GREENING NORTH KNOXVILLE: VISUALIZING SUSTAINABILITY IN URBAN CONDITIONS

Ted Shelton, AIA
University of Tennessee
College of Architecture and Design

When working in the urban context, it is difficult for even well-informed designers to understand how their decisions impact the environment. The urban condition is inherently complex; while many of the metrics of sustainability either have no visible manifestation or are composed of multiple layers - some of which are visible and some of which are not. This project developed methods whereby the complex interactions of environmental concerns and the urban condition are made visible for the purpose of informing the design process.

Investigators collected information on the geospatial conditions of an existing urban neighborhood, North Knoxville, Tennessee, and used CartaVista™ Geographic Information Visualization (GIV) software to perform graphic analyses of aspects of urban sustainability. GIV technology uses a layered system of Digital Elevation Models (DEMs). While these models typically correspond to elevation data, they can also be used to represent other data types. In this project, DEMs were manipulated to represent aspects of sustainability through the creation of thematically grouped Visual Analysis Layers. Relating and quantifying each of the parameters comprising each identified aspect of sustainability, the Digital Elevation Model was manipulated to create a Digital Data Model (DDM), which was in turn be displayed by CartaVista™ as points, lines, and surfaces colored with hypsometric tints to describe features of the dataset and drive visual investigation. Thus, from quantitative data comes qualitative readings, unlocking the visual processing abilities of the designer and informing integrated design decisions.

Greening North Knoxville: Visualizing Sustainability in Urban Conditions

Ted Shelton, AIA
University of Tennessee
College of Architecture and Design

Introduction

Sustainability is a complex issue. It is comprised of many overlapping concerns and factors. When one combines this with the complexity of operating in the urban realm, it becomes very difficult for even well informed and well intentioned designers to understand the ramifications of their actions. This project begins to address this problem.

One of the primary difficulties of sustainable practice in urban conditions is that many of the factors of sustainability and cities are invisible - take for example walkability which may have visible components such as quality of sidewalk or intensity of vehicular traffic but also has many factors that are invisible or not readily seeable such as climate, topography that extends beyond the immediate site, and distribution of amenities. This project represents an attempt to inform designers in the earliest stages of design by making several of these factors wholly visible. Using geographic information visualization (GIV) software multiple factors of urban sustainability are mapped and visualized. This "making visible" previously invisible or partially visible issues in the form of geospatial information provides architects and urban designers with the ability to process and understand information about a particular neighborhood's sustainability through the means with which they are most accustomed –visual information.

This research was centered on an undergraduate seminar course. Students were first asked to think broadly about the issue of sustainability and what it might mean in the urban environment. This discussion gradually led the students to identify several issues they were interested in exploring. Teams of two students then developed methods by which each issue's constituent parts might be identified, analyzed, quantified and finally given a visual manifestation. These visual arguments then became the basis for recommendations made by the teams for how future design interventions might increase the sustainability of the neighborhood. Finally, this information was then collected and expanded upon by the instructor.

The Project

The work performed thus far represents the first of two phases of work: one supported by an undergraduate seminar and the other supported by an undergraduate studio at the University of Tennessee College of Architecture and Design. Both phases will serve as a foundation of information for continuing research by the principal investigator, some of which has already begun.

Phase One was informed by a seminar held in the fall semester of 2007. The seminar began with students familiarizing themselves with the existing conditions of the study area in general terms. This was followed by a directed though wide-ranging discussion about the meaning of sustainability in urban conditions. This discussion sought to understand what might be the fundamental aspects of urban sustainability and to begin to visualize how these various aspects might interrelate in North Knoxville. Students were then charged with the following tasks:

Identify particular aspects of urban sustainability on which to focus the study. These identified aspects became the subjects of the various visual information layers developed by the class.

Develop a methodology by which these aspects of sustainability can be measured and ultimately expressed through a visual language.

Analyze the resulting visualizations seeking to understand their implications for neighborhood design.

Recommend targeted design projects as a starting point for the spring semester design studio.

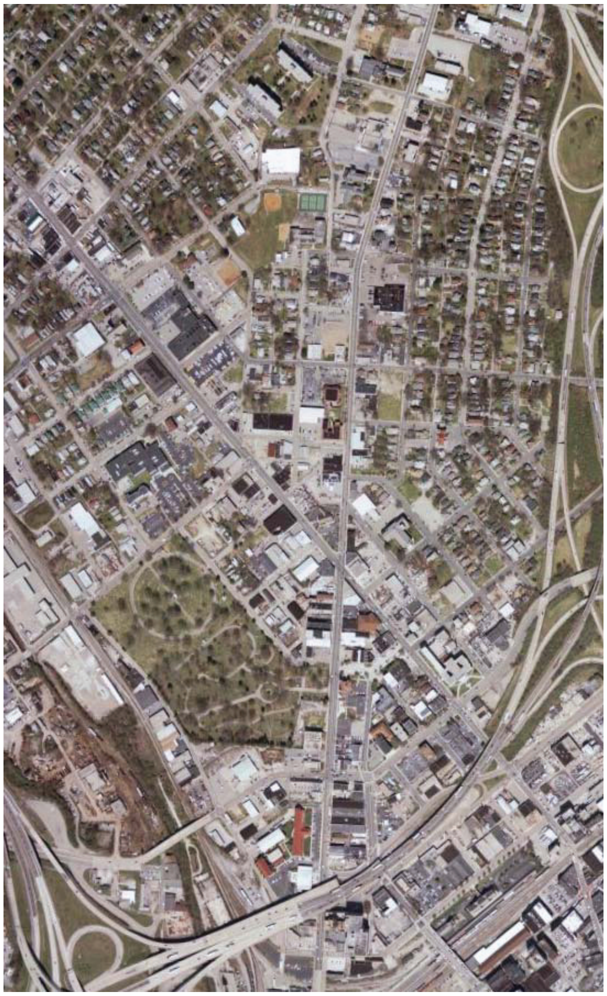
Phase Two will consist of a guided upper level undergraduate research studio that will build upon the work of the seminar. The studio is charged with:

Suggesting the siting and programming of catalytic projects for North Knoxville that will result in improving multiple aspects of urban sustainability identified in the preliminary research.

Providing compelling design decisions incorporating these catalytic projects in the future green development of the area

Analyzing the effectiveness of their proposals in improving sustainability in terms of a limited set of concerns.

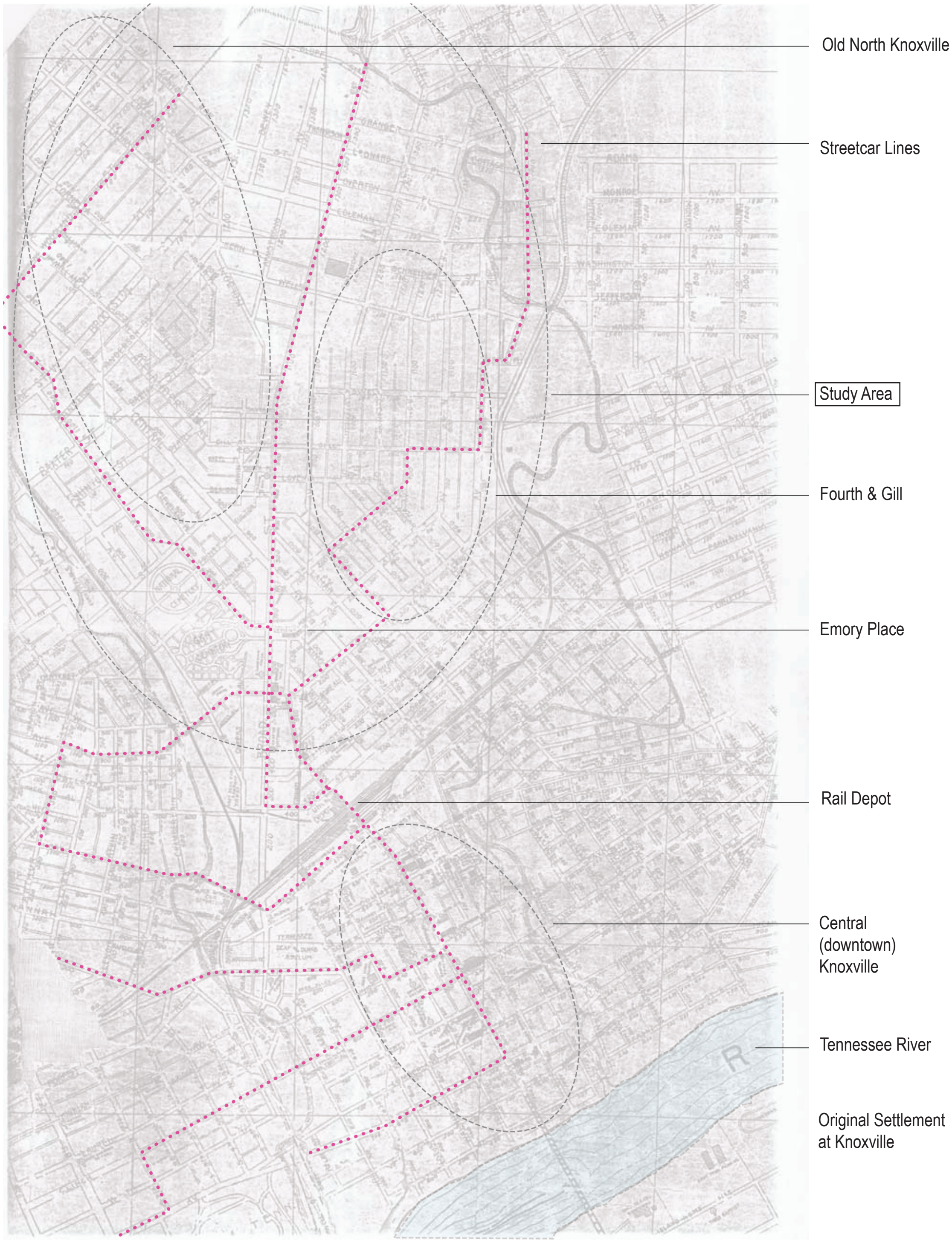
This work will be performed in the college's downtown studio, it's outreach center for community development. Both the local architecture profession and the municipal planning authority will be engaged through this process.



Study Area

North Knoxville is an inner ring neighborhood of Knoxville Tennessee. Its original lifeblood was a streetcar line that allowed easy access to the center city. As with many American streetcar neighborhoods, North Knoxville possesses many characteristics that make it a strong candidate for reinhabitation and redesign as a green neighborhood –residential areas that are closely aligned with commercial districts, densities that allow for easy bicycle and pedestrian mobility, a balance of built area and green space, and proximity to the amenities of downtown, to begin.

The designation " North Knoxville " applies to a collection of such neighborhoods. In an effort to be more precise about our study, a boundary was selected that coincided with the recent study performed by the local Metropolitan Planning Commission (see Appendix A.) This Small Area Plan, as it is called, focused on the intersection of Central Avenue and Broadway encompassing all or part of many surrounding areas including the Fourth and Gill neighborhood, the Old Gray Cemetery, Emory Place, and extending under the interstate slightly to touch what can be considered part of the Old City - the area that was once Knoxville's bowery. This boundary describes an area of .45 square miles. While it was preferable for student teams to consider this an area in its entirety, they were permitted to adjust the extent of their investigations according to their complexities.



Crozier Map and Suburbs, Knoxville, Tennessee (1895) showing proximity of North Knoxville streetcar suburbs, to the center of Knoxville. An extensive streetcar system (pink) spurred rapid development of North Knoxville from the 1890's to 1940's.

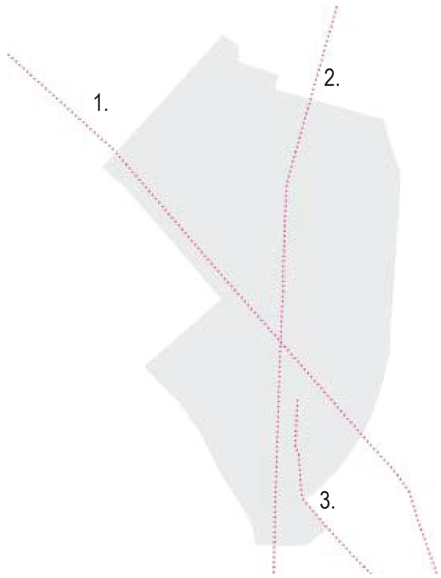
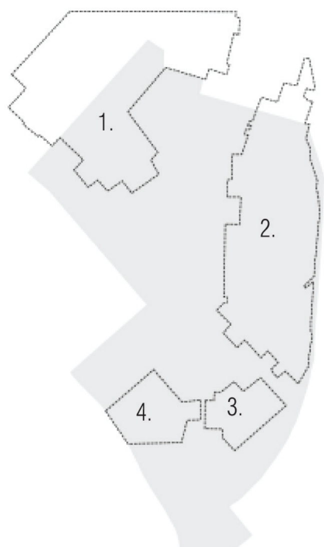


Diagram of the study area (gray) showing the primary organizing streets - (1.) Central Avenue, (2.) Broadway, and (3.) Gay Street. Each connects to downtown Knoxville to the south of the study area.

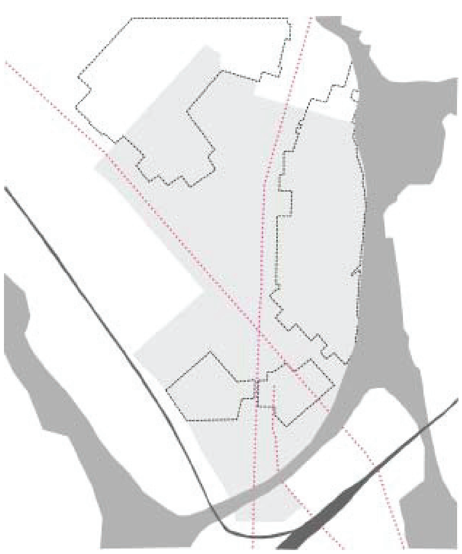


The study area contains four designated historic areas - (1.) Old North Knoxville, (2.) Fourth and Gill, (3.) Emory Place, and (4.) Old Gray Cemetery.

Active cargo rail lines define one edge of the study area and separate it from downtown Knoxville.
Interstate highways and their rights-of-way further segregate and intrude upon the study area, creating barriers to downtown and adjacent neighborhoods.

Interstate highways and their rights-of-way further segregate and intrude upon the study area, creating barriers to downtown and adjacent neighborhoods.

The three linking streets thus take on added importance as vital links to the center city.

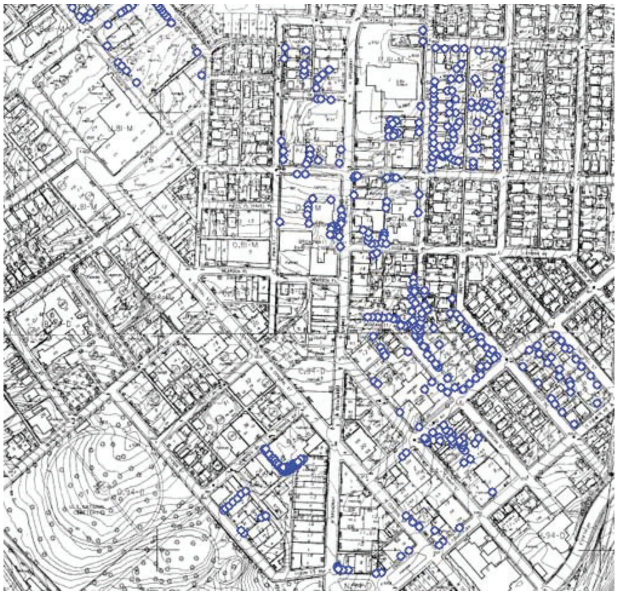


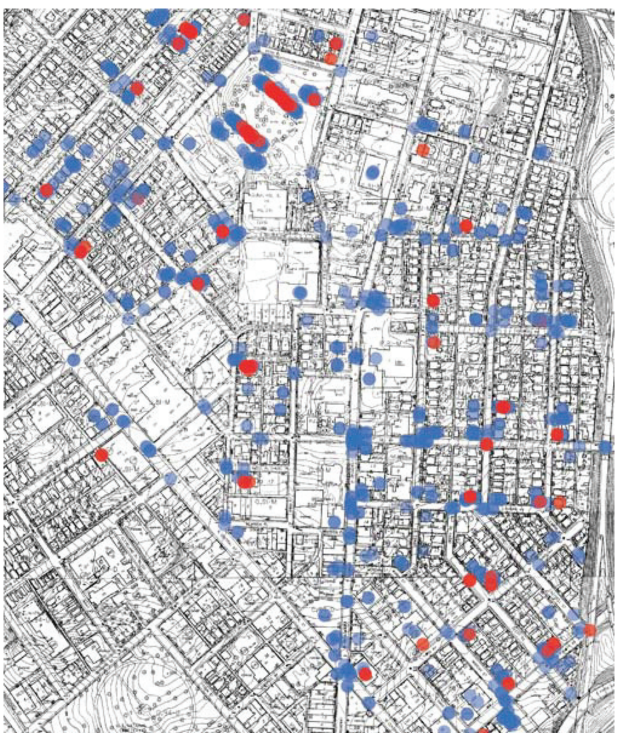
Taken as a whole, the characteristics of the study area - historic neighborhoods with good housing stocks, proximity to commercial streets and the downtown, difficult relationships to interstate highways, etc. - make it a good stand in for numerous inner ring neighborhoods across the country.

The Process

Students in the research seminar identified seven preliminary issues or aspects of sustainability to investigate: transit connectivity, stormwater, safety, proximity to amenities, walkability, solar access, and density. Additionally, the students compiled a detailed tree survey covering a significant portion of the study area. The ultimate goal of these investigations was to utilize graphic information visualization (GIV) software to display and analyze geospatial visual information related to each of these aspects of urban sustainability. The class utilized a variety of softwares to develop preliminary visualizations. However, the ultimate intent was to eventually develop a methodology that was clear and accurate enough to utilize the GIV software. CartaVista™ GIV software was made available for the class' investigations by Ambroziak Third Dimension Technologies, Inc.. Some new functions were added to the software during the process to accommodate the class' particular investigations. This software allows for the manipulation of geospatial data in relation to the interests of this study in two particular ways. The first involves the creation and manipulation of digital elevation models (DEM) where variables other than elevation are substituted for the Z. value. This type of model allows for a wide range of visual outputs and analyses ranging from the application of contour lines and hypsometric tints to the viewing of the models as three dimensional meshes. The second type of manipulation, point files, allow for multiple variables to be attached to a single point in space. These files provide the possibility of more complex methods of analyzing data that are as yet untapped by this project, including statistical regression analysis.

Over the course of the research this semester, it became apparent that the abilities of CartaVista™ yield four primary methods of visualizing data useful for understanding aspects of urban sustainability –cataloging, compilation, coincidence, and interaction.

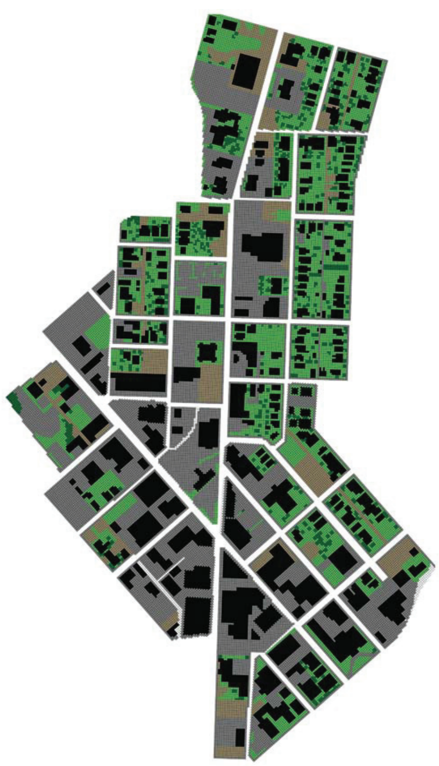




Cataloging

Cataloging is the simplest of the four methods of visualizing data. It serves two primary purposes – either to reveal simple patterns or holes in patterns or to serve as raw data that will later feed into other more complex analyses. A good example of both of these aspects of cataloging is the tree survey (above left.) One can visually analyze the locations of significant trees within the survey area noting particular concentrations or patterns. Such simple straightforward information can be helpful for the design process in itself. However, one of the reasons a tree survey was chosen for the initial cataloging exercise was the potential for information regarding the locations of significant trees to feed into numerous other analyses issues such as walking comfort, stormwater absorption and evapotranspiration, and solar access. As each point on the tree survey contains information on tree height, canopy diameter, and a classification as to whether each tree is evergreen or deciduous, it is even conceivable that this information could eventually feed into a neighborhood-wide evaluation of carbon balance.

Another of the initial investigations, safety, also became an exercise in cataloging (below left.) This graphic display of the locations of both violent and nonviolent crimes within the study area for each of the last four years (with a composite diagram showing the data combined) revealed certain information about patterns and severity of crimes being linked to particular locations. However, it’s connection to the other visual analysis layers is so tenuous as to call into question its future benefit. If this investigation is to proceed it would seem necessary to augment this raw crime data with other information such as nighttime lighting levels throughout the study area, proximity to police/fire stations and patrol routes, and density and vacancy patterns.

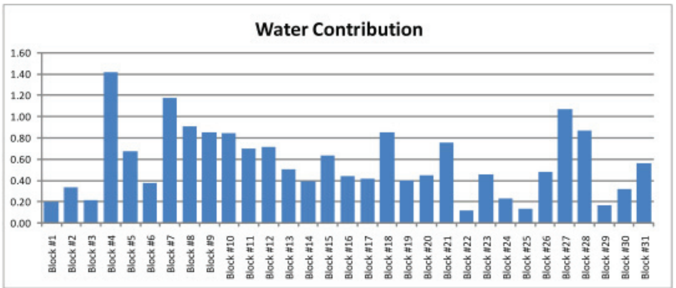


Compilation

Compilation is a more advanced form of analysis. It involves the combined display of an aspect of sustainability the values of which vary with location. This type of investigation presents opportunities to begin to develop visualizations of the unexpected interactions of complex and invisible aspects of urban sustainability.

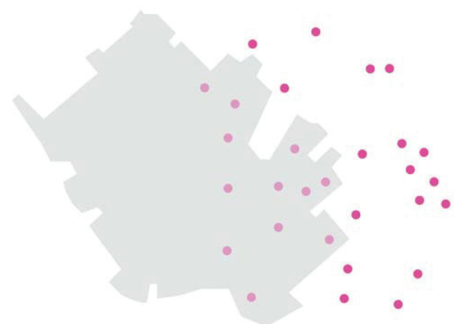
A good example of this type of investigation from the seminar course deals with the issue of walkability. Through field observation students evaluated the walkability of neighborhood streets, grading them on seven variables ranging from quality of sidewalk surface, to the presence and the nature of buffers between pedestrians and automobile traffic, to shading of the sidewalk. These were compiled into a composite score for each length of sidewalk. This information was then in turn made visual using CartaVista.™ The resulting images provide clear information on walkability within the study area that combines a variety of factors and is quickly digested through visual means (above left).

An example of the importance of both the visual nature of this information and its overt link to location comes from another class analysis, this one dealing with stormwater. The stormwater investigation began with a type of cataloging. Working within the watershed defined by the low point at the intersection of Broadway and Central Avenues, students began by dividing each constituent block into 5 foot by 5 foot grids. Each square with the grid was then designated as being predominantly one of five possible surface types: building, pavement, gravel, grass, or trees. Even the resulting pixelated image begins to provide important visual information by calling out large areas of paving within the watershed (below left).



Using standard values for the absorptivity of these various surfaces then allowed the students to predict the amount of stormwater contributed to the city system by each block in a two year storm event (approximately 1.5 inches per hour). Though the seminar students' investigation concluded with extensive and reliable information, its representation in bar graph form renders it very difficult to use during the design process, requiring cross referencing between the graph and a map labeled with the appropriate block numbers (above left). A limited amount of subsequent work with CartaVista™, however, makes the information graphic and links it to location, thus rendering it much more useful for design purposes (below left).

The final example of compilation analysis from the seminar course deals with the proximity of amenities. This analysis of is currently the focus of ongoing research and development and is covered in much greater detail later in this report. As compilation represents the most accessible level of analysis that truly begins to unlock the potential for location specific visual information about urban sustainability to inform design decisions it represents the most fruitful area for ongoing research at the present time. As more data is developed, the potential for conducting the more complex coincidence and interaction analyses will grow.



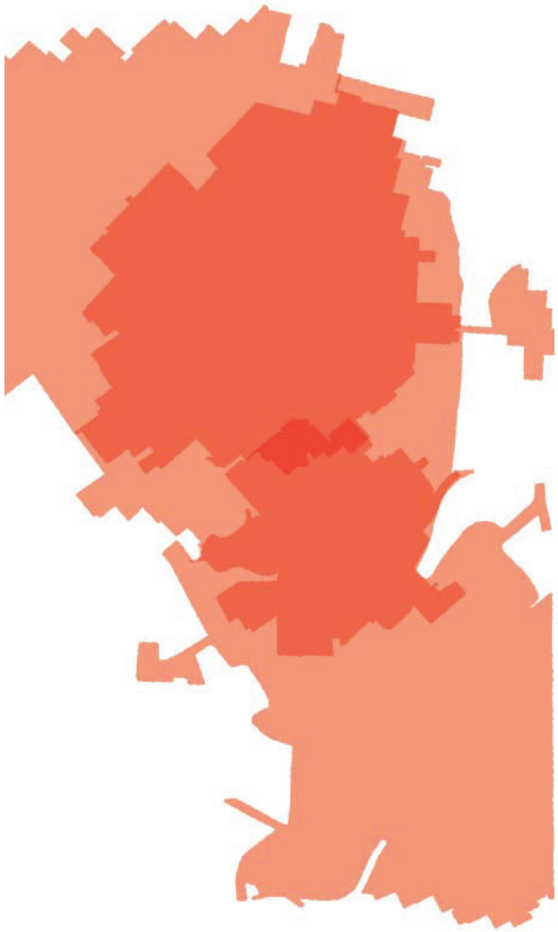
Coincidence

Coincidence represents the next level of evaluation whereby one begins to look at the interactions between related (or seemingly unrelated) aspects of urban sustainability. This type of analysis simply begins to look for an overlapping of these disparate concerns once each has been made visual through either cataloging for compilation. Though the seminar course did not overtly deal with coincidence analysis, participants speculated as to what might be opportune pairings of issues for further and more complex analysis in the future. One such example might involve overlaying the stormwater and walkability analyses. If one were to begin to see locations where both the walkability quality was low and the contribution of stormwater to the gutter system was high these areas might then be targeted as locations where a single design intervention dealing with the street edge might simultaneously improve both aspects of urban sustainability. Coincidence analysis represents the first step toward understanding and acknowledging the interconnectedness of both green issues and urban issues. Such analysis points to new questions and demands for design briefs and programs that address several complex issues simultaneously and integratively.

Interaction

The highest form of analysis foreseen by this project is interaction. Interaction analysis seeks to combine in one set of data the complex relationships between multiple aspects of urban sustainability, each of which has embedded in it values that vary with location. The true promise of using visual information to detangle and provide a coherent picture of the complex interrelationships between the many aspects of urban sustainability lies in this type of analysis. Aside from the obvious difficulties of compiling the large amounts of information necessary to creating a meaningful interaction analysis, the greatest hurdle is perhaps one of prioritization. An interaction analysis that relates seemingly unrelated aspects of sustainability will require many assumptions as to the relative weight of each of these aspects to be embedded within the analysis. For instance, how does one begin to assign relative values to concerns when attempting to combine disparate aspects of urban sustainability such as proximity of housing to transit stops and passive absorption of stormwater? Is one housing unit within 500 feet of a transit stop worth 100 gallons of passive storm water absorption? Is it worth more? Is it worth less? Ultimately such questions may either need to be tied back to common fundamental measures - carbon, energy, water - or left to individual municipalities or designers as a statement of local values. Surely they will not be well understood without much trial and error.

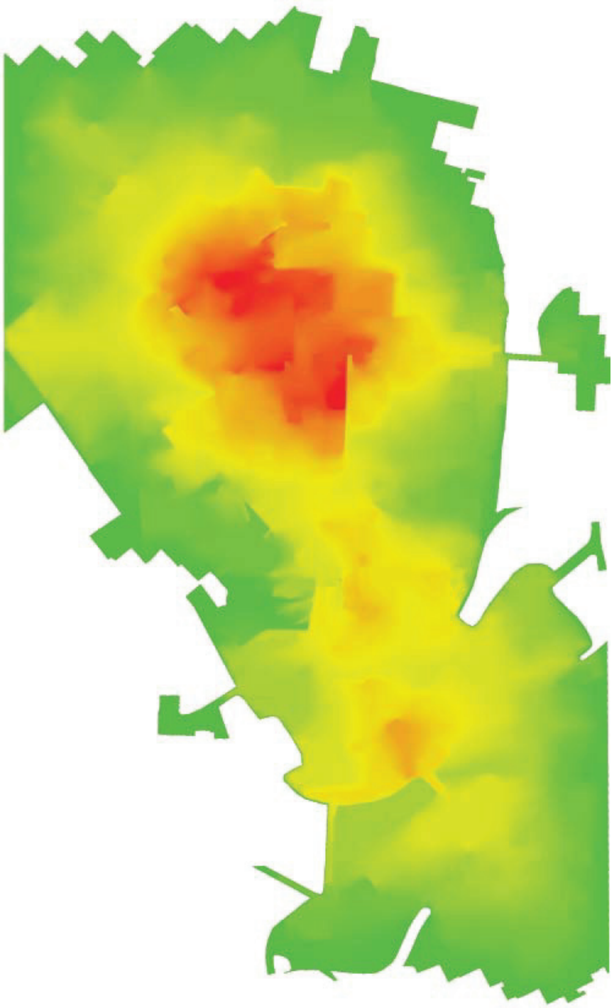
The top goal of next semester's studio investigation will be to perform a limited interaction analysis. This analysis will be confined to a finite area within the boundaries of the study area and will attempt to correlate a small number of aspects of urban sustainability. A preliminary list of these includes stormwater absorption, solar access, proximity of housing to transit stops, and walkability of the spaces in between. This analysis will be performed for the existing conditions. Students will then respond to analysis by proposing catalytic design interventions intended to improve the overall sustainability of the site. A resultant analysis will be then be performed. At the very least, the iterative exercise will provide a relative picture of increased or decreased sustainability linked to the location.



Detailed Compilation Analysis: Proximity to Amenities

Following the work of the seminar one aspect of urban sustainability has been identified as the subject for a more detailed compilation analysis. This aspect, proximity to amenities, is closely based on a concept found in the pilot version of the LEED™ for Neighborhood Development rating system – diversity of uses. The thinking behind the diversity of uses concept in the LEED-ND rating system is straightforward and well-founded. The rating system holds that if commonly used neighborhood amenities are within easy walking distance residents will tend to use more benign modes of travel (walking or bicycling) to access these amenities, thus alleviating some of the demand for car travel. The diversity of uses concept lists nineteen such uses and awards points on a sliding scale based on the number of these located within a ½ -mile walking distance of the development in question. This compilation analysis adopted the LEED-ND list of uses and located all instances within or near the study area.

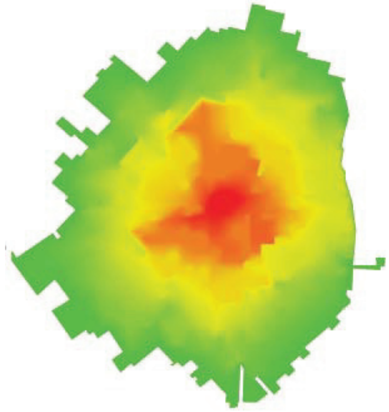
The LEED-ND rating system requires that applicants measure the actual distance of travel when attempting to qualify for these points. This is a distinct improvement over the typical practice of simply drawing a ½ -mile radius circle centered on one's development to delineate an easily walkable distance. This method takes into account the effect of obstacles -such as inaccessible topography, super blocks and roads that are not easy to cross - on walking distance. This consideration becomes extremely important when considering walking distance within the urban environment, as is clearly shown by the compilation analysis. The LEED-ND rating system, however, uses an understandable simplification for the purposes of calculating diverse uses points. Every location within the ½mile walking distance is considered to be equal. This sets up a type of binary system where one is either inside or outside of the walking shed - one either receives credit or does not. The diagram at left shows this simplified understanding of accessibility for three of the uses in the study area: a senior care facility, a fire station, and a restaurant. The small area of the highest saturation indicates where all three of these walking areas overlap and as such is identified as a preferable location even though it is at the outer limits of walking area for two of the uses. However, it is clearly preferable in terms of accessibility to be within 1/10 mile of a given amenity rather than 4/10 mile. While this cannot be taken into account within the limitations of a LEED™ submittal that already requires a project team to demonstrate performance in many different areas, the subtleties of this type of gradation of benefit is exactly the type of information that is most easily grasped through visual analysis.



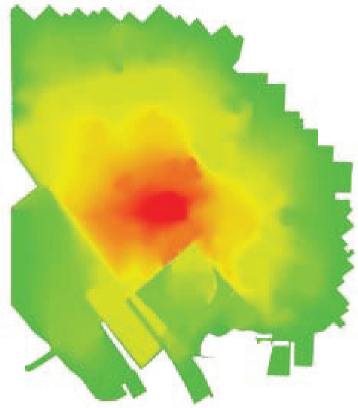
For this analysis CartaVista™was used to generate digital elevation models from contour maps, each identified neighborhood amenity was taken as a type of 100% ideal location where the most desirable position in terms of access to that amenity would be directly adjacent to it. From there, radiating contours of walking distances were drawn in 1/10 mile increments until ½-mile of walking distance from the amenity had been achieved. Each of these contour lines was then assigned a point value in two point increments with the line immediately adjacent to the amenity receiving ten points and the outermost line receiving zero. Ambroziak Third Dimension Technologies added a function to CartaVista™ that allows for multiple digital elevation models to be added to each other for the purposes of this investigation. Using this function we are able to create a composite image of accessibility to amenities across the study area. At left is such a diagram showing a proximity to the same three amenities as in the diagram on the previous page, though now clearly accounting for the importance of distance. To date eight neighborhood amenities have been mapped and added to the proximity to amenities compilation analysis. (See diagrams on the following pages.) This analysis will continue until all existing amenities on the list have been included. While these preliminary results are skewed by the selection of the amenities included thus far, interesting results are already emerging. One begins to understand the profound impact of Broadway and Central Avenues, which can only be traversed at particular locations. These obstacles clearly begin to contain accessibility to amenities located in between the two. The influence of super blocks such as the Guy B. Love Towers in the north and the Old Gray Cemetery in the south are clearly depicted as holes in the accessibility. It is further surprising to see how quickly proximity to amenities drops off within the Fourth and Gill neighborhood (at eastern edge of study are) which ostensibly seems quite well connected.

List of Diverse Uses:

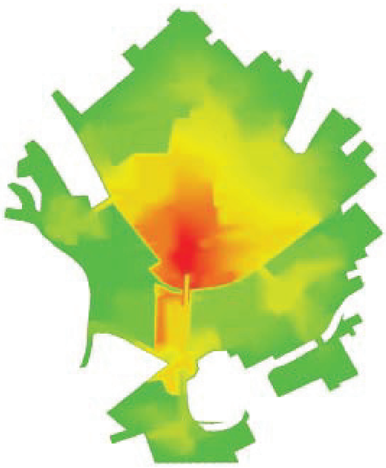
01	Bank
02	Child care facility
03	Community/civic center
04	Convenience store
05	Hair care
06	Hardware store
07	Health club or outdoor recreation facility
08	Laundry/dry cleaner
09	Library
10	Medical/dental office
11	Pharmacy (stand alone)
12	Place of worship
13	Police/fire station
14	Post office
15	Restaurant
16	School
17	Senior care facility
18	Supermarket
19	Theaer



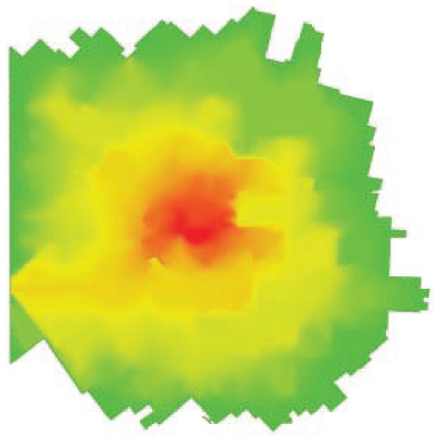
02 child care facility (licensed)
Boys and Girls Club



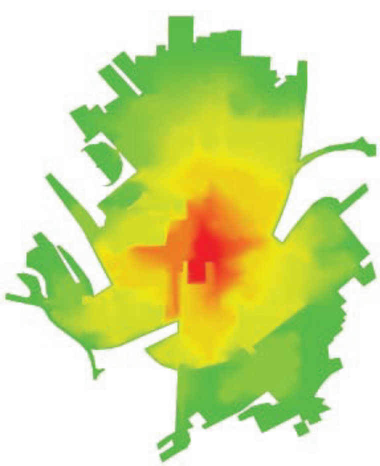
10 medical/dental
Knox County Health Center



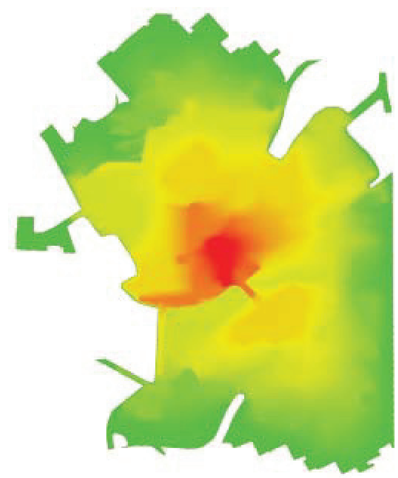
04 convenience store
Ray's Market



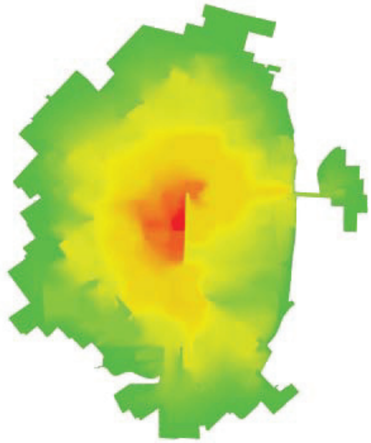
13 police/fire station
Fire station



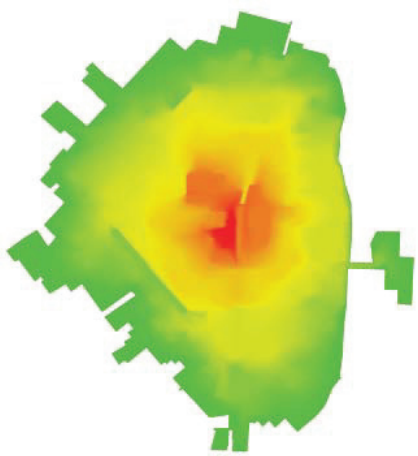
05 hair care
Barber shop



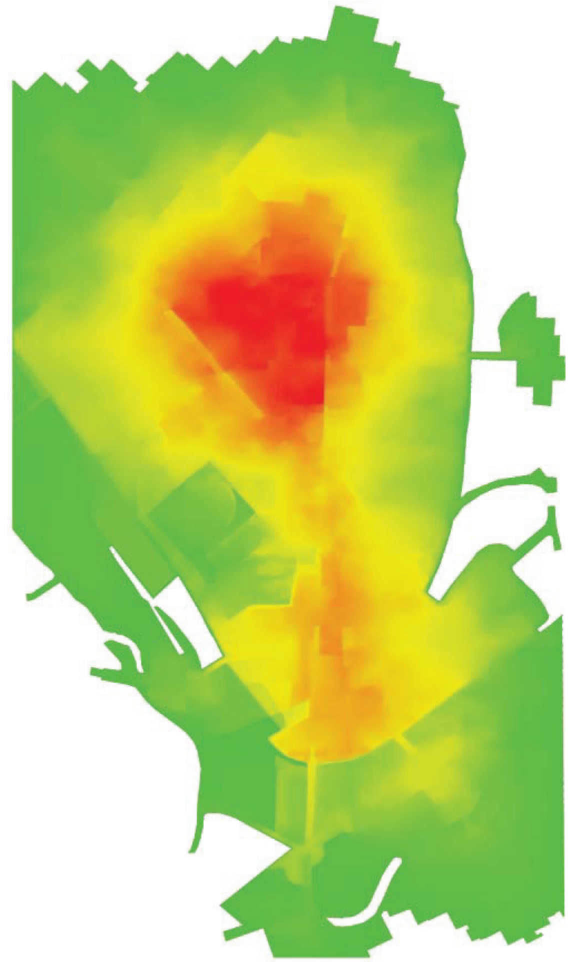
15 restaurant
Regas

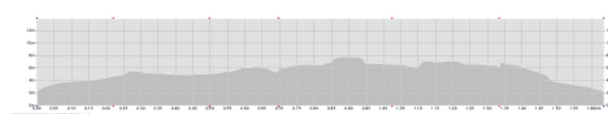


08 Senior care facility
Broadway Baptist Senior Housing

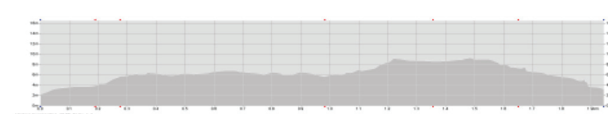


18 Supermarket
Three Rivers Food Co-op

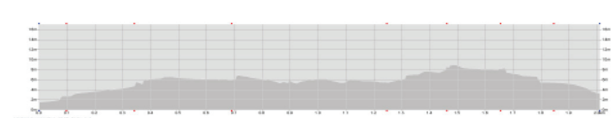




Section A-A: Central Avenue

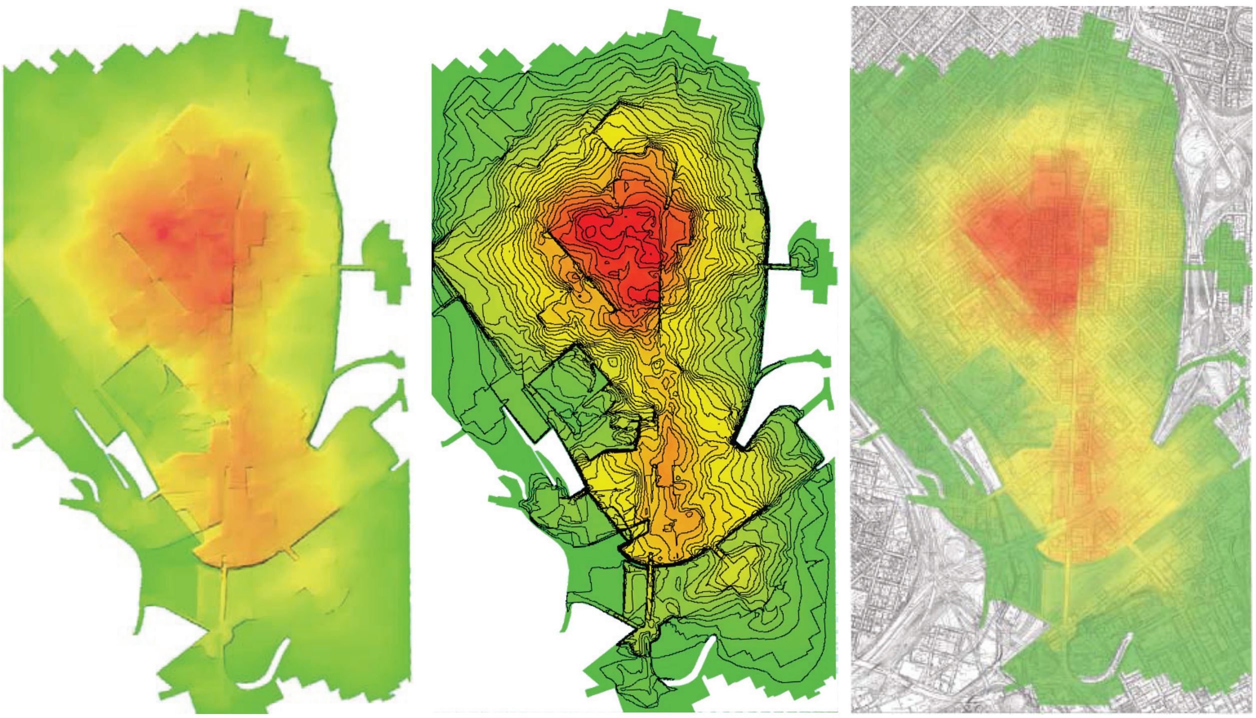


Section B-B: middle



Section C-C: Broadway

The resulting diagrams provide a clear indication of those aspects of the urban environments that affect walking access to the given amenities. This is true both for the constituent diagrams that show accessibility to individual amenities (above and preceding pages) and the composite diagram that shows proximity to all eight amenities (above right). Train tracks, interstates, superblocks, and even busy surface streets become distinct barriers whose relative impact can be clearly gauged through visual information. This analysis did take into account street realignments currently underway in the area (see Appendix B).



CartaVisa™ provides the ability to display visual information in a variety of ways allowing designers to choose the method that is the most helpful for any specific investigation. Show here are three different methods of viewing the information in the proximity to amenities analysis (from left to right) tinted and shaded, tinted with contour lines, and tinted as an overlay on a base map.

Conclusion

This project has taken a step toward being able to understand the interactions of environmental concerns in urban conditions through visual means. Though comprehensive images of the multiple aspects of urban sustainability will require significantly more effort, this project has laid the groundwork for such investigations by both demonstrating the usefulness of the information embodied in the constituent analyses and developing a clearer understanding of methods by which these might be combined into more complex information models.

This analysis begins to recognize urban entities - neighborhoods, districts, cities - as intricately functioning organisms comprised of many interrelated systems. As such, an analogy can be made between the potential usefulness of this effort and the role visual information currently plays in medicine. If architects, planners, and urban designers were to begin to understand the sustainability of a neighborhood as something akin to its health, then interventions in that neighborhood could be focused, adjusted, and targeted toward its improvement. Visualizations of the various aspects of urban sustainability might then become as invaluable to the work of the professions of the built environment as x-rays, sonograms, and MRI's are to physicians.

As has already been stated, ongoing efforts are focused on two short term goals: developing a set of comprehensive compilation analyses for the study area and conducting a first interaction analysis using a limited area and scope of issues. Each will then be evaluated for resulting information and methodologies that could be transferable to other inner ring neighborhoods.

Acknowledgements

The following organizations have provided financial and material support for this project: AIA Board Knowledge Committee, AIA East Tennessee Chapter, the University of Tennessee College of Architecture and Design, and Ambroziak Third Dimension Technologies Incorporated. Of particular assistance were Brian Ambroziak and Russell Ambroziak. Their work in both explaining and extending the functionality of the CartaVista™ software was invaluable. Additionally, the comments, thoughts and work of the students in the visualizing sustainability course helped tremendously in advancing the investigation. They are: Travis Brooks, Michael Davis, Eric Huffstetler, Elizabeth Keyt, Ben Lorance, Matthew Miller, Adam Mize, Todd, Alex Pisha, Jarvis Randall, Lana Sorin, Zach Spivey, Lance Thornton, John Waehler, and Jamison Walkup. Students Emily Bradley and Dianna Morelock offered assistance in preparing for the investigations. Finally the author would like to express sincere thanks to Tricia Stuth, AIA for considerable assistance in compiling this report.

Appendices

Appendix A - Excerpts from the Broadway-Central-Emory Place Small Area Plan, Knoxville Metropolitan Planning Commission

Appendix B - Excerpt from I-40 SmartFix Plan, Tennessee Department of Transportation

Broadway-Central Emory Place Study

MAP 1: Study Area Basemap

N
W E
S

1 inch equals 800 feet

0 400 800 1,600 Feet

Legend

Driveways | Parking Areas | Roadways | Buildings

March 2007 • Knoxville-Knox County Metropolitan Planning Commission

Appendix A

Broadway-Central Emory Place Study

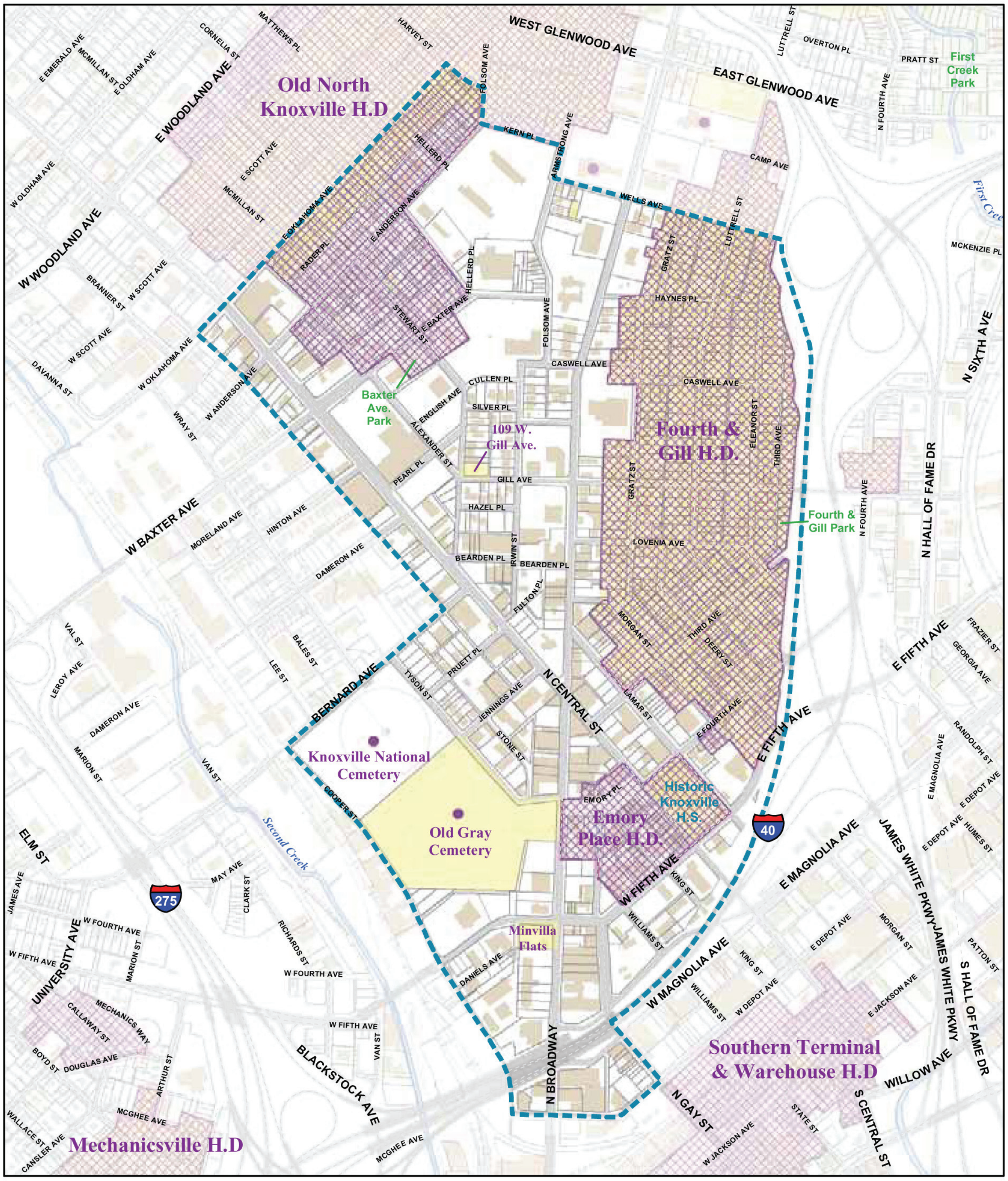
MAP 2: Historic Districts and Landmarks

Legend

- National Register Historic Sites
- National Register Historic Districts
- H-1 Zoning Overlay

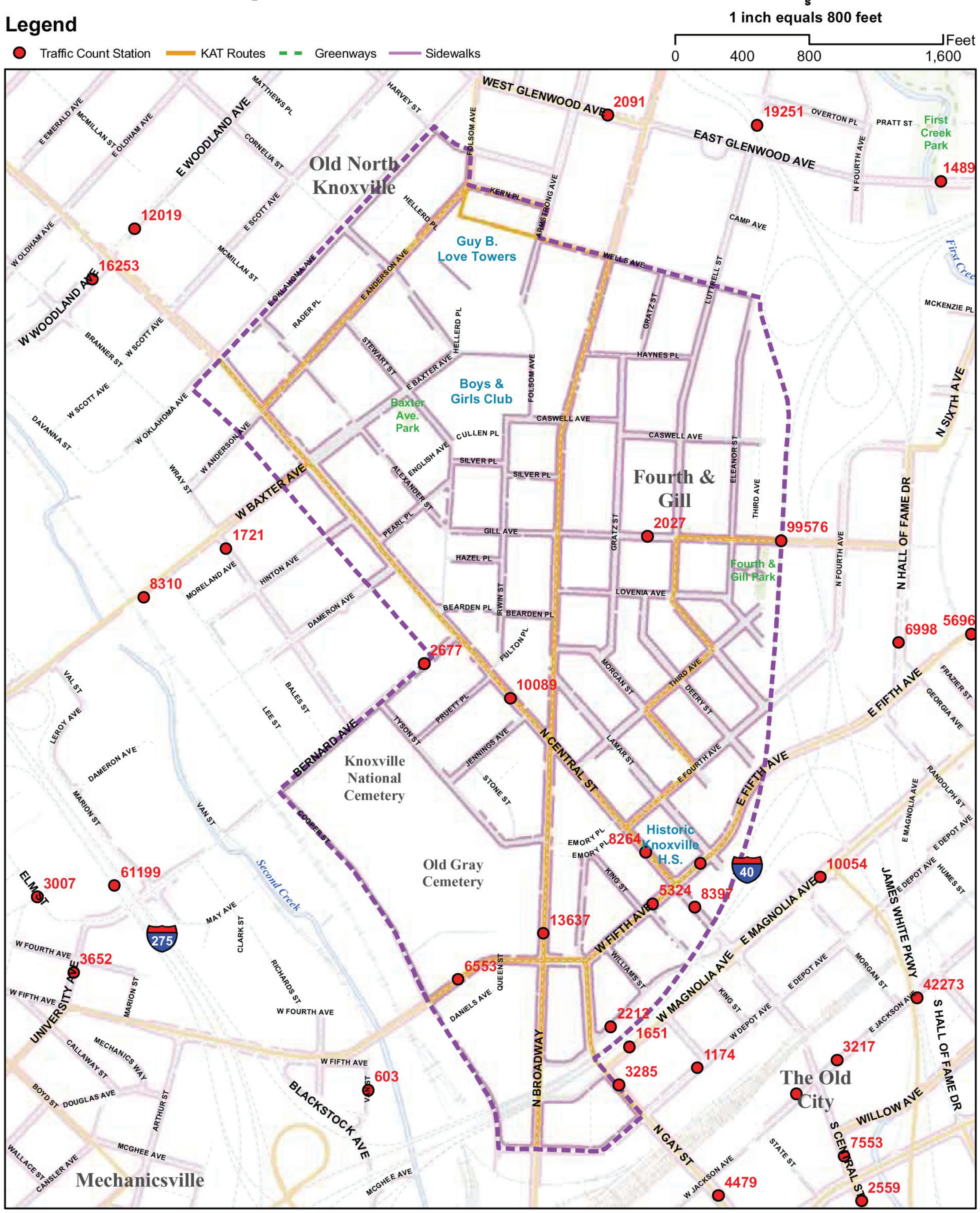
1 inch equals 800 feet

Feet: 0, 400, 800, 1,600



Appendix A

Broadway-Central Emory Place Study
MAP 6: Transportation

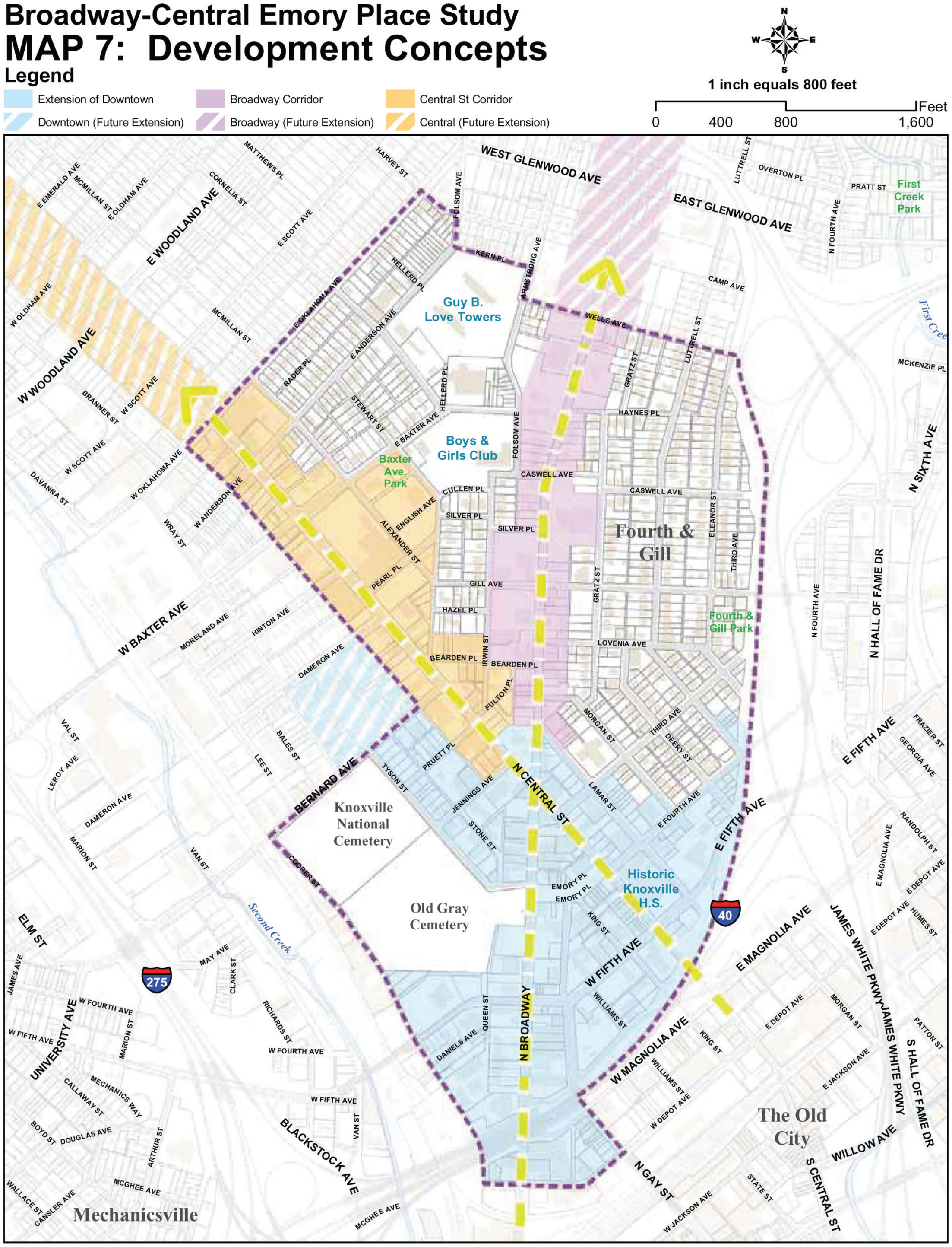


Knoxville-Knox County Metropolitan Planning Commission March 2007

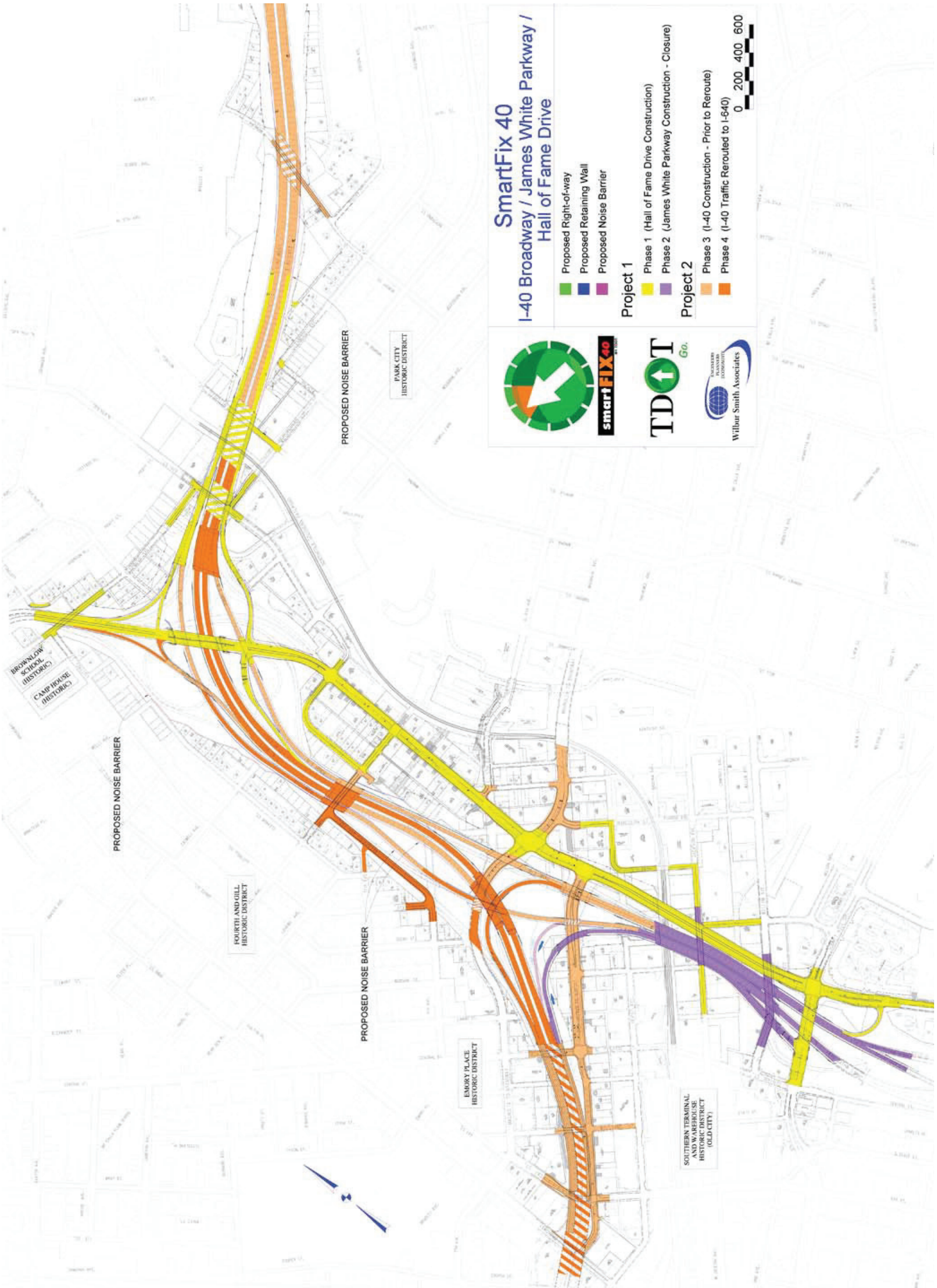
Appendix A

Broadway-Central Emory Place Study

MAP 7: Development Concepts



Appendix A


SmartFix 40
I-40 Broadway / James White Parkway / Hall of Fame Drive
Proposed Right-of-way
Proposed Retaining Wall
Proposed Noise Barrier
Project 1
Phase 1 (Hall of Fame Drive Construction)
Phase 2 (James White Parkway Construction - Closure)
Project 2
Phase 3 (I-40 Construction - Prior to Reroute)
Phase 4 (I-40 Traffic Rerouted to I-640)
0 200 400 600
TDOT
Wilbur Smith Associates
PROPOSED NOISE BARRIER
PARK CITY HISTORIC DISTRICT
BROWNLOW SCHOOL (HISTORIC)
CAMP HOUSE (HISTORIC)
PROPOSED NOISE BARRIER
FOURTH AND GILL HISTORIC DISTRICT
PROPOSED NOISE BARRIER
EMORY PLACE HISTORIC DISTRICT
SOUTHERN TERMINAL AND WAREHOUSE HISTORIC DISTRICT (OLD CITY)

Appendix B