The Role of GIS Analysis in the South Central Kent County Land Use and Transportation Study
Track: Transportation Planning
Author: Jay Gerner

Abstract

This study evaluates a rapidly growing area of the state to identify transportation infrastructure that is likely to experience traffic congestion problems in a 25-year future timeframe. ArcGIS was employed to quantify the amount of currently available buildable land within the study area through the use of complex spatial queries between multiple polygon-based GIS layers. Forecasted population and employment growth rates and subsequent trip-generation model outputs were utilized to develop 25-year base and build-out scenarios. From this information, traffic congestion trends were derived and examined to identify roads and intersections that could need improvement in the future.

The above process yielded valuable guidance in planning for roadway and intersection improvements in a timely manner to keep up with and anticipate the rapid pace of development that our state is experiencing. The various tools available in ArcGIS proved to be instrumental in the successful outcome of this study.

Introduction

For many years, the state of Delaware has been experiencing tremendous growth in population and housing development. Some of the most notable attributes of the state that have attracted this growth are low property taxes relative to neighboring states, the beach resorts and the relatively close proximity of the northern part of the state to the greater Philadelphia area.

The state of Delaware consists of three counties: New Castle in the north, Sussex in the south and Kent in between. The capital of Delaware, Dover, is located in the center of Kent County, in the middle of the state. Kent County has lagged behind the other two counties in growth, mainly because it is farther from the urban centers of Wilmington and Philadelphia and the beach resorts than New Castle and Sussex Counties, respectively.

However, recent trends show that Kent County has emerged as another fast-growing "frontier" in Delaware, with real estate that in general is a relative bargain compared with the more heavily suburbanized New Castle County and the high-value beach area of Sussex County. Large amounts of new residential development have been proposed and planned in Kent County. The current stalled real estate market has likely slowed the pace of development in the near term, but as this cycle comes to an end, the pace of development is expected to increase steadily.

Within the Planning Division of the Delaware Department of Transportation, the comprehensive South Central Kent County Land Use and Transportation Study focuses

the growth trends of a portion of the county where a large number of subdivisions and other development has been proposed and entered into the approval process. The study examines the trends of land use and traffic change over the last decade and the projections to 2030 for the growth in population, dwelling units, vehicles and daily traffic on the transportation system. The ongoing analysis highlights areas within the study area that are projected to have inadequate transportation facilities within this timeframe.

Study Area Geography

The study area consists of over 46,300 acres, or approximately 72 square miles, situated in the south central part of Kent County and is bounded by two main north-south highways on the east and west sides. (See Figure 1.) This area is broken into 24 Traffic Analysis Zones (TAZs), and many of the trends examined in the study are calculated at the TAZ level. The study area overall is mostly rural and includes the two small towns of Magnolia and Frederica, as well as the outlying areas of the towns of Milford, Harrington, Camden and Dover. The 2005 population estimate for the area is 20,479, and the number of dwelling units in 2005 was 7,715.

Figure 1. Outline of the State of Delaware showing the location of the study area.

Study Process

Beginning with the 2005 population and dwelling unit numbers as a base, three different growth projections were examined with a 2030 timeframe: the University of Delaware's ongoing growth trends and projections (Trend), a trend that doubles the university's projections (Trend X2), and a full build-out scenario of the study area (Buildout). Each of these scenarios were analyzed to include growth of population,

numbers of dwelling units (DU), average daily traffic (ADT), and arterial level of service (LOS). From these analyses, the study examined key intersections for level of service, and potential improvements were recommended for parts of the transportation network that were most likely to be significantly impacted in the future.

Figures 2 and 3 below show how ArcGIS was used to analyze and represent the growth trends in population and dwelling units. These growth trends were expressed in percentages by TAZ. The trends are also shown in graphical comparisons.

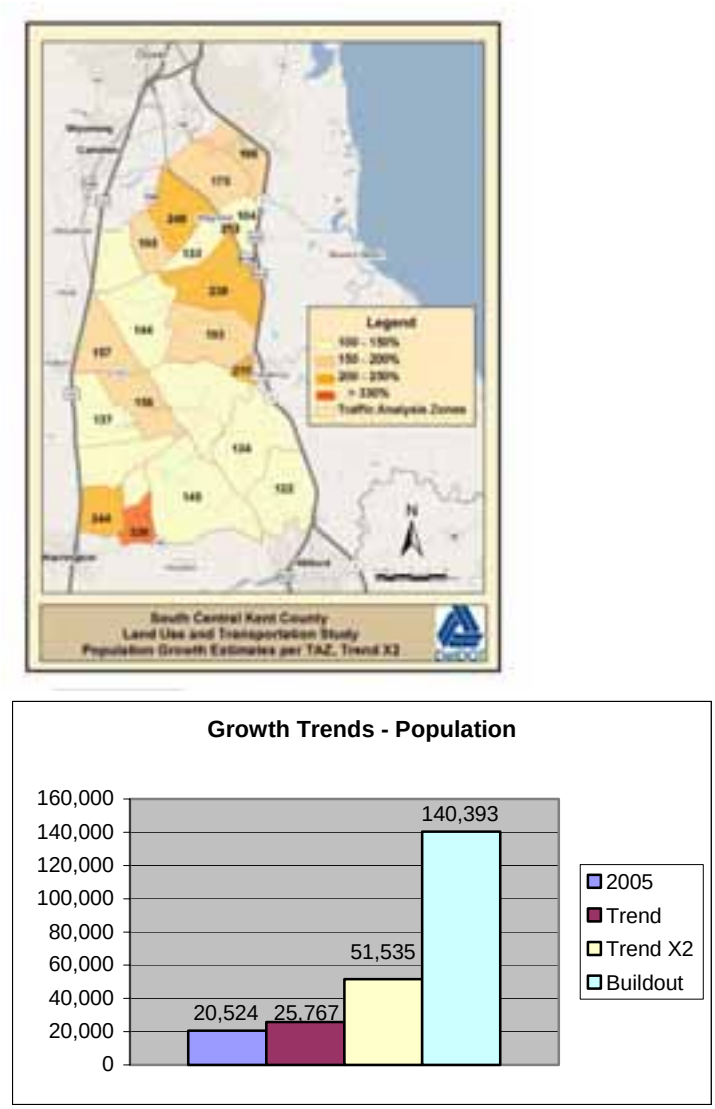

Figure 2. Population growth estimates per TAZ. The layout image shows the growth projected in the 2030 Trend X2 scenario, and the graph shows the growth in all three scenarios relative to the 2005 base.

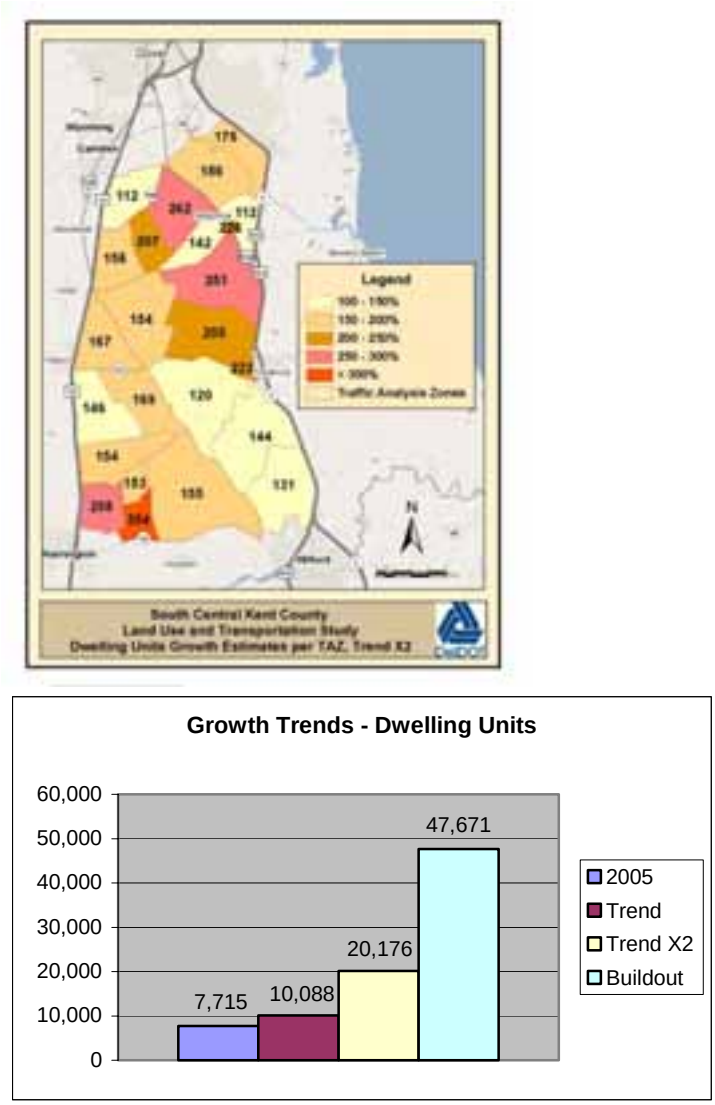

Figure 3. Dwelling unit growth estimates per TAZ. The layout image shows the growth projected in the 2030 Trend X2 scenario, and the graph shows the growth in all three scenarios relative to the 2005 base.

The growth trend depicted in these figures is called "Trend X2." This was derived by doubling the university's Trend projections for the 2030 timeframe. This is justified as a plausible scenario because the number of proposed dwelling units in various stages of the approval process at the present time is close to twice the Trend growth projection. Also, it should be noted that the number of dwelling units in the approval process only includes developments of 200 or more units and not smaller developments, so the actual number of units would be even greater, assuming all of the proposed units are eventually built.

Based on the number of dwelling units in the approval process, as mentioned above, the Trend X2 growth scenario is being regarded as the more realistic scenario than the Trend projection. However, in addition to the Trend and the Trend X2 scenarios, a Buildout scenario was examined in the study. This was achieved, initially by GIS, by quantifying an estimate of realistically buildable land, in acres, within the study area and

applying an average of two dwelling units per acre to this number of acres. The resulting estimate of dwelling units and population was used as a "worst case" scenario and as a comparison to the other two growth scenarios.

Deriving the Buildable Land Estimate - Methodology

The methodology for deriving the amount of buildable land with GIS began with gathering as many relevant land use layers as possible that could be used to discern between buildable and unbuildable land and applying them to the study area base map. Starting with the latest available general statewide Land Use layer (2002), layers for Protected Lands and Natural Areas were added.

The layers comprising the Protected Lands group were provided by the state Department of Natural Resources and Environmental Control (DNREC) and consisted of state parks, state and federal fish and wildlife areas, county and municipal parks, nature preserves, Delaware Wild Lands program areas, Nature Conservancy lands, conservation easements, and agricultural districts and easements. Although some of the agricultural easements are relatively short-term, such as ten years, they were considered unbuildable for this purpose because of the possibility of the easements being renewed upon their expiration. The Natural Lands layer, also provided by DNREC, is an independent layer primarily consisting of tidal and freshwater wetlands and certain wooded and other sensitive areas that are under regulatory control and may or may not be covered by any of the above programs or categories.

The steps in deriving the buildable land using GIS were as follows:

1. The Protected Lands layers were combined into one layer. This was accomplished by adding all the layers in this group to the map then using the Union tool in ArcToolbox to join all the layers. The "Gaps Allowed" checkbox was checked in the Union tool.

2. The new Protected Lands layer was combined into the general Land Use layer using the same process with the Union tool again.

3. Then the Natural Areas layer was combined into the general Land Use layer in the same manner. The newly combined layer is called Land Use with Protected and Natural Lands. These layers are show in Figure 4 below.

Figure 4. Combination of Protected Lands and Natural Areas layers.

4. Within the new layer, the attributes of the Protected Lands and Natural Areas were combined with all other "unbuildable" attributes of the Land Use layer. These unbuildable attributes included all categories of residential, commercial, industrial, airports, parking lots and roadways. In Edit mode, all the above "unbuildable" attributes were selected. A new layer was created from this selection. The selection was then joined with the Protected Lands layer using the Union tool. The resulting layer was called Unbuildable Land.

5. The next step was to separate, or "subtract," the Unbuildable Land from the general Land Use layer. Using the Erase tool in ArcToolbox, the Unbuildable Land layer was removed from the general Land Use layer. The remaining area was formed into a new layer called Buildable Land and consisted primarily of various categories of present agricultural lands and rangeland. The derived Buildable Land layer is shown in contrast with the unbuildable land layers in Figure 5 below.

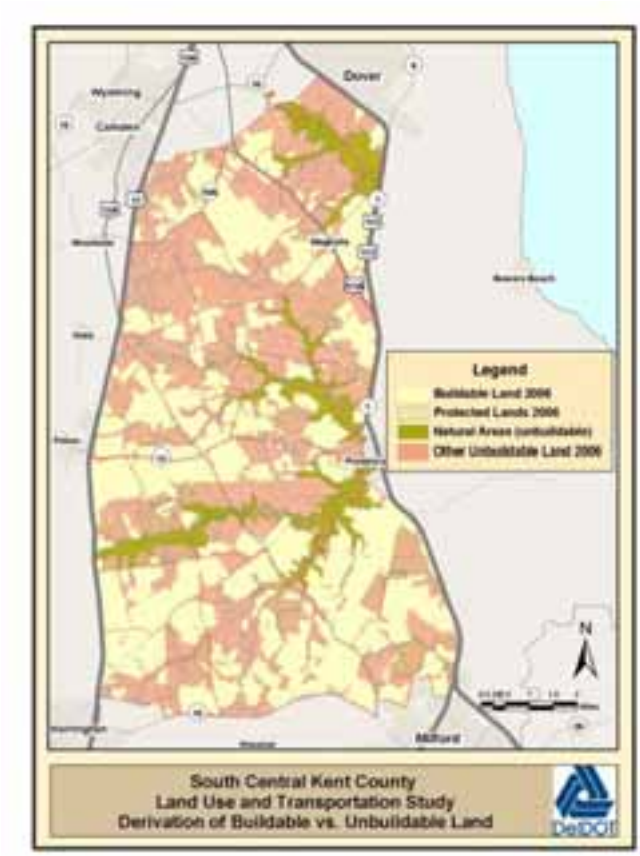

Figure 5. Derived Buildable Land layer shown with unbuildable lands.

6. With the Traffic Analysis Zones (TAZs) overlaid on the map, the Buildable Land layer was split out per TAZ using the Split tool in ArcToolbox. This yielded 24 individual TAZ files showing the buildable land for each TAZ.

7. The area of each TAZ was then updated and converted to acres in each attribute table. The combined total area of buildable land in the study area, as well as the buildable land in each of the TAZs, was then added to the Excel spreadsheet of growth data for the study so that percentages could be calculated.

The Unbuildable and Buildable Land layers were subsequently given the designation "2006" to reflect that much of the Protected Lands and other data added to the Land Use layer was created in 2006.

Analysis of Buildout Scenario Results

The GIS exercise outlined above yielded a total area of buildable land of 19,959 acres within the 46,359-acre study area, or approximately 43%, leaving 57% of the area unbuildable because of existing development or the various forms of protected lands. The TAZs within the study area vary greatly in size and current development density. The TAZs range from a low of 9% buildable land to a high of 77% buildable land. Using

the average of two dwelling units per acre, the Buildout growth scenario would translate into an increase of 39,919 dwelling units added to the existing 7,715, or an increase of 517%. Subsequently, when an average of three persons per dwelling unit is applied to the dwelling unit estimate, the population would increase by 119,757, or 583%, from the existing population of 20,524, for a total of 140,281.

The next phase of analysis following the Buildout scenario projections of population and dwelling units was to use the CUBE Traffic Demand Model software to generate ADT and LOS for all road segments in the study area, also for the Buildout scenario. The CUBE model results were exported as shapefiles and subsequently applied to the study area base map. The symbology depicting the ADT was broken out in levels of traffic volume and depicted in different colored segments, expressed in vehicles per day. An example of this representation is shown in Figure 6 below.

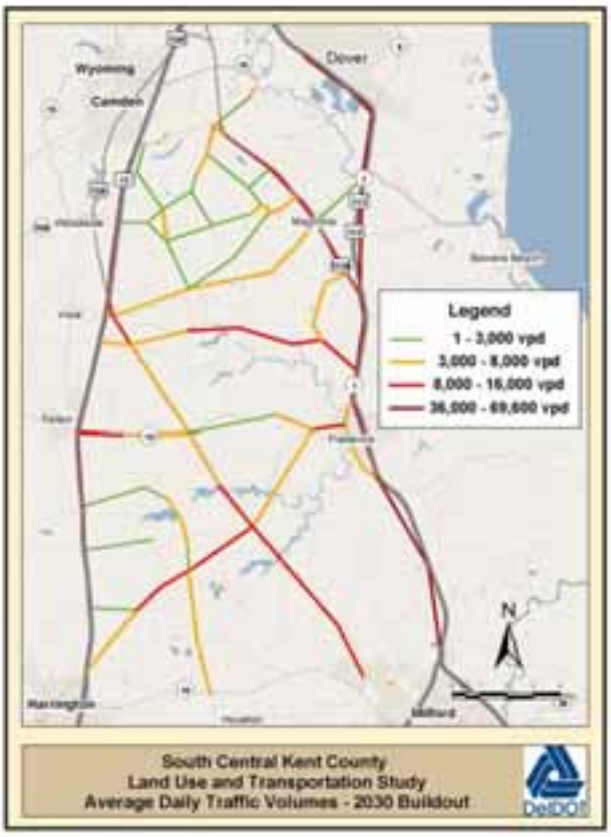

Figure 6. Average Daily Traffic volumes for the 2030 Buildout scenario.

The Level of Service for the various road segments in the study area was also analyzed and represented with GIS. For each segment, the CUBE model generates a ratio of traffic volume to the road's vehicle capacity. The range of these ratios is classified into Levels of Service from A to F, with A being the least congested and F being the most congested. The LOS for the Buildout scenario is shown in Figure 7 below.

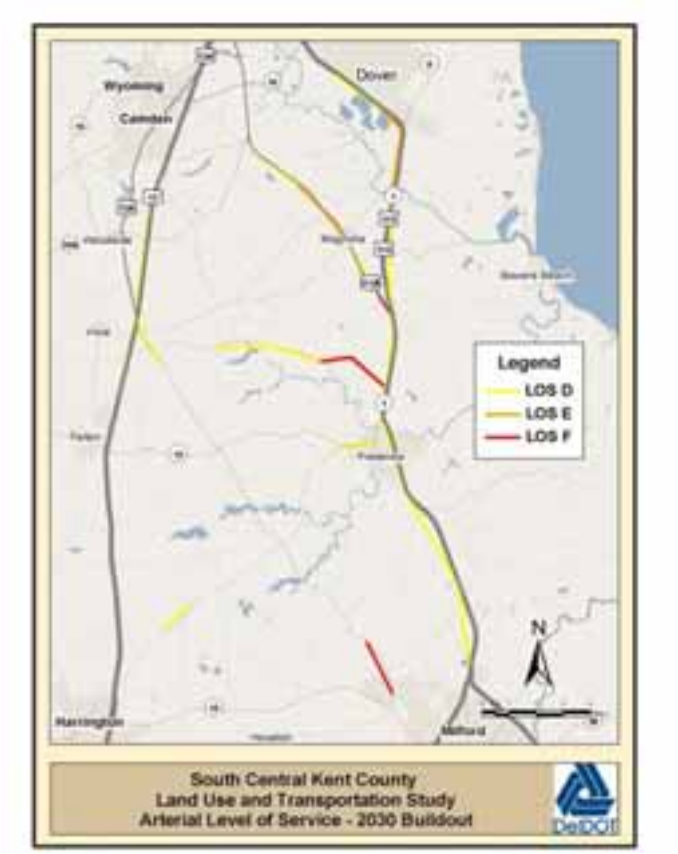

Figure 7. Level of Service of road segments for the 2030 Buildout scenario.

Study Findings and Recommendations

As mentioned previously, the Buildout scenario represents a "worst case" situation in which every available buildable parcel of land would be developed, with an average of two dwelling units per acre and three persons per unit, by the year 2030. While this scenario is rather unrealistic and growth rates needed to attain that amount of growth are not sustainable, the Department found it useful to model this scenario to establish an "upper limit" for potential traffic impacts on the existing road network.

Although not as dramatic in its GIS representations, the Trend X2 growth scenario emerged as the most realistic, given current growth rates and amount of proposed development currently in the approval process. The Trend X2 analyses showed that no major capacity increases to the existing roads were needed within the study area in the 2030 timeframe. The projected increases in travel demands can be accommodated by improvements such as signalizing some unsignalized intersections and making upgrades to some intersections and road segments such as turn lanes, bypass lanes, curbing and shoulder and drainage improvements. Roundabouts may also be considered as an alternative to signals for some intersections where signals may cause significant delays.

This study will serve as an "umbrella" study under which several localized studies will be spawned. Local roads in sub-areas will be reviewed for sufficiency, and timelines and costs will be quantified for when local road improvements will be needed in anticipation of growth in specific areas. Future modeling will include possible new connector roads and improvements to the existing connector system to enhance traffic flow in areas with previously poor connectivity and insufficient access to major arterials.

Synchro and SimTraffic traffic simulation software applications were also used in this study to analyze certain intersections for Level of Service and queue delays, and these applications will play a significant role in the future sub-area studies that are developed.

ArcGIS proved to be instrumental in the successful outcome of this study. The comprehensive results obtained through the various analytical tools available in ArcGIS GIS will enable planners and traffic engineers to anticipate and plan key facility improvements in the face of the rapid development that our state is experiencing.

References and Data Sources

State of Delaware, Office of State Planning and Coordination
State of Delaware, Department of Natural Resources and Environmental Control
State of Delaware, Department of Transportation
State of Delaware, Department of Agriculture
University of Delaware, Center for Applied Demography and Survey Research

Jay Gerner
Delaware Department of Transportation
Planning Division
P.O. Box 778
Dover, DE 19903
Phone: 302-760-2530
E-mail: jay.gerner@state.de.us