, focus groups were created to gauge students'

perceptions of decision making, regularity in commuting behavior, safety and traffic concerns, as well as alternative transport options (Lee & Tudor-Locke , 2005, p. 213). From the general survey sample of 87 students, 27 students were used for focus groups. Focus groups were comprised only of those students living less than one mile from school because they were viewed as a priority target population for an “active commuting intervention” (p. 213). Students living one mile or greater from school were required to be bused or driven to school in personal vehicles. Students living at such distance were excluded from the study (p. 213), once again emphasizing the significance of distance as a major predictor of active transportation use for school commutes. Of the active commuters participating in the focus groups, primary reasons for choosing active transportation over driving were the “close proximity of their home to school” as well as their “enjoyment of exercise” (p. 214). Of the passive commuters participating in the focus groups the predominant reasons for not choosing to actively commute were living too far from school (although their homes were less than one mile away), “heavily trafficked streets with a high speed limit,” and enjoyment of riding in the car (p. 214). This study also identified mothers as the primary decisionmakers in regard to mode choice, and parents’ work schedules as a major predictor of students’ mode choice in the morning as opposed to the afternoon. Although parent work schedules were not explored in Schlossberg et al’s travel behavior study, varying parent schedules may account for the change in students’ travel mode from morning to afternoon as it did for some students in Lee and Tudor-Locke’s study.

The insight gained from Lee and Tudor-Locke’s use of focus groups highlights the utility and necessity of using strategies which explore the reasons for which students do or do not use active transportation for school commutes. This study demonstrates once again that although urban form characteristics may be conducive to active transportation use, there are external factors further impacting students’ decisions to walk or bike to school. These factors should be acknowledged if researchers are to succeed in increasing the number of children walking to school and in turn impacting a determinant behavior of obesity. Naturally, the leading external factor in a child’s decision to actively commute is parental perceptions of safety; however, the weight of students’ backpacks, carrying school projects, and commute times are also important factors to consider when examining students’ decisions to actively commute. As a difference in mode share from school arrival

to school dismissal was observed in Schlossberg et al's study, the impact of these aforementioned factors should not be underestimated. Additionally, another factor which should not be underestimated is the possibility that a child may be unwilling to explore active transportation if they travel by automobile for most trips (as cited in McMillan, 2005, p. 441). McMillan's assertion is certainly a valid one considering the student feedback gained in Lee and Tudor-Locke's study.

### **Aspects of the built environment explored in this thesis.**

In analyzing both Lee & Tudor-Locke, and Schlossberg et al studies, the recognition of the difference between the built environment's supportiveness for walking and a child's decision to walk to school re-emerges. As previously noted, the presence of pedestrian infrastructure does not guarantee increases in walking. As the two studies show, this assertion is supported.

It is undeniable that exploring factors beyond the built environment which contribute to children's decision to walk to school is important. In fact, the original intent of this thesis was to explore the impact of physical and socio-economic environment factors on travel behavior. However, data availability forced a shift in that aim. Therefore, the supportiveness of the built environment for children actively commuting, rather than a child's decision to walk is the aspect of walkability at the center of this research.

The following section defines walkability from this physical design (i.e. supportiveness of the built environment) perspective.

### ***What is walkability?***

Though an individual's ease in accessing destinations by walking is impacted by both the physical environment and socio-economic environment, "Walkability" is a term generally used to describe the sum of physical design elements which enables easy access to various destinations within a community by walking or biking (Sallis & Glanz, 2006). Physical design elements contributing to walkability have been explored at the macro neighborhood level, as well as at the pedestrian level. In transportation and planning research, design elements at the neighborhood level such as high residential density, mixed

land uses, connected street networks and compact building design have been attributed to formations preceding suburbia often characterized as “traditional” and walkable (Sallis and Glanz, 2006, p. 92). Together, the aforementioned design elements allow for proximity between “homes, stores, employment centers and government services” which is conducive to walking and biking for transport (92); ideally within a desirable, less than one-half mile distance (Leslie, Coffee, Neil, Frank, Bauman, & Hugo, 2007, p. 113).

In contrast to the exploration of walkability at the macro neighborhood level, at the pedestrian level, design elements such as sidewalks, crosswalks and lighting (Renne, 2009, Appendix A, pgs. 1-3) have been examined in context to the safety of using walking and biking for transport. Thus, at the macro neighborhood level, there is a broader examination of accessibility which focuses on the spatial design of neighborhoods. At the more narrow pedestrian level, there is a focus on examining design elements within the broader neighborhood design which contribute to the safety of using walking and biking for transport. Renne’s review of pedestrian and bicyclist safety indicators drawn mostly from “guidelines and recommendations from government agencies, professional organizations, pedestrian and bicycle advocacy groups and scholars within the fields of transportation planning and engineering” (Renne, 2009, Appendix A, p. 1), offers a sense of the physical design features important to safe walking and biking for transport. An index of pedestrian level design elements commonly utilized in walkability indexes is found in Table I on the following page.

Table I. Pedestrian and Bicyclist Safety Indicators	
<b>Sidewalks</b> <ul style="list-style-type: none"><li>• Accessibility</li><li>• Sidewalks widths</li><li>• Sidewalks and driveways</li><li>• Sidewalks surface quality and pavement treatments</li></ul>	<b>Intersections</b> <ul style="list-style-type: none"><li>• Curb radii</li><li>• Curb facilities and design</li><li>• Curb cut-outs</li><li>• Marked crosswalks</li><li>• Pedestrian crossing signals and signage</li><li>• Channelized right turns</li><li>• Curb extensions</li><li>• Alternative designs</li><li>• Roundabouts</li><li>• Raised intersections</li><li>• Neighborhood traffic signals</li><li>• Additional intersection facilities for bicyclists</li><li>• Phased intersection for bicyclists</li></ul>
<b>Mid-Block Crossings</b> <ul style="list-style-type: none"><li>• Medians/ crossing islands</li><li>• Crosswalk design</li><li>• Raised crosswalks</li><li>• Speed limits</li><li>• Lighting</li><li>• Street lane width</li></ul>	
<b>Traffic Calming</b> <ul style="list-style-type: none"><li>• Two-Way to One-Way Conversion</li><li>• Chicanes and Chokers</li><li>• Speed Humps</li></ul>	
Source (Renne, 2009, Appendix A, pgs. 1-17)	

This research explores walkability at a macro neighborhood level with proximity, land uses and road types representing the major facets (physical design elements) investigated. There are two primary reasons for which these elements were chosen. First, these elements were chosen based on their use in previous active transportation research. With the exception of land uses, proximity and road types are facets of walkability which have been explored in active transportation research specific to children. Land use mix is commonly used in walkability indexes for adult pedestrians. However, this research acknowledges that the presence of certain land uses, rather than the total mix of land uses may prove a more important factor for children walking to school. Second, facets were chosen based on their conduciveness to analysis within a Geographic Information System (GIS). This ‘conduciveness’ is based primarily on demonstrated use within other studies, as well as the availability of GIS data for these elements. Please see Chapter 4 for a detailed description of how these facets were investigated.

From these elements, a determination of the level of walkability existing in HISD-E middle school neighborhoods was obtained. This level of walkability entailed information

regarding: proximity to amenities, the land area available to HISD-E middle school students within a two mile “crow flies” distance from school, as well as neighborhood design features hazardous to children walking to school.

### **Research methodologies used in active transportation research.**

In researchers’ attempts to understand those elements of the built environment impacting travel behavior, there are some methods of analysis which recur throughout the research. Cross-sectional studies are regularly used to determine socio-economic information about study participants in addition to travel behaviors. Additionally, the use of geographic information systems utilizing walkability audits has gained popularity and is based on built environment observations conducted for study areas. The use of the GIS utilizing walkability audits result in walkability analyses which are less labor intensive than pedestrian audits. For studies bringing these two data sets together and identifying which elements of the built environment are associated with impacts of travel and socio-demographic characteristics on these behaviors, logistic regression or chi square analysis are commonly used. However, the research has not articulated which method of analysis is preferable.

In the Schlossberg et al study previously discussed, chi square analysis was used in exploration of the relationship between children’s travel mode to school, urban form and distance (2006, p. 340). Below are further examples of studies employing logistic regression.

*Rodriguez and Vogt’s study. (2009)* This study revealed results of the Michigan Safe Routes to School Student Survey. Using logistic regression, the study examined the impact of demographic, environmental, access, and attitude factors on children’s mode choices for school commutes. The study generally revealed that car availability, access to school sponsored bus service, and increased distance from school were associated with children’s passive commuting.

*Mota et al’s study. (2007)* This study attempted to identify active transportation predictors between socio-economic position and perceived environmental attribute variables. One finding from this study showed that the likelihood of active transportation increased with lower socio-economic position.

*Lawrence Frank and Company's study. (2008)* This study disclosed the results of an Atlanta, Georgia study examining the factors associated with children 5 to 18 years old traveling to school. This study revealed the mode share for students' school commutes as well as the impacts of that mode share on BMI index and vehicle emissions.

*McCormack et al study. (2006)* A cross-sectional study and objective environmental audit were paired to create summary indices for those elements of the built environment conducive to walking.

*Wood et al. (2010)* A child-specific walkability index, as well as a cross-sectional survey was used to determine which elements of the physical and socio-economic environment impacted Australian primary school children's travel behavior (2010).

Though the aforementioned active transportation studies employed both cross-sectional surveys and observed measures of the built environment/GIS enabled walkability audits, some transportation studies have employed GIS enabled walkability studies solely. Below are examples of studies which have created and employed walkability indices.

*Leslie et al study. (2007)* A geographic information system was used to create indices for dwelling density, street connectivity, net area retail, land use accessibility and diversity of land uses. This index was used to "measure features of the built environment that may influence adult's physical activity" (2007, p. 111).

*Huang & Hawley. (2009)* This study provides a GIS data model for "Safe Routes to School" in which SRTS centric "data specifications, storage solution, evaluation methods, and information distribution are integrated" (2009, p.21). Various modules and web portals are enabled by this model, which include: a walkability/bikeability assessment module, a network analysis module, a web mapping module, a field data entry portal, a walking/biking monitoring portal/ a public opinion surveying portal, and a safety concern reporting portal (p. 26).

*Zhu Study. (2010)* Geographic information systems measures objectively capturing "the walkability and safety of the physical environment in the area between home and school" as well as a pedestrian audit tool examining the "walkability and safety of street segments" were created. A parental survey was deployed to test the

observed measure of walkability and safety against parent's perceived measures of walkability and safety, however, the method of analysis used to determine agreement between these data is unknown by the author (Robert Wood Johnson Foundation, 2010).

As summarized in the aforementioned studies, there are multitudes of methods with which walkability can be assessed. Some studies have focused on children's decision to walk to school while other studies have centered solely on evaluating elements of the built environment which contribute to walkability. While the cross-sectional study has been utilized for gaining insight on travel behavior, GIS enabled walkability audits have been utilized to inventory and analyze elements of the built environment spatially.

It has been stated previously that conduciveness of the built environment for children walking, rather than a child's decision to walk (i.e. travel behavior) is the aspect of walkability investigated in this research. Therefore, utilizing GIS, physical design elements (proximity, land uses and road types) contributing to walkability are analyzed at the macro neighborhood level. Although all of the methodologies within in this section contain elements which could be used to determine the existing level of walkability in HISD-E middle school neighborhoods, and utilized in objectively targeting schools for SRTS programming, the Wood et al study (2010) informs the methodology applied in this research. Please see Chapter 4 for an in depth description of the Wood et al study, along with details of how this methodology has been adapted for this research.

### **Smart Growth: the nexus between school siting and walkability.**

Previously noted in the "Safe Route to School" program section, the implementation of neighborhood schools is one state policy for which SRTS advocates. This research acknowledges that beyond SRTS's efforts to modify neighborhoods' built environment, advocating for broader design policy supporting the minimal future need for "Safe Routes to School" programming is an important long term goal. Smart growth represents such a design policy. Smart growth has been recognized by the Council for Education Facility Planners International, as well as utilized by districts in the United States as a policy tool through which neighborhood school siting can be achieved. With post-WWII neighborhood design and subsequent placement of education facilities in conflict with children's access to



walking for commutes, the implementation of smart growth policy presents itself as a natural nexus between school siting and improved access to walking. This research recognizes that smart growth state policy support is important for guiding new developments towards walkable design; minimizing and perhaps eliminating the future need for SRTS program installations within areas of new sustainable development. Thus, school siting, smart growth and SRTS must work together if sustainable, long term access to walking for school commutes is to be achieved.

The United States' continued dependence on the automobile in its neighborhood design will have a decided impact on the future siting of schools throughout the nation as an increasing population necessitates the expansion of the current provision of educational facilities. In 2004, there were over 53 million students K-12 in the U.S. public education system, and by 2030, it is estimated by the U.S. Department of Education that the K-12 student population will reach 60 million (2003, Council of Education Facility Planners International, 2004). This means that in the next 24 years, public school districts across the country will be forced to create capacity for seven million additional children in a historically underfunded U.S. public school system. Therefore, it is crucial that school siting occurs in a way in which the taxpayers' money is spent efficiently, and the entire community is enriched.

Fortunately, concepts of smart growth and walkability have emerged as tools through which these goals can be accomplished. Select school districts around the United States have utilized these concepts to consolidate resources through the implementation of neighborhood schools. Future school siting will play a significant role in increasing transportation options for students; therefore, the siting of schools in neighborhoods utilizing smart growth and walkability concepts holds promise for improving children's access to active transportation for commutes. Moreover, the implementation of such policy holds promise in eliminating the need for such programs as SRTS.

### ***Smart growth.***

Principles of smart growth ensure that development occurs in a manner in which aspects of a community such as housing, transportation, retail, and in this study, education facilities, work together to create walkable communities. Due to the Council of Education Facility Planners International's status as a guiding authority in American education facility

planning (i.e. school siting), the council's use of the Environmental Protection Agency's (EPA) definition of smart growth is recognized in this study. According to EPA, smart growth is "development that serves the economy, the community and the environment. It provides a framework for communities to make informed decisions about "how and where they grow" (Council of Education Facility Planners International, 2004, p. 9).

Informed by the ten tenets of smart growth set forth by EPA's Smart Growth Network, the Council of Education Planners International provides guidance for school districts pursuing the implementation of neighborhood schools. Smart growth's potential for accommodating the needs of people over automobiles makes it an effective tool for implementing neighborhood schools. Below are the ten smart growth principles promoted by the council (Council for Education Facility Planners International, 2004, pgs. 9-10):

- Create mixed land uses
- Embrace compact building design
- Increase housing opportunities and choices
- Create walkable neighborhoods
- Creating distinctive, attractive communities with a sense of place
- Preserve the environment
- Direct development toward existing communities
- Increasing transportation choices
- Creating predictable, fair, and cost-effective development decisions
- Increase community and stakeholder and community collaboration

In the creation of communities with mixed residential, commercial, educational, and other land uses, more walkable communities are created. Mixed land uses result in "streets, public spaces, and pedestrian-oriented shopping areas" that serve as public spaces for the mixing and socialization of people (9). Furthermore, mixed land uses are enabled by compact building design as buildings are built closer together than in suburban developments, thus enabling more cost efficiency in providing public goods such as water, and electricity. In addition, driving, as well as alternative transportation options such as walking, biking, and public transit are all accommodated by compact building design as this layout shortens travel distance between residences and other destinations (Council of

Education Facility Planners International, 2004, p. 9). Increased housing opportunities and choices for individuals of all income levels as well as increased mode choices further encourage equity in housing and transportation. Communities with a strong sense of place give individuals a sense of belonging as development reflects a community's culture and history. Additionally, development directed towards existing communities utilizes already established infrastructure and encourages the preservation of open space, farmland, natural beauty and critical environment areas. Predictable, fair, and cost-effective development decisions encourage private investment, and community and stakeholder collaboration ensures that development reflects the needs and desires of the community.

***Milwaukee, Wisconsin: revolutionized school siting and neighborhood design using smart growth.***

This case study details the legislative actions taken to implement smart growth and enable the implementation of neighborhood schools in Wisconsin. Many of the issues addressed by SRTS work involves informing decision makers and moving through the legislative process so that policy makers will support program implementation. This case study illustrates how one state achieved such success using its legislative power to mandate smart growth.

This case study provides a precedent for how a school district confronting challenges paralleling those faced by HISD has used smart growth as a policy solution. Accordingly, this case study is relevant to HISD for three primary reasons.

1. Milwaukee Public School District faced budget cuts just as the Houston Independent School District is presently. In particular, student busing service was retracted in Milwaukee. Similar to many school districts facing budget shortfalls in the current economic downturn, for the Houston Independent School District, a retraction in student busing service is imminent. See Chapter 3 for an account of HISD's current busing dilemma.
2. As noted in the "Safe Routes to School" section of this literature review, Texas has not attempted policy changes in support of the "Safe Routes to School" at the state level since the program's implementation. Such policy support is critical to the implementation of the program. As the state of Wisconsin enacted a statewide Smart Growth Law in order to guide the design of new neighborhoods toward pedestrian friendliness, this case study

provides a model through which Houston may attempt a broader policy change regarding walkability. Such policy would not only prove beneficial to the implementation of “Safe Routes to School,” but it has the power to inform the design of neighborhoods statewide; increasing walkability and access to physical activity opportunities within the built environment.

3. The implementation of neighborhood schools was central to the Milwaukee Public School District’s reorganization plan. The implementation of neighborhood schools is also a policy initiative supported and pursued by SRTS. This case study outlines a state policy making process, as well as a neighborhood school policy implementation process which Houston may wish to emulate in pursuit of the implementation of neighborhood schools.

### ***Smart growth in state law.***

In 1999, the state of Wisconsin implemented the Comprehensive Planning Law also known as the Smart Growth Law. This law required that jurisdictions within the state use principles of smart growth to engage in comprehensive planning (Schneider, 2000). As outlined in the law, by 2010, all land use actions within a jurisdiction would have to comply with the provisions adopted in that jurisdiction’s<sup>5</sup> comprehensive plan, giving jurisdictions ten years to adopt design guidance.

In addition, all Wisconsin jurisdictions over 12,500 were required to adopt a traditional neighborhood development ordinance, mandating that all new neighborhood design adhere to a traditional aesthetic. This mandate clearly asserted a return to historic (traditional) neighborhood design as the desired goal of comprehensive planning in Wisconsin.

The Model Ordinance for a Traditional Neighborhood Development<sup>6</sup>, created as a model for jurisdictions creating their own neighborhood design guidance, recognizes that the residential developments of Wisconsin pre-WWII to post-WWII differ in their design. Pre- WWII communities of Wisconsin represent the more desirable neighborhoods

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<sup>5</sup> The law defined the jurisdiction or “local government unit as” a “county, city, village, town, and a regional planning commission” (Schneider, 2000).

<sup>6</sup> Traditional neighborhood development is defined under the Comprehensive Planning Law as a neighborhood with compact building design; thus enabling close proximity between civic, commercial, and residential buildings (Ohm, LaGro, & Strawser, 2001).

outlined in the Model Ordinance (Ohm, LaGro and Strawser, 2001). Specifically, lot and block standards outlined in the model ordinance are a sharp contrast to the lot and block standards observed in current suburban development. For example, the model traditional neighborhood ordinance calls for diversity in lot and block sizes due to such diversity's pedestrian friendliness (2001).

Another useful feature of the Model Ordinance for Traditional Neighborhood Development is its explanation of the "Attributes of Streets in a Traditional Neighborhood Development" (Ohm et al, 2001, p. 21). The street attribute section is particularly important because it outlines the infrastructure requirements for sidewalks, planting strips, curbs and gutters, parking, bicycle lanes, and auto travel lanes in traditional neighborhood developments (21). In suburban development today, it is common place for neighborhoods to lack sidewalks and bike lanes. Therefore, the model ordinance's value on sidewalk and bike lanes placement reaffirms their importance and rightful place in neighborhoods. The implementation of such an ordinance in Houston would serve to guide development towards pedestrian friendliness (complete streets); providing policy backed by funding supportive of SRTS.

In support of the comprehensive planning process, Wisconsin jurisdictions received smart growth grants to aid in the planning process and shift focus toward pedestrian oriented development. A significant feature of the Smart growth Law is the list of 14 comprehensive development goals set forth for all jurisdictions within the state. The most relevant of these goals relates to the implementation of neighborhood schools, and supports SRTS 's valuing re-use of facilities and infrastructure over new construction on the periphery of communities. The goal states that the

"promotion and redevelopment of land with existing infrastructure and public services, and maintenance and rehabilitation of existing residential, commercial and industrial structures, and the encouragement of neighborhood designs that support a range of transportation choices" should be pursued (Schneider, 2000, p. 1).

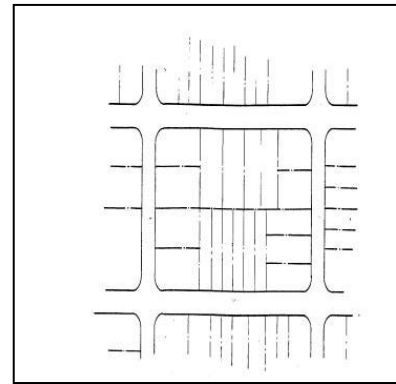


Figure IV. TND Street Grid

Source

A Model Ordinance for Traditional Neighborhood Development

<http://urpl.wisc.edu/people/ohm/tndord.pdf>

As an incentive for jurisdictions to engage in smart growth comprehensive planning and pursue such goals, the state created an aid program to reward communities actively employing prescribed practices. For example, jurisdictions would be given “one aid credit” in the program for each unit of rented or sold housing on lots of no more than ¼ acre (Schneider, 2000, p. 4). The initiative shown by the Wisconsin legislature is a practical and necessary level of initiative required to make smart growth a pervasive part of land use planning. The resources (i.e. funding and technical assistance) made available to jurisdictions contributed to their ability to integrate smart growth principles in new development.

### ***Milwaukee Public School District, Wisconsin.***

An example of how Wisconsin’s funding of programs supporting smart growth initiatives has assisted one particular jurisdiction in implementing smart growth practices in their communities is illustrated by Milwaukee, Wisconsin’s Neighborhood School Initiative program. This implementation of state Smart Growth principles at the school district level provides a precedent for which the Houston Independent School District may wish to emulate in an attempt to reduce busing costs and support increased access to walking.

At the same time the state passed its comprehensive planning and Smart Growth law in 1999, the Wisconsin legislature also approved \$170 million in loans for the Milwaukee Public School District to implement neighborhood schools. The district was to achieve this either through the construction of new school buildings, or the renovation of existing school buildings (Council of Education Facility Planners International, 2004). In order to achieve the implementation of neighborhood schools, the district initiated a public planning process, which informed the district’s decision making. The goal of this process was to determine what variables impact parents’ decision to send children to neighborhood schools. It is worth noting that the Wisconsin legislature mandated that the Milwaukee Public School district either pursue the neighborhood schools initiative or lose aid for student transfers within the district (intra-district aid) (Office of Communications and Public Affairs, 2008). The Milwaukee Public School district chose the former and through “310 community outreach meetings, door-to-door surveys of 940 households,

telephone surveys of 1,473 parents, 13 focus groups, and 1,617 parent information surveys” a wealth of community input was obtained informing the objectives of its neighborhood school plan (Council of Education Facility Planners International, 2004, p. 31). As revealed in surveys, in order for parents to send their children to neighborhood schools, generally, they desired extended before and after school care, more kindergarten through eighth grade seats, in addition to the continued right to choose what school their child attended (2004).

In response to community input, a neighborhood schools plan was formulated which targeted the “28 most crowded elementary schools and the six most crowded middle schools” (Council of Education Facility Planners International, 2004, p. 31). Thirty-Seventh

Elementary School was the first facility upgraded through the Initiative. This upgrade was particularly progressive because under the leadership of the Milwaukee Public School board and through partnerships with Habitat for Humanity, the Milwaukee Housing Authority, and the West End Development Corporation, the construction of the new 37<sup>th</sup> Street school was accompanied by affordable housing redevelopment in the area. Two homes were to be rehabilitated or rebuilt for every one home that was demolished for the school’s construction (2004). To

address safety concerns, volunteer programs were created which enabled children to walk to school safely.

In all, the Milwaukee Neighborhood Schools Initiative has been praised as a great success because it has allowed



Figure V. Old 37<sup>th</sup> Street Elementary School  
Source  
[http://www.epa.gov/dced/pdf/SmartGrowth\\_schools\\_Pub.pdf](http://www.epa.gov/dced/pdf/SmartGrowth_schools_Pub.pdf)



Figure VI. New Mary McLeod Bethune Academy (formerly 37<sup>th</sup> St.) Source <http://mpsportal.milwaukee.k12.wi.us>

the school district to “reduce busing, upgrade buildings, replace an out-dated facility, add science rooms, and overall, provide quality environments that support learning” (Office of Communications and Public Affairs, 2008, p. 1). Moreover, the Milwaukee Neighborhood Schools Initiative program is a prime illustration of how policies supporting smart growth can be mandated at the state level and backed with funding, thus making the implementation of these principles practical at the municipal level. In effect, the Milwaukee school district was able to use state funding to construct new and rehabilitate old buildings, in addition to increasing housing options within school neighborhoods. Moreover, in the implementation of a “Safe Haven” home program in which volunteers remain on their porches throughout the community to ensure commuting children’s safety, parents’ cited safety concerns were allayed.

Once again, the Houston Independent School District can learn from the Milwaukee Public School District’s plan for neighborhood schools and the state of Wisconsin’s Smart Growth Law. Facing budget cuts, and in contemplation of the need for reduced student busing service, it is important that Houston attempts to address the policies which necessitate its unsustainable policies. In particular, the pervasive suburban transportation and land use patterns which have created great distances (over two miles) between homes and schools must be addressed.

As observed in this case study, based on a state legislative mandate, Wisconsin jurisdictions and school districts were charged with integrating smart growth principles into their long term development plans. Accordingly, this research acknowledges that city planning commissions and departments of public works departments are appropriate organizations for advocating smart growth policy at the municipal level. An opportunity exists within a planning commission, or in the case of Houston, its planning and development department, to integrate smart growth principles into long range municipal growth plans. In addition, an opportunity exists with departments of public works to retrofit streets (embracing complete streets policy) in a manner of smart growth. Between state legislatures, school districts, planning commissions and public works departments advocating smart growth, a consciousness regarding the impact of transportation and land use policy on public health more sustainable development policy within cities, regions and states will begin to emerge.



## Summary

Chapter 2 introduces the rationale, methodology and policy issues addressed in this research. First, the rising childhood obesity epidemic is introduced as a primary rationale for this research. Considering the potential for SRTS to negatively impact childhood obesity prevalence through its serving as a long term intervention; the objective and widespread implementation of the program is imperative.

Secondly, this chapter highlights literature relating to the methodologies employed in active transportation research to identify variables impacting children's travel behavior and walkability. The intent of this thesis is to demonstrate a methodology for measuring the impact of physical and socio-economic environment variables on Houston Independent School District-E middle school neighborhoods' walkability. In addition, how that analysis can be used to objectively target SRTS programming is proposed. From this review of literature, proximity, land uses and road types represent the major facets of walkability (physical design elements) to be explored in support of this study. Furthermore, the approach to assessing school neighborhood walkability employed in the University of Western Australia project informs the methodology (the "Shelling Model") utilized in this research.

In regard to socio-economic environment variables, primary data on crime or parental concern could not be collected. However, their importance has not been discounted. These variables have been incorporated into the "Ideal Model" as well as recommendations for future research discussed in the conclusion chapter. Despite the data availability constraint, socio-economic variables were included in the study, as outlined in Chapter 4.

Moving past the rationale and methodology of this thesis, complete streets and neighborhood schools are discussed, with smart growth emerging as a policy tool with which these concepts can be implemented. Smart growth holds promise in raising a level of consciousness among educators, planners and public health researchers regarding the impact of transportation and land use patterns on public health. Through advocacy within these audiences, smart growth provides a greater framework through which development in cities regions and states can be move toward pedestrian orientation.

## Chapter 3: The Houston Independent School District

### Overview

This chapter introduces Houston/Harris County, Texas and the Houston Independent School District as the study area of this research. A background of this study area will provide context for the methodology described in Chapter 4. This chapter contains three parts, Parts I, II and III. Part I provides general demographic information for Harris County and the Houston Independent School District. Part II provides insight into the busing policies of Texas as well as the Houston Independent School District, supporting a “Call for Increased Access to Opportunities for Physical Activity.” Part III provides insight into the current implementation of the “Safe Routes to School” program in Houston, Texas.

### Part I

#### **Houston, Texas/Harris County, Texas demographic overview.**

With a population of 2.2 million, Houston, Texas, located within Harris County, ranks as the fourth most populous city in the United States (Bernstein, 2009). The location of Houston within Harris County is important as the city represents 65% of the county’s population, and all necessary ArcGIS compatible datasets necessary for this study were extracted from this larger geographic area. For these reasons, Harris County is the focus of the following demographic overview. Furthermore, as discussed in Chapter 2, age and race are important factors of consideration regarding the rising childhood obesity epidemic. Therefore, changes in these characteristics, as well as poverty status over the past 30 years are central to this Harris County demographic overview.

*On the following page is Table II, which outlines Harris County’s socio-demographic characteristics.*

Table II. Harris County Socio-demographic Characteristics

	1970		2000	
	Absolute	Percentage	Absolute	Percentage
Total Population	1,741,912.00		3,400,578	
Age 17 years or younger	660358.84	37.19	986167.62	29.0
Race	1379594.30 white 350124.31 black or African American 121933.84 Some other race alone	79.2 white 20.1 black or African American .7 Some other race alone	1996139.29 white 629106.63 black or African American 482882.076 Some other race alone 102017.34 Two or more races 173429.48 Asian Alone	58.7 white 18.5 black or African American 14.2 Some other race alone 3.0 Two or more races 5.1 Asian Alone
Poverty Status: Families with income below the poverty level	161997.82	9.3	275446.82	8.1
Source 1970 and 2000 Census data obtained from <a href="http://socialexplorer.com">http://socialexplorer.com</a>				

As observed in Table II, Harris County experienced a 49% increase in population from 1970 to 2000. In line with this population increase, Harris County also experienced growth in racial diversity. In the 1970 Census, Harris County had a dichotomous racial mix, with “white” and “black or African American” classifications representing a majority of the population. However, by the 2000 Census the “Some other race alone” classification increased by 13.5% and “Asian Alone” and “Two or more races” classifications were also included in the racial mix of Harris County.

In addition to growth in racial diversity, Harris County also experienced an increase in its “17 years and younger” population, as well as families living in poverty. Although there was a 9.17% decrease in the “17 and younger” population in Harris County from

1970 to 2000, there was also an absolute increase in this population. In 1970, Harris County had a “17 and younger” population of 647817.07. By 2000, Harris County had a “17 and younger” population of 986167.62. As such, Harris County increased its “17 and younger” population by 34% from 1970 to 2000. Regarding poverty levels, although a 1.2% decrease in families living below the poverty level occurred from 1970 to 2000, the absolute number of people living below the poverty level increased. In 1970, Harris County had 161997.82 families living below the poverty level while in 2000 this figure increased to 275446.82. From 1970 to 2000, the population of families living below the poverty level in Harris County increased by 41%.

### **Houston Independent School District overview.**

Originally founded in 1923, the Houston Independent School District has experienced marked growth since its founding 86 years ago. In 1930, the school district had a student population of 57,000, and today has 205,000 within 300 schools and programs. HISD is recognized as Texas’s largest public school system (Houston Independent School District, 2009). HISD is also ranked as the largest employer in the Houston metropolitan area with a workforce of nearly 30,000 (2009); a testament to the economic significance of HISD to Houston’s economy.

The Houston Independent School District has a majority minority student population. According to HISD, the district has a “58 percent Hispanic, 30 percent African-American, 9 percent White, and 3 percent Asian/Pacific Islander” student population (General Information, Student Enrollment 2009). Also, reflective of its majority minority population, HISD has an over 25% limited-English-proficient population representing speakers of over “90 different native languages” (General Information student enrollment, 2009).

Nearly 81% of students are “economically disadvantaged,” meaning that they qualify for reduced or free lunch, while nearly 68% are considered “at risk” for dropping out of school.

On the next five pages, maps displaying the locations of HISD-E middle school neighborhoods included in this study are provided. As noted in the Appendix A glossary, this study diverges from Houston Independent School District defined middle schools. HISD primarily identifies schools exclusively serving grades 5-8 and 6-8 as middle schools. However, in this study, HISD institutions serving grades 6-5, 6-8, PK-8, 1-12 and 6-12 are identified as middle schools. This expanded characterization is the basis for district schools being identified as HISD-E middle schools in this research. Middle schools, rather than elementary or high schools were targeted for this study because this student population is most likely to actively commute. Elementary school-aged children may be too young to walk to school unaccompanied, and high school students are approaching driving age, reducing their likelihood of actively commuting as well.

The locations of 49 HISD-E middle schools are shown within their respective SuperNeighborhoods, The SuperNeighborhood represents the geographic area in which HISD-E middle schools will be analyzed.

According to the Houston Planning and Development Department a SuperNeighborhood is a “geographically designated area where residents, civic organizations, institutions and businesses work together to identify, plan, and set priorities to address the needs and concerns of their community. The boundaries of each super neighborhood rely on major physical features (bayous, freeways, etc.) to group together contiguous communities that share common physical characteristics, identity or infrastructure” (Houston Planning and Development Department, 2010).

**Figure VII. HISD-E Middle School Neighborhoods, Map 1 of 5**

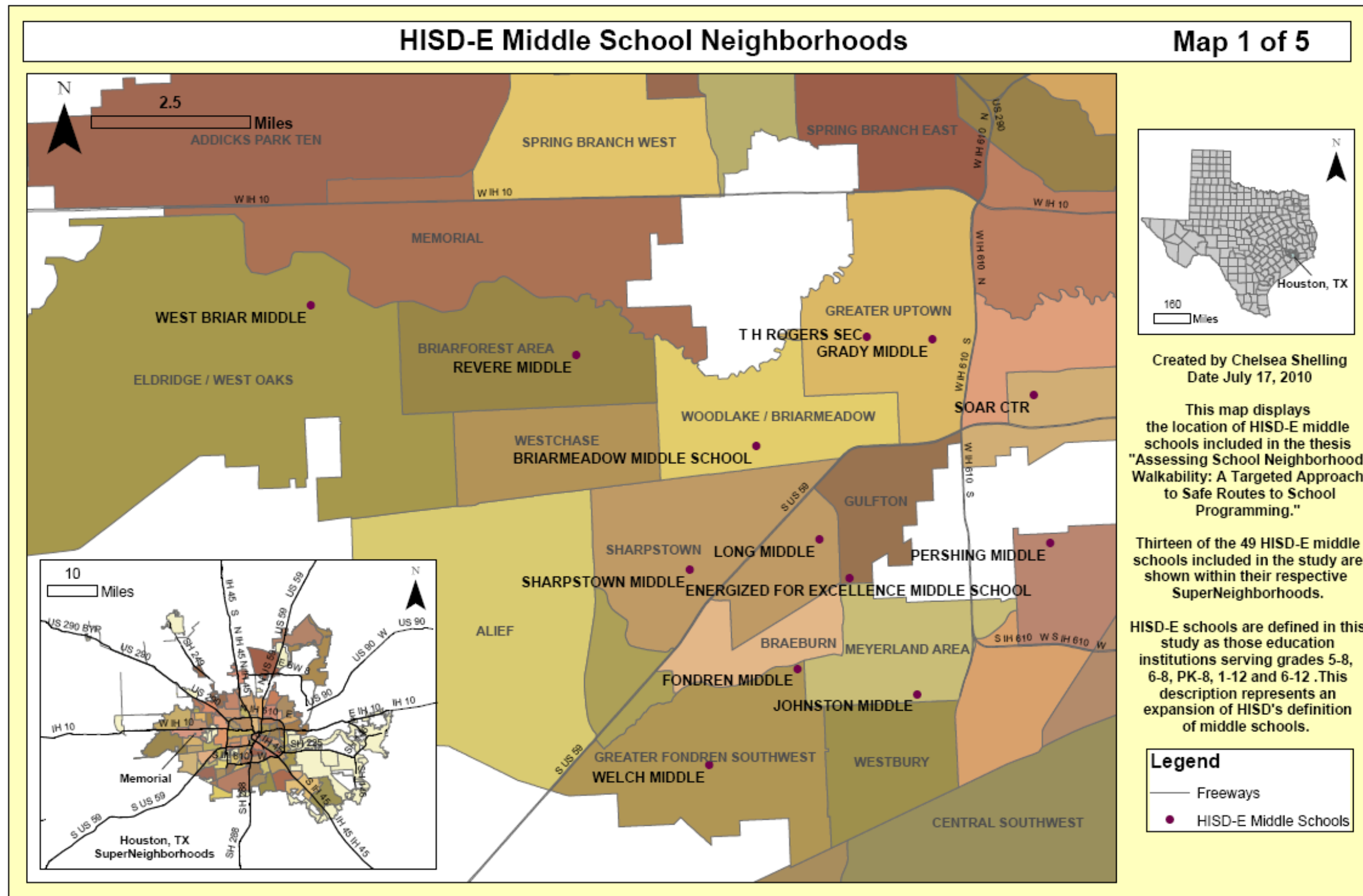


Figure VIII. HISD-E Middle School Neighborhoods, Map 2 of 5

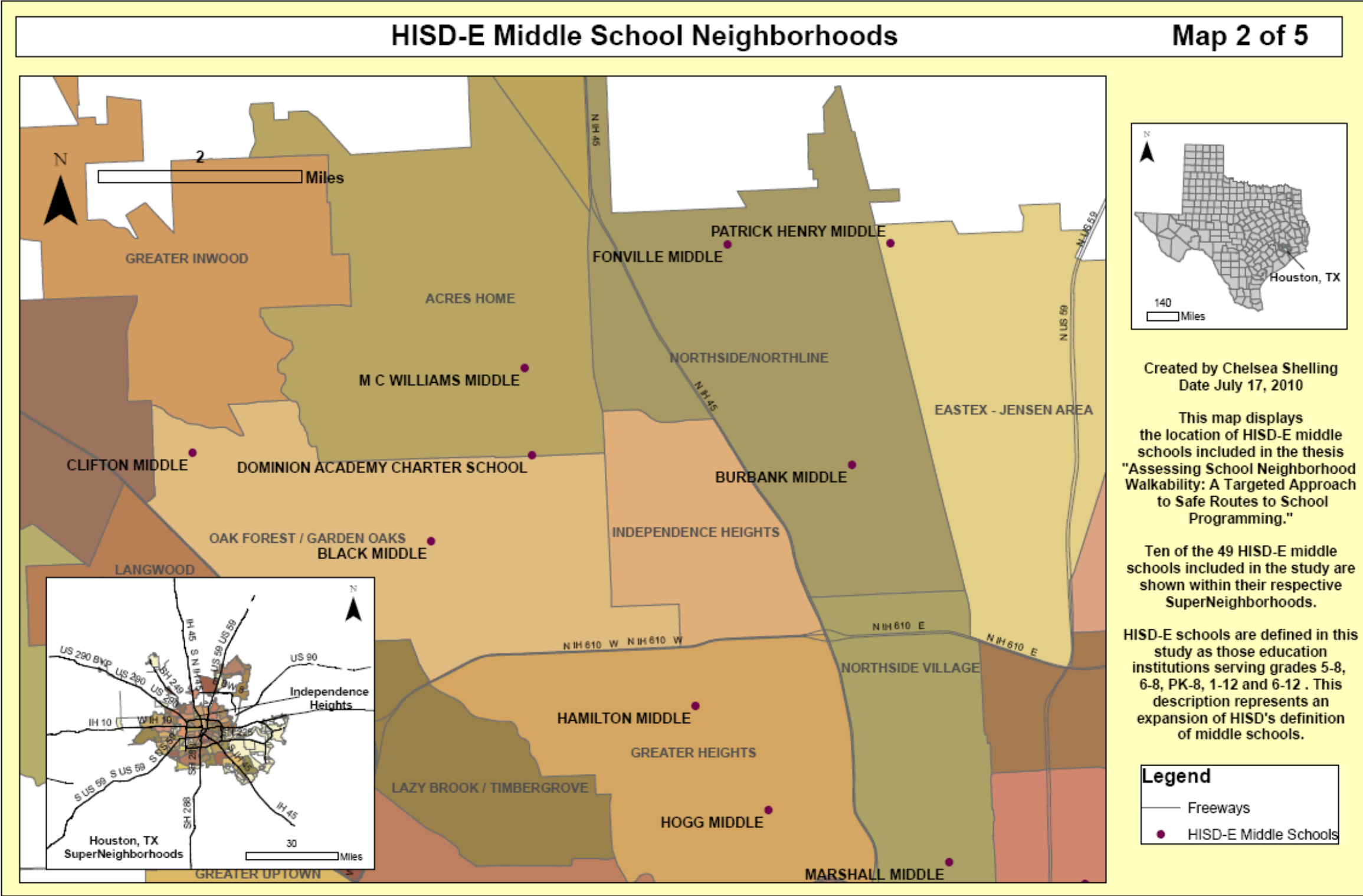


Figure VIV. HISD-E Middle School Neighborhoods, Map 3 of 5

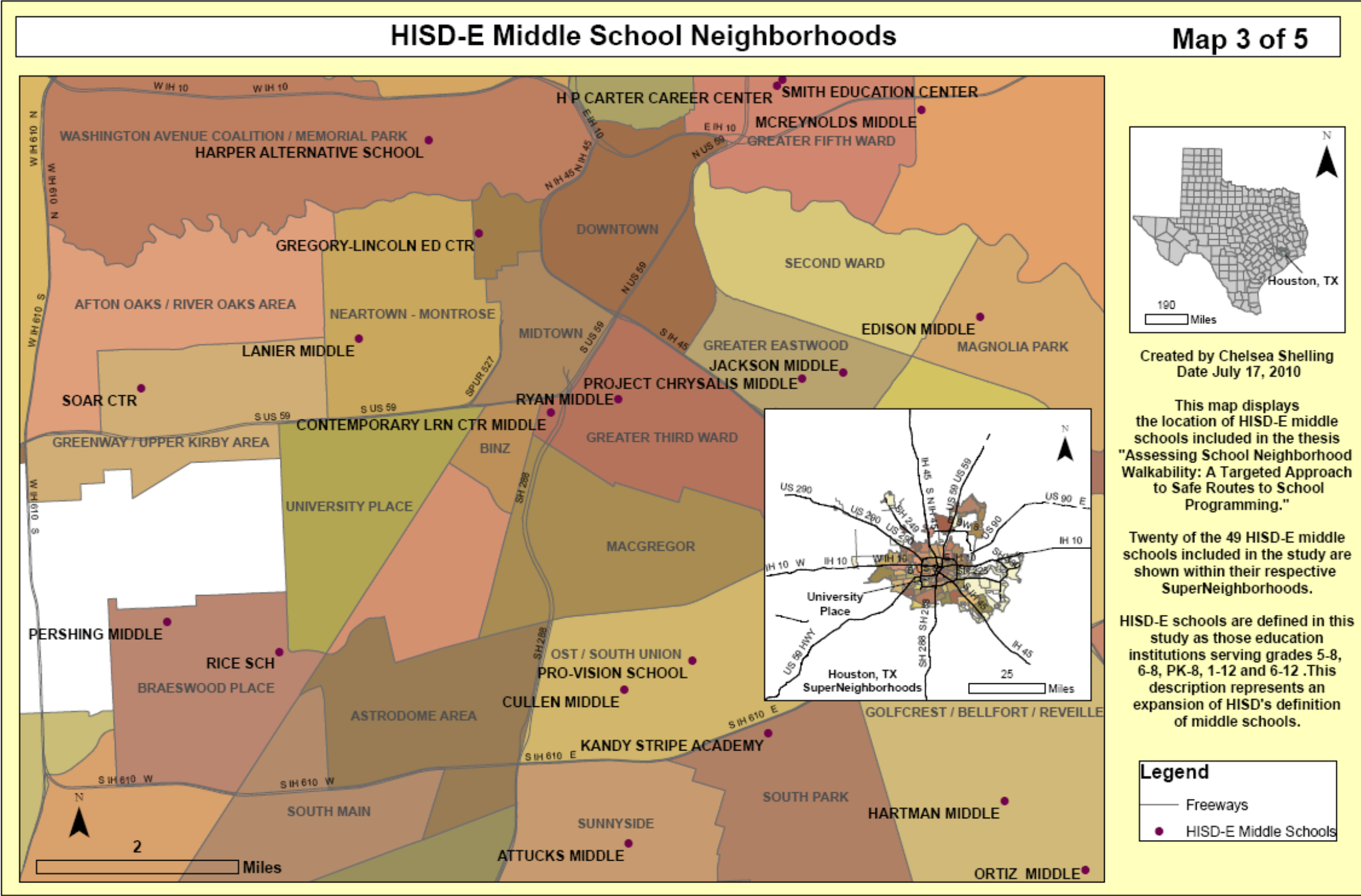
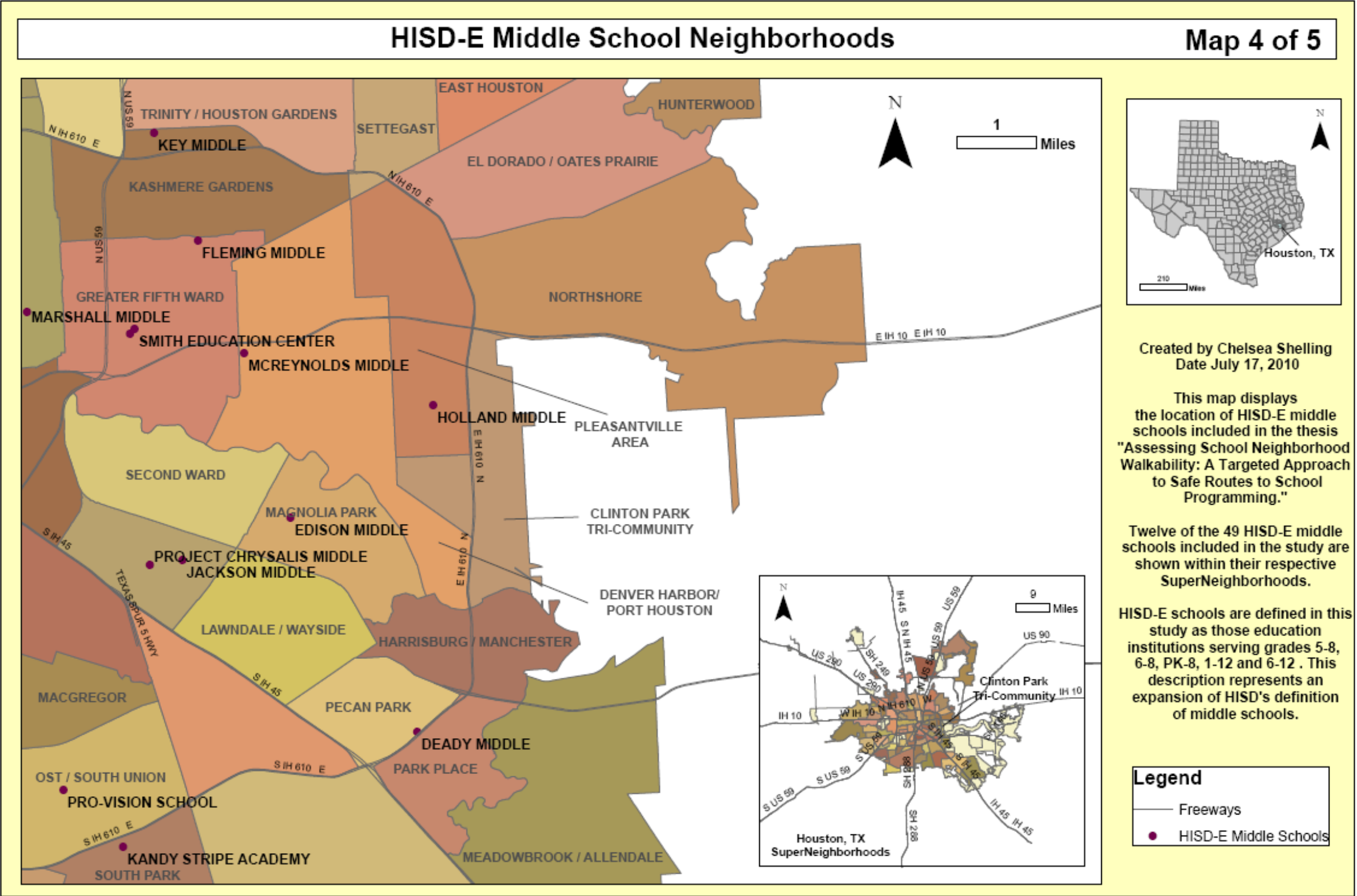




Figure X. HISD-E Middle School Neighborhoods, Map 4 of 5



## HISD-E Middle School Neighborhoods

### Map 5 of 5

This map displays the location of HISD-E middle schools included in the thesis "Assessing School Neighborhood Walkability: A Targeted Approach to Safe Routes to School Programming." The map shows the distribution of 49 middle schools across various SuperNeighborhoods in Houston, Texas. The SuperNeighborhoods are color-coded and labeled: SHARPSTOWN, LONG MIDDLE, PERSHING MIDDLE, RICE SCH, MACGREGOR, DEADY MIDDLE, PRO-VISION SCHOOL, CULLEN MIDDLE, KANDY STRIPE ACADEMY, SOUTH MAIN, HARTMAN MIDDLE, STEVENSON MIDDLE, FONDREN MIDDLE, JOHNSTON MIDDLE, WESTBURY, ATTUCKS MIDDLE, SUNNYSIDE, ORTIZ MIDDLE, WELCH MIDDLE, WOODSON MIDDLE, THOMAS MIDDLE, CENTRAL SOUTHWEST, MINNETEX, GREATER HOBBY AREA, SOUTH BELT / ELLINGTON, DOWLING MIDDLE, FORT BEND / HOUSTON, and SOUTH ACRES/CRESTMONT PARK. The map includes a north arrow, a scale bar (0 to 4 miles), and an inset map of Houston, TX, showing the location of the study area. A legend indicates that red dots represent HISD-E Middle Schools and blue lines represent Freeways.

**Legend**

- Freeways
- HISD-E Middle Schools

**Map 5 of 5**

## **Part II**

### **Texas and HISD busing policy.**

In the Texas Education Agency's School Transportation Allotment Handbook, the agency outlines a myriad of bus transportation services eligible for state funding. However, the agency allows school boards to determine the extent to which bus transportation services will be provided, especially when considering funding availability. Among other criteria, the Transportation Allotment Handbook identifies students eligible for bus service as those students who

“...legally reside two or more miles from his or her assigned campus of regular attendance as measured along the shortest route that may be traveled on public roads (hereinafter, "two-or-more-mile student") or “ legally reside in a designated hazardous traffic area within two miles of the student's attendance zone campus as determined by the district's board of trustees policy regarding students that would be subject to hazardous traffic conditions if walking to or from school” (Texas Education Agency, 2009, p. 1-2).

The Houston Independent School District does transport students living two or more miles from their zoned school, as well as students with special needs. However, HISD does not provide bus transportation to those students living within two miles of their attendance zone campus. Bus service is denied regardless of the presence of hazardous conditions impeding safe walking to school, such as hazardous traffic areas.

In determining a student's distance from campus, HISD uses the *Trapeze Routing Program* to calculate a student's nearest route to school using public roads (Houston Independent School District, Student Eligibility, n.d.). A student's address, as well as their school's address is input into the software and the pupil's nearest walk path is calculated. If based on Trapeze's GIS calculation, a student lives less than two miles from school, then they are ineligible for bus service.

### **HISD Cost of busing.**

The long distances (two miles or greater) between students' homes and schools of attendance contribute to the significant amount of HISD's budget dedicated to student busing. Annually, the cost of busing for the Houston Independent School District is \$26.4 million. Of this \$26.4 million, the busing of magnet school students costs \$16.6 million, while “most of that cost (\$8.9 million) is for transporting students who live 10 or more

miles from their school” (Saavedra, 2008, p. 1). Despite the possibility that much of the busing costs may be due in part to HISD’s open access policy, the disproportionate amount of funding dedicated to magnet school busing has led HISD to contemplate retracting its magnet school bus service.

Currently, any magnet student living more than two miles from their school is bused. Proposed alternatives to this level of service include: transporting students living within two to ten miles from campus only; transporting students living within 2 to 10 miles from campus only, and establishing "drop and ride" stops inside the 10-mile limit for those students who reside more than 10 miles from their Magnet school”; or establishing “drop and ride" locations within 10 miles of each school for all Magnet students” (Saavedra, 2008, p. 1).

The emergence of busing costs as a point of contention in current budgeting further highlights the need for schools sited within neighborhoods and accessible by walking as smart growth principles encourage. As previously mentioned, the Milwaukee Public School District’s neighborhood schools plan serves as an example of how Houston can attempt to remedy its busing dilemma long term.

This thesis looks at the supportiveness of HISD-E middle school neighborhood environments for active transportation use. If within HISD’s prescribed two mile busing eligibility distance, there are physical design elements impeding children’s safe walking to school, this research will have significant policy implications for district transportation policy. It may serve as a call to re-evaluate HISD busing policies, with the district potentially providing busing to children living within two miles of school, and/or being compelled towards an aggressive pursuit of SRTS programming and smart growth policies.

### **Part III**

#### ***Safe Routes to School in Texas: An Interview with Carol Campa, Texas Safe Routes to School Coordinator***

Given HISD’s busing policies and lack of accommodation for students facing physical environments hazardous to safe active commuting, “Safe Routes to School,” which takes into consideration such dangers, holds promise in informing the design of communities.

Below is a summary of an interview with Carol Campa, Texas Coordinator for the “Safe Routes to School” program. The purpose of this interview was to gain insight into the implementation of SRTS in Texas, a sense of the most prevalent barriers to walking, as well as predominant school siting policies.

1. *What do you believe are the top three barriers to walking for children in Texas?*

The top three barriers to walking are hazardous traffic conditions (i.e. roads with high traffic volumes and speed limits), distance from home to school, and parent’s concern regarding crime, in particular child abductions. See Figure 2B, in Appendix B for an excerpt from the Texas SRTS Project Application. This figure shows possible safety barriers which applicants may identify.

2. *Are there state school siting policies which have impacted the siting of schools away from students homes on the edges of neighborhood?*

Most of the time, schools are built on the periphery of communities because the land is cheap. School districts tend to build schools where they can get the most land for their money. It just so happens that the land fitting that criteria tend to be on the periphery of communities.

3. *How is the “Safe Routes to School” program implemented in Texas? Do you target schools for programming?*

The application process for “Safe Routes to School” is very community led. If a school or community is interested in implementing an SRTS program, they must first submit an SRTS Plan. This plan details the need for programming (i.e. safety hazards) as well as information regarding mode share for school commutes. An applicant must conduct surveys of the walking conditions around the school and create a plan for implementing the 5 E’s of SRTS,<sup>7</sup> which includes a protocol for program evaluation, in addition to a host of other criteria. See Figure 1B, in Appendix B for an excerpt from the Texas DOTD SRTS Program

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<sup>7</sup> The 5 E’s of the “Safe Routes to School” program represent the strategy employed for encouraging increased walking and biking for school commutes. They are: engineering, education, enforcement, encouragement and evaluation (Texas Department of Transportation, 2009).

Guidance and Application Instructions manual. This excerpt outlines some “Safe Routes to School” requirements for SRTS plans.

Once an SRTS plan has been approved, applicants then submit a project application. A considerable time investment is required to complete an application. It’s really the communities that are interested in the program who come to us for funding. Those are the schools that get programs

*4. How is success measured? Have you recorded the increases in children walking?*

Each applicant is required to track how many children walked to school before and after the program is implemented. We have a report in progress which will summarize the level of walking before and after program implementation.

*5. In Houston, there is a Safe Sidewalk program in which neighborhoods or schools interested in getting sidewalks installed within a three block distance around schools can apply for them through the Harris County Department of Public Works. Does SRTS actively seek other sources of funding to defray the costs of projects?*

Other funding sources are always welcomed, but we do not have a composite list of possible funding sources we can draw on within each jurisdiction to defray the cost of the program or couple it with other capital improvements. If an applicant makes us aware of a funding source, then we would use that funding as well, but that scenario is not commonplace.

## Summary

This chapter provides the context in which the “Shelling Model” is pursued. First a demographic overview of Harris County and HISD is offered. This overview suggests that Harris County and HISD maintains at least one population which is at increased risk for obesity, further supporting the rationale for this research. That population is primarily non-Hispanic blacks.

This chapter also introduces HISD’s busing policy. HISD currently denies service to children facing hazardous environments within two miles of school. The Texas SRTS

Coordinator's identification of proximity and hazardous road conditions as major barriers to students' active commuting throughout the state reveals a conflict between HISD busing policy and the reality of children's experience in the physical environment.

Additionally, nearly a third of the HISD's cost of busing is for students living more than ten miles from school. Regardless of HISD's open access policy, the fact remains that proximity is a major barrier to children walking to school. This impediment suggests that beyond SRTS efforts in making the walkable distance between pupils' home to school safe, the fact is that many students do not have the benefit of such proximity. This reality further emphasizes the importance of pursuing smart growth policy; encouraging transportation and land use patterns informed by public health consideration. In the end, such consideration may lead to children's improved access to active transportation long term and reduced obesity prevalence.

## Chapter 4 Assessing School Neighborhood Walkability: A Methodology

### **Overview**

Following an introduction to the “Houston Independent School District,” this chapter describes the research methodology informing the approach employed in this thesis. Thereafter, the data collection and methods of analysis associated with each of the research questions posed in Chapter 1 are provided. This description is followed by key findings regarding the use of GIS technology in analysis. All research questions will be re-examined through discussion in Chapter 6.

### **The TREK Project: methodology.**

The inspiration for the methodology employed in this thesis is the Transport, Environment and Kids (TREK) project sponsored by the University Of Western Australia School of Population Health. The objective of this project was to assess the impact of the urban design of neighborhoods on children’s mode of transport to school and other neighborhood locations (Wood, Giles-Corti, Pikora, Bulsara, McCormack & Timperio, 2010).

As recognized by the TREK project and through a search for the best available literature exploring school neighborhood walkability attempted in this thesis, it is the first research effort to explore school neighborhood-specific walkability. As expressly stated on the TREK project website, “there is no objective data on the extent to which the urban design surrounding schools hinders or facilitates walking to school” (University of Western Australia School of Population Health, n.d.). As previously mentioned, McMillan eludes to this lack of connection as she notes that research has not definitively revealed the connection between urban design elements and children’s mode of travel to school (2005).

### ***TREK methodology.***

In the project a child-specific walkability index was created to enable the categorization of school neighborhoods as more or less walkable. The 12 school neighborhoods with the highest and the 12 school neighborhoods with the lowest walkability ratings were targeted for a cross-sectional survey which gathered information



on modes of transport to school and other destinations, in addition to gathering demographic data (Woods et al, 2010). The walkability index was composed of two indices: a “ped shed rating” and a “traffic exposure rating.” In calculating ped sheds, informal pedestrian networks rather than street networks in isolation were used. The traffic exposure rating was “measured by a ratio of local access roads to busier roads within 2 km of school” (Wood et al, 2010, p. 5). This exposure rating requires the kilometers of Primary Distributors, District Distributors and Local distributors to be summarized then divided by the miles of local access roads. Values were separated into deciles and recoded to generate a walkability rating.

### ***Major findings of TREK study.***

Street connectivity, traffic exposure and parental perceptions of safety are all important factors in children walking to school. As results of the study show, children in neighborhoods with high ped shed ratings and traffic volume exposure were less likely to walk to school than those students within communities with high ped shed ratings, but low traffic exposure (Woods et al, 2010). Furthermore, the study showed, similar to those studies described in the “Urban Form and Active Transportation” section of this thesis that parental perceptions of safety, regardless of the conduciveness of the built environment for walking, may pose a valid hurdle to children’s increased use of walking for school commutes (2010).

Together these findings further support the importance of evaluating elements of the built environment impacting children’s ability to walk to school. This thesis supports and attempts to contribute to this research through the adapted methodology described hereafter.

### **HISD-E middle school neighborhood walkability: a methodology.**

*What does this thesis take from the TREK project?-Delimitations in adapting methodology?*

In consideration of the large scope of the TREK project and the large investment of resources required to engage in such a research effort, the methodology was scaled down

significantly for this thesis's objective; providing a model with which "Safe Routes to School" administrators may target programming.

This research does take into account the relevance of TREK's findings regarding the importance of street connectivity and traffic exposure. Street connectivity (i.e. school commute distance) as well as hazardous road conditions are articulated in active transportation research, in addition to being identified by the Texas "Safe Routes to School" Coordinator as factors impacting children's decision to walk to school. As such, street connectivity as measured through ped shed ratings and miles of freeways, toll ways and major roads intersecting catchments are integral to the regression analysis conducted in this thesis. With these variables explored, the theoretical proximity from homes to schools, as well as the level of traffic exposure within that proximity may be revealed.

Ped shed calculations were calculated for 49 HISD middle schools. Informal pedestrian networks were not used in these calculations as aerial imagery was unavailable. Furthermore, the sample for this thesis is narrower than the 238 primary schools included in the TREK study. The inclusion of the 49 HISD-E middle schools in this study was determined by the location of a school within the City of Houston, its serving either grades 5-8, 6-8, PK-8, 1-12, or 6-12<sup>8</sup>, and the availability of GIS compatible data. *See Data Dictionary in Appendix A for an index of all GIS data used in this study.*

Though as stated in Chapter 2 this thesis recognizes the importance of deploying cross-sectional surveys in an effort to identify environmental and social factors impacting travel behavior, the methodology of this thesis is meant to serve as a first step (identifying variables) in a procedure to first categorize the least and most walkable HISD-E middle school neighborhoods. Beyond the scope of this thesis, in future research a walkability index based on variables included in a model unlimited by the availability of primary data would be used to rate the walkability of school neighborhoods. Thus, a cross-sectional study would be deployed and data extracted for use within a walkability index, rather than after schools have already been targeted. In effect, physical design and socio-economic environment improvements impacting travel behavior (as determined in the cross-

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<sup>8</sup> Students in grades 5-8 were targeted for this study because "Safe Routes to School" does not extend funding to high schools, and parents of students in grades below grade 5 may be unwilling to allow children to walk to school unassisted

sectional study) could be identified and addressed through this targeting of “Safe Routes to School” funding.

### ***The “Shelling Model.”***

The purpose of this thesis is twofold. As previously mentioned, this thesis demonstrates how the impact of physical and socio-economic environment variables on HISD-E middle school neighborhoods’ walkability can be measured through regression analysis. The regression analysis measures the impacts of:

- hazardous road types (i.e. tollways, freeways<sup>9</sup> and major<sup>10</sup> roads),
- commercial and industrial land use,
- average household density,
- average car availability,
- student population,
- Texas Education Agency school performance ratings,
- the number of 1 unit detached housing units, and
- the number of housing units built by 1939 or earlier on

walkability (as measured by ped shed and Walkscore ratings) of 49 Houston Independent School District middle school neighborhoods. This research further proposes how an analysis of middle school neighborhood walkability can be employed to create a walkability index appropriate for targeting “Safe Routes to School” programming.

This thesis acknowledges that the findings of this research cannot be generalized, and that these findings are relevant to Houston Independent School District middle school neighborhoods only.

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<sup>9</sup> Freeways are “limited access roads with frontage or access roads, excluding tollways” (Fu, 2010).

<sup>10</sup> The “Major” road classification refers to “all highways without limited access, including FM roads and all other roads with multiple lanes and high volumes” (Fu, 2010).

### ***Revisiting Research Questions.***

RQ1. What level of walkability exists in Houston Independent School District (HISD) middle school neighborhoods?

The following questions were utilizing in answering RQ1.

#### ***How pedestrian accessible are amenities in HISD-E middle school neighborhoods?***

Walkscore Rating- This rating measures proximity to amenities.

This rating reflects the ease with which a pedestrian may access amenities from a neighborhood location. In the case of this thesis, HISD-E middle schools are the neighborhood locations. The Walkscore algorithm awards points to those amenities<sup>11</sup> closest to the neighborhood location, awarding maximum points to amenities within a quarter mile walking distance of a location and awarding no points to amenities beyond a one mile distance from a neighborhood location (Walkscore.com, 2010). The points awarded for each amenity are input into the Walkscore algorithm and a rating between 0 and 100 is generated. Ratings closer to 100 indicate higher walkability.

Critiques of Walkscore.com

As noted on Walkscore.com, its rating algorithm does not consider all factors within the physical environment impacting walkability. Such excluded factors include street design, street width and block length, crime and traffic accidents, community design, weather, topography, freeways and water bodies (Walkscore.com 2010). In this thesis, further analyses are used to capture such factors impacting walkability; specifically, block lengths, community design in regard to land uses, as well as freeways and major roads are considered in this study.

#### **Data collection/method of analysis.**

The addresses of 49 HISD-E middle schools were input into the Walkscore.com tool, in which ratings generated. All ratings were recorded in an excel spreadsheet for input into a regression analysis.

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<sup>11</sup>Examples of amenities charted on Walkscore.com include restaurants, grocery stores, malls, book stores, schools, libraries, fitness centers, etc (Walkscore.com, 2010)

***What land area within a two mile “crow flies” distance from HISD-E middle schools is accessible to middle school students walking to school?***

Walkable Catchment/Ped Shed Rating- This rating measures proximity (access) to neighborhood land area, taking into consideration block lengths and street connectivity. The walkable catchment/ped shed technique is used in this study to assess children’s access (i.e. proximity) to land within a two mile “crow flies” distance. This method captures block lengths as it measures various two-mile routes from HISD-E middle school. This technique, usually intended to measure quarter mile and one-half mile distances from neighborhood centers and transit stops respectively, recognizes 60% as an ideal rating. Although a larger distance is being explored, this thesis also recognizes 60% as an ideal catchment rating.

To calculate a ped shed rating, the quotient of an actual walking distance divided by a theoretical distance is multiplied by 100.

It should be noted that although Walkscore.com measures distance to amenities and the ped shed technique measures proximity to neighborhood land area, taking into consideration block lengths, neither the ped/shed technique nor the Walkscore algorithm capture land uses or road types which may pose as hazards to children walking to school. This thesis provides further analyses of these factors which also impact walkability.

**Data collection/methods of analysis.**

Using Network Analyst<sup>12</sup>, an ArcGIS 9.3 Desktop extension, catchment ratings were generated for each HISD-E middle school. All ratings were recorded in an excel spreadsheet for input in a regression.

***Are there potentially hazardous community design features for HISD-E middle school students walking to school?***

Based on the findings of active transportation research, as well as Texas “Safe Routes to School” program identification of physical design elements negatively impacting children’s travel behavior, potentially hazardous land uses and road types were integrated into this methodology. Potentially hazardous land uses analyzed in this thesis are industrial

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<sup>12</sup> For this thesis network Analyst enabled “network-based spatial analysis” (ESRI, 2009) through its Service Area creation tool.

land, commercial land over 1 acre and vacant commercial. Potentially hazardous road types analyzed in this thesis are freeways, tollways and major roads. See footnotes 1 and 2 on page 3 for definitions of these road types.

The acreage of hazardous land uses and road types within each HISD middle school's walkable catchment was recorded in an excel spreadsheet for input into a regression.

### ***The regression models.***

Once all values were input into excel, two regression models were generated. The regression equation is  $Y=a+bx$ . "Y" represents the dependent variable the equation attempts to predict. Walkscore and catchment ratings are the dependent variables used in this research. "X" represents the independent variable that is used within the regression to predict change in the dependent variable. In this research, independent variables include: hazardous road types (i.e. tollways, freeways<sup>13</sup> and major<sup>14</sup> roads), commercial and industrial land use, average household density, average car availability, student population, Texas Education Agency school performance ratings, the number of one unit detached housing, and the number of housing units built by 1939 or earlier. "A" represents the constant/intercept while "B" represents the slope/B coefficient.

The Walkscore Model (1) captures the impact of independent variables on access to amenities within HISD-E middle school neighborhoods. The Catchment Model (2) captures the impact of independent variables on the percentage of land area available to children walking to school within a two mile "crow-flies" distance. This distance represents the direct route from home to school that can be flown by a crow, rather than along the street network. While the Catchment Model provides a sense of the general expanse of land accessible to a child walking to school, the Walkscore Model provides a sense of the amenities available in a neighborhood within that catchment, some of which may be utilized by children. Fast-food restaurants are an example of such an amenity which children may utilize and for which a sense of walkability is important. Though

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<sup>13</sup> Freeways are "limited access roads with frontage or access roads, excluding tollways" (Fu, 2010).

<sup>14</sup> The "Major" road classification refers to "all highways without limited access, including FM roads and all other roads with multiple lanes and high volumes" (Fu, 2010).

Walkscore.com only rates proximity to amenities within a one mile distance, it does provide a sense of the amenities present within a neighborhood.

### ***Additional elements.***

In addition to the elements measured in response to RQ1, additional variables were added to create a more robust regression. This allows for socio-economic and physical environment variables not identified by Texas SRTS or active transportation research as barriers to walking to provide further context for this study. These variables provided data regarding socio-economic status, school performance, as well as residence type and year of construction for HISD-E middle school neighborhoods. Additional variables included:

- average household density,
- average car availability,
- student population,
- Texas Education Agency school performance ratings,
- the number of one unit detached housing units, and
- the number of housing units built by 1939 or earlier.

Values for each of the aforementioned values were recorded in an excel spreadsheet for input into a regression.

*RQ2. How can a broad analysis of middle school neighborhoods' walkability be employed to objectively target schools for "Safe Routes to School" programming?*

### **Data Collection/Method of Analysis.**

This question was answered using the substance of the literature reviewed in this thesis, in conjunction with an interview with Carol Campa, Texas Safe Routes to School Coordinator and RQ1 findings. This question is revisited in Chapter 6.

## **Using GIS Technology in Assessment of School Neighborhood Walkability**

Through the use of GIS technology in assessing school neighborhood walkability, a key lesson pertinent to bringing the "Shelling Model" into practice arises. Due to the time

commitment required for data collection, as well as the technical knowledge necessary to operate ArcGIS 9.3 with the Network Analyst extension, it is evident that professional capacity is critical in bringing this proposed model into practice. This model does not lend itself easily to use by community groups. Rather, it is a tool for use by transportation professionals or others deemed capable. For example, due to their professional capacity and access to data, the Houston-Galveston Area Council or the Texas Department of Transportation would serve as appropriate institutions in which this walkability analysis can be conducted

## Summary

Through the findings of a review of literature and an interview with the Texas SRTS Coordinator, variables pertinent to children's safe active commuting were identified, and a model for objectively targeting programming was crafted. As suggested in both this and chapter 2, the variables utilized in this study do not represent all elements which may impact walkability. For example, variables such as crime data, and the results of cross-sectional survey data would have provided depth to this research regarding deterrents for walking within neighborhoods, as well as information on school commute mode shares respectively.

In the process of running the "Shelling Model"<sup>15</sup> the need for possessing the professional capacity to create and run the archetype reveals itself. Therefore, such expertise limits the extent to which certain organizations such as community groups may be able to utilize the model. Rather, this model lends it itself to transportation professionals, in addition to experts from other organizations collaborating on the construction of this archetype. If the "Shelling Model" is eventually expanded in future research to include those variables currently excluded, such as crime, mode share and obesity prevalence data, then a partnership of organizations is necessary for the creation of the model. As suggested in Chapter 2, school districts, municipal planning commissions and departments of public works, as well as public health researchers would serve as

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<sup>15</sup> The "Shelling Model" was created by the author and is an adaptation of a generalized model to evaluate influences on middle school pedestrian trip behavior



appropriate smart growth advocates at the local government. Similarly metropolitan planning and departments of transportation would prove as organizations maintaining the professional capacity needed for model construction. The technical analysis described in Chapter 5 is a testament to this assertion.

## Chapter 5: HISD Results and Discussion

### Overview

This chapter discloses the findings of the “Shelling Model” described in Chapter 4 and answers RQ1 and in part, RQ2, which was partially answered in Chapter 2 and will be addressed in full in Chapter 6. This chapter contains two parts. Part I defines the variables explored in the “Shelling Model” as well as summarizes the descriptive statistics which answer RQ1: What level of walkability exists in Houston Independent School District (HISD) middle school neighborhoods? Part II describes the analyses undertaken in running the Walkscore and Catchment regression models and reveals the findings of those analyses, partially answering RQ2: How can an analysis of middle schools neighborhoods’ walkability be employed to objectively target schools for “Safe routes to School” programming?

Through the process of creating datasets for the 13 variables (Described in the “How To” Guide in Appendix C) input into the regression models, three findings, which are discussed in Part I, were revealed regarding the existing level of walkability in HISD-E middle school neighborhoods. First, the land area accessible to students actively commuting within a two mile “crow flies” distance from HISD-E middle schools was revealed. Secondly, insight was gained into how pedestrian accessible amenities are within HISD-E middle school neighborhoods. This finding reveals the proximity of amenities within a “walkable” one-quarter mile distance from schools. As previously noted, in walkable or pedestrian oriented neighborhood design “homes, stores, employment centers and government centers” are in close proximity to one another” (Sallis & Glanz, 2006, p. 92). Therefore, beyond revealing the walkability in HISD-E middle school neighborhoods as determined by accessibility to land area, this finding provides a sense of pedestrian orientation as determined by proximity to amenities. Thirdly, the extent to which students actively commuting are exposed to potentially hazardous design features was also obtained.

In addition to these findings, a “How To” guide for “Using ArcGIS to Assess Walkability of School Neighborhoods” was created as a companion to this thesis. It can be viewed in Appendix C. The purpose of this guide is to provide directions to researchers

seeking to replicate, or adapt facets of this research. This guide is also for individuals seeking to become familiar with tools and methods of analysis available within ArcGIS.

Through running the Walkscore and Catchment models described in Chapter 4, the first step in the process of creating a walkability index to target schools for SRTS programming was conducted. The results of these models are revealed in Part II of this chapter.

### **Part I. The “Shelling Model” Variables**

Table III lists, defines and provides source information for the independent and dependent variables utilized in the Walkscore and Catchment regression models. The units of measurement utilized in the regression models for each variable are described in the “Description” column. This table is provided so that researchers are informed of the variables utilized in this research. Such information may be critical to research aiming to replicate the methodology employed in this thesis and to identify opportunities for the use of other variables in future studies.

*On the following page is Table III. Variable Dictionary.*

<b>Table III. Variable Dictionary</b>		
<b>Variable</b>	<b>Description</b>	<b>Source</b>
<b>Walkscore Rating (Walkscore)</b>	Walkscore ratings are accompanied by the following designations: 0-24 is severely “car dependent”; 25-49 is “car dependent”; 50-69 is “somewhat walkable”; 70-89 is “very walkable,” and 90-100 is denoted as a “walker’s paradise” (Walkscore.com, 2010). Walkscores were generated for each school	Walkscore.com
<b>Walkable Catchment Rating (Catchment)</b>	The percentage of land area accessible to children walking to school within a two mile "crow flies" distance was measured on a rating scale from 0 to 100. Ratings closer to 100 denoted greater walkability. A catchment rating was generated for each school.	Centerline Data- Houston Department of Planning and Development
<b>Miles of Freeways, Toll Ways and Major Roads (FreewaysTollwaysMajRoads)</b>	The miles of freeways, toll ways and major roads intersecting each school's catchment were measured.	Centerline Data- Houston Department of Planning and Development
<b>Acres of Industrial Land (Industrial)</b>	The acres of Industrial land (parcels) having their centroid within each school's catchment was measured.	Parcel Data- Houston-Galveston Area Council
<b>Acres of Commercial Land &gt; 1 acre (CommOverOneAcre)</b>	The acres of commercial land (parcels) > 1 acre having their centroid within each school's catchment was measured.	Parcel Data- Houston-Galveston Area Council
<b>Acres of Vacant Commercial Land (VacantComm)</b>	Acres of vacant commercial land (parcels) having their centroid within each school's catchment was measured.	Parcel Data- Houston-Galveston Area Council
<b>Avg. Number of Vehicles Available (AvgVehiclesinCensusTracts)</b>	The average number of vehicles available within census tracts intersecting each school's catchment was measured.	2000 Census Data
<b>Pop. in Households (PopinHshldByBlock)</b>	The population in households within blocks intersecting each school's catchment was measured.	2000 Census Data
<b>Avg. Median Household Income (AvgMedHshldIncome)</b>	The average median household income for block groups intersecting each school's catchment was recorded.	2000 Census Data

Table III Continued		
<b>School Population (SchoolPop)</b>	The student population of each school was recorded.	2008-2009 Texas Education Agency Performance Reports
<b>TEA Performance Rating (TEARating)</b>	Performance ratings for each school were recorded. School ratings included exemplary, recognized, acceptable, unacceptable, and none. Based on these ratings schools were rated 4,3,2,1 and 0 respectively.	2008-2009 Texas Education Agency Performance Reports
<b>Individuals Living Below Poverty Level (IndinPoverty)</b>	The number of individuals living within each school's superneighborhood was recorded.	Houston Department of Planning and Development Superneighborhood Demographics
<b>Housing Units Built by 1939 or Earlier (HsUnitsBuilt1939orEarlier)</b>	The number of housing units built 1939 or earlier within each school's superneighborhood was recorded.	Houston Department of Planning and Development Superneighborhood Demographics
<b>1 Unit Detached Housing Units (OneUnitdetachRes)</b>	The number of 1 unit detached housing units within each school's superneighborhood was recorded.	Houston Department of Planning and Development Superneighborhood Demographics
"Variable" column terms within parentheses denote the abbreviations used in SPSS Regression output.		

### **HISD school sample.**

Prior to conducting regression analyses on the variables listed in Table III, the distributions of variables across all 49 HISD-E middle schools were observed. Refer back to pages 39 through 43 for a series of maps displaying the locations of HISD-E middle schools within their respective neighborhoods. As stated on these maps and in the glossary in Appendix A, middle schools are defined in this research as those institutions of education serving grades 5-8, 6-8, PK-8, 1-12 and 6-12. Schools serving grades PK-8, 1-12 and 6-12 are not regularly identified as "middle" schools by the Houston Independent School District. Therefore, with the omission of these institutions from this research, a portion of the target population of this study, "middle school" (grades 5-8) students, would have also been eliminated. While this sample is adequate for this research as it allows for quantitative

analysis, this sample cannot be generalized to represent middle school neighborhoods in any other school district except HISD.

Table IV. Summary Descriptive Statistics of Variables

<b>Variables</b>	<b>N</b>	<b>Mean</b>	<b>Std. Deviation</b>	<b>Range</b>	<b>Min.</b>	<b>Max.</b>
Walkscore Rating	49	54.16	14.37	66	25	91
Walkable Catchment Rating	49	40.02	4.4	24	26	50
Miles of Freeways, Tollways and Major Roads	49	24.63	7.39	34	10	44
Acres of Industrial Land	49	51.32	71.43	334	0	334
Acres of Commercial Land > 1 Acre	49	375.51	187.09	879	61	940
Acres of Vacant Commercial Land	49	147.91	64.64	280	27	307
Avg. Number of Vehicles Available	49	2368.39	751.12	2851	1314	4165
Population in Households	49	56914.24	32466.22	108399	14530	122929
Student Populations	49	741.67	453.88	1722	73	1795
Avg. Median Household Income	49	39654.47	19820.07	78877	19547	98424
Table IV. Continued						
TEA Accountability Rating	49	2.1	1.02	4	0	4
Individuals Below Poverty Level	49	6061.67	4314.2	17742	619	18361
Housing Units Built 1939 or Earlier	49	708.31	1216.13	8149	17	8166
1 Unit Detached Housing Units	49	5595.41	3135.69	12357	173	12530

Figure XII. Distribution of Walkscore Ratings

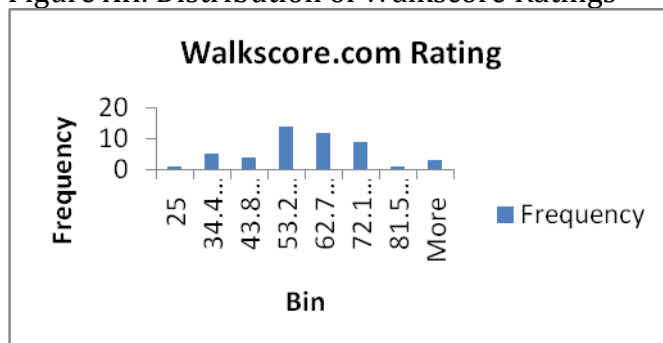


Figure XIII. Distribution of Catchment Ratings

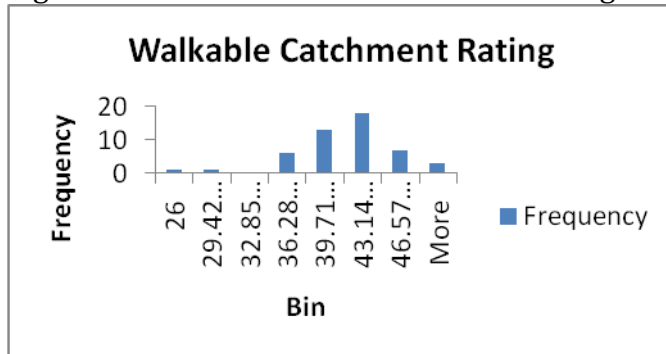


Figure XIV. Distribution of Miles of Freeways, Tollways and Major Roads

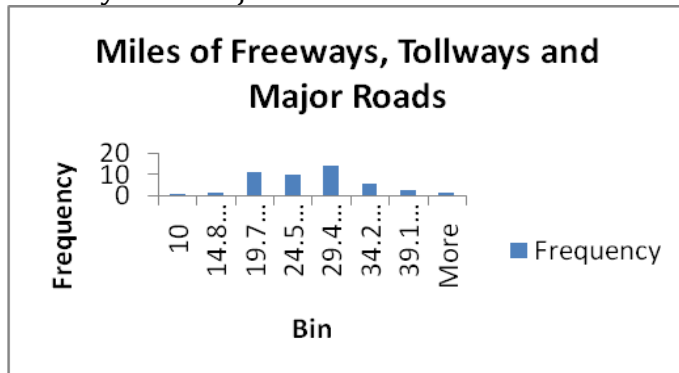


Figure XV. Distribution of Industrial Land

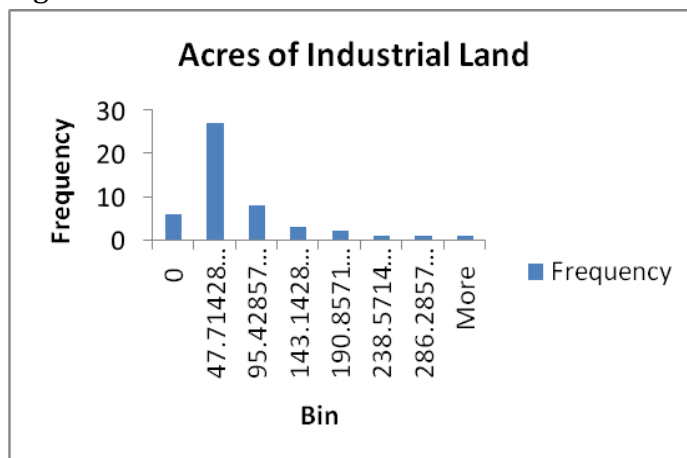


Figure XVI. Distribution of Vacant Commercial Land

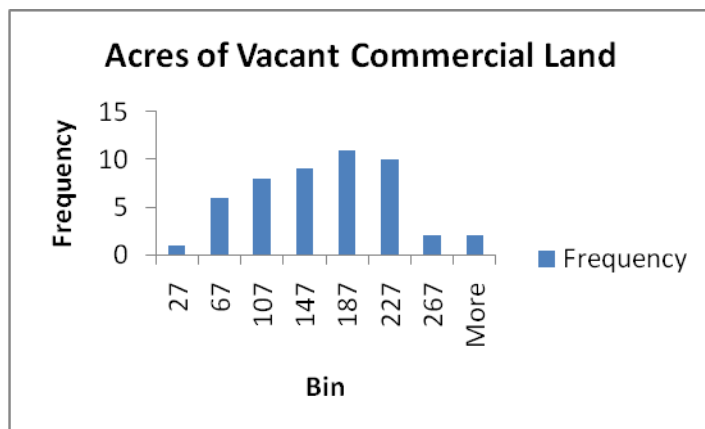
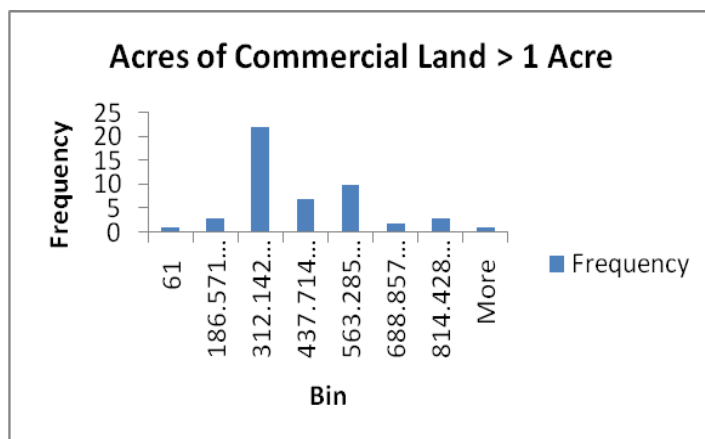


Figure XVII. Distribution of Acres of Commercial Land > 1 Acre



Summary statistics of variables are listed in Table IV and histograms illustrating the distributions of: walkable catchment ratings, walkscore ratings, hazardous road types and land uses are viewed on the previous pages. Histograms for all other variables can be viewed in Appendix D.

#### **Table IV and histogram key findings.**

The following questions, first introduced in Chapter 4, assisted in answering RQ1: What level of walkability exists in Houston Independent School District (HISD) middle school neighborhoods? Table IV and Figures VIII through XIII are utilized in answering the following questions.



### ***How pedestrian accessible are amenities in HISD-E middle school neighborhoods?***

As highlighted in Table IV, in regard to Walkscore ratings, the average for HISD-E middle schools is 54. Walkscore.com measures the proximity of amenities to neighborhood locations on a rating scale of 0 to 100. Locations with ratings closer to 100 have more amenities within a quarter mile walking distance than locations with ratings closer to zero.

The distribution of the ratings is similar with a majority (53%) of the 49 HISD middle school neighborhood rated as “somewhat walkable,” meaning that “some amenities” are within a recommended .25 mile walking distance of HISD-E middle schools. A total of 26.5% of schools ranged from ratings of “very walkable” to “walker’s paradise.”

HISD-E middle school neighborhoods ranked as severely car dependent. However, most schools did rank as car dependent to the extent that only “some amenities” were within a walkable distance from schools. As Houston is generally recognized as a city embracing a suburbanized, car dependent neighborhood design (Lewyn, 2005), the results of this thesis support that recognition. Based on walkscore.com rating the proximity of amenities from neighborhood locations on a scale of 0 (car dependent) to 100 (walker’s paradise), the results of this school sample suggest that low walk scores denote higher car dependency.

However, although Walkscore.com charts the presence of amenities within a walkable one-quarter to one mile distance, this rating does not guarantee that the neighborhood environment is conducive to walking. As previously mentioned, this rating does not consider the presence of sidewalks, block lengths, land uses, and a myriad of other elements within the built and socio-economic environments which are critical to walkability.

### ***What land area within a two mile “crow flies” distance from HISD-E middle schools is accessible to middle school students walking to school?***

In regard to walkable catchment ratings, school neighborhoods received on average, a score of 40. Only 12.2% of schools received this score. Receiving ratings between 35 and 39 were 34.7% of schools, while score within a range of 41 to 50 was characteristic of 45%. One school generated a rating of 50. Although this rating system is not accompanied by a description attached to it similar to the Walkscore, catchment ratings closer to 100 indicate greater walkability. The Congress for the New Urbanism recognizes 60 as the minimum for

this ideal. With no HISD-E middle school ranking a 60 or above a 50, these findings show that HISD-E middle school neighborhoods fall short of the ideal walkability environment.

***Are there potentially hazardous community design features for HISD-E middle school students walking to school?***

Hazardous land uses and road types do pose as barriers to walking for HISD-E middle school students. On average, schools have nearly 25 miles of freeways, tollways and major roads intersecting their two mile catchments, while having 51 acres of industrial land, 375 acres of commercial land > 1 acre and 148 acres of vacant commercial land within their catchments. Approximately 59.2% of schools had between 20 and 30 miles of freeways, toll ways and major roads intersecting their two mile catchments, with 10.2% experiencing over 30 miles. One hundred percent of schools had at least 61 acres of vacant commercial and commercial land greater than one acre while 87.8% had at least one acre of industrial land within their catchment.

**Summary of findings/discussion.**

Catchment and Walkscore ratings confirm that HISD-E middle school neighborhoods are not ideal environments for walking. Students have minimal access to amenities from school and even less access to land area within a two mile “crow flies” distance from school.

The presence of hazardous road types and land uses within catchments confirms that children actively commuting to school within a two mile walking distance do confront potential barriers. In particular, the mileage of hazardous road types intersecting school catchments supports the Texas Safe Routes to School Coordinator’s assertion that traffic concerns are one of three predominant barriers to walking for children throughout the state. Also, nearly all school neighborhoods had hazardous land uses present within their catchments.

In order to provide further insight into the results discussed herein, maps displaying the highest and lowest rankings of walkscores, catchment ratings, hazardous road types and hazardous land uses are provided on the following pages. Summaries of these findings follow each map layout.

Figure XVIII. Highest and Lowest Walkable Catchment Ratings Among HISD-E Middle School Neighborhoods, Houston, TX

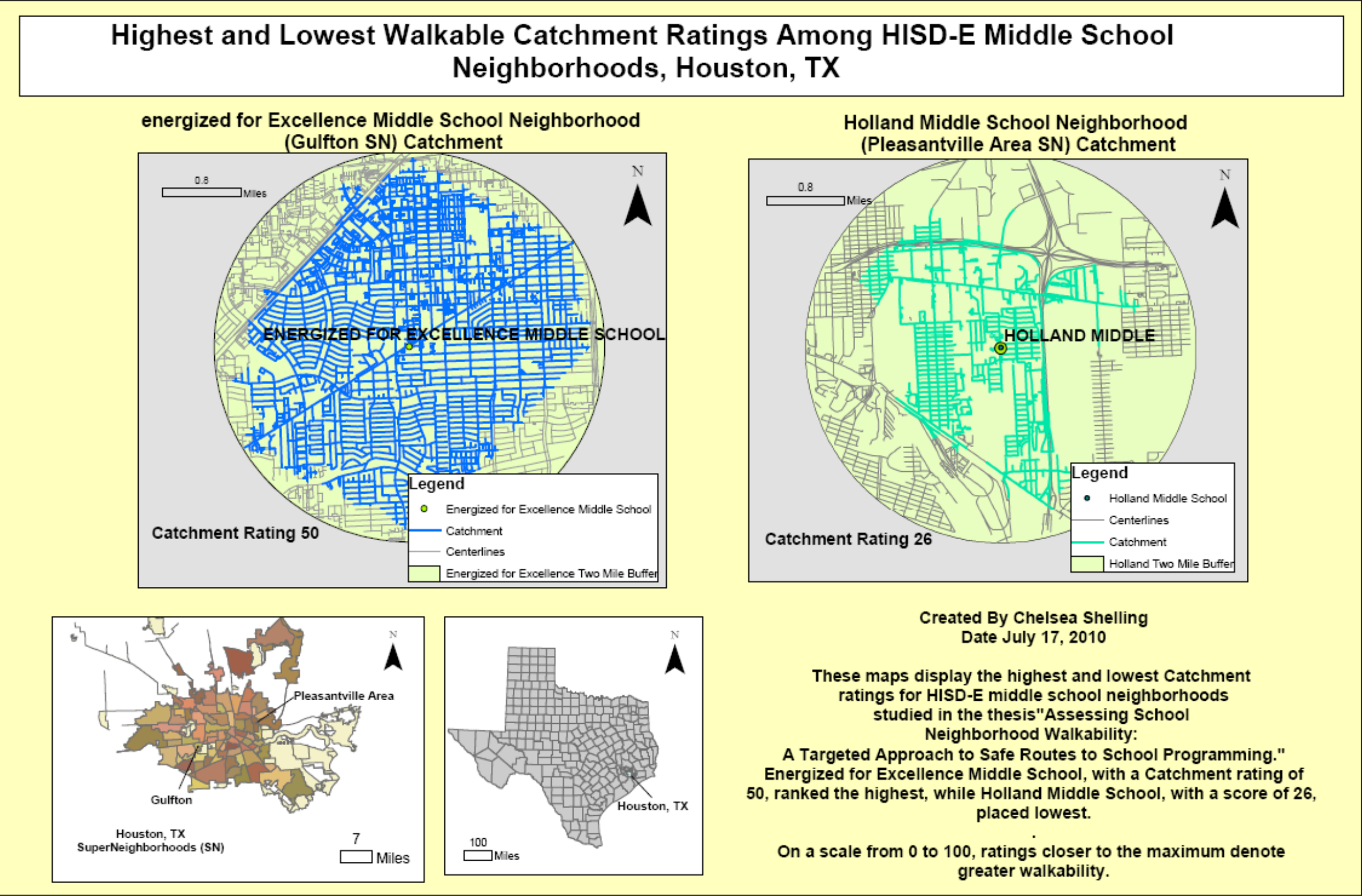
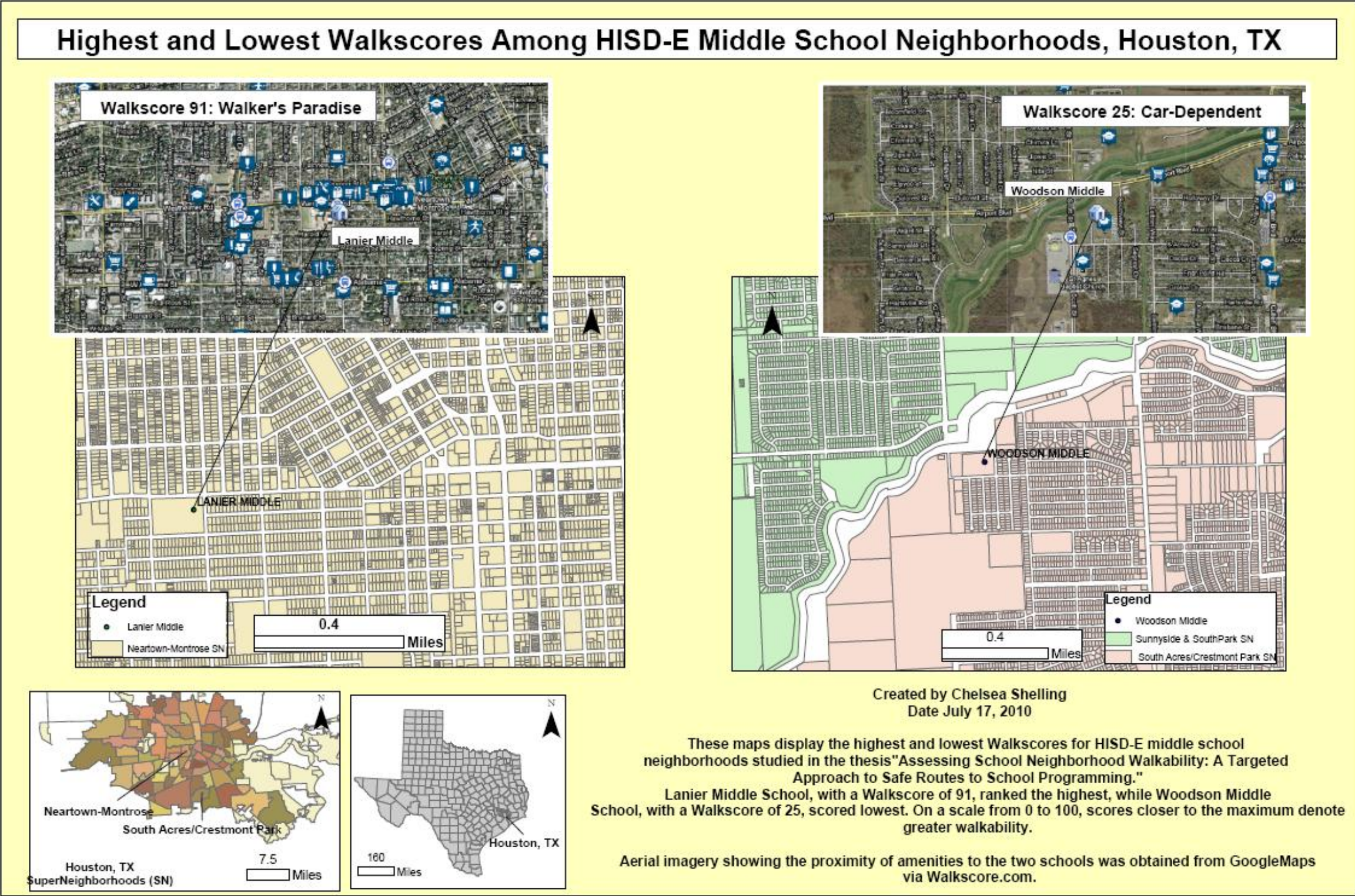


Figure XVIII shows a map layout illustrating that a greater the land area is accessible to students walking within a two mile distance of Energized for Excellence Middle School than Holland Middle School. The difference in accessible land area between Energized for Excellence Middle, with a rating of 50, and Holland Middle, with a score of 26, is evident in this layout. However, a neighborhood's catchment only tells a portion of the story regarding the conduciveness of the built environment for walking. Proximity to amenities is also within a land area provides insight into the condition of the pedestrian environment. Specific to children, hazardous land uses and road types have a significant impact on access to walking for school commutes. This significance is weighted heavily as parental perception of safety may prove the determinant predictor of a child's active transportation use.

*On the following page is Figure XVIV, which shows the highest and lowest walkscores among HISD-E middle school neighborhoods.*



Figure XIV. Highest and Lowest Walkscores Among HISD-E Middle School Neighborhoods, Houston, TX

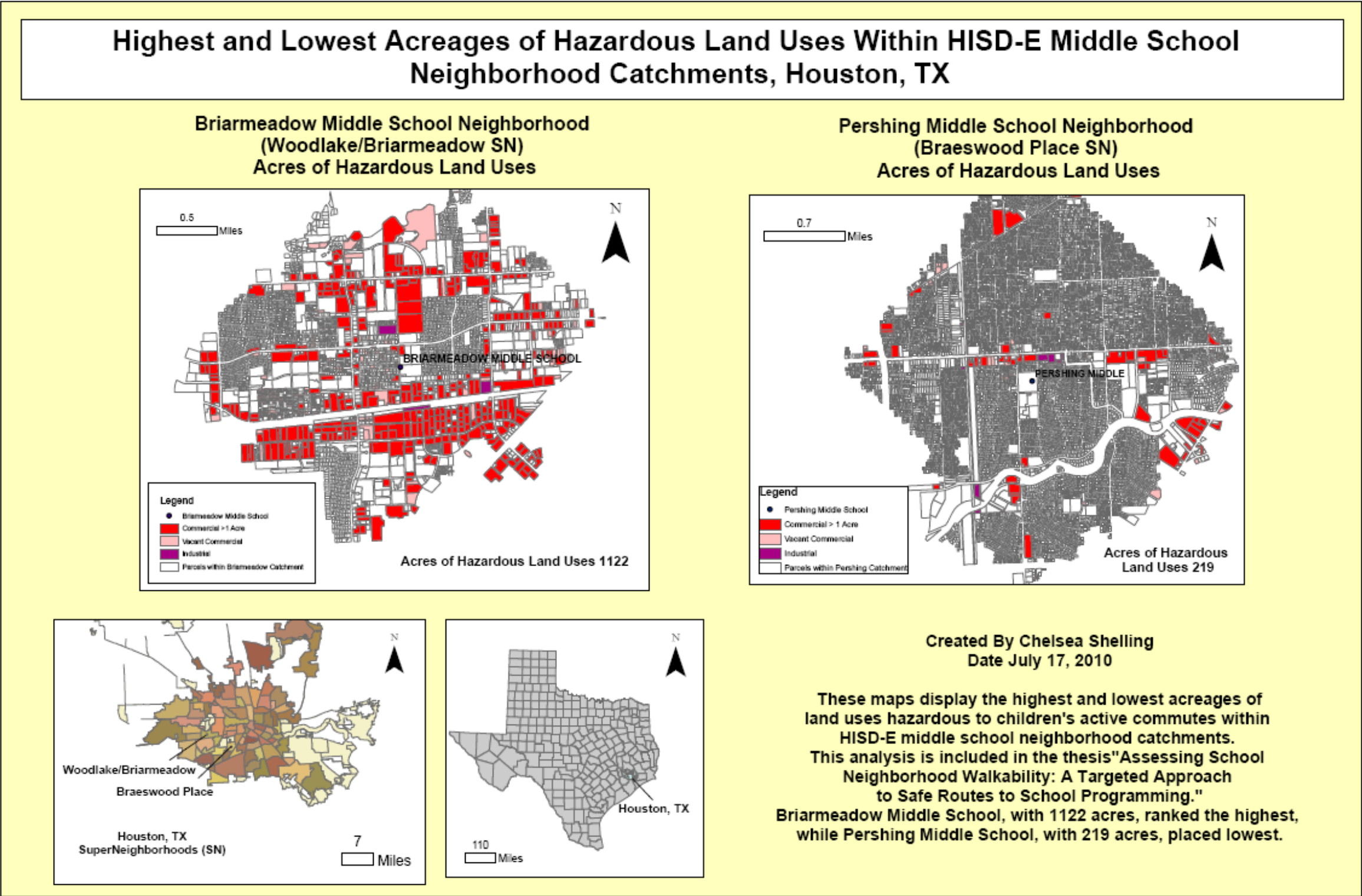


In Figure XVIV, the Lanier Middle School neighborhood, with a walkscore of 91, is described as a walker's paradise, while Woodson Middle School Neighborhood is categorized as car-dependent based on its score of 25. By the volume of icons representing amenities observed in GoogleMaps aerial imagery, it is evident that Lanier Middle experiences more facilities within walking distance than Woodson. Furthermore, when observing the parcel formations for each school, a grid pattern emerges in the Lanier Middle School neighborhood while a curvilinear design is seen for Woodson. These findings support literature reviewed in Chapter 2 which suggest grid patterned design decreased proximity to neighborhood destinations, enabling walkability. However, it should be noted that grid patterns may not necessarily denote higher walkscores.

*On the following page is Figure XX, which shows the highest and lowest acreage of hazardous land uses among HISD-E middle school neighborhood catchments.*



Figure XX. Highest and Lowest Acreage of Hazardous Land Uses Among HISD-E Middle School Neighborhood Catchments, Houston, TX

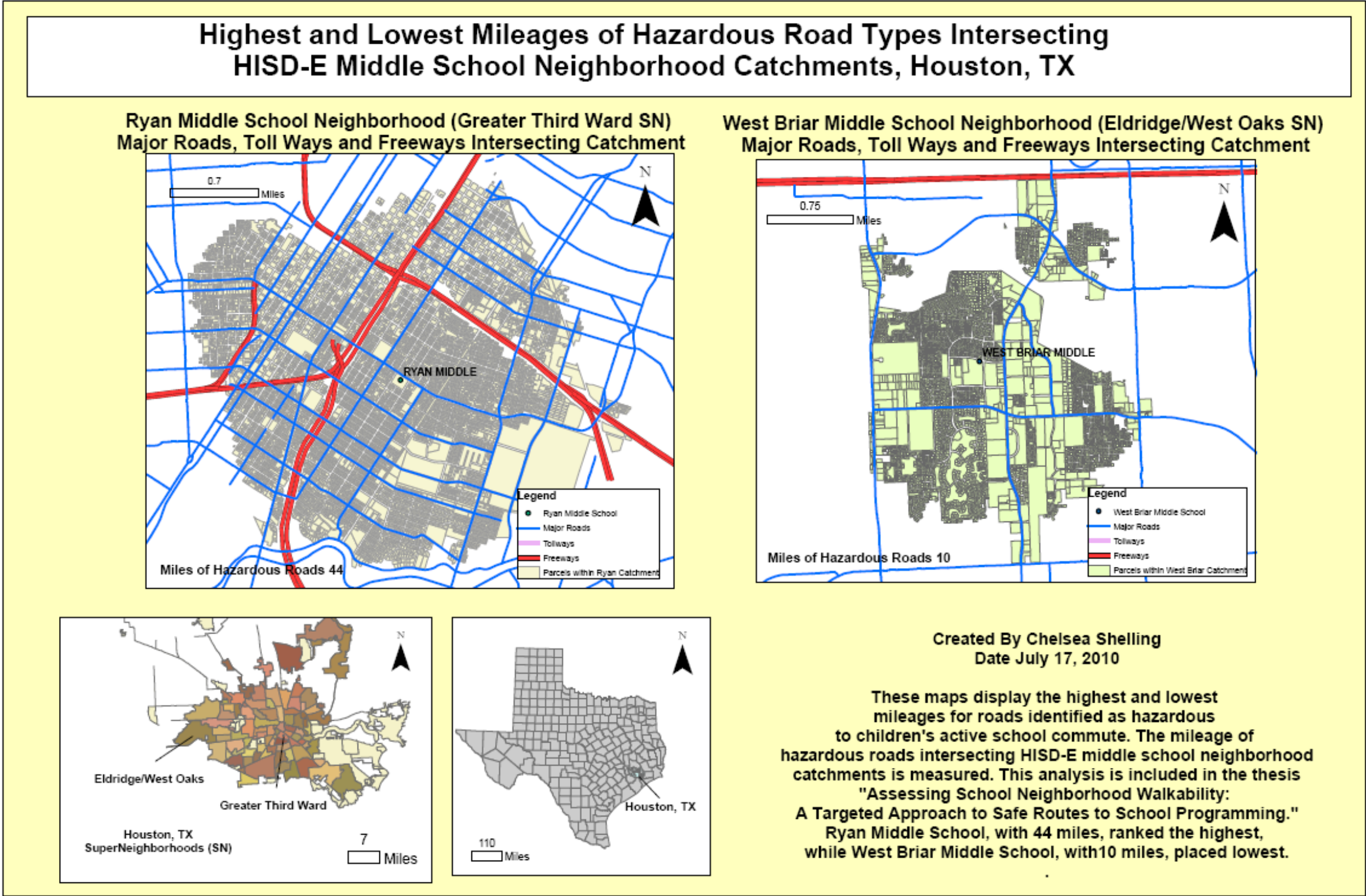


While having access to amenities within walking distance is a positive indicator of walkability, for children, substantial amounts of commercial activity within their school commute distance may prove hazardous. Highest and lowest land use acreages shown in Figure XX demonstrate this point. In the Briarmeadow Middle School neighborhood, the substantial amount of commercial land over one acre presents a hazard to children walking to school. The presence of this size of commercial size suggests that the neighborhood may attract significant automobile traffic to the neighborhood. With that attraction, concerns for speeding and unaware drives threaten children's safety. Regardless of whether Perishing Middle School is a more or less walkable as defined by walkscore and catchment ratings, due to the moderate acreage of hazardous land uses within its catchment, holding all variables constant students would face safer traffic conditions in this community than in Briarmeadow.

*On the following page is Figure XXI, which shows the highest and lowest mileages of hazardous road types intersecting HISD-E middle school neighborhood catchments.*



Figure XXI. Highest and Lowest Mileages of Hazardous Road Types Intersecting HISD-E Middle School Neighborhood Catchments, Houston, TX



Beyond the adverse impact of hazardous on children's access to walking, hazardous road conditions, previously alluded to in the land uses discussion, is also a parental concern.

Besides the presence of hazardous roads within catchments, their proximity to schools is also important, and is therefore illustrated in Figure XXI. Ryan Middle School, with 44 miles intersecting its catchment, encounters freeways and major roads within a distance of .7 miles or less. Though West Briar Middle School experiences the least mileage, major roads are encountered within a distance less than .75 miles. These findings show that regardless of what walkscore and catchment ratings may suggest regarding walkability, the presence of hazardous road conditions within the distance traveled by children is an important consideration. For children, as reiterated throughout this research, hazardous road conditions adversely impact safety perceptions for walking.

Overall, the theme that these maps illustrate is that the transportation and land use patterns pursued in Houston create unsafe environments for children's school commutes. Furthermore, the significant presence of hazards to walking within school commuting distances suggests that it would be a difficult endeavor to retrofit HISD-E middle school neighborhoods with walkable design. SRTS may be able to address impediments within very close proximities to schools (i.e. a few blocks), however, moving major roadways or freeways away from school catchments moves beyond the scope of SRTS. Furthermore, such an effort is unlikely to occur under the initiative of the city. However, through the employment of smart growth principles at the city, regional, and state level, as previously recommended, new developments may subscribe to walkable neighborhood design. The desired impact on existing "unwalkable" neighborhood design may not be feasible; however, an opportunity exists for future developments to be impacted accordingly.

## **Part II. Walkscore and Catchment Regression Analysis**

Before regression analyses could be conducted, a correlation analysis was administered on all variables in order to identify high correlations which could skew results. Variables with high correlations<sup>16</sup> are particularly important to identify because their relationship may manifest itself in multi-collinearity within a regression. If based on

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<sup>16</sup> High correlations in this study are recognized as Pearson values equal or greater to .687.

collinearity tests, high multi-collinearity is found, variables must be combined or omitted to reduce high correlations, which may result in a model's reduced predictive ability (R-Square Value). The tolerance<sup>17</sup> and variance inflation factor (vif)<sup>18</sup> values within the Statistical Package for the Social sciences (SPSS) collinearity output test were analyzed to detect variable correlations within the Walkscore and Catchment models. The closer tolerance values are to 0 and the higher vif values, the more unstable beta coefficients (Garson, 2010).

As can be observed in the correlation matrix in Appendix F, a number of independent variables showed associations of varying intensities. However, only those correlations equal or above .687 were removed from the regression models. Independent variables meeting these criteria were Population in Households and Miles of Major Roads (.811), and Average Median Household Income and the Average Number of Vehicles Available (.687).

As described in the methods chapter, two linear regression models were created to measure variables' ability to predict two measures of walkability. Model 1 measured variables' ability to predict variations in walkscore ratings. Walkscore.com measures the proximity of amenities to neighborhood locations. Model 2 measured variables' ability to predict variations in walkable catchment/ped shed ratings. In this study the walkable catchment technique measured the percentage of land area available to students traveling to school by walking within a two mile "crow flies" distance.

Prior to running the regression analyses disclosed in this section, pilot regression models were run in SPSS to investigate the presence of collinearity. High collinearity was found within the pilot Catchment Model, with a more moderate degree found in the Walkscore archetype. In an effort to reduce the collinearity present in the models, four subsequent regressions were conducted for each archetype, the fourth of which are the disclosed individually in this chapter.

A two-step process was undertaken in reducing the collinearity present within models. First, those independent variables identified as being within the same category (i.e. land uses, road types) and were quantified using the same unit of measurement were

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<sup>17</sup> The closer a tolerance value is to zero, the higher the multi-collinearity between independent variables. This thesis acknowledges a tolerance value of .20 or less as an indicator of multi-collinearity (Garson, 2010).

<sup>18</sup> When the variation inflation factor is high, multi-collinearity will be high as well (Garson, 2010).

consolidated into composite variables. Freeways, Toll ways and Major roads were consolidated into one variable and run in the first regression. As collinearity was still detected following this regression, Industrial Land, Commercial Land Greater Than One Acre, and Vacant Commercial Land were then consolidated into another variable and run in a second regression.

In response to the remaining presence of collinearity subsequent to the first two regressions, those variables with Pearson coefficients of .687 or more were eliminated from the regression. Population in Households and Miles of Major Roads (now composite variable with all road types) and Average Median Household Income and the Average Number of vehicles Available were the variables displaying high correlations. In the interest of retaining independent variables measuring elements of the physical environment, Populations in Households and Average Median Household Income were omitted from the regression models in the third and fourth regression models respectively. The outcomes of the Walkscore and Catchment regression models viewed in this chapter are products of the aforementioned process of elimination. As a result, collinearity has been significantly reduced in both models, ensuring the reliability of the model results. For SPSS pilot and subsequent regression results for both models, please see Appendix E.

While there was a marked difference between collinearity statistics observed in the initial pilot models, subsequent to the creation of composite variables and the omission of factors exhibiting high correlations, figures between both models were identical. On the following pages are summary tables of the Adjusted R-Square value changes, as well as the statistically significant variable changes which resulted from collinearity reduction. The fourth models within each table represent the models whose results are disclosed individually and in more detail later in this chapter.

Table V. Adjusted R-Square Changes With Collinearity Reduction

<b>Walkscore Model</b>				
Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate
Pilot	.812	.659	.532	9.83192
1 (Composite Hazardous Road Types Variable)	.812	.659	.532	9.83192
2 (Composite Land Uses Variable)	.802	.644	.550	9.64335
3 (Pop. In Households Variable Omitted)	.767	.388	.493	10.23938
4 (Med. Household Income Variable Omitted)	.739	.546	.455	10.61153
<b>Catchment Model</b>				
Pilot	.756	.571	.412	3.37261
1 (Composite Hazardous Road Types Variable)	.63	.397	.196	3.94522
2 (Composite Land Uses Variable)	.542	.293	.107	4.14676
3 (Pop. In Households Variable Omitted)	.539	.291	.127	4.11094
4 (Med. Household Income Variable Omitted)	.529	.280	.136	4.08926

Table VI. Changes in Statistically Significant Variables With Collinearity Reduction

<b>Walkscore Model</b>	
Model	Statistically Significant Variables
Pilot	Avg. Number of Vehicles Available at 90% level (.353) Population in Households at 95% level (.539) Average Median Household Income at 90% level (.362)
1 (Composite Hazardous Road Types Variable)	Avg. Number of Vehicles Available at 90% level (.354) Population in Households at 95% level (.545) Average Median Household Income at 90% level (.362)
2 (Composite Land Uses Variable)	Avg. Number of Vehicles Available at 90% level (.338) Population in Households at 95% level (.537) Average Median Household Income at 95% level (.425)
3 (Pop. In Households Variable Omitted)	Freeways, Tollways and Major Roads at 99% level (.538) Avg. Median Household Income at 90% level (.386) Industrial/Vacant Commercial/Commercial Land > One Acre at 90% level (.190)
4 (Med. Household Income Variable Omitted)	Freeways, Tollways and Major Roads at 99% level (.696) Avg. Number of Vehicles Available at 99% level (.542) Individuals Living Below the Poverty Level at 90% level (-.223)
<b>Catchment Model</b>	
Pilot	Freeways and Tollways at 99% level (-.504) Major Roads at 95% level (.558) Industrial Land at 99% level (-.482) Commercial Land > One Acre at 95% level (.402)
1 (Composite Hazardous Road Types Variable)	Industrial at 95% level (-.508)
2 (Composite Land Uses Variable)	Individuals Living Below the Poverty Level at 90% level (.331)
3 (Pop. In Households Variable Omitted)	Individuals Living Below the Poverty Level at 90% level (.341)
4 (Med. Household Income Variable Omitted)	Freeways, Tollways and Major Roads at 90% level (.433)

### **Summary of Tables VI and VII findings.**

Table VI shows that from the initial pilot to the final run of the Walkscore Model, decreases in the Adjusted R-Square value were more gradual than within the Catchment Model. An immediate .216 decrease in the Catchment Model Adjusted R-Square value resulted after the composite hazardous road type variable was introduced while in the Walkscore Model, the Adjusted R-Square value held constant.

As observed in Table VII, statistically significant variables within the Walkscore Model showed more consistency during collinearity reduction than the Catchment Model. Average number of vehicles available, population in households as well as average median household income held constant throughout the first three runs of the model. Only when the population in households and median household income variables were omitted did the statistically significant variables change.

Results shown in Tables VI and VII suggest that collinearity (highly correlated variables) impacted the Catchment Model greater than the Walkscore Model. The findings of the Walkscore and Catchment models are discussed in greater detail in the following sections.

## Walkscore Model (1) Findings

Table VII. Walkscore Model (1) Regression Results

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.739(a)	.546	.455	10.61153
a Predictors: (Constant), IndustrialCommOverOneAcreVacantComm, AvgVehiclesInCensusTracts, OneUnitDetachRes, TEARating, HsUnitsBuilt1939orEarlier, IndInPoverty, SchoolPop, FreewaysTollwaysMajRoads				
b Dependent Variable: Walkscore				

Table VIII. Walkscore Model (1) Regression Coefficients and Collinearity

Model		Standardized Coefficients			Collinearity Statistics	
		Beta	t	Sig.	Tolerance	VIF
1	(Constant)		-.189	.851		
	FreewaysTollwaysMajRoads	.696	4.578	.000	.492	2.034
	AvgVehiclesInCensusTracts	.542	4.463	.000	.771	1.298
	SchoolPop	.019	.149	.882	.672	1.489
	TEARating	-.157	-1.335	.190	.825	1.212
	IndInPoverty	-.223	-1.801	.079	.740	1.352
	HsUnitsBuilt1939orEarlier	.093	.674	.504	.591	1.692
	OneUnitDetachRes	-.006	-.042	.967	.537	1.862
	IndustrialCommOverOneAcreVacantComm	.175	1.500	.141	.838	1.193
a Dependent Variable: Walkscore						

This model revealed that 45.5% of the variability in Walkscore ratings, as indicated by the Adjusted R-Square value, can be predicted by variables employed in this regression, with three variables showing minimally statistically significant impacts on the dependent variable. Freeways, Tollways and Major Roads, Average Number of Vehicles Available and Individuals Living Below the Poverty Level are significant variables within this model.

For every one unit change in Freeways, Tollways and Major Roads, there is a 99% chance that walkscore ratings will change by .696 units. The positive relationship between this composite variable and Walkscore ratings compels some interesting discussion, particularly as the review of literature as well as the Texas Coordinator interview revealed that these road types negatively impact walkability. This finding may suggest that



neighborhoods with increased access to amenities benefit from increased capital infrastructure investments in contrast to communities with less access to facilities.

Regarding automobile prevalence, for every one unit change in Average Number of Vehicles Available, there is a 99% chance that walkscore ratings will change by .542 units. Individuals with higher economic status tend to have greater access to cars than individuals lacking such wealth. Therefore, if neighborhoods with more amenities benefit from increased capital infrastructure and economic investment, then such findings may suggest that the wealth associated with car ownership follows this trend.

In further support of this theory is the statistically significant relationship found between Walkscore ratings and the number of Individuals Below the Poverty Level. For every one unit change in Individuals Living Below the Poverty Level, there is a 90% chance that Walkscore ratings will change by -.223 units. Therefore, as the level of poverty increases in a neighborhood, the walkscore rating (i.e. amenities, capital and economic investment, number of vehicles available) decreases. The presence of amenities in a community is a sign of economic investment, thus the findings of this model in regard to the dynamic between poverty and ratings supports the real world relationship between these variables.

### **Walkable catchment model (2) Findings**

Table VIV. Walkable Catchment Model (2) Regression Results

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.529(a)	.280	.136	4.08926
a Predictors: (Constant), IndustrialCommOverOneAcreVacantComm, AvgVehiclesInCensusTracts, OneUnitDetachRes, TEARating, HsUnitsBuilt1939orEarlier, IndInPoverty, SchoolPop, FreewaysTollwaysMajRoads				
b Dependent Variable: Catchment				

*Table X, which shows Walkable Catchment Model (2) coefficients and collinearity is on the following page.*

Table X. Walkable Catchment Model (2) Coefficients and Collinearity

Model		Standardized Coefficients			Collinearity Statistics	
		Beta	t	Sig.	Tolerance	VIF
1	(Constant)		5.945	.000		
	FreewaysTollwaysMajRoads	.433	2.262	.029	.492	2.034
	AvgVehiclesInCensusTracts	.144	.944	.351	.771	1.298
	SchoolPop	-.115	-.702	.487	.672	1.489
	TEARating	.245	1.662	.104	.825	1.212
	IndInPoverty	.259	1.659	.105	.740	1.352
	HsUnitsBuilt1939orEarlier	-.206	-1.181	.245	.591	1.692
	OneUnitDetachRes	.219	1.194	.239	.537	1.862
	IndustrialCommOverOneAcreVacantComm	-.175	-1.194	.239	.838	1.193
a Dependent Variable: Catchment						

The Catchment Model revealed that 13.6% of the variability observed in ratings, as indicated by the Adjusted R-Square, can be predicted by the variables analyzed within this regression, with one variable having a minimal statistically significant impact on the dependent variable. For every one unit change in miles of Freeways, Tollways and Major Roads there is a 95% chance that catchment ratings will change by .433 units.

Similar to the Walkscore Model (1), a positive relationship between catchment ratings and miles of freeways, tollways and major roads exists within this model. However, the findings of this model may be attributable to the street network rather than the pedestrian network being used to measure access to land area within the catchment technique.

### **Summary of findings/discussion.**

Walkscore and Catchment Model analyses were utilized in partially answering RQ2: *How can an analysis of middle school neighborhoods' walkability be employed to objectively target schools for "Safe Routes to School" programming?*

Two statistically reliable regression models are the result of the analyses conducted. Though identical variables were utilized and matching collinearity statistics were displayed in both models, the Walkscore model showed a higher predictability at 45.5% than the

Catchment Model at 13.6%. However, based on the analyses of these findings together, the “Shelling Model” yielded regression results in which the Walkscore Model explained nearly half of the variation in the Catchment archetype.

Furthermore, these regression model findings incite interesting questions regarding the relationship between socio-economic status and access to amenities within communities as well as the utility of using a street network, rather than informal pedestrian routes within techniques assessing walkability. Below are some questions for consideration.

- Are there more capital infrastructure investments made in communities with increased amenities?
- Is car ownership a sign of wealth, and if so, do communities with high automobile ownership have more amenities than neighborhoods with lower prevalence?
- Why do communities with high poverty concentrations and less access to vehicles benefit from decreased amenities within walking distance?
- Has using the street network rather than informal pedestrian routes to explore walkability had an impact on the positive relationships seen within both the Catchment and Walkscore models?

All of the said questions have arisen as a result of the “Shelling Model,” however, it should be noted that the archetype does not answer these questions definitively. This thesis only suggests explanations for relationships between variables.

In all, the two regression models did provide a plethora of information regarding the levels of walkability existing in HISD-E middle school neighborhoods, in addition to identifying physical and socio-economic environment variables which bare statistically significant impacts on walkability. Meaningful insight was gained into the land area accessible to children within a two mile walking distance from school, and further enriching this awareness, the “Shelling Model” provided a sense of proximity to amenities, and the presence of hazardous land uses and road conditions within catchments.

In consideration of the reliability of the regression models, in theory, statistically significant variables could be used to create a walkability index for which school neighborhoods would be categorized as more or less walkable and SRTS programming targeted accordingly. However, the results of these models reveal interesting variable

relationships which encourage further research. Probing subsequent questions posed in this chapter may lead to a realization that different or an expanded list of variables should be included in the “Shelling Model,” Therefore, this model is not yet ready to be brought into practice.

However, the “Shelling Model” does provide a solid starting place for investigating variables impacting walkability. In fact, it has set the foundation for an expanded exploration of the relationship between student travel behavior, obesity prevalence, and physical and socio-economic environment factors, returning to the issues central to this research.

## Chapter 6: Summary, Limitations, Ideal Model, Future Research Questions, Policy Recommendations

This thesis is meant to assist planners and school administrators with a framework for considering how capital investments can be targeted objectively, using the “Safe Routes to School” program as a framework for implementation. This thesis explores many reasons to support targeted implementation, with the prevalence of childhood obesity in the United States introduced as the primary rationale for pursuing an objective approach. An objective method for targeting SRTS programming does not currently exist and consequently, participants have been self selected. However, this thesis proposes the “Shelling Model” as a tool for objectively identifying environmental and socio-economic variables impacting walkability. Identifying significant impacts (as measured in regression models) would serve as the first step in creating a school neighborhood-specific walkability index. By employing an objective methodology, the level of walkability in neighborhoods could be identified, and schools could be targeted for programming accordingly.

Due to the inability to collect primary or secondary data revealing HISD-E students’ mode share for school commutes, the design of the model was modified from the initial design. Instead, this thesis, through construction of the “Shelling Model,” moved to determine what variables explained differences in walkability levels between HISD-E middle school neighborhoods. This model utilizes analysis of walkable catchment and walkscore ratings as proxies for gauging the condition of the pedestrian environment. The model assumes that neighborhoods with greater walkability would have more students utilizing active transport for school commutes. Due to a lack of data availability, the reasons for which children actively commute in some neighborhoods more than others was not able to be determined by the “Shelling Model.” However, the archetype does begin to answer the research questions posed in this thesis, which explore the levels of walkability in HISD-E middle school neighborhoods, as well as the best methodology for such analysis.

This chapter consists of four sections. First, research questions are revisited; detailing the level at which this study has provided answers. Thereafter, a discussion of the foremost limitation impacting this research in addition to how that constraint can be overcome through future study is outlined. Lastly, policy implications for broad application

necessary to the process of model construction, advocacy and implementation are offered for the City of Houston.

## **Research Questions**

*RQ1. What level of walkability exists in Houston Independent School District (HISD) middle school neighborhoods?*

Through the process of constructing the “Shelling Model,” in addition to the findings from running the archetype in SPSS, a dual approach was synthesized, which provided key insights into the level of walkability existing in HISD-E middle school neighborhoods. The findings of a 13.6 Adjusted R-Square value for the Catchment Model and a 45.5 Adjusted R-Square value for the Walkscore Model proved to complement one another. Essentially, the Walkscore.com Model provides further insight into the pedestrian experience of students walking within a two mile catchment of school. The walkable catchment revealed the land area accessible to students within a two mile “crow flies” distance from school while the walkscore rating provided insight into the amenities present within that area. Additionally, statistically significant variables, although unanticipated, provoke interesting questions regarding the relationship between walkability and physical and socio-economic environment variables. Are there more capital infrastructure investments made in communities with increased amenities? Is car ownership a sign of wealth, and if so, do communities with high automobile ownership have more amenities than neighborhoods with lower prevalence? Why do communities with high poverty concentrations and less access to vehicles benefit from decreased amenities within walking distance? These are all questions which the “Shelling Model” did not answer, but are thought provoking questions for future research.

Despite these questions, both measures of walkability explored in the “Shelling Model” showed that overall, HISD-E middle school neighborhoods are less than ideal environments for children walking to school. Furthermore, in measuring the presence of elements of the physical environment potentially hazardous to children’s safe commute to school, this thesis reveals that students living within a two mile catchment of HISD-E middle school neighborhoods are confronted with such impediments to walking. This revelation is relevant to the implementation of “Safe Routes to School” in Houston,

especially as the Texas Coordinator identified hazardous road conditions as one of the top three barriers to children actively commuting to school in Texas (2010). Students living within two miles of school have no recourse, and efforts should be made to improve their access to walking for commutes.

Also, the HISD should begin evaluating its open access school policy, in addition to exploring the implications of residential development on the proximity between students' homes and schools. This thesis proposes smart growth as a broader policy tool through which new development can be guided toward pedestrian orientation. Moving past the scope of SRTS, the aim of smart growth advocacy is to bring a level of consciousness to institutions regarding the implications of neighborhood design on public health. It is recommended that HISD take this issue under consideration.

*RQ2. How can an analysis of middle school neighborhoods' walkability be employed to objectively target schools for "Safe Routes to School" programming?*

There are a multitude of methods of analyzing middle school neighborhoods' walkability which can be employed to objectively target schools. In this study, the "Shelling Model" demonstrated a methodology for targeting schools whereby: a regression analysis measuring the impact of physical and socio-economic environmental variables on an objective measure of walkability was conducted. Based on the model's predictability as denoted by the R-Square value, in addition to an analysis of statistically significant variables; a school neighborhood-specific walkability index would be constructed in future research. This index would be used to identify more or less walkable middle school neighborhoods and accordingly, schools would be targeted for SRTS programming.

Though the "Shelling Model" has revealed interesting findings regarding statistically significant variables, these findings compel further research. The need for further probing of this model limits its ability to be converted to a walkability index presently. However, the statistical significance and reliability of the "Shelling Model" has laid the necessary foundation for an expanded study to be undertaken. This model suggests that an expanded study exploring student travel behavior, obesity prevalence, physical and socio-economic factors may provide further insight useful to the objective targeting of SRTS programming. Such exploration would move beyond the mere conduciveness of the built environment for

walking, but would reveal the impact of physical and socio-economic environment factors, as well as obesity prevalence on HISD-E middle school students' decision to walk to school. Inquiry into this relationship is at the root of this thesis, and although a lack of data availability limited its appropriate pursuit, the "Shelling Model" provides a framework which can be built upon and possibly used as leverage in gaining data pertinent to this exploration.

### **Limitation: Data**

As in most studies, a lack of data availability was the foremost limitation of this research. As a result, the variables explored in this study do not represent all factors impacting children's access to walking for school commutes. The lack of data availability prevented the inclusion of variables which may have added depth to this study. In particular, data detailing crime, obesity prevalence, addresses of students attending HISD-E middle schools, as well as pupils' mode of transport for commutes were not available. Thus, they were not included as variables in the regression analysis.

Although crime data, excluding the location of pedophiles, is available on Houston's Police Department website, it is not GIS compatible. The time commitment required for conversion rendered these data unusable for the purpose of this study. However, the addition of this primary data to the regression models would have added an interesting safety dimension to the analysis. Beyond the potentially hazardous elements of the built environment hindering children's access to walking for school commutes, crime data offers a sense of the social environ impacting pupils' ability to utilize active transportation. As noted in active transportation research, parental safety concerns regarding crime may prove a determining factor in children's access to walking to school (Lee & Tudor-Locke, 2005; "Barriers to Walking," 2002). Therefore, they should be considered in policies encouraging children's active commuting.

Due to privacy concerns the addresses of students attending HISD-E middle schools could not be gained from the Houston Independent School District. The addition of these data to the regression analyses would have provided insight into the number of HISD-E middle school students living within a two mile catchment from school. These data would have also generated household-level demographic information.



As the principal rationale for this study, the inclusion of variables measuring obesity prevalence, for example, student Body Mass Index data would have offered invaluable insight into the relationship between factors impacting HISD-E middle school neighborhood walkability and obesity prevalence. Also, adding information on the mode share for HISD-E middle school students' school commutes would have clarified the relationship between students' travel behavior and obesity prevalence, providing further depth to these data.

Together variables consisting of data that was unavailable would have offered a positive contribution to this research, with greater insight gained regarding the relationship between physical and socio-economic environment factors, obesity prevalence, and students' travel behavior.

### **Limitation: The “Ideal Model”**

As noted in the limitation section of this chapter, the lack of data availability restricted the variables included in the “Shelling Model,” which was based on secondary information. In light of that limitation, an “Ideal Model” is proposed that can be used to determine primary data needed for a more in-depth study. The “Ideal Model” consists of factors that were identified in the literature review, impact children's travel behavior, and those identified by the Texas SRTS Coordinator. In eliminating the lack of data availability constraint, researchers are offered a model for assessing neighborhood walkability with which primary, rather than secondary data is utilized and can be applied to any school. In this way, the “Ideal Model” serves as an expanded version of the “Shelling” archetype.

The “Ideal Model,” with its expanded number of variables centers on predicting variations in travel behavior using primary data. Regression analysis is applied to this ideal model to measure the impacts of obesity prevalence, school characteristics as well as food, physical and socio-economic environments on the travel behavior of students.

The “Ideal Model” may provide insight into the connection between obesity prevalence, food environments and crime with the walkability of school neighborhoods (as determined by travel behavior). If identified as statistically significant through regression analysis, such information may potentially serve as criteria for targeting SRTS

programming and inform investment decisions. Accordingly, “Safe Routes to School” administrators may use these variables as the basis for a walkability index.

Table XI. The “Ideal Model”: Dependent and Independent Variables

<b>Dependent Variable</b>	<b>Data Type Needed/ Institutional Source</b>
Travel Behavior: share of school commute trips made by travel mode	Primary Data Needed/School Board
<b>Independent Variables</b>	<b>Data Type Needed/Institutional Source</b>
<b><u>Obesity Prevalence and Food Environments</u></b>	
Body Mass Index of students 11 to 18 years old	Primary Data Needed/ Department of Health (local, state, federal), School Board
Number of establishments selling food with minimal nutritional value within two- mile catchments. Such establishments would include McDonald’s, Burger King, select cornerstores, etc.	Secondary Data Needed- land use data/ Metropolitan Planning Organization (MPO), Appraisal District or municipal Department of Planning
Servings of vegetables eaten at home and school each day	Primary Data Needed/ Department of Health (local, state, federal), School Board
Number of hours spent playing outside each week	Primary Data Needed/ Department of Health (local, state, federal), School Board
<b><u>Physical Environment</u></b>	
Walkable Catchment Rating	Calculated by researcher/ MPO, Department of Transportation (DOT) (local, state, federal)
Pedestrian Audit Rating of Walkability	Calculated by researcher/MPO, DOT (local, state, federal), Department of Public Works
Number of one unit detached housing within neighborhoods	Secondary Data Needed/municipal Department of Planning
Number of housing units built by 1939 or earlier in neighborhoods	Secondary Data Needed/municipal Department of Planning
Proximity from home to school	Primary Data Needed/ School Board
Miles of freeways, toll ways and major roads within two-mile catchments	Secondary Data Needed/MPO, DOT (local, state, federal)
Acres of industrial, vacant commercial, and commercial land over one acre within two-mile catchments	Secondary Data Needed/MPO, DOT(local, state, federal), municipal Department of Planning
<b><u>Socio-Economic Environment</u></b>	
Median household income within census blocks intersecting two-mile catchments	Secondary Data Needed-U.S. Department of Census: 2000 Census data/MPO, municipal Department of Planning
Number of individuals living below the poverty level in neighborhoods	Secondary Data Needed/municipal Department of Planning
Average Household Density within census blocks intersecting two-mile catchments	Secondary Data Needed-U.S. Department of Census: 2000 Census data/MPO, municipal Department of Planning
Number of vehicles available for student households	Primary Data Needed/ School Board
1. Crime stats, including the location of pedophiles within two-mile catchment 2. Crime perception survey for parents/guardians	1. Secondary Data Needed-state and local Police Departments/ MPO 2. Primary Data Needed/School Board
<b><u>School Characteristics</u></b>	
Frequency of physical education curriculum at least one hour, three times a week	Primary Data Needed/School Board, Department of Health (local, state, federal)
School Performance Ratings	Secondary Data Needed/School Board
Student population: race, socio-economic status	Secondary Data Needed/School Board

As referenced in the methods chapter, the “Shelling Model” cannot be generalized for schools other than those explicitly identified in this study. Therefore, in exploring study areas beyond HISD-E middle school neighborhoods, “Ideal Model” variables require new data collection. However, realizing that resource constraints are inevitable, this thesis offers recommendations for further research; integrating some elements of the “Ideal Model.”

### **Research Recommendation 1.**

This study assesses access to walking for school commutes based on objective measures of the built environment. However, parental safety concerns are equally important in assessing children’s access to walking for school commutes. Therefore, this thesis proposes creating a regression model exploring the impact of objective measures of walkability on parental perceptions of safety (e.g. children’s access to safe routes for walking).

Drawing from the methodology put forth in the TREK project, a cross-sectional survey of parents/guardians of all HISD-E middle school students is recommended. This survey would gather information on a student’s address, mode of transport and route taken to school, as well as parent/guardian perceptions of crime. They would be asked to rank<sup>19</sup> safety concerns they believe impact students’ access to walking for school commutes.

The newly created *safety perception index rating* would be used as the dependent variable in a regression analysis while all other variables explored in the survey, in addition to the elements explored in this thesis would serve as independent variables. In the end, researchers would achieve insight into the elements of the built environment impacting perceptions of safety in school neighborhoods. A walkability index can be created based on those statistically significant variables and schools can be targeted for SRTS programming from this assessment of pedestrian orientation.

### **Research Recommendation 2.**

If maintaining purely objective measures of the built environment is desired, it is recommended that an exploration of elements of the physical environ impacting

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<sup>19</sup> The rating of barriers to walking draws on Azavea’s Walkshed.org tool which measures walkability in terms of amenities based on how users weight amenities against one another (Azavea, “n.d”)

walkability ( as measured by the walkable catchment rating) is pursued. Rather than using the street network in calculating catchments, the informal pedestrian network (i.e. parks, multi-use paths) would be computed so that greater accuracy about the land area accessible to children within a designated walking distance could be quantified. In order for the informal pedestrian networks to be assessed a dataset showing the networks would be created using aerial imagery (Woods et al, 2010). This avenue of research holds promise by expanding the “Shelling Model,” creating an archetype in which more variables are explored and analyzed.

### **Research Recommendation 3.**

The “Shelling Model” methodology can be used to target areas for municipal capital improvements focused on improving walkability by measuring citizens’ latent demand for pedestrian infrastructure upgrades. Similar to the survey deployed in Recommendation 1, an attitudinal survey would be deployed to gauge citizens’ perceptions of safety when walking in their communities. They would also be asked to disclose the potential level of use which would result from capital improvements that improve the perception of safety. Citizens could be asked whether they would walk more, for how long and how often based on certain capital improvements made in their community<sup>20</sup>. Regression models could be run, using the varying frequencies of use as the dependent variables, and using appropriate physical and socio-economic environment factors related to walkability as independent variables. If citizens’ support for such improvements is demonstrated quantitatively, a municipality may be more likely to make an investment, especially if it meets multiple community goals including improved health, air quality, or reduced traffic congestion.

### **Policy Implications**

In order to access existing data and gather new primary data needed to run the regression analyses described in this research here-to-for, referred to as “model

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<sup>20</sup> One transportation study deployed a survey which in part gauged the extent to which City Park users would use the park given the implementation of certain street closures throughout the week (Renne & Bennett & Bennett, 2010).

construction<sup>21</sup>,” it is critical that multiple agencies collaborate and coordinate efforts. Stakeholders may include education departments, public health departments, municipal, state and regional transportation agencies, non-profits and community groups. The policy implications for organizations participating in these efforts compel a level of openness to cross-institutional communication which may be currently lacking. This section lists stakeholder organizations that are important to smart growth advocacy and model construction and outlines the policy implications of their role in collaborative efforts.

Once stakeholders are assembled, an initial conversation would be to define the roles and responsibilities of each agency to inform and participate in the work effort. Responsibilities would be assigned to the institutions best suited for the work. Examples of responsibilities include designing and implementing surveys, conducting analysis, pursuing funding sources and maintaining data storage. Any working group would have to consider the political, financial and structural nuances of each area under analysis to determine the best organizational model for their needs and goals. The policy implications and recommendations for organizations listed in this section have been considered for the City of Houston specifically. Therefore, these recommendations may not prove appropriate for organizations within different study areas.

#### *Metropolitan Planning Organization (MPO) and Department of Transportation (DOT)*

Metropolitan Planning Organizations (MPOs) engage primarily in transportation planning efforts for regionally significant roadways and forecast travel demand, primarily for vehicles, using census data and travel surveys. State DOTs collect similar data for state controlled roadways. MPOs typically have a strong data and mapping capacity because their primary function requires this capability. These organizations are tasked with facilitating public outreach and interagency coordination.

MPOs are structured differently from each other depending on the region they serve. Some MPOs may encompass multiple states while others may include various incorporated jurisdictions. Regardless of structural differences, all MPOs collect and analyze data as the regional traffic analysis entity. Due to the Houston-Galveston Area

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<sup>21</sup> “Model construction” refers to the process of building an archetype based on the methodology set forth in the “Shelling Model.”

Council serving as the greatest resource for usable data in this thesis, the metropolitan planning organization is identified as an institution which could serve as a repository for data and information relating to model construction. Regardless of what portions of an expanded “Shelling Model” are implemented or what areas within the Houston-Galveston area are studied, the MPO could manage the datasets related to that work. In conjunction with their role as regional facilitator, the Houston-Galveston MPO would be a good candidate to bring collaborating institutions together to discuss and design a study framework. Within this forum the MPO may also be able to facilitate data accumulation.

As a result of the MPO’s proposed role as a data repository, one major policy implication arises. The MPO is limited in its ability to contribute to planning activities on local roads. However, with the MPO’s active involvement in transportation planning and research, they have a responsibility to decrease pedestrian incidents and fatalities which may positively impact children’s access to active transportation. With the implementation of objective targeting of SRTS and accompanying advocacy for policies encouraging smart growth, the MPO may begin to incorporate the impact of transportation planning on public health; regularly integrating these issues into project considerations.

### *Departments of Planning, Health & Public Works*

#### *Planning Department*

Planning departments have a considerable impact on the design of cities as they are responsible for charting municipalities’ short and long term development. As such, a planning department would prove an appropriate advocate for smart growth policy. Through the integration of smart growth principles into municipal master plans and zoning ordinances, pedestrian oriented development would slowly become a common practice in U.S. cities.

In this thesis, the Houston Department of Planning and Development, through its policy setting ability may prove a formidable advocate for smart growth. Although the City of Houston does not employ zoning, it does utilize land use regulations in guiding development. A first step in the direction of pedestrian oriented development may be the department integrating smart growth considerations into its existing land use regulations.

## Public Health Department

Public health researchers are asked to impact factors within the physical and socio-economic environment which adversely affect public health. Accordingly, public health researchers are credible advocates with the potential to shape transportation policy at all levels of government. Ultimately, public health considerations may influence how transportation planners prioritize funding; impacting local and federal fiscal expenditures for streets and sidewalks. The transportation and public health communities do not have a strong history of collaboration. However, given the rising childhood obesity in the U.S. and Americans' continually increasing public health awareness around this issue, this partnership is essential.

Houston's Department of Health and LiveSmart Texas are organizations which possess the knowledge to advocate for smart growth within the transportation planning community. Additionally, these organizations may provide funding and expertise necessary in collecting the obesity prevalence data outlined in the "Ideal Model"; namely the Body Mass Indexes of children 11 to 18 years old.

## Public Works Department (DPW)

Generally, public works departments are responsible for local infrastructure, including the maintenance and improvement of local roads. Their participation in model construction is important because the capital improvements sought by SRTS are many times, on roadways under the jurisdiction of the local Public Works Department. Therefore, in making public works departments aware of physical impediments that create unsafe walking conditions for students and involving them in analysis that will inform their priorities, it will help create a greater sense of ownership. Repairs to sidewalks, creation of safe walking/bicycle routes to school, facilitation of pedestrian friendly traffic signalization and other safety interventions that benefit children's active commutes are all projects that can be undertaken.

The City of Houston Public Works and Engineering Department handles infrastructure maintenance. This department's Safe School Sidewalk program offers one avenue through which pedestrian access and safety issues can be addressed. As previously mentioned Texas SRTS does not currently pursue avenues for supplemental funding or seek DPW expertise to implement projects. Thus, opportunities for leveraging resources

are not being captured. Therefore, closer collaboration between SRTS and the Houston Public Works and Engineering Department would prove beneficial.

### *School Districts/Boards*

School Districts do not typically collaborate with public health researchers or transportation planners regarding broader implications of transport policies. However, with childhood obesity rising, and districts facing budget cuts; many times resorting to reducing student transportation service offerings, they should become more open to consistent conversations with these audiences. In fact, this level of openness is critical to researchers' ability to gain data necessary for creating the "Ideal Model"; namely school characteristics, obesity prevalence and students' socio-economic environment. Through these conversations, school districts may find that they must become more involved in advocating land use patterns that encourage more walking and less bus use. Increased local area enrollment could have positive implications for reducing student transportation costs and improving system finances, as well as students' health.

In this study, the HISD's lack of data concerning students' mode share for school commutes and obesity prevalence suggests that there has not been a strong relationship forged between educators, public health researchers and transportation planners. Furthermore, it suggests that the district does not fully recognize the implications of neighborhood design on its transportation policies and subsequently, students' health. Together, these revelations provide a credible rationale for HISD to become more proactive in transportation and land use policy.

To remedy the busing dilemma long term, HISD should examine its school access, siting, curriculum and busing eligibility policies to evaluate whether the district is contributing to an environment in which childhood obesity is enabled. This examination calls for a myriad of questions to be answered. Have open access schools drawn children away from the schools closest to their homes? Have historic school siting decisions made busing a necessity within the school district? Have physical education curriculum or recess been minimized in schools to the long term detriment of student health? What is the prevalence of childhood obesity amongst HISD students?



If through this self evaluation HISD finds that its policies are contributing to children's decreased access to physical activity opportunities and increased obesity prevalence, the district should consider formulating a strategy to modify education policy. The reasons for which children attend open access and magnet schools are complex and will be difficult to tackle for the sake of implementing neighborhood schools. However, HISD can start with adopting school siting policies which value joint use or rehabilitation over new construction on the peripheries of communities. Again, the district should consider taking inventory of the obesity prevalence among its students and pursuing funding for curriculum and programs which would increase opportunities for physical activity, thus impacting one of the determinant behaviors of the epidemic. For example, if HISD is unwilling to offer busing service to students facing hazardous conditions within a two mile distance from school, external assistance from programs such as SRTS and the City of Houston's Safe School Sidewalk program (public works department) should be sought in earnest to improve access to walking.

### *Safe Routes to School*

SRTS has had national success in implementing its program. However, due to a lack of an objective approach to targeting programming, school participation is self-selecting. SRTS provides a unique opportunity as a long term obesity intervention, encouraging children to adopt active lifestyles through adulthood. Therefore, a special effort should be made to ensure that those communities most impacted by the childhood obesity epidemic are in fact benefitting from SRTS programming in schools. Achieving this goal requires heightened collaboration between the organizations outlined in this section.

It will take a collaborative effort, pursued by MPOs, departments of planning, health & public works, as well as school districts and SRTS for a widespread level of consciousness to take hold regarding the impact of transportation policy on pedestrian safety and public health. An opportunity exists for SRTS to serve as both an advocate and facilitator within this collaboration, and with the results of this thesis, the Texas program is in a prime position to lead the charge.

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## Appendix A: Glossary of Terms and Data Dictionary

### **Glossary**

#### Active Commuting/Active Transportation

Active commuting, also known as active transportation refers to walking and/or biking for transport (Lee & Tudor-Locke, 2005; Kerr et al, 2006). For the purpose of this study active transportation/active commuting will only refer to walking for transport.

#### Geographic Information Systems

According to ESRI, a geographic information system (GIS) is a tool which “integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information” (ESRI, 2010).GIS allows enables data to be viewed and analyzed spatially.

#### HISD-(Expanded) E Middle School

This study diverges from Houston Independent School District defined middle schools and uses an expanded characterization. HISD primarily identifies schools serving grades 5-8 and 6-8 as middle schools. However, in this study, HISD institutions serving grades 5-8, 6-8, PK-8, 1-12 and 6-12 were identified as middle schools. With this characterization, a segment of the population which would have been omitted based on HISD’s definition was included in the study.

#### Obesity Intervention

An obesity intervention is a strategy in which a decreased prevalence of obesity is attempted through behavior modification. Increases in physical activity and nutritious eating may be focuses of an obesity intervention although approaches vary based on the intervention (Boon & Clydesdale, 2005).

## Walkability

The walkability of a community refers to the ease with which residents can reach various destinations throughout a community by walking or biking (McCann, 2005).



## Data Dictionary

File	Size	Data Set Pub. Date	Description	Source	Link
TX_County	8507KB	1995	Shows all county boundaries within the state of Texas	Texas General Land Office	<a href="http://www.glo.state.tx.us/gisdata/gisdata.html">http://www.glo.state.tx.us/gisdata/gisdata.html</a>
City.shp	1787MB	2008	Contains the City of Houston boundary	Harris County Appraisal District	<a href="http://pdata.hcad.org/GIS/index.html">http://pdata.hcad.org/GIS/index.html</a>
SuperNeighborhood.shp	526KB	2007	This layer shows SuperNeighborhood boundaries.	Houston Dept. of Planning and Development	Administrative Boundary Datasets <a href="http://cohgis.houstontx.gov/cohgis2007/COHGIS2007Release13_1.html">http://cohgis.houstontx.gov/cohgis2007/COHGIS2007Release13_1.html</a>
Schools2009.shp	229KB	2009	Point dataset of Texas regular, charter, and alternative schools, excluding disciplinary alternative ed. (DAEP) and juvenile justice alternative ed. (JJAEP) institutions.	Texas Education Agency	<a href="http://ritter.tea.state.tx.us/SDL/sdldownload.html">http://ritter.tea.state.tx.us/SDL/sdldownload.html</a>
HC_Parcels.shp	689,140 KB	2008	Contains parcel boundaries for all of Harris County	Houston-Galveston Area Council	NA
HC_Parcel_LU.dbf	200,217 KB	2008	Contains land use information for all parcels in Harris County	Houston-Galveston Area Council	NA
Centerline_Files.shp	69,691 KB	2008	Contains street centerlines	Houston Dept of Planning and Development	NA

## Appendix B: “Safe Routes to School” Document Excerpts

Figure 1B. Appendix from Texas DOTD SRTS Program Guidance Report Outlining Data Needed for Submittal of a “Safe Routes to School” Plan

**Appendix A — Drafting an SRTS Plan: Required Elements**

The purpose of the plan is to define the fundamental needs, issues, and impediments facing the school(s) in their attempt to increase the number of students who bike and walk to school and the goals that have been set to achieve increased participation in biking and walking.

The Plan is also intended to set the path towards implementing action-oriented solutions that increase biking and walking to school, as well as to define who will be involved in that effort and their respective roles. An SRTS Plan should include the following information:

**Description of Existing Conditions:**

- Location of school(s)
- Environment type (urban, suburban, rural)
- Enrollment
- Type of school (elementary, middle)
- Student participation data for each school, including, but not limited to, the following elements:
  - total number of students
  - % students within 2 mi
  - % students walking or bicycling
  - potential walking/bicycling outside 2 mi (remote drop off — survey)
  - % participating in a free or reduced lunch program
- Identification of the current walking and biking routes to a school(s). Inclusion of a graphic representation (diagram, picture, etc.) of the current routes provides a better representation of the current environment as well as highlights the potential for improvement, especially for those who are not as familiar with the local situation. However, it is acceptable to articulate these routes in a narrative format (see [Appendix B](#)).
- Current travel modes including student survey results (including walk, bike, bus, auto).

**Identification of Existing Problems or Needs:**

- Detailed analysis of existing conditions and impediments to safe biking and walking (physical barriers, safety issues, awareness)
- Parent and student desired travel modes (include survey data)
- Traffic, safety, and other relevant data including citations, crashes, injuries and/or fatalities, if applicable.

**Proposed Activities Related to Problems or Needs:**

- Identification of a program “Champion” — person(s) to spearhead the effort
- Identification of a “Team” or Action Committee that will develop and implement the Plan and subsequent projects or activities

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Figure 2B. Section from SRTS Project Application Requesting Identification of Potential Safety Problems Which Necessitate Need for Programming

**Statewide Problem Identification**

Total points available - 25

Identify any potential safety problem(s) related to Safe Routes to School by indicating the type of educational and/or enforcement issues relating to walking and/or biking to and from the school site(s):

Please check at least one

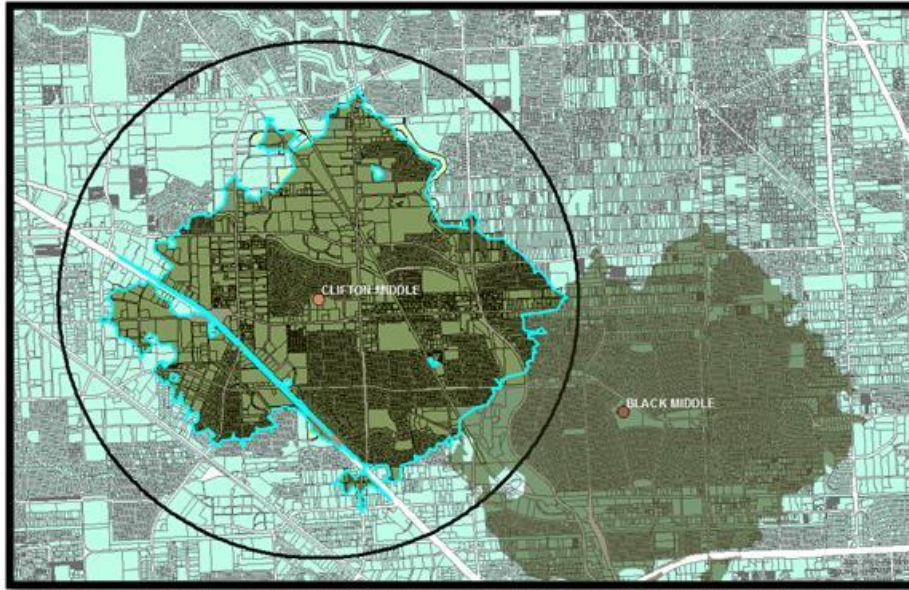
<input type="checkbox"/> Absence of or lack of training for crossing guard(s)	<input type="checkbox"/> Enforcement of speed limits
<input type="checkbox"/> Children walking in street safely	<input type="checkbox"/> Lack of teacher / student training
<input type="checkbox"/> Lack of safe biking techniques	<input type="checkbox"/> Lack of bicycle / pedestrian education
<input type="checkbox"/> Use of bike helmets	<input type="checkbox"/> Potential users not traveling due to perceived risk
<input type="checkbox"/> Poor utilization of walkability/bikeability studies	<input type="checkbox"/> Other <input style="width: 150px; height: 20px;" type="text"/>

**Instructions:** Use the following space to demonstrate the need for proposed services in support of SRTS Programs by identifying risks or hazards facing children who bike and/or walk to school and how they will be addressed by the proposed services. If crashes or incidents have occurred, identify date, time, frequency, type, and severity of crashes that will be addressed by the proposed services. Other information, such as health statistics may also be included as support documentation. If documentation such as sketches, pictures, maps, exhibits, diagrams, examples of materials and tables are submitted, they must be referenced in the text and numbered sequentially.

In addition, describe the target audience (i.e., students, community leaders, teachers or other populations) as it relates to the problem(s) identified in this section. (limit 5,000 characters)

## Appendix C: “How To” Guide

### Using ArcGIS to Assess Walkability of School Neighborhoods



### Exploring the Relationship Between Walkability and Houston Middle School Neighborhoods

A Guide Created By Chelsea Shelling  
Master of Urban and Regional Planning Candidate  
Department of Planning and Urban Studies  
University of New Orleans  
Summer 2010

Dear User:

This manual has been created to convey directions for using ArcGIS to assess walkability indicators. This manual accompanies a thesis which explores the relationship between walkability and Houston Independent School District-E Middle School Neighborhoods.

The purpose of this thesis is twofold. As previously mentioned, this thesis demonstrates how the impact of physical and socio-economic environment variables on Houston Independent School District (HISD) middle school neighborhoods' walkability can be measured through regression analysis. The regression analysis measures the impacts of:

- hazardous road types (i.e. toll ways, freeways<sup>22</sup> and major<sup>23</sup> roads),
- hazardous land uses (commercial and industrial land use),
- average household density,
- average car availability,
- student population,
- Texas Education Agency school performance ratings,
- the number of 1 unit detached housing units, and
- the number of housing units built 1939 or earlier on

walkability (as measured by ped shed and Walkscore ratings) of 49 Houston Independent School District-E middle school neighborhoods. This thesis further proposes how an analysis of middle school neighborhood walkability can be employed to create a walkability index appropriate for objectively targeting "Safe Routes to School" programming.

For the information of individuals attempting to replicate this work or attempting similar research, this guide provides instructions for using tools within ArcGIS 9.3 to create walkable catchments, analyze land uses, freeways and major roads, in addition to conducting socio-demographic analyses.

Chelsea Shelling, Master of Urban and Regional Planning Candidate

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<sup>22</sup> Freeways are "limited access roads with frontage or access roads, excluding tollways" (Fu, 2010).

<sup>23</sup> The "Major" road classification refers to "all highways without limited access, including FM roads and all other roads with multiple lanes and high volumes" (Fu, 2010).

# The Guide

Steps 1 and 2 provide directions for creating and calculating a walkable catchment for Clifton Middle School. Within the process of creating this catchment, a buffer is created around Clifton, a service area is built around the school using the ArcGIS 9.3 Network Analyst extension, and the total acreage within the newly created service area is calculated so that a walkable catchment rating may be generated.

Walkable Catchment= (Area of land within catchment/ Area of land within buffer) X 100

Step 3 provides directions for measuring freeways and major roads intersecting Clifton Middle School's catchment while Step 4 provides directions for analyzing land uses within catchments.

## STEP 1

1A. An empty ArcMap document is opened and all shape files necessary for completing a walkable catchment are added to the Table of Contents. The shape files needed are as follows:

- Harris County Parcels: This shape file includes acreage and land use categories for all parcels. Before adding parcels to the map "public roads," denoted by land use code OT5 and "land under water" denoted by land use code OT3 were omitted from the dataset.
- Harris County Middle Schools: Once this shape file is added to the map, the ArcToolbox Clipping tool is used clip out all Houston Independent School District Schools. Within this clipped data, all schools serving grades, 5-8, 6-8, 1-12, 6-12, EE-12 or PK-8 are selected in the attribute table. These schools represent the "middle schools" explored in this manual. A layer is then created from these selected features and added to the Table of Contents. From this new layer, each school is individually selected within the attribute table and a layer is created for each school.

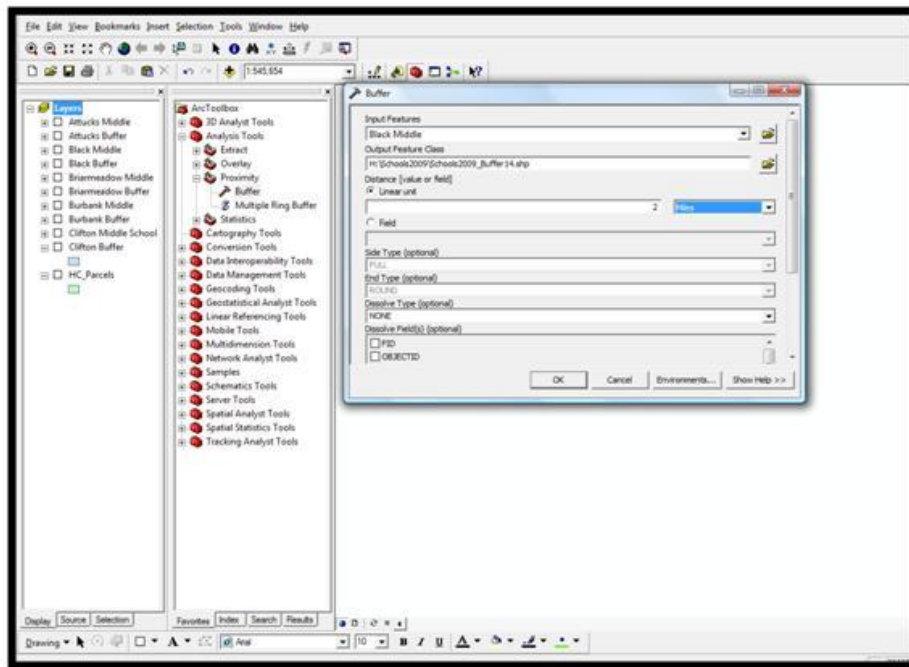
Once all necessary modifications to the shape files have been made, it is time to begin creating the walkable catchment, starting with creating the buffers around all HISD-E middle school. Clifton Middle School is used in this guide to demonstrate the process.

2A. A two mile buffer is drawn around Clifton Middle School using the ArcToolbox Buffer tool. The two mile buffer represents the "theoretical" two mile distance middle school

students would be able to walk to school. Figure 1 illustrates how this buffer is created and Figure 2 shows the buffer once it has been generated.



**Figure 1 Buffer Tool in ArcToolbox**



**Figure 2 Clifton Middle School Buffer**



## STEP 2

Once the two mile buffer has been created around Clifton Middle School, a new service area is generated around the school. This service area represents the “actual” two mile walking distance a middle school can walk for school commutes. To calculate the walkable catchment rating, the area of this service area is divided by that of the two mile buffer and the quotient multiplied by 100.

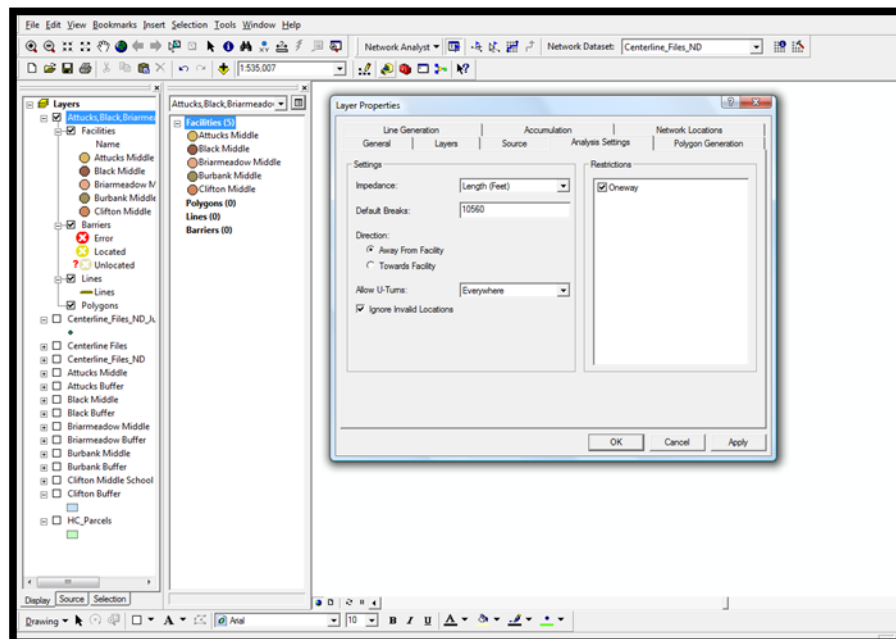
Before the catchment rating is calculated, the Centerline shape file is converted to a network dataset and “built” within ArcCatalog. This newly created and built network dataset is added to the ArcMap Table of Contents as it is necessary for the generation of a Network Analyst service area.

2A. The Centerlines shape file is converted to a Network Dataset in ArcCatalog by right clicking on the file in the Contents window and selecting Create Network Dataset. Once the network dataset is created, a dialog box appears prompting the network dataset to be built. Select yes and build the Centerline Files Network Dataset.

2B. In ArcMap, the newly created Centerline Files ND is added to Table of Contents. All accompanying feature classes such as edges and junctions are added to the map.

2C. A New Service Area is selected in the Network Analyst toolbar and the locations of all schools are loaded in the Network Analyst Window. The layer properties in the Network Analyst Window are set to: generate polygons under the Polygon Generation tab and under the Analysis Settings tab, a default break of 10560 feet (i.e. 2 miles) away from facility (i.e. middle schools) is set. Figure 3 illustrates the layer properties window. Once locations are loaded and layer properties are set, the Solve icon is clicked so the service area can be drawn.

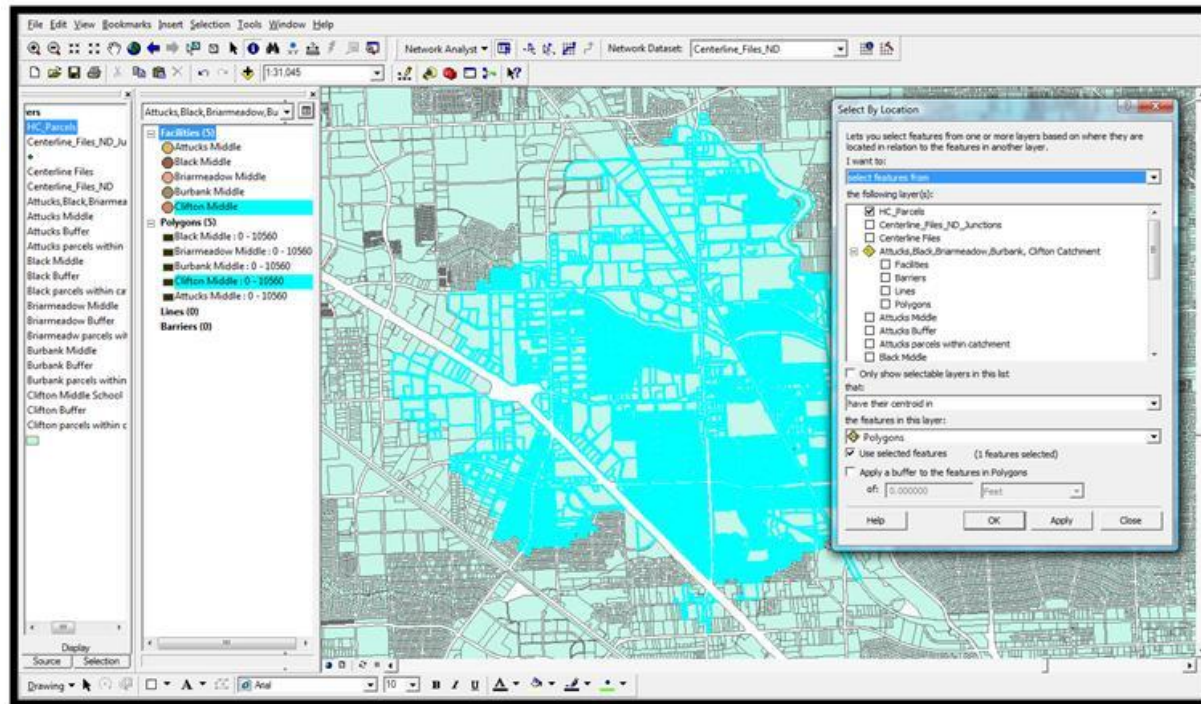
**Figure 3 Layer Properties for Clifton Service Area**



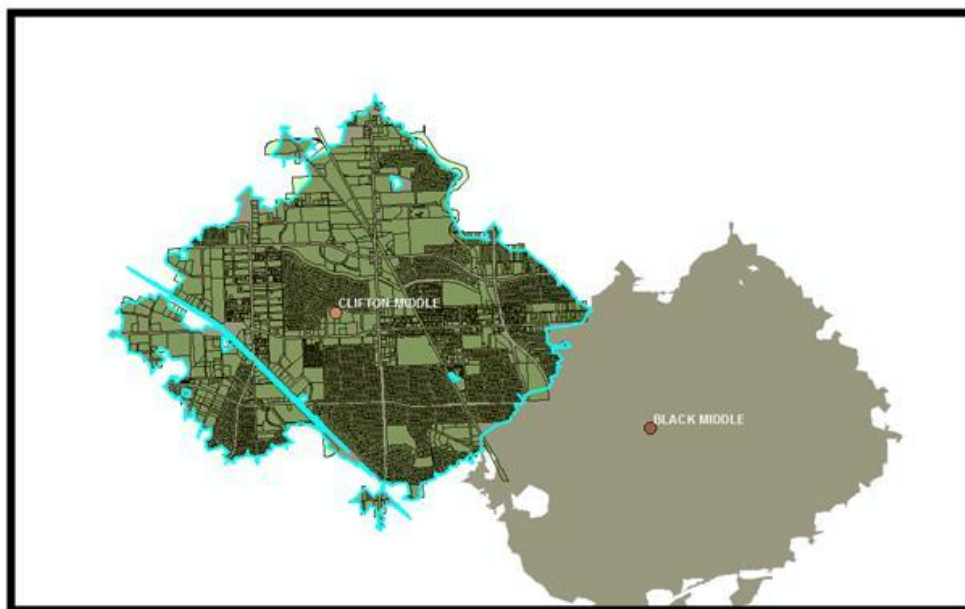


2D. Using an SQL query, parcels that “have their centroid in” the generated catchment polygons are selected. Layers representing those parcels for each school catchment are created from this selection. Each layer is created by clicking on the polygons in the Network Analyst Window before each query. Figure 4 illustrates the SQL query for Clifton Middle School along with the selected parcels within its catchment polygon. Figure 5 illustrates the end product of the SQL query and layer creation process. Figure 6 illustrates in part, the end products of Steps 1 and 2, a map of a walkable catchment around Clifton Middle School.

**Figure 4 SQL Query and Selected Parcels Within Clifton Catchment**



**Figure 5 Parcels Within Clifton Catchment**

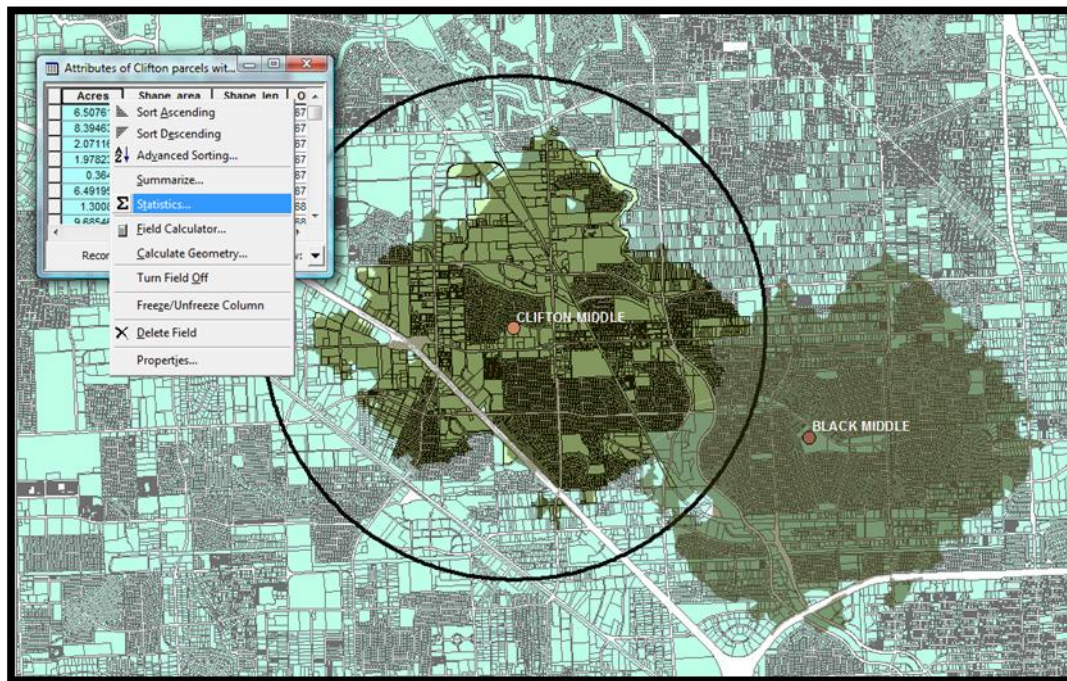


2E. Once the catchment is mapped, the area of parcels within the catchment is calculated. Open the attribute table for each school layer of selected parcels. Right click on the Acres field and use the statistics function to find the sum acreage. For Clifton Middle School the area of catchment area is 2894 Acres. The acreage of the two mile buffer is 8038 acres.

Walkable Catchment Rating =  $(2894/8038) \times 100$

Walkable Catchment Rating = 36

**Figure 6 Measuring Acreage for Clifton Catchment**

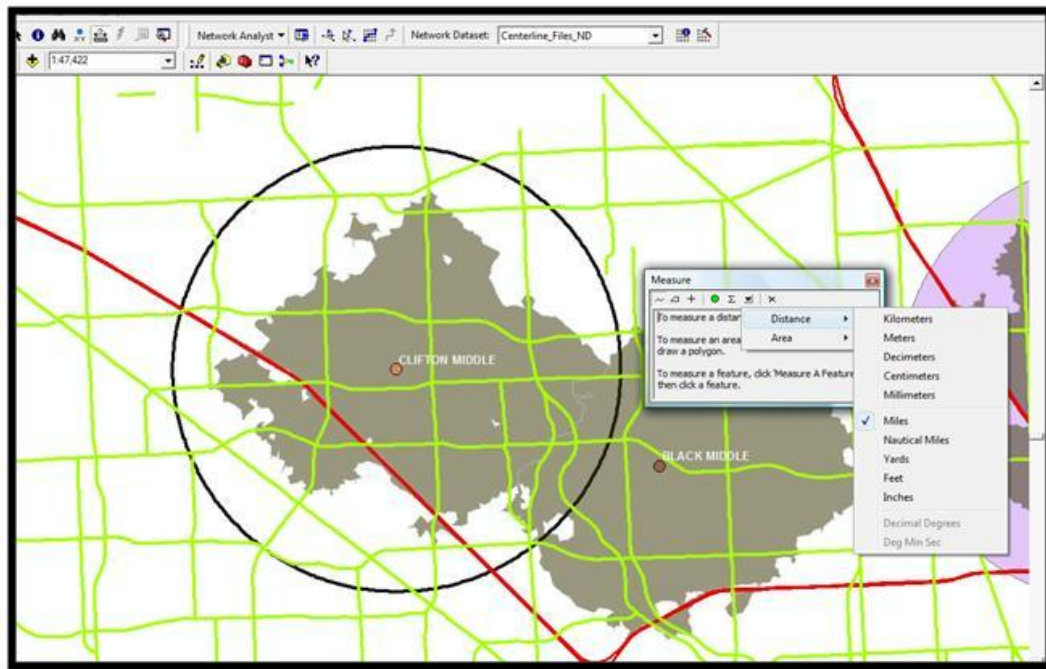


### STEP 3

The buffers and catchment polygons used in the catchment map are also used to analyze road types which may prove hazardous to children's school commutes. In this manual, freeways and major roads intersecting school catchments are analyzed (i.e. measured in miles). All layers in the map are turned off except the buffer, catchment polygon, freeway and major road layers. Freeway and Major Roads layers are created through the use of SQL queries. The respective layers are created from these queries and are then added to the map.

3A. Once the Freeway and Major Roads layers are added to the map, the measure tool is used to calculate the length of major roads and freeways intersecting each school's catchment polygon. Figure 8 illustrates the freeways and major roads intersecting Clifton's catchment. Freeways are denoted in red while major roads are denoted in lime green. Seventeen miles of major roads and nearly three miles of freeways are measured for Clifton.

**Figure 7 Freeways and Major Roads Intersection Clifton Catchment**



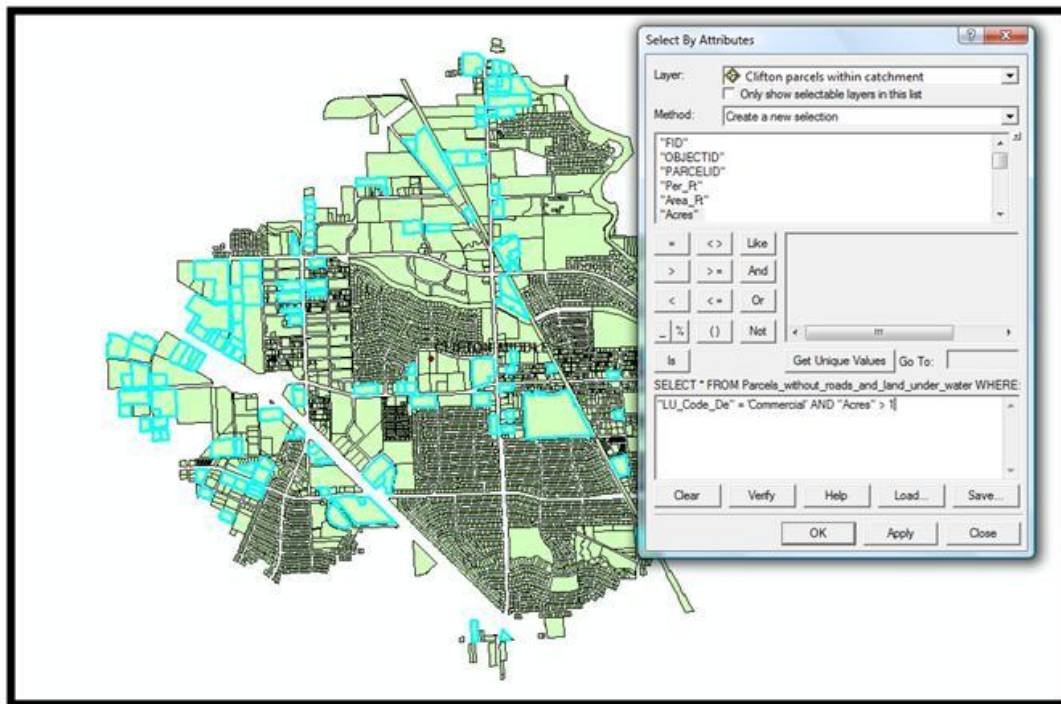
#### **STEP 4**

The parcel layers created in STEP 2 are used in the analysis of land uses within school catchments which are hazardous to the school commutes of children. All layers are turned off except catchment parcels layers.

4A. SQL Queries are used to obtain the acreage of select land uses within catchments. The land use code descriptions queried include: commercial land over 1 acre, industrial, vacant industrial, vacant commercial and vacant residential lots or tracts. Figure 9 illustrates and SQL Query for Clifton Middle School.



**Figure 8 SQL Land Use Query for Parcels Within Clifton Catchment**



## **STEP 5**

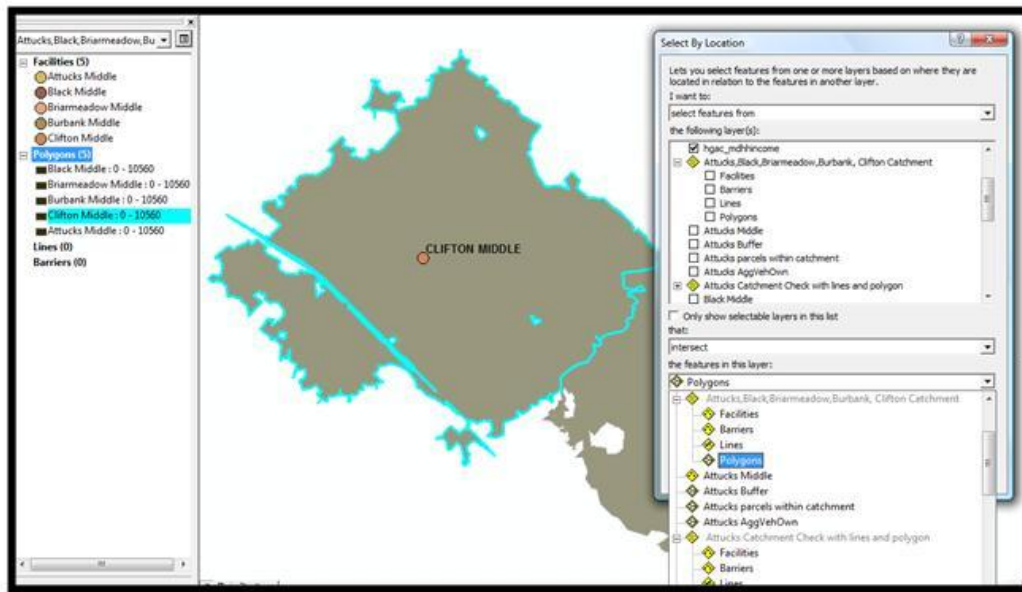
The catchment polygons created in STEP 2 are used in the analysis of average median household income by block group, population in households by block, and average number of vehicles available by census tract.

5A. Census 2000 census tract, block, and block group boundaries are downloaded from the Houston Department of Planning and Development website. These boundary shape files can also be downloaded from the Houston-Galveston Area Council website.

5B. Appropriate Summary File Census data must be downloaded from [www.census.gov](http://www.census.gov). Since data is needed for a large geographic area (i.e. Harris County, TX), summary file data from the American FactFinder Download Data Center is used. This data which is usually in rich text format must be formatted into an excel table. The formatted excel tables are then joined with the census 2000 boundaries already added to the map document.

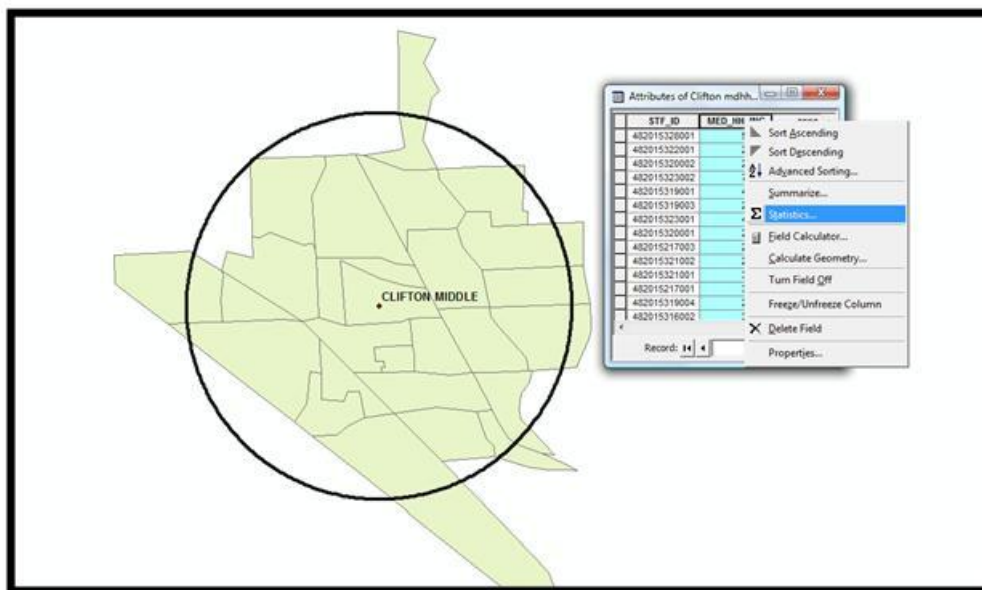
5C. An SQL Query is used to select all census block groups intersecting Clifton Middle School's catchment. A layer is then created from that selection.

**Figure 9 SQL Query for Census Block Groups Intersecting Clifton Catchment**



5D. The statistics tool is used to calculate the average median household income for census block groups intersecting the Clifton catchment.

**Figure 10 Calculating Avg. Med. Hshld. Income in Census Block Groups**



The directions for Step 5 are repeated for the average number of vehicles in census tracts and population in households in blocks intersecting catchments.

## Appendix D: Variable Histograms

Figure 1D. Distribution of Population in Households

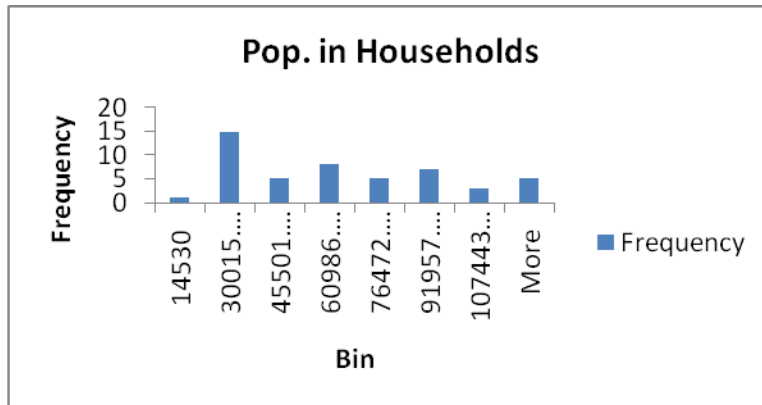


Figure 2D. Distribution of Avg. Number of Vehicles Available

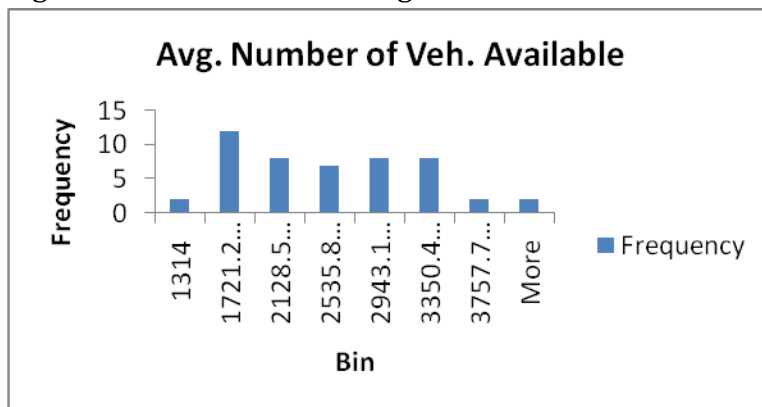


Figure 3D. Distribution of School Populations

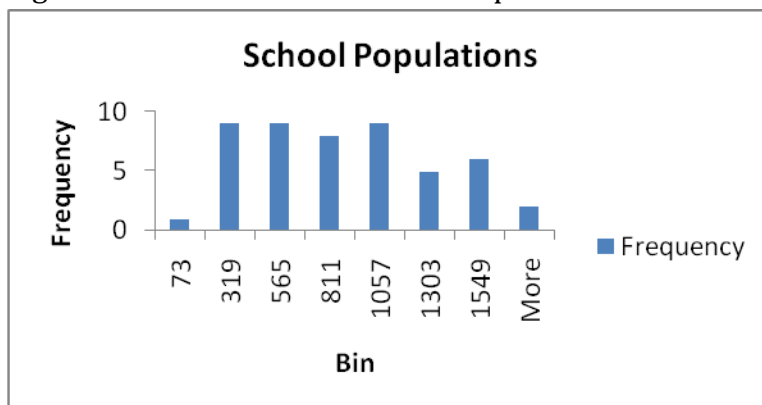


Figure 4D. Distribution of Avg. Median Household Income

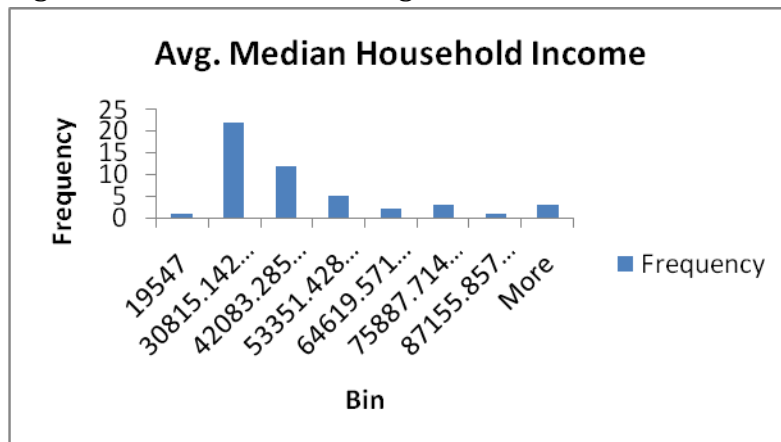


Figure 5D. Distribution of TEA Performance Ratings

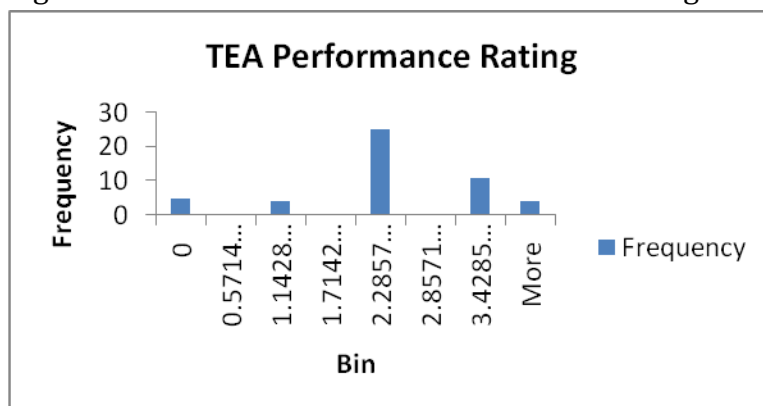


Figure 6D. Distribution of Individuals Living Below Poverty

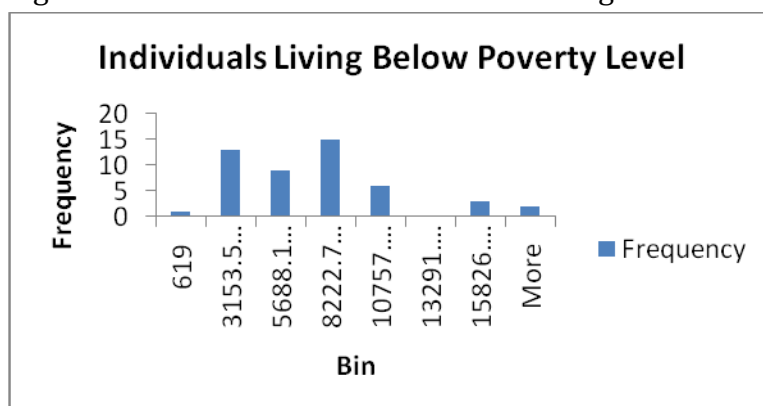


Figure 7D. Distribution of Housing Units Built 1939 or Earlier

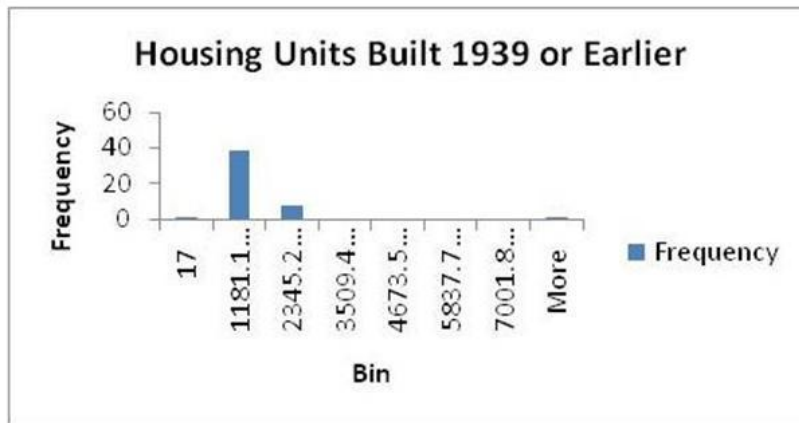
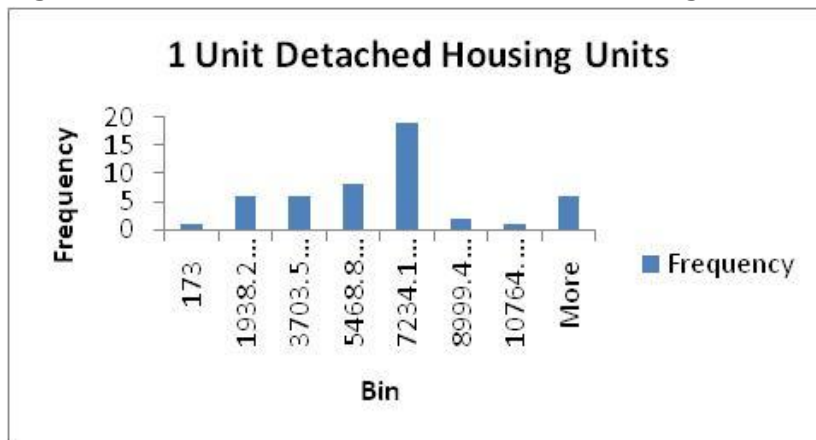


Figure 8D. Distribution of 1 Unit Detached Housing Units





## Appendix E: Results of Pilot and Subsequent Regression Runs

### Pilot Regression Model Results

#### Walkable catchment pilot results.

Table 1E. Catchment Adjusted R-Square

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.756(a)	.571	.412	3.37261
a Predictors: (Constant), OneUnitDetachRes, CommOverOneAcre, FreewaysAndTollways, Industrial, TEARating, SchoolPop, IndInPoverty, HsUnitsBuilt1939orEarlier, VacantComm, MajorRoads, AvgVehiclesInCensusTracts, AvgMedHshldIncome, PopInHsldByBlock				
b Dependent Variable: Catchment				

Table 2E. Catchment Coefficients and Collinearity

Model		Standardized Coefficients			Collinearity Statistics	
		Beta	t	Sig.	Tolerance	VIF
1	(Constant)		5.928	.000		
	FreewaysAndTollways	-.504	-3.047	.004	-.1748	-.350
	MajorRoads	.558	2.106	.042	.015	.793
	Industrial	-.482	-2.920	.006	-.050	-.009
	CommOverOneAcre	.402	2.323	.026	.001	.018
	VacantComm	.087	.452	.654	-.021	.032
	AvgVehiclesInCensusTracts	-.314	-1.375	.178	-.005	.001
	PopInHsldByBlock	-.031	-.115	.909	.000	.000
	SchoolPop	.095	.605	.549	-.002	.004
	AvgMedHshldIncome	.006	.025	.981	.000	.000
	TEARating	.040	.291	.773	-1.015	1.354
	IndInPoverty	.254	1.541	.132	.000	.001
	HsUnitsBuilt1939orEarlier	-.059	-.381	.706	-.001	.001
	OneUnitDetachRes	.004	.024	.981	-.001	.001
a Dependent Variable: Catchment						

## Walkscore pilot results.

Table 3E. Walkscore Adjusted R-Square

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.812(a)	.659	.532	9.83192
a Predictors: (Constant), OneUnitDetachRes, CommOverOneAcre, FreewaysAndTollways, Industrial, TEARating, SchoolPop, IndInPoverty, HsUnitsBuilt1939orEarlier, VacantComm, MajorRoads, AvgVehiclesInCensusTracts, AvgMedHshldIncome, PopInHsldByBlock				
b Dependent Variable: Walkscore				

Table 4E. Walkscore Coefficients and Collinearity

Model		Standardized Coefficients			Collinearity Statistics	
		Beta	t	Sig	Tolerance	VIF
1	(Constant)		.405	.688		
	FreewaysAndTollways	.035	.235	.816	.447	2.235
	MajorRoads	.178	.754	.456	.174	5.739
	Industrial	.159	1.079	.288	.449	2.228
	CommOverOneAcre	.118	.761	.452	.409	2.444
	VacantComm	-.109	-.635	.529	.333	2.999
	AvgVehiclesInCensusTracts	.353	1.729	.093	.235	4.264
	PopInHsldByBlock	.539	2.226	.033	.166	6.012
	SchoolPop	-.164	-1.171	.250	.499	2.005
	AvgMedHshldIncome	.362	1.745	.090	.227	4.407
	TEARating	-.141	-1.165	.252	.662	1.511
	IndInPoverty	-.017	-.115	.909	.451	2.218
	HsUnitsBuilt1939orEarlier	.075	.537	.595	.505	1.980
	OneUnitDetachRes	.154	.944	.352	.368	2.716
a Dependent Variable: Walkscore						

## Subsequent Regression Runs- Walkscore Model (1)

### *Run 1. Walkscore Model with Miles of Freeways, Tollways and Major Roads Composite Variable*

Table 5E. Walkscore Adjusted R-Square- Run 1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.812(a)	.659	.545	9.69821
a Predictors: (Constant), OneUnitDetachRes, CommOverOneAcre, VacantComm, HsUnitsBuilt1939orEarlier, Industrial, TEARating, IndInPoverty, SchoolPop, PopInHsldByBlock, AvgVehiclesInCensusTracts, AvgMedHshldIncome, FreewaysTollwaysMajRoads				
b Dependent Variable: Walkscore				

Table 6E. Walkscore Coefficients and Collinearity- Run 1

Model		Standardized Coefficients			Collinearity Statistics	
		Beta	t	Sig.	Tolerance	VIF
1	(Constant)		.468	.642		
	FreewaysTollwaysMajRoads	.195	.771	.446	.148	6.763
	Industrial	.158	1.088	.284	.450	2.224
	CommOverOneAcre	.111	.754	.456	.440	2.272
	VacantComm	-.117	-.728	.471	.367	2.728
	AvgVehiclesInCensusTracts	.354	1.765	.086	.235	4.252
	PopInHsldByBlock	.545	2.310	.027	.170	5.872
	SchoolPop	-.169	-1.250	.219	.522	1.917
	AvgMedHshldIncome	.362	1.773	.085	.227	4.405
	TEARating	-.140	-1.172	.249	.666	1.502
	IndInPoverty	-.018	-.127	.900	.452	2.210
	HsUnitsBuilt1939orEarlier	.072	.530	.599	.510	1.961
	OneUnitDetachRes	.158	.992	.328	.376	2.660
b Dependent Variable: Walkscore						

*Run 2. Walkscore Regression with Industrial Land, Commercial Land > 1 Acre and Vacant Commercial Land Composite Variable*

Table 7E. Walkscore Adjusted R-Square- Run 2

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.802(a)	.644	.550	9.64335
a Predictors: (Constant), IndustrialCommOverOneAcreVacantComm, PopInHsldByBlock, TEARating, AvgMedHshldIncome, HsUnitsBuilt1939orEarlier, SchoolPop, IndInPoverty, OneUnitDetachRes, AvgVehiclesInCensusTracts, FreewaysTollwaysMajRoads				
b Dependent Variable: Walkscore				

Table 8E. Walkscore Coefficients and Collinearity- Run 2

Model		Standardized Coefficients			Collinearity Statistics	
		Beta	t	Sig.	Tolerance	VIF
1	(Constant)		.421	.676		
	FreewaysTollwaysMajRoads	.120	.518	.607	.174	5.746
	AvgVehiclesInCensusTracts	.338	1.822	.076	.272	3.678
	PopInHsldByBlock	.537	2.443	.019	.194	5.159
	SchoolPop	-.119	-.930	.358	.572	1.748
	AvgMedHshldIncome	.425	2.319	.026	.279	3.584
	TEARating	-.143	-1.339	.189	.822	1.216
	IndInPoverty	-.010	-.075	.940	.490	2.040
	HsUnitsBuilt1939orEarlier	.126	.982	.333	.567	1.765
	OneUnitDetachRes	.068	.480	.634	.473	2.113
	IndustrialCommOverOneAcreVacantComm	.170	1.599	.118	.829	1.206
a Dependent Variable: Walkscore						

*Run 3. Walkscore Regression with Population in Households Variable Omitted*

Table 9E. Walkscore Adjusted R-Square- Run 3

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.767(a)	.588	.493	10.23938
a Predictors: (Constant), IndustrialCommOverOneAcreVacantComm, AvgVehiclesInCensusTracts, OneUnitDetachRes, TEARating, HsUnitsBuilt1939orEarlier, IndInPoverty, SchoolPop, FreewaysTollwaysMajRoads, AvgMedHshldIncome				
b Dependent Variable: Walkscore				

Table 10E. Walkscore Coefficients and Collinearity- Run 3

Model		Standardized Coefficients			Collinearity Statistics	
		Beta	t	Sig	Tolerance	VIF
1	(Constant)		.374	.710		
	FreewaysTollwaysMajRoads	.538	3.230	.003	.381	2.626
	AvgVehiclesInCensusTracts	.238	1.239	.223	.286	3.498
	SchoolPop	-.001	-.008	.994	.667	1.499
	AvgMedHshldIncome	.386	1.990	.054	.281	3.556
	TEARating	-.158	-1.397	.170	.825	1.212
	IndInPoverty	-.059	-.403	.689	.500	1.999
	HsUnitsBuilt1939orEarlier	.146	1.072	.290	.569	1.758
	OneUnitDetachRes	-.043	-.303	.763	.528	1.895
	IndustrialCommOverOneAcreVacantComm	.190	1.691	.099	.834	1.199
a Dependent Variable: Walkscore						

## Subsequent Regression Runs- Catchment Model (2)

### *Run 1. Catchment Model with Miles of Freeways, Tollways and Major Roads Composite Variable*

Table 11E. Catchment Adjusted R-Square- Run 1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.630(a)	.397	.196	3.94522
a Predictors: (Constant), OneUnitDetachRes, CommOverOneAcre, VacantComm, HsUnitsBuilt1939orEarlier, Industrial, TEARating, IndInPoverty, SchoolPop, PopInHsldByBlock, AvgVehiclesInCensusTracts, AvgMedHshldIncome, FreewaysTollwaysMajRoads				
b Dependent Variable: Catchment				

Table 12E. Catchment Coefficients and Collinearity- Run 1

Model		Standardized Coefficients			Collinearity Statistics	
		Beta	t	Sig.	Tolerance	VIF
1	(Constant)		6.077	.000		
	FreewaysTollwaysMajRoads	.132	.393	.697	.148	6.763
	Industrial	-.508	-2.634	.012	.450	2.224
	CommOverOneAcre	.229	1.172	.249	.440	2.272
	VacantComm	-.131	-.613	.544	.367	2.728
	AvgVehiclesInCensusTracts	-.268	-1.005	.322	.235	4.252
	PopInHsldByBlock	.125	.399	.692	.170	5.872
	SchoolPop	-.030	-.166	.869	.522	1.917
	AvgMedHshldIncome	.026	.095	.925	.227	4.405
	TEARating	.079	.499	.621	.666	1.502
	IndInPoverty	.218	1.131	.265	.452	2.210
	HsUnitsBuilt1939orEarlier	-.117	-.643	.524	.510	1.961
	OneUnitDetachRes	.104	.492	.626	.376	2.660
a Dependent Variable: Catchment						

*Run 2. Catchment Regression with Industrial Land, Commercial Land > 1 Acre and Vacant Commercial Land Composite Variable*

Table 13E. Catchment Adjusted R-Square- Run 2

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.541(a)	.293	.107	4.15676
a Predictors: (Constant), IndustrialCommOverOneAcreVacantComm, PopInHsldByBlock, TEARating, AvgMedHshldIncome, HsUnitsBuilt1939orEarlier, SchoolPop, IndInPoverty, OneUnitDetachRes, AvgVehiclesInCensusTracts, FreewaysTollwaysMajRoads				
b Dependent Variable: Catchment				

Table 14E. Catchment Coefficients and Collinearity- Run 2

Model		Standardized Coefficients			Collinearity Statistics	
		Beta	t	Sig.	Tolerance	VIF
1	(Constant)		5.819	.000		
	FreewaysTollwaysMajRoads	.446	1.363	.181	.174	5.746
	AvgVehiclesInCensusTracts	-.030	-.115	.909	.272	3.678
	PopInHsldByBlock	-.118	-.381	.706	.194	5.159
	SchoolPop	-.099	-.550	.585	.572	1.748
	AvgMedHshldIncome	.185	.716	.478	.279	3.584
	TEARating	.241	1.605	.117	.822	1.216
	IndInPoverty	.331	1.698	.098	.490	2.040
	HsUnitsBuilt1939orEarlier	-.175	-.967	.340	.567	1.765
	OneUnitDetachRes	.176	.887	.380	.473	2.113
	IndustrialCommOverOneAcreVacantComm	-.163	-1.086	.284	.829	1.206
a Dependent Variable: Catchment						

*Run 3. Catchment Regression with Population in Households Variable Omitted*

Table 15E. Catchment Adjusted R-Square- Run 3

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.539(a)	.291	.127	4.11094
a Predictors: (Constant), IndustrialCommOverOneAcreVacantComm, AvgVehiclesInCensusTracts, OneUnitDetachRes, TEARating, HsUnitsBuilt1939orEarlier, IndInPoverty, SchoolPop, FreewaysTollwaysMajRoads, AvgMedHshldIncome				
b Dependent Variable: Catchment				

Table 16E. Catchment Coefficients and Collinearity- Run 3

Model		Standardized Coefficients			Collinearity Statistics	
		Beta	t	Sig.	Tolerance	VIF
1	(Constant)		5.888	.000		
	FreewaysTollwaysMajRoads	.354	1.619	.114	.381	2.626
	AvgVehiclesInCensusTracts	-.008	-.032	.975	.286	3.498
	SchoolPop	-.125	-.758	.453	.667	1.499
	AvgMedHshldIncome	.194	.761	.451	.281	3.556
	TEARating	.245	1.648	.107	.825	1.212
	IndInPoverty	.341	1.790	.081	.500	1.999
	HsUnitsBuilt1939orEarlier	-.180	-1.004	.321	.569	1.758
	OneUnitDetachRes	.200	1.078	.288	.528	1.895
	IndustrialCommOverOneAcreVacantComm	-.167	-1.131	.265	.834	1.199
a Dependent Variable: Catchment						



Appendix F: Correlation Matrix

	Walkscore Rating	Walkable Catchment rating	Miles of Freeways and Tollways	Miles of Major Roads	Acres of Industrial Land	Acres of Commercial Land > 1 acre	Acres of Vacant Commercial Land	Avg. Number of Vehicles Available	Pop. in Households	School Pop.	Avg. Median Household Income	TEA Performance Rating	Individuals Living Below Poverty Level	Housing Units Built 1939 or Earlier	1 Unit Detached Housing Units
Walkscore Rating	1														
Walkable Catchment Rating	0.112	1													
Miles of Freeways and Tollways	0.258	-0.083	1												
Miles of Major Roads	0.522	0.363	0.511	1											
Acres of Industrial Land	-0.066	-0.451	0.136	-0.115	1										
Acres of Commercial Land > 1 acre	0.218	0.156	0.132	-0.103	0.117	1									
Acres of Vacant Commercial Land	-0.173	-0.058	0.442	0.195	0.279	-0.180	1								
Avg. Number of Vehicles Available	0.214	0.057	-0.405	-0.358	-0.414	0.394	-0.629	1							
Pop. in Households	0.434	0.097	0.576	0.811	0.190	-0.204	0.349	-0.538	1						
School Pop.	-0.199	-0.126	-0.314	-0.412	-0.020	-0.153	-0.343	0.268	-0.248	1					
Avg. Median Household Income	0.481	0.073	-0.243	0.013	-0.396	0.219	-0.623	0.687	-0.183	0.111	1				
TEA Performance Rating	-0.104	0.175	-0.101	-0.089	-0.121	0.326	-0.310	0.203	-0.094	0.132	0.068	1			
Individuals Living Below Poverty Level	-0.127	0.316	0.219	0.035	-0.077	0.245	0.171	-0.020	-0.042	0.023	-0.402	0.087	1		
Housing Units Built 1939 or Earlier	0.187	0.052	0.319	0.366	0.034	-0.098	0.104	-0.233	0.331	0.059	-0.201	0.032	0.177	1	
1 Unit Detached Housing Units	-0.155	0.086	-0.147	-0.290	-0.198	-0.001	0.110	0.143	-0.396	0.305	-0.087	-0.136	0.365	0.307	1
Notes Yellow denotes correlation significance at the 99% level. Green denotes correlation significance at the 95% level.															

## **Vita**

The author was born in New Orleans, Louisiana. She obtained her Bachelor's degree in political science from Howard University in 2008. She joined the University of New Orleans graduate program to pursue a Master of Urban and Regional Planning degree.