

**Development and Evaluation of a Residential Allocation Model
Using Time Series Tax Parcel Data in GIS**

prepared for

Delaware Department of Transportation

By

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Executive Summary

Population projections are made available by State and County in Delaware thru the Delaware Population Consortium (DPC) based on a wide range of employment, trend, and demographic data as well as from the input from representatives of many agencies. To support land use and infrastructure planning, county population and housing projections are allocated to areas within the counties to examine where growth is expected in smaller areas within the counties land use.

Allocations of housing and population projections are currently estimated at traffic zone level (approximately 300 zones in New Castle County) based on first allocating to Census Planning Districts (10 districts), then apportioning to smaller areas based on the fraction of buildable lots of various kinds in each Planning District while considering other factors such as environmental restrictions, current land use, zoning, and historic building trends.

Common scenarios examined by planners include the consideration of community level developments and the question is how the implementation of various scenarios may affect other communities. For instance, how will a larger or higher density development in one community effect neighboring communities? The ability to examine policy “what-ifs” at the more detailed level of tax parcels is increasingly needed for sub-area or community transportation plans. Travel demand forecasting is moving more toward tax parcel based detail and a great deal of information is available at the property level, and much of it now in geographical information system format.

This project developed a tax parcel based allocation model (binary logistic regression) where factors (independent variables) could be compiled as attributes in a master property table that includes records representing each current, past, and expected future tax parcel in the future. This model estimates the probabilities for available land to be built to meet the demand for housing units as projected by DPC. Factors were explored and a model developed from a 10 year time series from year 1999 to 2009 of tax assessment data and digital property maps linked to master tables for display and reference of the historical data. Where and what residential lots were built for each year can be mapped. A categorization of all tax parcels in New Castle County for all years was developed. The subdivision and creation of new properties was examined.

The model estimating relative probabilities for lot construction was created after an extensive data preparation and examination of many potential factors. Projections were produced and compared to current methods. What results appears to have significant advantages over current methods. The property tables and related GIS maps provide an excellent framework to manage detailed information about properties and allow for easier examination, and defense and adjustment of probabilities. The organizational structure could handle other types of land use such as commercial property just as easily. It is much less of a “black box”. It is possible with the property data and maps to look at specific current and pending developments. Factors can be adjusted based on new knowledge or scenarios, and new probabilities and allocations can be regenerated relatively easy. The tight correspondence with GIS representations allows for the use of spatial analysis tools to update factors and select areas for study and adjustment. Working at the property level also allows for the incorporation of address based data which opens up a large resource. In contrast to previous methods the step of first allocating housing and population projections to Planning Districts is not necessary.

Factors include ones for capturing current spatial trends in building and presence of supporting infrastructure. Where construction occurs can be considered a competition between available residential lots, controlled by countywide estimates. Development in one area will necessarily affect development patterns in other areas. The modeled relative probabilities capture this competition.

Comparison of a 10 year projection of the previous methods of allocations with the new projections produced in this project showed a very close correspondence. Interestingly for areas of the county where the current projections were much higher than these modeled projections it was shown that there was specific knowledge of development projects that were omitted from the model. Where the model predicted much more construction than the current projection is was shown that current projection omitted development projects taken into account by the model. Adjusting for this new information in the current projection and the model is expected to result in a close correspondence. A difference though is that with the model, master tables can be updated to incorporate changes and detailed parcel maps can display the update and allocations can be regenerated easily. Adjusting the current aggregate base allocations is a more a more involved task.

Other factors such as housing value that are not included in the model could be investigated and the model further developed and calibrated. Application of the model to Kent and Sussex Counties would be instructive. As data is tracked in the future the predictive power of the model could be better judged. While model databases include categories for multi unit housing, future development of new multi unit housing is not addressed. The reconstruction or demolition of structures is not included in the model.

Project results indicate that the allocation method developed in this project is very promising as a replacement of augmentation to current methods, and takes full advantage of the more detailed tabular and geographic information now available.

Introduction

Residential projection allocation models assign probabilities to aggregate geographies, such as traffic zones, that are derived from and based on historical data such as one, five, and ten-year trends. The historical data often include the number of newly recorded residential lots and number of new constructed residential units. The probabilities are then applied to countywide or regional control totals to estimate the share of total projected growth that may occur in any given traffic analysis zone or census tract. Such methods using spreadsheets and databases are able to efficiently produce aggregate forecasts, however they do not work well for policy or scenario analysis at the tax parcel level. The ability to examine policy “what-ifs” at the more detailed level of tax parcels is increasingly needed for sub-area or community transportation plans.

Common scenarios examined by planners include the consideration of community level developments and the question is how the implementation of various scenarios may affect other communities. For instance, how will a larger or higher density development in one community effect neighboring communities? Projected development in one area, that is different from initial assumptions based on historical considerations, will necessarily affect pre-established expected development patterns in other areas. If the analyst wishes to change the expected growth in one traffic zone it will alter probabilities and allocations in other traffic zones. Analysts do not have simple procedures to go from an alteration of property level assumptions in one traffic zone to the effects on all others. Also, there has also not been considerable research in how property level developments in one area would effect development in other small areas, or in how the effects could cascade in future years. Only a certain amount of growth is seen and possible from year to year and small areas compete for that growth which is captured by an estimation of the relative probabilities for lots to be built and larger properties to be subdivided.

Since the desire is to work at the tax parcel and community level in scenarios, the larger focus of the research is to examine, at the tax parcel layer, the various factors that contribute to where growth occurs. From this growth modeling the relative probabilities for development at the property level can be estimated and readjusted with various new assumptions and suggested land use configurations. If every lot is equally likely to be developed, or every large undeveloped land track (referred to as a Plot here) were equally likely to be subdivided then the problem becomes much simpler. Many approaches where data is lacking assume uniform probabilities across developable land categories. But, some factors we would feel comfortable in expecting to make a difference, for instance lots in flood plains are less likely to be built than those not in floodplains. Lots with sewer service are expected to be built at a higher rate. Lots of very small size may have a smaller probability of being built as set backs may be an issue. A long and very narrow tract of land may be less likely to be subdivided. There are also year to year factors related to activity, for instance lots that are within a higher concentration of lots built in the previous year might have a higher probability of being developed. Recent history in this case would indicate this is a “hot spot” for activity. Whether a particular property will be developed in 10 years is a probability but the probabilities as a whole can lead to a suggested distribution that may be nearer to what is actually observed at larger levels of geography such as a traffic zone.

Working at this very detailed property level required a large data collection and processing effort. Ten years of assessment data were compiled and analyzed extensively. The first step was to categorize land use, whether residential, commercial, open space, protected from further development, or other category. Residential land was categorized as Built, a Lot, or a Plot, where

a Lot is property with little or no structure value less than 5 acres and Plots were land tracts with little or no structure value 5 acres or greater. The categorization led to a specification of “developable land”. From year to year (1999 to 2009) the database was developed to track changes in land use, in particular when a lot was built, or a plot was subdivided in any given year. Factors that might effect development potential such as whether a property was in a floodplain, zoning, presence of sewer service, proximity to development activity, land and housing value, and other factors were developed and associated with lots and plots This accounted for perhaps 90% of the effort in the project but yielded a valuable land use product for New Castle County to support modeling and additional studies.

For any given year there is an inventory of between 13,000 and 15,000 available lots for building, but only in the neighborhood of 15 percent of these lots are built, and less in recent years of economic downturn. When a large property is subdivided, a number of “potential” units can be created. How many housing units that can be created with the subdivision of a property is largely dependent on size, zoning, sewer service, and existence of restrictions such as floodplains or wetlands.

Population and housing projections at the Planning District level are available through the Delaware Population Consortium and this served as the control total for new units needed each year. A model for building of lots and creation of lots from the subdivision of larger properties was developed. Taking each 5 year population projection by Planning District, units were “developed” to meet the demand based on the relative estimated probabilities and the result is captured in GIS maps and tables.

Study of travel demand often involves considerations of the effects of specific new development scenarios and therefore a methodology to regenerate and visualize expected effects of various development assumptions is needed. This project demonstrates a procedure to alter land use assumptions and examine expected land use distributions that result. The number of housing units needed at any future time, and the pace of development is constrained to the DPC projections. Predicting the spatial allocation/distribution of development at the tax parcel level within the Planning District is the focus of this research. Rather than having a static projection of where development will occur, a methodology was developed to predict new distributions based on suggested growth scenarios.

PART One, Data Collection and Preparation

Assessment Data 1999 thru 2009

New Castle County Tax Assessment data was available for years 1999 thru 2009. Information of most interest was:

- * Land values
- * Building values
- * Property classifications (Residential, Commercial, Industrial, Exempt, etc)
- * Owner (particularly useful for public lands)
- * multi-unit dwellings

At the basis of this research is the focus on developing probabilities for development and various factors could be attached to property records such as:

- * presence of flood plains
- * exempt properties
- * agricultural preservation lands
- * zoning
- * growth areas as defined by the New Castle County Development Code
- * proposed development plan activity

The historical information in these files is useful to categorize land use and can be studied to identify development patterns. By examining year to year changes it was possible to determine for each year:

- * where built properties are
- * which large properties were subdivided
- * what lots were created
- * what lots were built

Processing and error checking 10 years of assessment data proved to take over a month and a half of processing and compilation time. For the purpose of this study properties were categorized as in Figure 1 on the next page. Smaller properties, less than 5 acres were designated as “Lots” or “Built” properties based on the tabulated building values. Properties that were 5 acres and above were considered large enough to be subdivided and these were termed “Plots”. Through each year there were about 15,000 to 16,000 lots available. Yearly comparisons are shown in figure 2 and 3.

Figure 1
Yearly Property Categories

Agricultural Preservation
Exempt – (Public and preserved lands)
Commercial
Industrial
Utility
Open Space
Multi Unit
Not Exist – (In a given year a property may not exist)
Removed – based on specific knowledge, removed from consideration for development,

Built Properties
 Very small – 0 to 0.2 acres
 Small - 0.2 to 1 acres
 Medium – 1 to 2 acres
 Large – 2 to 5 acres
 L – 5 to 10 acre property below the canal with SR Zoning and
 Property value > \$60,000 and/or some restrictions

Lots
 Very small – 0 to 0.2 acres
 Small - 0.2 to 1 acres
 Medium – 1 to 2 acres
 Large – 2 to 5 acres

Plots
 Very small – 5 to 10 acres
 Small - 10 to 20 acres
 Medium – 20 to 100 acres
 Large – greater than 100 acres

Farmet
 10 to 20 acre property in SR zoning below the canal with
 building value greater or equal to \$50,000 (1983 dollars)
 In many cases these were also singled out because of the shape of
 property or limited access to adjoining roads.

Figure 2, Comparison of Land Use Categories by Year

| Frequency of Categories By Year | | | | | | | | | | | | |
|--|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| Ag | | | | | | | | | | | | |
| Preservation | 135 | 135 | 130 | 136 | 136 | 136 | 138 | 138 | 138 | 138 | 139 | 137 |
| BLT | 214 | 214 | 202 | 204 | 216 | 214 | 204 | 204 | 204 | 206 | 205 | 209 |
| BLT large | 2483 | 2516 | 2553 | 2597 | 2619 | 2651 | 2676 | 2707 | 2714 | 2725 | 2729 | 2727 |
| BLT med | 4473 | 4569 | 4660 | 4785 | 4858 | 4929 | 5002 | 5050 | 5092 | 5121 | 5137 | 5136 |
| BLT small | 54600 | 55681 | 56705 | 58009 | 58984 | 59834 | 60812 | 62045 | 62733 | 63198 | 63302 | 63379 |
| BLT very small | 76248 | 77124 | 77945 | 78961 | 79823 | 80700 | 81519 | 82451 | 83047 | 83542 | 83802 | 83801 |
| BLT-C | 684 | 676 | 672 | 670 | 665 | 659 | 644 | 622 | 647 | 639 | 629 | 628 |
| COM | 7066 | 7174 | 7175 | 7089 | 7205 | 7694 | 7698 | 7673 | 7649 | 7768 | 7761 | 7508 |
| EXEMPT | 4968 | 4913 | 4939 | 4855 | 4827 | 4578 | 4611 | 4558 | 4537 | 4524 | 4542 | 5026 |
| Industrial | 432 | 432 | 450 | 449 | 453 | 443 | 443 | 443 | 442 | 441 | 442 | 495 |
| LOT | 25 | 1 | | | | 2 | | | | | 17 | 235 |
| LOT large | 723 | 710 | 682 | 641 | 617 | 594 | 588 | 565 | 577 | 580 | 574 | 574 |
| LOT med | 1138 | 1060 | 986 | 866 | 824 | 779 | 717 | 698 | 682 | 669 | 665 | 665 |
| LOT small | 6915 | 6555 | 6268 | 5654 | 5979 | 6006 | 6202 | 5966 | 7107 | 7295 | 7424 | 7422 |
| LOT very small | 7199 | 7101 | 7541 | 6867 | 7040 | 6644 | 6531 | 6159 | 6421 | 6743 | 6664 | 6664 |
| LOT-C | 259 | 242 | 225 | 232 | 227 | 220 | 248 | 202 | 235 | 225 | 226 | 226 |
| MULTIUNIT | 842 | 843 | 843 | 846 | 846 | 850 | 852 | 857 | 862 | 870 | 876 | 876 |
| OPENSOURCE | 1856 | 1899 | 1982 | 2013 | 2159 | 2221 | 2306 | 2371 | 2478 | 2515 | 2529 | 2529 |
| PLOT | 11 | 10 | 6 | 5 | 7 | 6 | 6 | 4 | 4 | 3 | 3 | 7 |
| PLOT large | 192 | 193 | 187 | 187 | 187 | 186 | 185 | 186 | 185 | 183 | 176 | 176 |
| PLOT medium | 540 | 545 | 543 | 545 | 550 | 550 | 549 | 557 | 564 | 554 | 547 | 547 |
| PLOT small | 788 | 794 | 799 | 811 | 819 | 828 | 838 | 855 | 884 | 894 | 891 | 891 |
| PLOT very small | 769 | 777 | 780 | 785 | 786 | 793 | 796 | 804 | 814 | 817 | 822 | 822 |
| Utility | 197 | 197 | 198 | 198 | 198 | 197 | 197 | 197 | 197 | 196 | 206 | 192 |

Figure 3, Comparison of Year 2009 and 2001 Categories

| Category Type | % of 2001 properties | % of 2009 properties |
|---------------------------|----------------------|----------------------|
| Built | 80 | 81.5 |
| Lots | 9% (about 15 to 16k) | 8 (about 15 to 16k) |
| Plots | 1.3% | 1.3 |
| Exempt | 2.8% | 2.5 |
| Commercial and Industrial | 4.5% | 4.3 |

Master Tax Parcel Map

There are general location fields in the New Castle County Tax Assessment files such as what Census County Division, traffic zone, or zipcode the property is in. To determine a better understanding of how properties are distributed and to analyze changes from year to year at the tax parcel level requires tax parcel maps. CADSR had a series of digital tax parcel maps at various times of the year mostly in the fall of each year. These show development thru the decade at a very detailed level.

Figure 4, CADSR New Castle County Parcel Map Series

1999 - Dec 3
 2000 - Sep 14
 2001 - Sep 28
 2002 - Sep 30
 2003 - Sep 8
 2004 - Aug 31
 2005 - Dec points, June 5 lines
 2006 - Oct 16
 2007 - Nov 14
 2008 - Sept 22
 2009 - Feb 13
 2010 - April 13
 2010 - Nov 29th

A master digital parcel map was made by combining these years. The master was useful for mapping assessment data at various times, assigning additional factors at a more detailed level of geography, and for error checking. The Master Tax Parcel Map is what is used in parcel maps for this project. Toward the close of the project a November 29th, 2010 New Castle County was added to the data collection to be used for projections but this was not incorporated into the masters used for modeling.

Development Potential

A larger property could be subdivided and a number of new lots could be created. A “development potential” could be assigned equal to the estimated number of housing units or lots that could be created. A housing unit or a property categorized as a “Lot” is assigned a development potential of one. A “Plot” which is a category for properties ranging from 5 acres to over 100 acres has the capacity for further subdivision and the potential units from any plot was determined based on the zoning for that property and adjustments that could be applied based on the presence of floodplains or other restrictions. The New Castle County Unified Development Code assigns net and gross housing unit densities (units per acre) for each zoning class and these were used to develop the potential units that could be created in each plot.

Figure 5, Estimation of Potential Units for Plots

| Zoning | Potential units Estimate |
|---------------|---------------------------------|
| S | Acreage / 0.8 |
| SR | Acreage / 5 |
| SE | Acreage / 3 |
| ST | Acreage / 0.35 |
| NC2a | $0.75 * \text{Acreage} / 2$ |
| NC40 | $0.75 * \text{Acreage} / 1$ |
| NC21 | $0.75 * \text{Acreage} / 0.5$ |
| NC15 | $0.75 * \text{Acreage} / 0.66$ |
| NCpud | $0.75 * \text{Acreage} / 0.33$ |
| NC10 | $0.75 * \text{Acreage} / 0.25$ |
| NC6.5 | $0.75 * \text{Acreage} / 0.16$ |
| NC5 | $0.75 * \text{Acreage} / 0.125$ |
| NCmm | $0.75 * \text{Acreage} / 0.125$ |
| Nga | $0.75 * \text{Acreage} / 0.05$ |
| NCap | $0.75 * \text{Acreage} / 0.025$ |

Figures on the next pages show tabulations of potential units and existing units by Census County Division. From these it is evident which areas are reaching their maximum growth and which areas are growing. Examining the sum of potential units and existing units provides a complete build out estimate and for New Castle County, total housing unit numbers fluctuate around 260,000 using this method. A good understanding of the potential for development and build-out is useful for the planning process. Due to the scope of the project there was a limited amount of time to establish categorizations and estimates at the tax parcel level and they represent a best first guess at figures to use in developing a methodology. It is envisioned that if such a parcel based approach was pursued there would be systematic updates and refinements each year.

Figure 6, Estimate of Potential Units by Year by Census County Division

| CCD | 1999 | 2000 | 2001 | | | | 2005 | 2006 | 2007 | 2002 | 2003 | 2004 |
|-----------------------------|-------------|-------------|-------------|-------|-------|-------|-------------|-------------|-------------|-------------|-------------|-------------|
| | | | | | | | | | | 2008 | 2009 | 2010 |
| Brandywine | 1428 | 1338 | 1295 | 1288 | 1277 | 1363 | | | | | | |
| Central Pencader | 8417 | 8104 | 7504 | 6648 | 6635 | 5989 | 1314 | 1264 | 1296 | 1267 | 1307 | 1299 |
| Greater Newark | 2099 | 2037 | 1689 | 1645 | 1601 | 1572 | 5790 | 5690 | 5976 | 6009 | 5803 | 5739 |
| Lower Christiana | 455 | 567 | 605 | 616 | 551 | 551 | 1545 | 1494 | 1465 | 1225 | 1224 | 1224 |
| Middletown-Odessa | 41172 | 41304 | 39640 | 38880 | 39438 | 39236 | 513 | 460 | 473 | 467 | 468 | 462 |
| New Castle | 4815 | 4901 | 5083 | 4945 | 5698 | 5439 | 39339 | 38971 | 41072 | 40942 | 39737 | 39731 |
| Piedmont | 4906 | 4960 | 4747 | 4641 | 4572 | 4591 | 5200 | 5067 | 5207 | 5161 | 4662 | 4646 |
| Pike Creek-Central Kirkwood | 1089 | 1053 | 959 | 880 | 868 | 860 | 4537 | 4482 | 4485 | 4528 | 4470 | 4467 |
| Red Lion | 1821 | 1839 | 2053 | 1917 | 1953 | 1918 | 879 | 970 | 1105 | 1090 | 960 | 958 |
| Upper Christiana | 1780 | 1445 | 1373 | 1225 | 1137 | 1030 | 1818 | 1964 | 1868 | 1771 | 1569 | 1567 |
| Wilmington | 1175 | 1123 | 1089 | 1098 | 1203 | 1433 | 971 | 1042 | 984 | 977 | 807 | 806 |
| Total | 69157 | 68671 | 66037 | 63783 | 64933 | 63982 | 1393 | 1239 | 1315 | 1093 | 1088 | 949 |

Figure 7, Estimate of Existing Units by Year by Census County Division

| CCD | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|-----------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Brandywine | 32508 | 32571 | 32626 | 32651 | 32690 | 32707 | 32760 | 32899 | 32931 | 33059 | 33109 | 33109 |
| Central Pencader | 11340 | 11889 | 12418 | 12921 | 13525 | 13961 | 14262 | 14543 | 14650 | 14824 | 14847 | 14846 |
| Greater Newark | 23002 | 23112 | 23203 | 23317 | 23369 | 23419 | 23454 | 23553 | 23609 | 23859 | 23792 | 23868 |
| Lower Christiana | 13731 | 13765 | 13804 | 13836 | 13902 | 13948 | 13998 | 14063 | 14015 | 14096 | 14106 | 14106 |
| Middletown-Odessa | 8856 | 9522 | 10164 | 11107 | 12009 | 12721 | 13572 | 14509 | 15192 | 15922 | 16147 | 16145 |
| New Castle | 30716 | 30858 | 31064 | 31280 | 31419 | 31681 | 31930 | 32345 | 32435 | 32620 | 32660 | 32659 |
| Piedmont | 10448 | 10474 | 10578 | 10687 | 10742 | 10888 | 10947 | 11044 | 11029 | 11078 | 11102 | 11100 |
| Pike Creek-Central Kirkwood | 16072 | 16113 | 16210 | 16290 | 16304 | 16316 | 16342 | 16399 | 16407 | 16461 | 16481 | 16481 |
| Red Lion | 1995 | 2099 | 2146 | 2294 | 2388 | 2511 | 2673 | 2832 | 2922 | 2983 | 3012 | 3012 |
| Upper Christiana | 9896 | 10060 | 10198 | 10351 | 10474 | 10586 | 10647 | 10672 | 10732 | 10764 | 10777 | 10776 |
| Wilmington | 25018 | 25004 | 25013 | 25216 | 25081 | 25149 | 25192 | 25401 | 25457 | 25892 | 25947 | 25947 |
| | 183582 | 185467 | 187424 | 189950 | 191903 | 193887 | 195777 | 198260 | 199379 | 201558 | 201980 | 202049 |

**Figure 8, Estimate of Existing Plus Potential Units by Year by Census
County Division**

| CCD | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | Average |
|--------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | |
| Brandywine | 33936 | 33909 | 33921 | 33939 | 33967 | 34070 | 34074 | 34163 | 34227 | 34326 | 34416 | 34408 | 34113 |
| Central Pencader | 19757 | 19993 | 19922 | 19569 | 20160 | 19950 | 20052 | 20233 | 20626 | 20833 | 20650 | 20585 | 20194 |
| Greater Newark | 25101 | 25149 | 24892 | 24962 | 24970 | 24991 | 24999 | 25047 | 25074 | 25084 | 25016 | 25092 | 25031 |
| Lower Christiana | 14186 | 14332 | 14409 | 14452 | 14453 | 14499 | 14511 | 14523 | 14488 | 14563 | 14574 | 14568 | 14463 |
| Middletown-Odessa | 50028 | 50826 | 49804 | 49987 | 51447 | 51957 | 52911 | 53480 | 56264 | 56864 | 55884 | 55876 | 52944 |
| New Castle | 35531 | 35759 | 36147 | 36225 | 37117 | 37120 | 37130 | 37412 | 37642 | 37781 | 37322 | 37305 | 36874 |
| Piedmont | 15354 | 15434 | 15325 | 15328 | 15314 | 15479 | 15484 | 15526 | 15514 | 15606 | 15572 | 15567 | 15459 |
| Pike Creek-Central Kirkwood | 17161 | 17166 | 17169 | 17170 | 17172 | 17176 | 17221 | 17369 | 17512 | 17551 | 17441 | 17439 | 17296 |
| Red Lion | 3816 | 3938 | 4199 | 4211 | 4341 | 4429 | 4491 | 4796 | 4790 | 4754 | 4581 | 4579 | 4410 |
| Upper Christiana | 11676 | 11505 | 11571 | 11576 | 11611 | 11616 | 11618 | 11714 | 11716 | 11741 | 11584 | 11582 | 11626 |
| Wilmington | 26193 | 26127 | 26102 | 26314 | 26284 | 26582 | 26585 | 26640 | 26772 | 26985 | 27035 | 26896 | 26543 |
| Total | 252739 | 254138 | 253461 | 253733 | 256836 | 257869 | 259076 | 260903 | 264625 | 266088 | 264075 | 263897 | 258953 |

F

Figure 9, Estimate of the Percentage of Total Units That Are Potential Units by Year by CCD

| CCD | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|--|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Brandywine | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Central Pencader | 43 | 41 | 38 | 34 | 33 | 30 | 29 | 28 | 29 | 29 | 28 | 28 |
| Greater Newark | 8 | 8 | 7 | 7 | 6 | 6 | 6 | 6 | 6 | 5 | 5 | 5 |
| Lower Christiana | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 |
| Middletown-Odessa | 82 | 81 | 80 | 78 | 77 | 76 | 74 | 73 | 73 | 72 | 71 | 71 |
| New Castle | 14 | 14 | 14 | 14 | 15 | 15 | 14 | 14 | 14 | 14 | 12 | 12 |
| Piedmont | 32 | 32 | 31 | 30 | 30 | 30 | 29 | 29 | 29 | 29 | 29 | 29 |
| Pike Creek-Central Kirkwood | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 5 |
| Red Lion | 48 | 47 | 49 | 46 | 45 | 43 | 40 | 41 | 39 | 37 | 34 | 34 |
| Upper Christiana | 15 | 13 | 12 | 11 | 10 | 9 | 8 | 9 | 8 | 8 | 7 | 7 |
| Wilmington | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4 |
| All CCD's - New Castle County | 27 | 27 | 26 | 25 | 25 | 25 | 24 | 24 | 25 | 24 | 24 | 23 |

Population Projections and control totals

The Delaware Population Consortium produces population and housing projections for 30 year horizons at the County level. Other agencies take these estimates and allocate them to the Census County Division, also called Planning Districts and this is useful as a starting point to make more detailed allocations. Within each Planning District a certain number of housing units are expected to be “built” on existing lots or lots on newly subdivided properties. The figure below shows one allocation of projections at the Planning District level provided by WILMAPCO in December 2010.

Figure 10, WILMAPCO CCD Housing and Population Projections

| New Castle County Households by Planning District- 2011 Series (DRAFT) | | | | | | | | | | | | | | |
|--|----------------|----------------|----------------|----------------|----------------|--|--|----------------|----------------|----------------|----------------|---------------|---|---|
| Planning District | HH 1970 | HH 1980 | HH 1990 | HH 2000 | HH 2010* | HHs to Be built from Development plans | Potential HH Units based on current zoning | HH 2015 | HH 2020 | HH 2030 | HH 2040 | HH CHG 10-40 | Share of Growth 2010-2040 (2011 Series) | Share of Growth 2010-2040 (2010 Series) |
| Brandywine | 26,379 | 30,276 | 31,337 | 32,292 | 31,790 | 1,569 | 859 | 32,570 | 33,030 | 33,650 | 33,980 | 2,190 | 5.2% | 5.1% |
| Central Pencader | 602 | 2,899 | 6,140 | 11,316 | 13,740 | 2,704 | 1,821 | 14,940 | 15,800 | 16,980 | 17,470 | 3,730 | 8.9% | 8.7% |
| Greater Newark | 13,105 | 17,304 | 20,215 | 23,151 | 23,690 | 701 | 501 | 24,090 | 24,340 | 24,770 | 25,090 | 1,400 | 3.3% | 3.0% |
| Lower Christina | 14,341 | 14,254 | 14,304 | 14,496 | 13,990 | 108 | 357 | 14,470 | 14,740 | 14,960 | 15,030 | 1,040 | 2.5% | 1.1% |
| MOT | 2,970 | 3,816 | 5,881 | 9,549 | 14,380 | 19,397 | 6,022 | 18,710 | 22,920 | 31,300 | 36,990 | 22,610 | 53.9% | 58.4% |
| New Castle | 14,125 | 18,799 | 24,557 | 30,309 | 31,840 | 4,028 | 1,944 | 32,950 | 33,990 | 35,770 | 36,860 | 5,020 | 12.0% | 11.6% |
| Piedmont | 4,200 | 5,608 | 8,313 | 10,654 | 10,480 | 1,154 | 1,099 | 10,850 | 11,210 | 11,940 | 12,460 | 1,980 | 4.7% | 4.6% |
| Pike Creek-Central Kirkwood | 8,811 | 11,255 | 15,182 | 17,173 | 17,510 | 610 | 390 | 17,710 | 17,880 | 18,197 | 18,390 | 880 | 2.1% | 2.0% |
| Red Lion | 1,003 | 1,137 | 1,316 | 1,906 | 2,660 | 471 | 343 | 2,840 | 3,130 | 3,410 | 3,620 | 960 | 2.3% | 1.9% |
| Upper Christina | 2,673 | 5,274 | 7,841 | 9,472 | 10,210 | 433 | 152 | 10,320 | 10,440 | 10,620 | 10,840 | 630 | 1.5% | 1.3% |
| Wilmington | 27,565 | 26,092 | 28,444 | 28,617 | 27,880 | 561 | N/A | 28,270 | 28,470 | 28,850 | 29,370 | 1,490 | 3.6% | 3.4% |
| New Castle County | 115,774 | 136,714 | 163,530 | 188,935 | 198,170 | 31,686 | 13,488 | 207,720 | 215,950 | 230,447 | 240,100 | 41,930 | | |
| DPC Control Totals | | | | | 198,173 | | | 207,723 | 215,962 | 230,447 | 240,107 | 41,934 | | |
| * Adjusted to reflect new HH control totals from Census | | | | | | | | | | | | | | |

GIS Data Collection

Close to 150 GIS layers and tabular data sets were developed as part of this project and they are made available in a DVD collection. From this, figures and tables in this report can be reproduced and more detailed areas mapped and analyzed. A description of the layers is made available in the appendix.

Main Data Items

The five items below are the projects main data compilations. The master table can be used to form other tabular set like projections or scenarios. Links to the parcel polygon file (NCPARnov10) allows for visualization and spatial operations on the data.

MastertabFeb11 - Project master table. Contains records for all properties that existed from the year 2000 to November 2010. modeling factors and probabilities are included with a wide range of descriptive data about each historic, present, or future tax parcel. Also includes records for synthetic lots.

Modeltab – a more extensive version of the master table that contains more historical variables, in SPSS format.

NcparNov10 – Most current GIS tax parcel map collected. Matches current properties with records in the master.

Parmaster9910 – A polygon GIS tax parcel map created for all properties from 1999 to 2010 that ever existed. A link to historical parcel data

SynthptsFeb11 - A GIS point file locating synthetic lots

GIS Files

Source New Castle County GIS Taxparcel Files (ncYYMMDD)

Nc101129
 Nc100413
 Nc090213
 Nc080922
 Nc071114
 Nc060816
 Nc050605
 Nc040831
 Nc040831_Project
 Nc030908
 Nc020930
 Nc010928
 Nc000914

NCC_TAZ_2010 – New Castle County Traffic Zones, courtesy of WILMAPCO

Pendingdev2010 – polygon coverage showing properties with Pending status in the New Castle County Subdivision Activity File.

DE_WATERCPCN_070708 – Water Service Providers

PDR – preserved properties

Plotsrestrict – plots that were seen as environmentally restricted, partial

PUB_PRI_OPENSOURCE – Public and Private openspace

ZONING10june – New Castle County zoning layer

State_Ag_Districts – State Agricultural Preservation District land

Plotdev10 – Plots developed by 2010 in the decade, partial

De-nongrowth – Delaware areas identified as NonGrowth in State land use plan

De-growth-lo – Delaware areas identified as Low Growth in State land use plan

De-growth-hi - Delaware areas identified as High Growth in State land use plan

Lotblt10 – lots that were built in 2010

Lotblt09 – lots built in 2009 and also available for years in the decade
Lots10 – lots in 2010 and also available for years in the decade
Devactivityde10 – New Castle County development activity
Community – community layer for NCC, includes subdivision delineation
Deccd – Delaware Census County Divisions
Sewer_service_areas09 - NCC Sewer Service Areas
Lot09pt – point layer for lots built in 2009, also available for other years in the decade
DE_Floodplains - FloodPlains
Exempt09- Exempt properties in 2009
Indust09 – Industrial properties in 2009
Municipal – municipal boundaries, Fall of 2010
Com09 – Commercial properties in 2009
Vacant_res_lots – Dec 2010 vacant residential lots from NCC Dept of Land Use

A Note on Errors in the Data

Data in this project is at the very detailed property level. Various kinds of errors exist in assessment files and historical tax parcel GIS files. Changes from year to year in how the data was managed sometimes introduces additional errors and anomalies. While a great deal of very time consuming compilation and data checking was done, in this relatively small project it was impossible to go through an exhaustive check of 190,000 + property records. Errors do exist. The data sets created are a good start to an effort to address land use at a more detailed level, and establish a foundation for a powerful information resource for studying development. Working at this detailed level involves considerable ongoing efforts in quality control and update. Examination of development trends could benefit from a continuous update of information as it is made available each year.

Models are based on historic data in most cases without the benefit of detailed information about each property. For instance, a significant probability of subdivision of a property might be assigned where based on other plans of the owner, the probability would actually be near zero. Where there are many properties, each with a relatively small chance of being built or subdivided, accurately predicting action on a particular property from year to year is difficult. It is hoped that the models can show significant and reliable information when predicting patterns for larger areas over longer periods of time.

Master Table Item Descriptions

HANSENKEY – numeric, identifier from NCC Government database
 SIGMAKEY - numeric, identifier from NCC Government database
 CCDFIPS – string, fips code of Census County Division
 CCDNAME – string, name of Census County Division
 ZIPCODE – string, zipcode
 SHDSTID – numeric, school district id
 SCHDIST – string, School District Name
 COUNCIL – string, Council District
 GRID – string, modified grid
 OWNER10 – string, owner in 2010
 ACREAGE – number, acreage
 LOTNUM – numeric, lot number for synthetic lots
 SYNTHLOT – numeric, equals 1 if record is a synthetic lot
 PLCLASS – string, Property Class (R, C E, F...)
 PROPDESC – string, property description, sometimes for lots
 PROP_CLASS – string, property class code
 PARCELROOT - string, first 10 characters of PARCELID
 PARCELID – string, unique property identify and primary ID of tax parcel
 CAT10 – string, Land use categories
 CAT10SIMP – string, a simplified version of CAT10
 TAZ – string, Traffic zone name
 SEWER – numeric, equals 1 if property is in a sewer district
 CAT90N – numeric, equals 1 if Lot in 2010 and was lot in 1990
 COMLOT – numeric, equals 1 if a commercially zoned lot
 INSUBDIV – numeric, equals 1 if a subdivision name is in the assessment database
 NOTLOT – numeric, a 1 if record is a synthetic lot
 TAZVAR – the total number of built lots in the past 5years in the home traffic
 Zone divided by the total available lots in the past five years in the home
 Traffic zone
 PROB1115 – calculated probability for lots being built for projection year 2011 to 2015
 PROB1115ADJ – PROP1115 adjusted for the number of lots built in 5 year projection
 period
 PROB115pend – probability of lot being built if PENDING development is considered
 CAT15 – projected land use categories for 2015
 CAT20 – projected land use categories for 2020
 Z115 – Z factor in model calculation
 Z115PEND – Z factor in model calculation when PENDING development is considered
 BLT0610VAR – whether this record is a lot that was built between 2006 and 2010
 LOT0610VAR - whether this record was a lot between 2006 and 2010
 SUBDIV – subdivision name
 PLANSTAT – status in NCC subdivision review process
 SIZE – categorization of tax parcel size
 POTUNIT10 – potential housing units that could be constructed in this tax parcel

Master Table Item Descriptions (continued)

EXISTUNIT10 – Existing housing units in this tax parcel
 PLCLASS – Plan classifier, NCC Subdivision Review
 PLANNAME – Plan classifier, NCC Subdivision Review
 PLANNAPPNO – Plan application number, NCC Subdivision Review
 PLANLOTS – Plan number of lots, NCC Subdivision Review
 PLANCMT – Plan comments, NCC Subdivision Review
 TOTASS10 – total assessed property value, 2010, in 1970 dollars
 TAXASS10 – taxes owed for this property, 2010, in 1970 dollars
 LAND10 – land value in 1970 dollars
 BLDG10 – land value in 1970 dollars
 FARM10 – farm value in 1970 dollars
 ESTVALTOT – estimated total value of property in 1970 dollars
 VALUEperACRE – estimated value per acre
 MAXSALE – maximum previous sale value
 MAXSALEDT – maximum sales date
 ASS2SALES – Assessed value to sales ratio
 ZONING10 – 2010 zoning
 BELOWCANAL – is 1 if a property below the C&D Canal
 RESTRICTIONS – 1 if presence of environmental restrictions
 OPENPUBPRB – 1 if public or private open space
 EXEMPT – 1 if exempt
 NEARMOT – 1 if parcels around MIDDLETOWN, ODESSA, or TOWNSEND
 NEARSMYRNA – 1 if property near Smyrna
 SLIVER – generally a property with relatively high perimeter versus area
 GROWFACTOR – Growth factor from State land use mapping
 AGPDR – preserved agricultural land
 AGDIST – Agricultural district flag
 MUTYPE, HUTYPE, MUTYPE2 – housing unit types for multifamily housing
 MULTYEAR – year became a multiunit
 MULTIPOT – housing unit potential for multiunit dwelling
 NUMISL – referred to number of distinct polygons making up tax parcel in GIS file
 UNIT – unit designator, for multiunit housing
 ABEGYEAR, YEARCREATE – when this property came into existence, equals 1998 if before 1999
 AENDYEAR – year property went out of existence
 BUILTYEAR – year property was built
 ORIGINPAR – the parent parcel that was subdivided to form this property
 NUMHU – number of housing units on this property
 LAND09 – land value in 2009
 BLDG09 – building value in 2009
 ZONING09A – zoning in 2009
 SEWRCONN, SEWRCONS – sewer service district information

PART TWO, Initial examination of the data and candidates for model variables

The Development Process

An area is seen as being made up of “Plots”, larger properties that can be subdivided and are available for residential development, and “Lots”, properties that can contain housing units, and existing residential and non-residential development. A certain number of plots are subdivided each year to create new lots and a certain number of lots become built housing units and this is the main processes that are modeled. Factors that may affect where and if development occurs were studied in models to ultimately estimate a set of relative probabilities for development of properties. Two types of development are considered, the subdivision of larger properties into housing unit lots, and building on those lots.

The rate of development is constrained by Delaware Population Consortium Projection estimates. The rate of subdivision and construction is considered independent of the patterns of development over time.

Multi-Unit Housing

Existing condominiums, apartment buildings, and trailer parks are shown in GIS and tabular property files. Most new construction over recent years has been as subdivisions made up of single family detached housing units. It is expected that with the economic downturn there will be an increase in multi-unit housing construction in the future. Examining the market for multi-unit housing was beyond the scope of this project and housing type in general is not addressed though it is certainly an area of interest when describing the housing market.

Initial View of Lot Data

Lots are identified as properties of less than 5 acres and no or low (< \$2000 in 1976 assessment dollars). Close to 90% of lots are less than an acre, and of these more than half are 0.2 acres or less, as shown in a sample from 2003 below. The category “LOT-C” is for properties that are lots but have a commercial or industrial zoning although these lots could be used for residential development.

Figure 11, Lots in 2003, New Castle County

| | Number | % of lots |
|--------------------------------|--------|-----------|
| LOT large (2 to 5 acres) | 682 | 4.3 |
| LOT med (1 to 2 acres) | 986 | 6.3 |
| LOT small (0.2 to 1 acre) | 6,268 | 39.9 |
| LOT very small (0 to 0.2 acre) | 7,541 | 48.0 |
| LOT-C | 225 | 1.4 |
| Total | 15,702 | 100 |

The number of lots in New Castle County fluctuates from year to year ranging from 14,000 to 16,000 properties. Between the year 2000 and 2009 there was an average of about 1800 lots built per year, with a maximum of 2365 built in 2002 and a minimum of only 507 in 2009. The effects of the economic downturn could clearly be seen. Figures for total lots and built lots are on the next page. One interesting feature of the this data is that it is clear that at the Planning District Level, the percentage of lots that are built each year varies greatly between the Planning Districts as shown in figure _____. The City of Wilmington, Brandywine, and Lower Christina Planning Districts show in general a lower percentage of built lots each year than other Districts even though they show several hundred lots in their inventory. Any model created for lot build out would seek to explain this kind of difference.

Where lots were **not** built was studied as much as where lots were built. It can be seen for instance that a newly created subdivision would typically not show building activity until a few years after it was subdivided. For the 10 year period lots which were lots in 1999 and still lots in 2009 were mapped and reasons why some of these lots weren't developed could be considered. Some were in flood plains, some were of a very small size, some seemed to be part of urban renewal in the City of Wilmington. This report contains a series of maps showing lots together with lots that were built in the following year. These maps and data are also included in the project data sets.

**Figure 12, Example area of lots (red dots) not built since 1990
Northern New Castle County near Naamons Rd.**

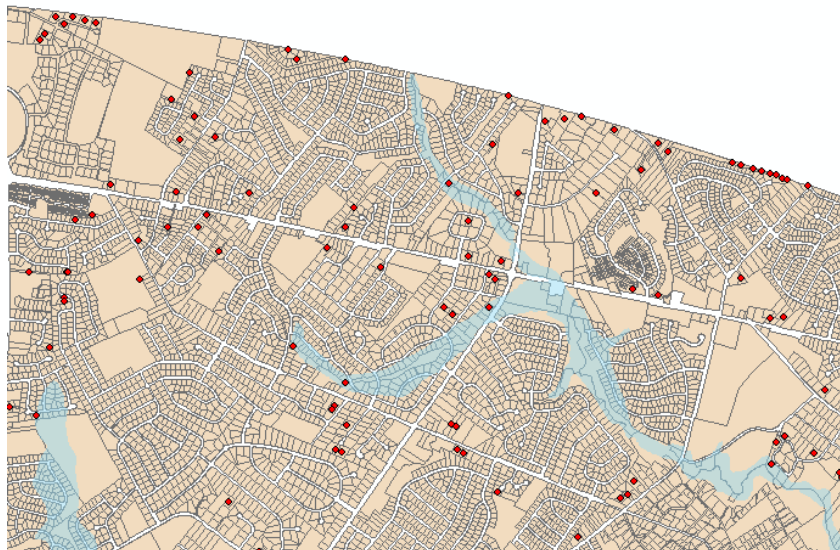


Figure 13, Lots Available by Year by CCD

| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Brandywine | 762 | 685 | 641 | 634 | 623 | 709 | 664 | 657 | 619 | 588 |
| Central Pencader | 3311 | 2994 | 2589 | 2210 | 1662 | 1464 | 1268 | 1078 | 1012 | 1214 |
| Greater Newark | 731 | 622 | 709 | 648 | 593 | 564 | 538 | 486 | 477 | 445 |
| Lower Christiana | 443 | 553 | 593 | 602 | 537 | 537 | 499 | 446 | 453 | 447 |
| Middletown-Odessa | 5890 | 5870 | 6097 | 5714 | 6069 | 6049 | 6843 | 6482 | 7854 | 8184 |
| New Castle | 1476 | 1497 | 1648 | 1508 | 2267 | 2066 | 1832 | 1671 | 1833 | 1814 |
| Piedmont | 910 | 809 | 757 | 649 | 625 | 595 | 557 | 519 | 521 | 665 |
| Pike Creek-Central Kirkwood | 519 | 437 | 343 | 264 | 252 | 293 | 312 | 413 | 497 | 482 |
| Red Lion | 391 | 409 | 623 | 481 | 517 | 482 | 382 | 528 | 432 | 391 |
| Upper Christiana | 674 | 693 | 623 | 475 | 347 | 240 | 184 | 256 | 195 | 189 |
| Wilmington | 1152 | 1100 | 1079 | 1075 | 1195 | 1246 | 1207 | 1053 | 1128 | 1092 |
| Total | 16259 | 15669 | 15702 | 14260 | 14687 | 14245 | 14286 | 13590 | 15022 | 15512 |

Figure 14, Lots Built by Year by CCD

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|------------------------------------|------|------|------|------|------|------|------|------|------|------|
| Brandywine | 91 | 68 | 38 | 48 | 21 | 57 | 93 | 66 | 40 | 14 |
| Central Pencader | 553 | 528 | 507 | 619 | 367 | 300 | 280 | 117 | 56 | 24 |
| Greater Newark | 155 | 90 | 89 | 66 | 48 | 41 | 65 | 35 | 29 | 10 |
| Lower Christiana | 1 | 22 | 31 | 80 | 60 | 52 | 71 | 18 | 26 | 17 |
| Middletown-Odessa | 631 | 650 | 949 | 966 | 699 | 854 | 839 | 720 | 555 | 232 |
| New Castle | 204 | 205 | 213 | 215 | 272 | 255 | 389 | 158 | 120 | 61 |
| Piedmont | 105 | 115 | 109 | 60 | 48 | 61 | 49 | 15 | 24 | 13 |
| Pike Creek-Central Kirkwood | 87 | 99 | 81 | 45 | 10 | 28 | 47 | 38 | 33 | 22 |
| Red Lion | 103 | 53 | 147 | 100 | 121 | 170 | 148 | 100 | 57 | 32 |
| Upper Christiana | 175 | 137 | 150 | 127 | 109 | 59 | 29 | 68 | 12 | 16 |
| Wilmington | 48 | 25 | 51 | 26 | 29 | 67 | 161 | 69 | 75 | 66 |
| Total | 2153 | 1992 | 2365 | 2352 | 1784 | 1944 | 2171 | 1404 | 1027 | 507 |

Figure 15, Percentage of Lots Built in the Following Year

| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|--|------|------|------|------|------|------|------|------|------|------|
| Brandywine | 12 | 10 | 6 | 8 | 3 | 8 | 14 | 10 | 6 | 2 |
| Central Pencader | 17 | 18 | 20 | 28 | 22 | 20 | 22 | 11 | 6 | 2 |
| Greater Newark | 21 | 14 | 13 | 10 | 8 | 7 | 12 | 7 | 6 | 2 |
| Lower Christiana | 0 | 4 | 5 | 13 | 11 | 10 | 14 | 4 | 6 | 4 |
| Middletown-Odessa | 11 | 11 | 16 | 17 | 12 | 14 | 12 | 11 | 7 | 3 |
| New Castle | 14 | 14 | 13 | 14 | 12 | 12 | 21 | 9 | 7 | 3 |
| Piedmont | 12 | 14 | 14 | 9 | 8 | 10 | 9 | 3 | 5 | 2 |
| Pike Creek-Central Kirkwood | 17 | 23 | 24 | 17 | 4 | 10 | 15 | 9 | 7 | 5 |
| Red Lion | 26 | 13 | 24 | 21 | 23 | 35 | 39 | 19 | 13 | 8 |
| Upper Christiana | 26 | 20 | 24 | 27 | 31 | 25 | 16 | 27 | 6 | 8 |
| Wilmington | 4 | 2 | 5 | 2 | 2 | 5 | 13 | 7 | 7 | 6 |
| Total | 13 | 13 | 15 | 16 | 12 | 14 | 15 | 10 | 7 | 3 |

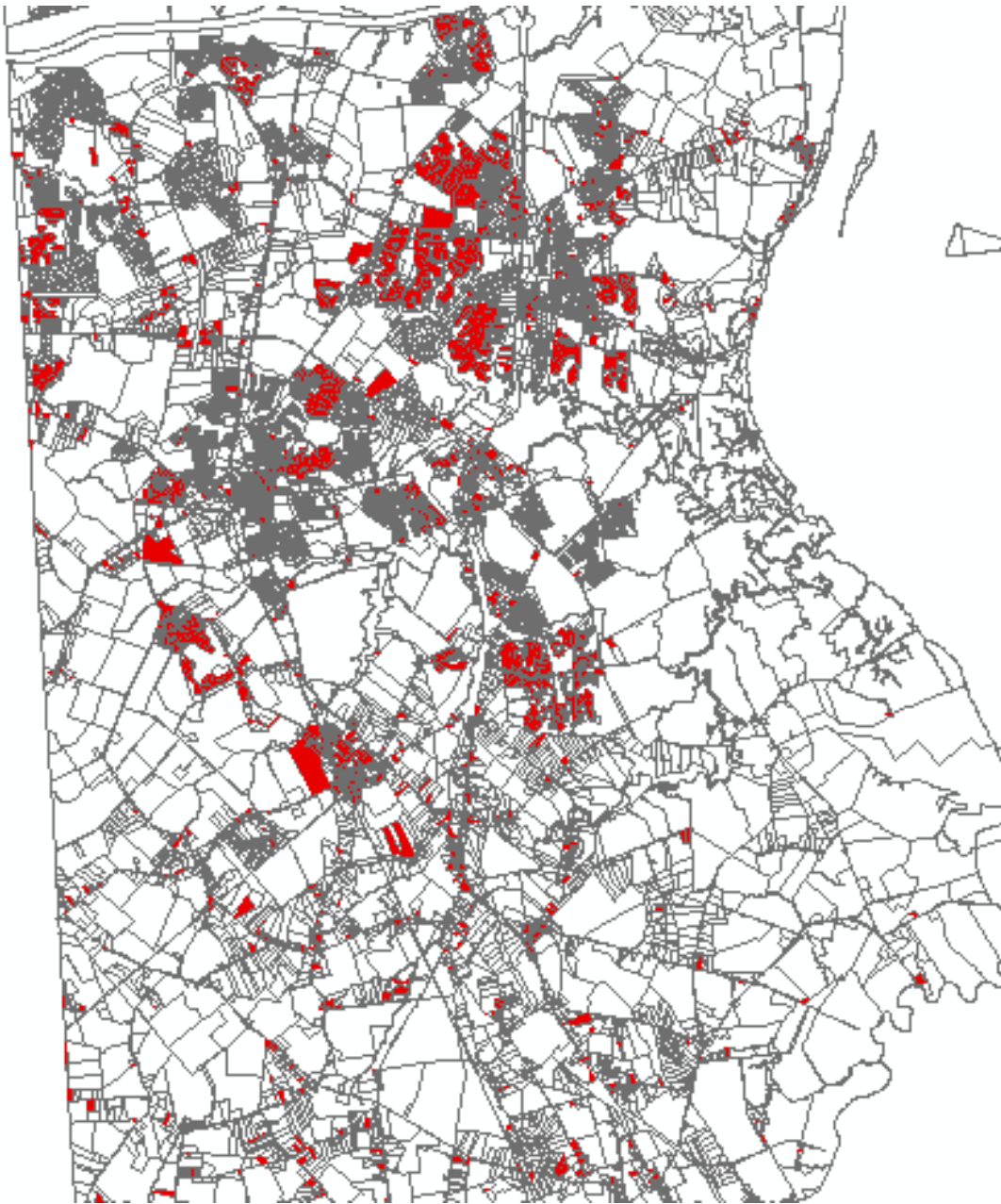
Figure 16, Year 2001 Lot Data In Southern New Castle County

Figure 17, Year 2001 Lot Data In Northern New Castle County



Figure 18, Lots in 2001 with Lots Built in 2000
Green Dots = 2001 Lots Red Dots = Lots Built in 2000
Tax Parcel Base Sept 2001

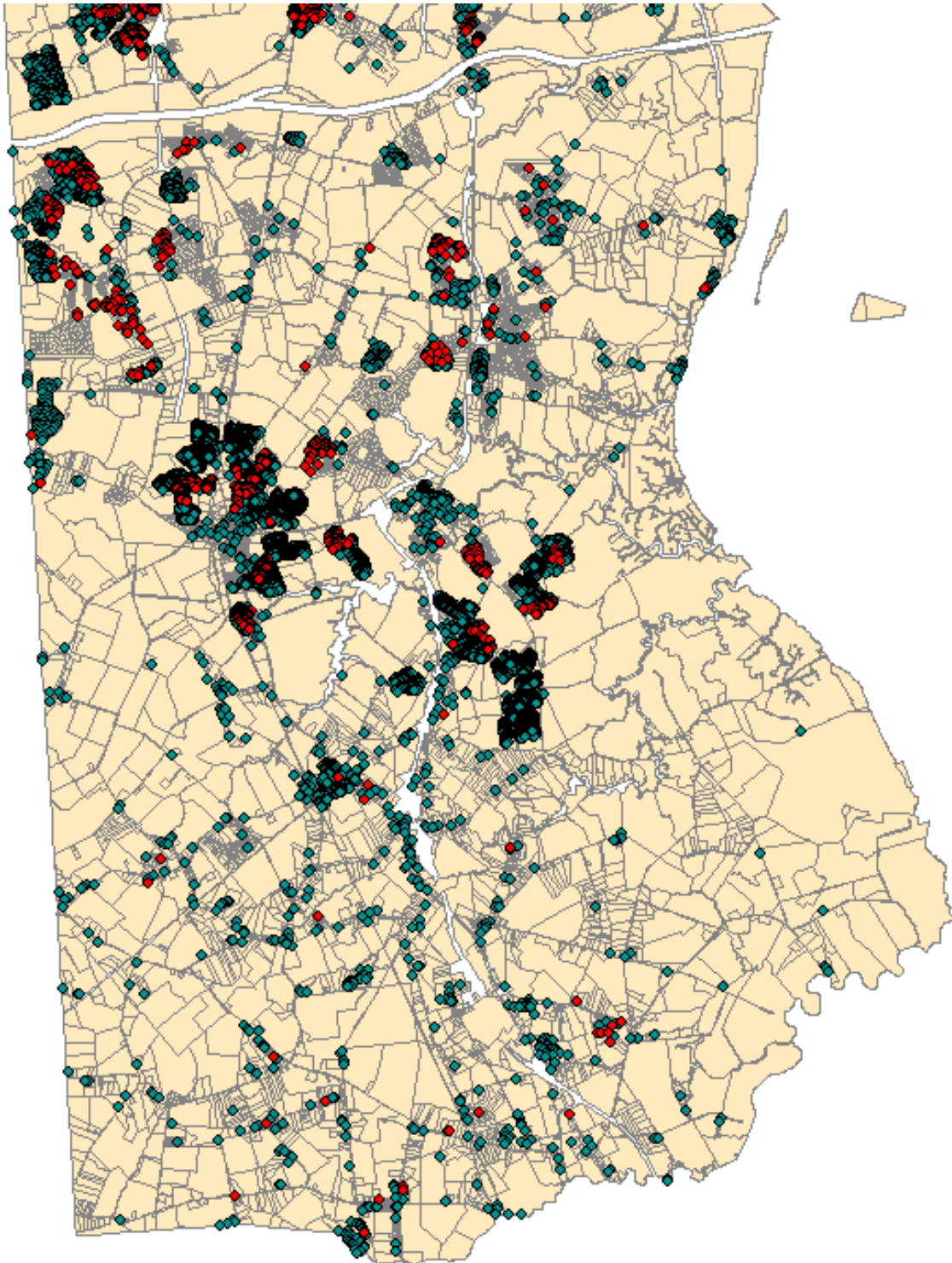
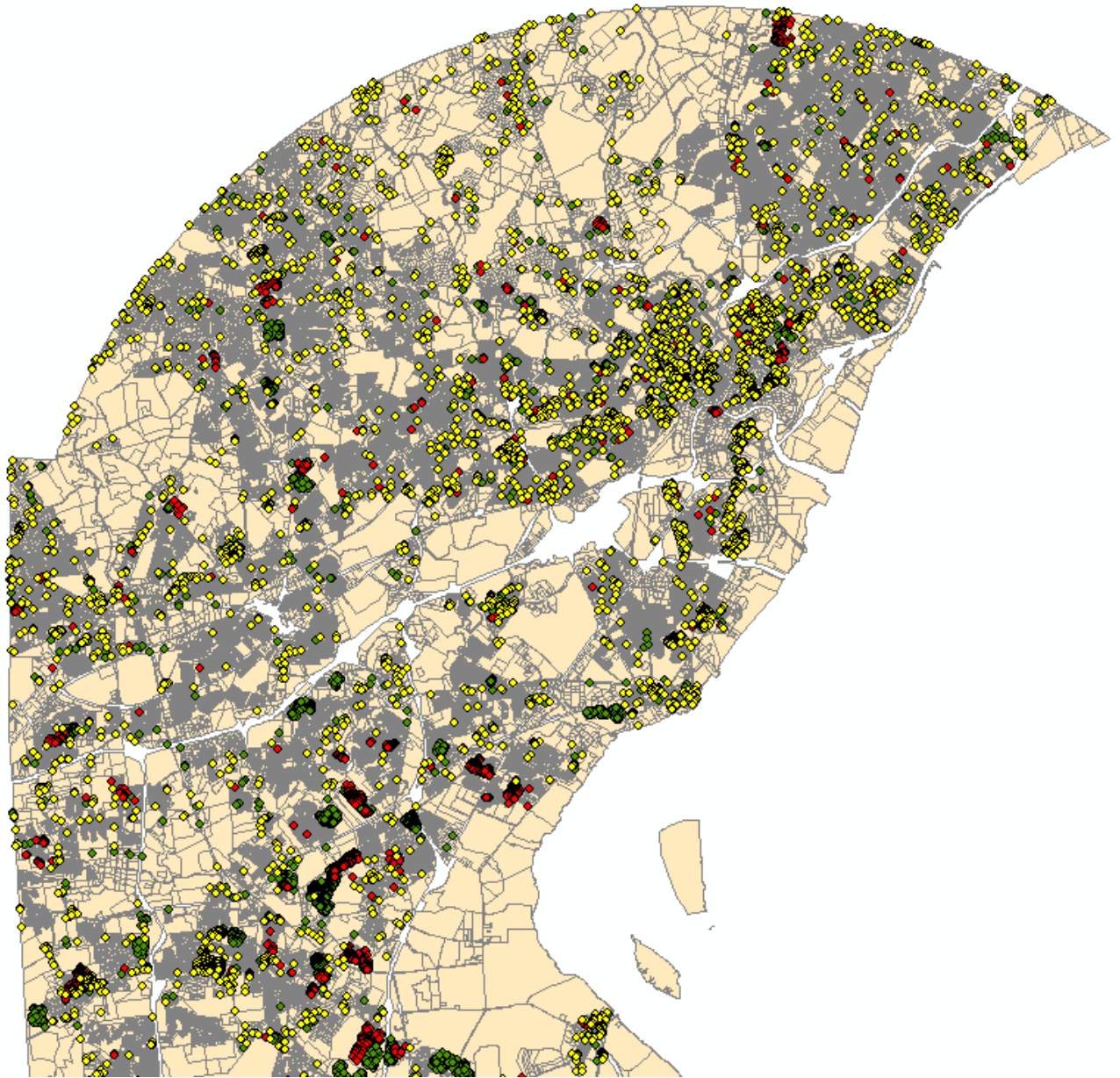


Figure 19, Year 2007 Lot Data In Northern New Castle County
Green Dots = 2007 Lots Red Dots = Lots Built in 2006 Yellow Dots = Lots from 1999 to 2009
Tax Parcel Base November 2007



Factors Considered for Estimating Probability of a Lot Being Built

There are a number of factors that would influence where the development of lots would occur. The list of factors included for study and associated with each property in the master property data for years 1999 thru 2009 include:

Size in Acres – In particular it is expected that lots of very small size

Sewer District – Lots not in served by a sewer system in particular. Could be a useful factor to view different parts of the county as well.

Flood Plains and Wetlands – Lots in floodplains and other environmentally restricted areas are not expected to be built

Lot Age – If a property was a Lot for the past 20 years for unknown reasons it is expected that it is less likely to be developed in the future. On the other side of this, Lots just created generally see a lag time (like a few years) before building starts.

Proximity to Building in the Previous Year – If lots are available near a high number of lots that were built in the previous year this could be an indicator of expected activity.

Zoning – Most lots are of a residential zoning category though some have commercial or industrial zoning. These are eligible for residential building though it is expected that these will have a different development pattern. Most subdivisions are in the Suburban zoning category with few being in Suburban Reserve (SR) or Suburban Estate (SE)

Place Factors – For instance lots below the C & D Canal may be built at different rates. City of Wilmington lots appear to be different than lots in non-urban areas.

Sewer Service Areas – Plots with access to the county sewer system or within a designated sewer district

Percentage of Community that Is Built

Development Factors Related to Proximity to Existing Development or Activity

One type of factor was of particular interest. If it is shown that the probability of a plot being subdivided or a lot being built depends on the proximity of existing development or where plots were previously developed or lots built, then the probability of where development occurs needs to be estimated in an interactive process year to year. It is often thought that development activity occurs around other activity. On the other hand if where development takes place does not depend on where it took place before then development patterns would be expected to be the same through time and only effects development in other areas to the extent that places would be competing for a limited housing demand. As development is limited by estimated control totals produced by the Population Consortium the effect of a scenario that postulates that a particular property(s) will be subdivided and built before others will generally be to postpone the expected subdivision of other properties to a later time and probabilities wont have to be adjusted from year to year.

Initial View of Plot Data and Factors for the Development of Plots

Plots are defined here as those non-commercial properties greater than 5 acres and are what can be considered developable land. Not included in this category are public and other exempt lands including open space set asides, agriculture preservation areas and other preserved or protected lands, and existing multi-unit complexes like condominiums and trailer parks

Figure 20, Plots in 2009

| | Number | Percentage of Plots |
|--------------------------------|--------|---------------------|
| Very small – 5 to 10 acres | 822 | 34% |
| Small - 10 to 20 acres | 891 | 37 |
| Medium – 20 to 100 acres | 547 | 22 |
| Large – greater than 100 acres | 176 | 7 |

Larger tracts of developable land mostly occur just above and just above the Chesapeake & Delaware Canal. Maps of plots and developed plots are shown on the next pages.

Various factors were developed and examined for plots to use in modeling the probability for a plot to be subdivided/developed.. These factors include:

Zoning = SR = Suburban Reserve

Zoning = SE = Suburban Estate

“Slivers” - Properties where the ratio of perimeter to area was greater than 150, generally longer thinner properties. This type of property often exists in the bottom quarter of the county in the suburban reserve zoning category, and many of these were classified as “farmets” and considered as built properties rather than as developable land.

Size in Acres

Growth Areas – The State Development Strategies mapping categorizes areas as No Growth Areas, Low Growth Areas, and High Growth Areas

Below the Canal – Properties below the C & D Canal

Built Factor / Proximity to Existing Development – The number of existing housing units within a mile from plots was calculated. The average number of housing units for all plots was roughly 1000 where the average for plots that were developed was a little over 2000. A factor was built where a “1” corresponded to plots having over 1500 existing housing units within a mile.

Environmentally restricted properties - 5% of properties that were partly within floodplains were subdivided.

Exempt, Open Space, Public Lands, Ag Preservation – No properties of this type were subdivided. They are placed in their own categories and not listed as Plots.

Sewer Service Areas – Plots with access to the county sewer system or within a designated sewer district

Present in New Castle Counties Subdivision Review Process Database– Probably the most reliable factor that would indicate development in the near term. All subdivided plots go through this process.

Land Value – in 1974 dollars the average value in dollars per acre is about \$5000 for all plots, and about \$6700 for developed plots. Processing of property values from assessment files (assessed values) was difficult and perhaps left to further research and processing.

Zoning of course has a major effect on the probability of development. Suburban Reserve and Suburban Estate zoning classes were only developed at 2% rate in the study period. Related to this are the State Growth Areas where No Growth Areas includes SR and SE zoning. Also related to the zoning factors and growth area factors is where no sewer service is available. Only 3% of plots that were developed were in areas outside of county sewer districts. Larger plots, those greater than 20 acres tend to be developed at a higher rate than smaller plots. Plots nearer the towns, Middletown, Odessa, and Townsend were developed at a slightly higher rate than other plots. About half the developed plots were above the C&D Canal and about half were below. Where about 67% of plots are below the canal, the development of plots above the canal was slightly higher though plots above the canal are often smaller. When mapping plots it seems visually that subdivided plots tend to cluster and this is shown by a higher value for proximity to existing development. The percentage breakdown for developed plots and all plots is shown in the figure below. Figures mapping land use in plots, sewer service, and growth areas are shown on the next pages.

Figure 21, Plots by Zoning

| | % Developed Plots | % All Plots | Number of Plots |
|-------------------------------------|----------------------------------|----------------------------|----------------------------|
| Zoning SR | 2 | 40 | 1034 |
| Zoning SE | 2 | 9 | 225 |
| Not a "sliver" | 79 | 52 | 1356 |
| Size 5 to 20 acres | 38 | 68 | 1779 |
| Size 20 to 100 | 62 | 32 | 823 |
| Near MOT | 22 | 10 | 254 |
| > 2000 blt factor | 36 | 17 | 449 |
| > 1500 blt factor | 43 | 22 | 2024 |
| No Growth Area | 4 | 53 | 1375 |
| Low Growth Area | 73 | 42 | 1092 |
| High Growth Area | 23 | 5 | 136 |
| Below C&D Canal | 55 | 67 | 849 |
| Size 5 to 10 | 17 | 33 | 854 |
| Size 10 to 20 | 21 | 35 | 921 |
| Size 20 to 100 | 39 | 24 | 616 |
| Size > 100 | 23 | 8 | 207 |
| Restricted (Floodplains) | 7 | 17 | 459 |
| No Sewer Service | 3 | 54 | 1404 |

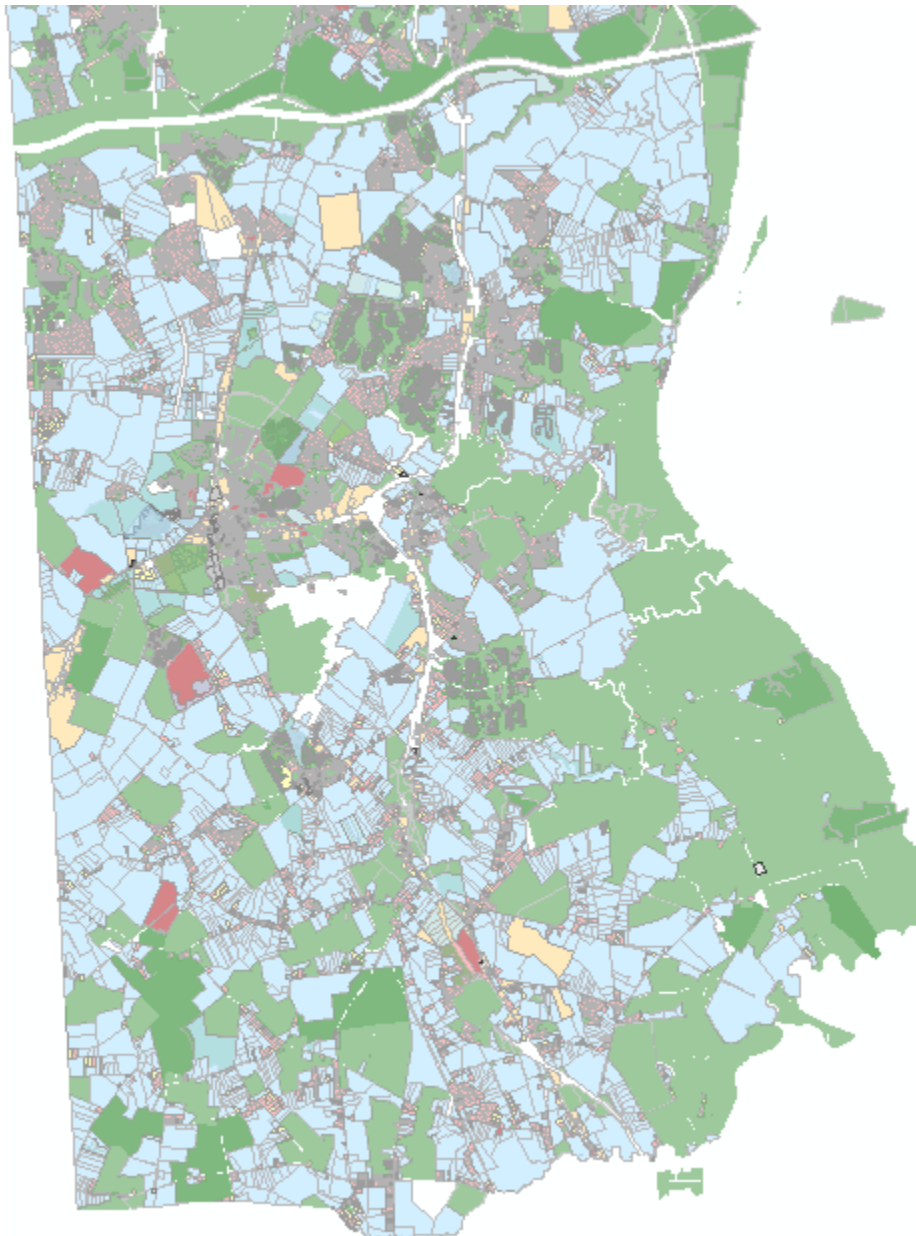
Figure 22, Land Use Below the Canal, Plots in Blue

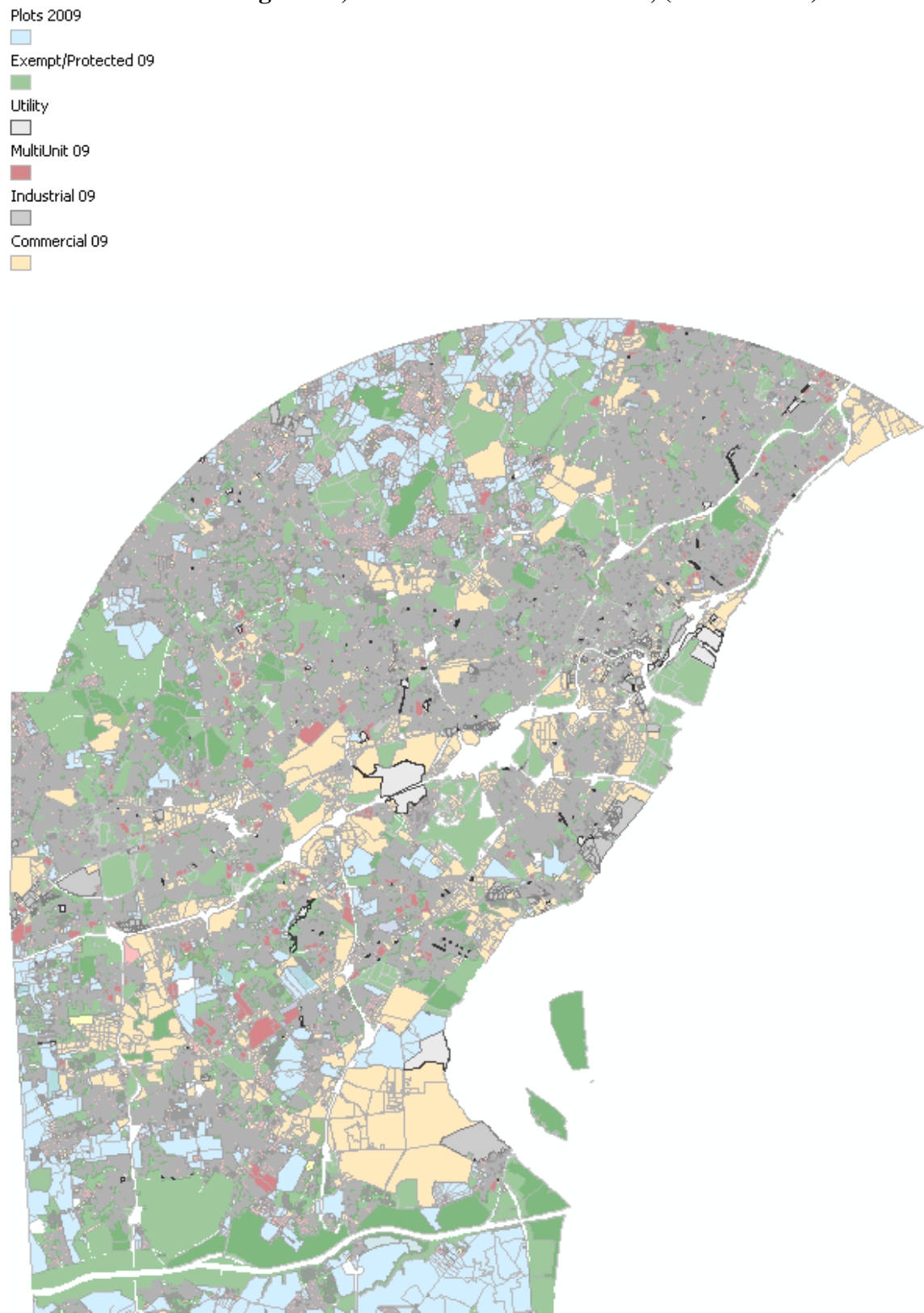
Figure 23, Land Use Above the Canal, (Plots in Blue)

Figure 24, Plots That Were Developed in Northern New Castle County between 1999 and 2009 (Shown with purple shading)

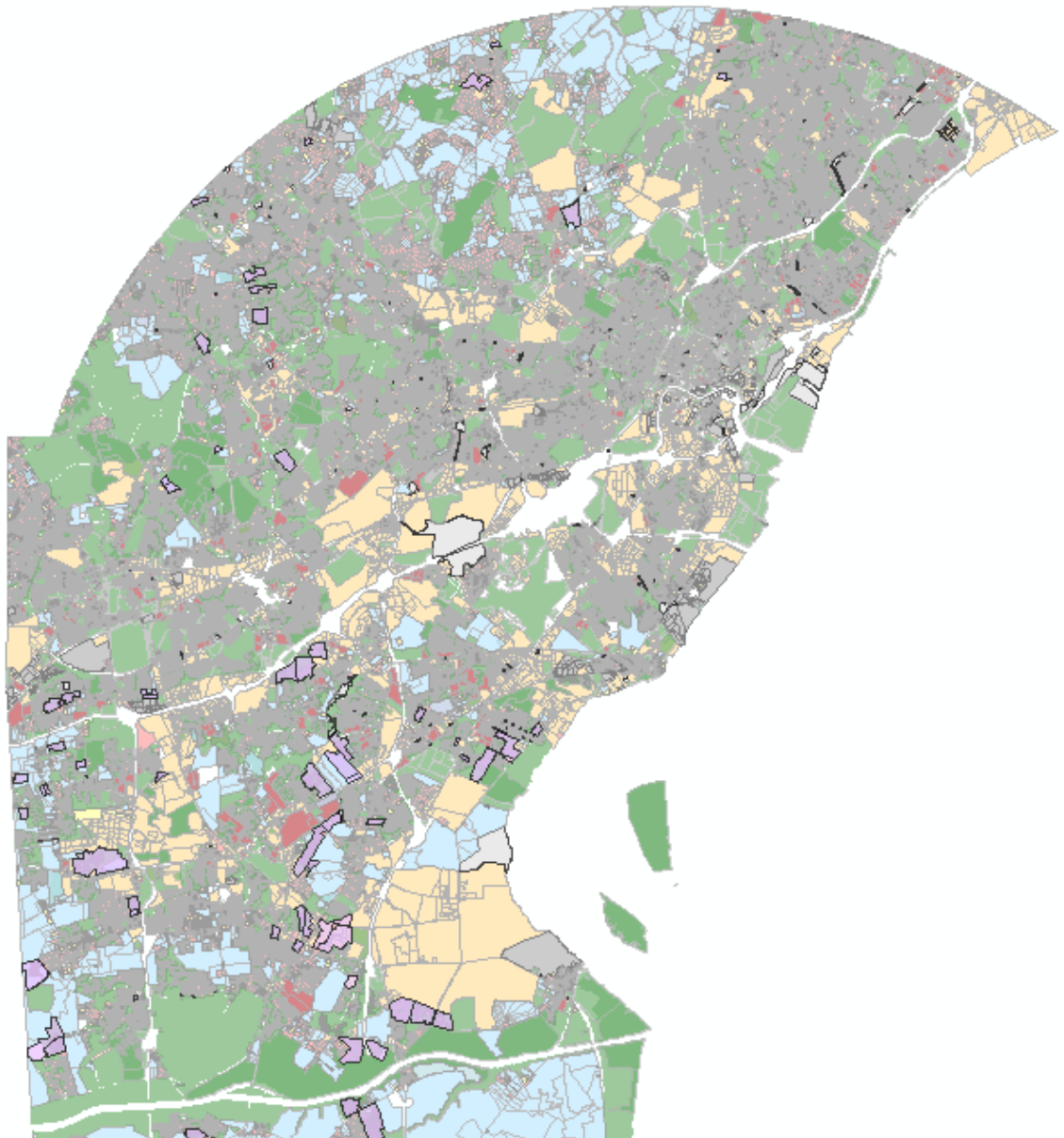


Figure 25, Plots That Were Developed in Southern New Castle County between 1999 and 2009, (Shown with purple shading)

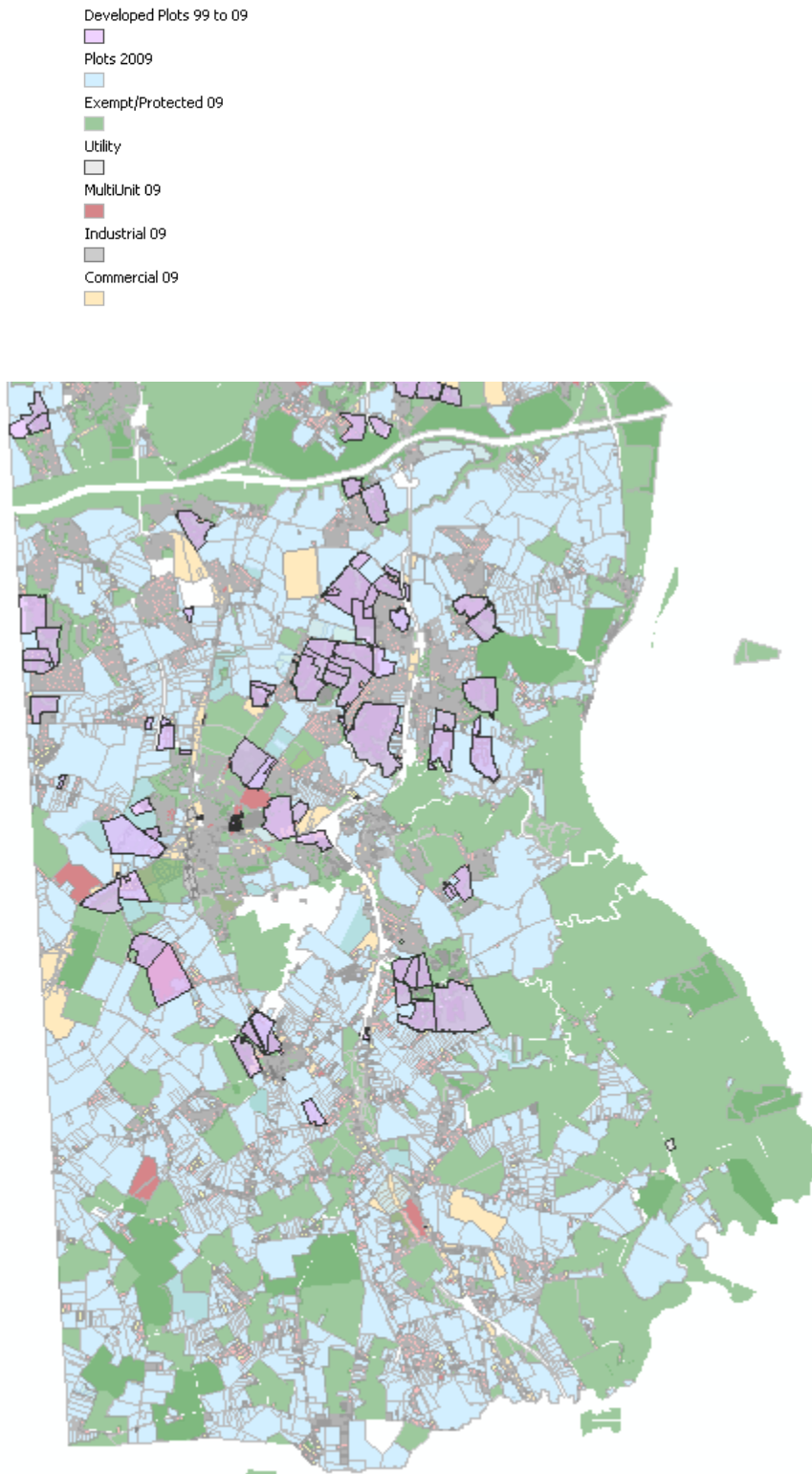


Figure 26, Sewer Service Areas in New Castle County (shown in blue)

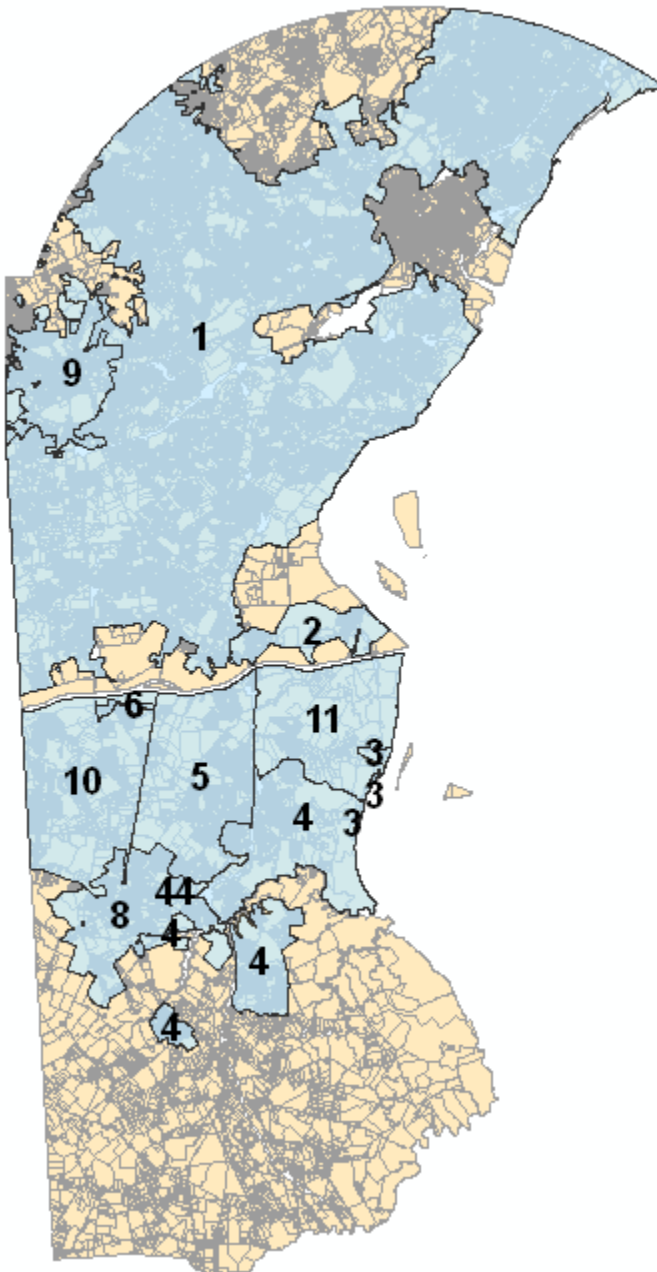
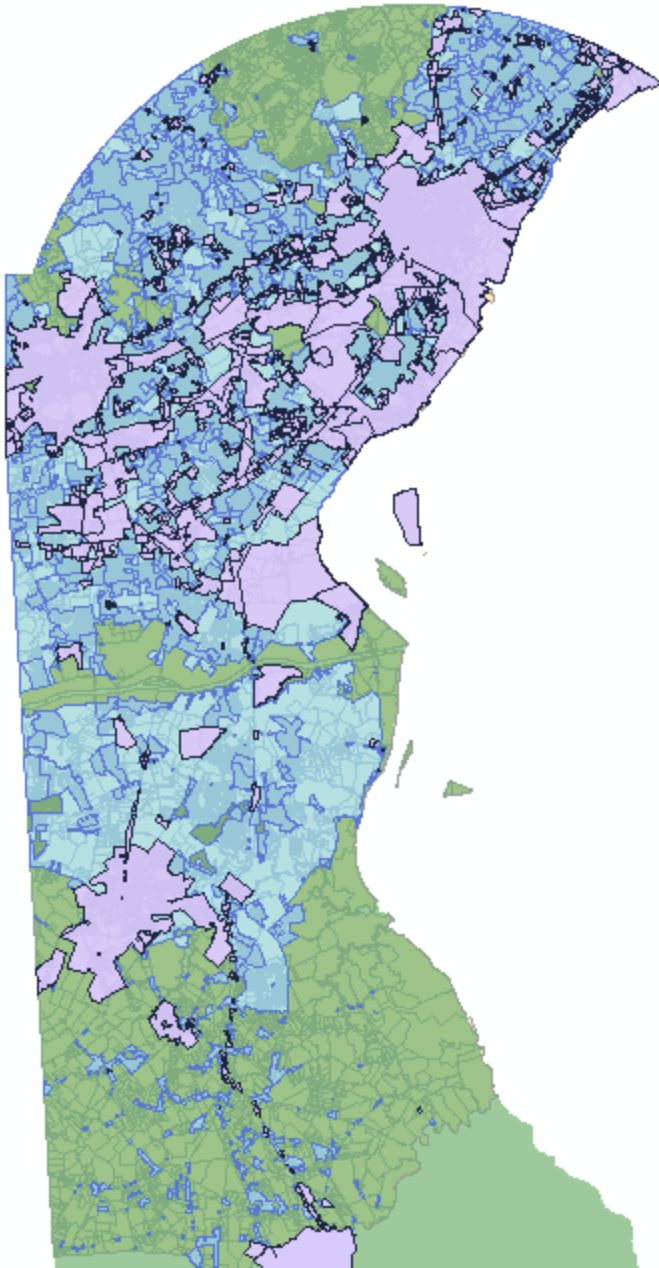


Figure 27, State Land Use Strategies in New Castle County
(Areas of High Growth in purple, Medium Growth in blue, and Lo Growth in green)



PART Three, Development of the Model

The allocation of population and households to traffic analysis zones (TAZ) in Delaware has been done annually in New Castle County and infrequently in the Kent and Sussex counties. The allocation process follows a fairly straightforward method from the top down. First, the expected households were taken as a given by the most recent projection of the Delaware Population Consortium (DPC) for the three counties. In a second stage, the projected increase in households was allocated to the 27 census county divisions (CCD) in the state by county. This is done largely by trend and/or shift/share with input from local planners.

In the second stage of the allocation process all available land that was deemed buildable was summarized by modified grid (a commonly used small demographic unit used in Delaware) . Land that was dedicated open space, in flood plains, in agricultural reserves, in recognized wildlife habitats, or was zoned inappropriately for further subdivision was excluded. This buildable land was categorized into groups (existing lots, lots in new subdivisions, un-subdivided residential land, and farm land) within a given modified grid. Un-subdivided land was split into synthetic lots of a size consistent with recent activity in the CCD.

In the third stage, the estimated lots in the modified grid are accumulated with varying arbitrary weights. Existing lots and lots in new subdivisions have a weight of 1, un-subdivided residential land a weight of 25, and farm land was weighted by .10. With the weighted lots available for each modified grid, each modified grid received the proper proportion of the projected units allocated to the CCD as determined by their share of weighted lots. Experience has shown that this process does not truly reflect the concentrated nature of most development. It also does not utilize much of the attributes readily available about each lot. At the end of the process there was a necessary adjustment process driven by experienced planners conducted at the grid level before aggregating the grids into the TAZ's.

This research is meant to improve on this process by developing a model that operates at the parcel/lot level rather than the more aggregate modified grid level. The model will estimate the probability that each available parcel will be built over a five year period. A model based on this period is justified by the DPC projection process and the inherent volatility associated with shorter periods of time.

In order to build this model each available parcel in the year 2000 assessment database provided by New Castle County was followed annually from the base year through 2005. At the end of the period, the dependent variable took on a value of 1 if it had been built and 0 otherwise. In actuality this process was done backwards from 2010 in order to account for the fact that many parcels in 2000 were subdivided in the intervening years. Thus a parcel that was built by 2005 may not have existed in 2000. Finally, a binary logistic regression model was selected as the most appropriate one to estimate for this situation.

The independent variables were selected from a large set of candidate variables computed from the 10-year time series of factors developed from the assessment files and GIS mapping overlays.. The final set included variables which had both positive and negative expected relationships to the probability that the particular lot would be built. For example, if a lot is in an existing sewer district then it should have a higher probability of being built compared to those that are not. On the other hand, if a lot has been in existence for the last 20 years and yet hasn't been built it should have a lower probability than newer lots. This was an indication that the lot may be irregular or otherwise impaired. Two other variables in the model, both dummy variables, indicated whether the lot was in a subdivision and whether the lot was classified as commercial. The first was anticipated to have a positive sign and the second was expected to have a negative sign.

The more interesting question involved how best to incorporate the spatial distribution of growth. In a sense, this was done previously by allocating households first to the Census County Division (CCD) level. In this model that could be accomplished by introducing dummy variables, one for each CCD less one that would be contained in the constant term. Essentially each CCD variable measures the difference in the probability that a parcel will be built given its current location relative to the omitted CCD. When the forecasted probabilities are summed across all parcels in a given CCD, a forecast of the new units in each CCD is obtained independent of the allocation procedure described above.

While the CCD approach is useful, a close examination of the development process over the past decade suggests a more disaggregated approach would come closer to predicting actual development. Most development has come in small clusters dictated by the subdivision planning process. While subdivisions are not fully developed over night, they tend to be completed within a 15 year time frame other things equal. This clustering suggested the need for a smaller spatial area than that represented by the CCD. The most obvious choice was the Traffic Analysis Zone (TAZ). The metric was defined as the percentage of available lots at the beginning of the period that was built during the time period. Said another way for the preceding 5 year period the number of lots that were built divided by the number of lots available in each traffic zone during the previous 5 year period forms a ratio for each traffic zone which was a TAZ based factor associated with each lot. For the first five year period the measure is highly correlated with the probability that a given property will be built. Since the objective is to project the future probability of construction, the model utilizes the measure lagged one period, i.e. the variable in 2006-2010 reflects the patterns in construction in 2001-2005. To fully implement this variable a measure for TAZ activity was developed for the 1996-2000 period. This variable was included in the 2001-2005 equation.

Residential housing construction has been anything but stable in this decade. For the first 6 years 2001-2006, more than 2000 units (excluding multi-family) were constructed annually. Then in the year following the financial crisis this number was halved to 1000 then again to 500. There has been a modest rebound to 1000 in 2010. This raises the question as to whether a model built on 2001-2005 is at all similar to that for 2006-2010. If they were substantively different then it might raise questions about the accuracy of

forecasts in subsequent five year periods e.g. 2011-2015. To address this issue we estimated a fully interactive model with an interaction term based on time period introduced into the model. The results of this analysis showed significant differences in the coefficients between time periods. It is not surprising that the coefficients estimated for the first time period were significantly higher than for the second time period. The probability that a given parcel would be built was nearly twice as high in the first time period. The question then arises as to which model is more likely to be a better estimator of construction in the future. Given the nature of the housing bubble, the second period model was deemed more likely to approximate the future.

At this stage in the modeling process, we first had to construct the TAZ variable which measures activity in the zone 2006-2010. This will be introduced as the lagged variable for the 2011 period. A second issue arose as the production of forecasted construction began. As was noted earlier, it is not only possible but is certain that lots not in existence at the beginning of the period will be built by the end of the new period. In the new time period, the parcels are either classified as lots or they are synthetic lots, lots derived from un-subdivided land at the beginning of the period. The idea of synthetic lots is fundamental to this modeling approach. Synthetic lots can be seen as “potential” lots. The idea of potential and existing lots was described briefly in the preceding section. Each large land area can be subdivided into a number of housing units and that number can be estimated based on what current zoning would allow and the presence of various kinds of development restrictions like flood plains or wetlands. As land develops large tracts of land called “PLOTS” in this project are converted to lots and the lots are eventually built to create new housing units. One option considered during the project was to develop two separate models, one for the probability of subdivision of Plots and another for the probability that a lot would be built. This proved to be cumbersome as it required two modeling processes and sets of factors. Also records needed to be created in any case to hold information for potential lots both in the master modeling table and the GIS layers that would visualize the projections. The modeling process developed in the project is based on the idea that each plot has potential lot records, called synthetic lots, and relative probabilities are modeled for lots and synthetic lots in the same model. This approach proved to be much easier to implement.

In general, one would expect that synthetic lots would be less probable to be built than existing lots. To reflect this new relationship, the variable NOTLOT was created and estimated for the two preceding time periods. A NOTLOT is a parcel that did not exist at the beginning of the period but was either a vacant lot or a built lot at the end of the period. Predictably, being a notlot reduces the probability of being built in both time periods. NOTLOT proved to be a useful variable for 10 and 15 year projections and to adjust the model based on scenarios or information about properties going through the subdivision process with county government. For the projection period all synthetic lots were classified as notlots.

After constructing the notlot variable the model was re-estimated for both periods. In addition, to the introduction of the new variable one further screen of the parcels to be used in the model was introduced. The parcel at the beginning could only be a notlot or a lot in 3rd quarter of 2005 and it could only be a lot or built in the fourth quarter of 2010. This excluded any record that was essentially non-existent at the beginning and the end of the period. It also excluded lots that became open space or ag-preservation or any other non-buildable category. This set the parcel base at 19,974 of which 6,210 or 31.1% would be built by 2010.

The analysis introduced other influential independent variables to use in the model. A factor `SEWER`, was introduced to reflect that the probability of a lot being built was much higher for lots in a sewer district. This factor took the place of a growth area type factor or factor developed from zoning classifications. Another factor was added for those lots that were zoned commercial (`LOT_C`) these were shown to be less likely to be built as a residential lot. A review of the data also showed a set of widely distributed lots that for some reason were not built through time. Some of these “old” lots were very small or were within environmentally restricted areas. A factor `CAT90n` was introduced and was set to 1 for lots that were lots in 2010 but were also lots in 1990 tax assessment files. The `CAT90n` lots had some probability of development but it was shown to be less than other lots. An additional variable proved significant, within the New Castle County Assessment file a name a subdivision name is provided for 97% of the PLOTS. This was seen as an indicator of consideration for subdivision.

Some 38.5% of the parcels were currently in a sewer zone and only 0.8% were classified as commercial. The old lots, `cat90n`, accounted for 21.3% of the lots and 96.1% were considered to be in subdivisions. Finally, `notlots/synthetic`, accounted for 33.7% of the parcels. The model that resulted predicts 76.1% of the lots built status correctly and the Nagelkerke R Square was calculated as .219 or 21.9% of the variance was explained by the model. All of the variables in the model were significant at the 95% level or better and all but one were significant at the 99% level. The positive effects were associated with sewer, being in a subdivision, and being associated with a TAZ that had a higher level of construction activity in the previous five years. The three negative factors included `comlot`, `cat90n`, and `notlot` as predicted. A summary of the factors and form of the model is provided on the next page.

This model is robust by most social science standards although it will be evaluated based on performance in the future. There appear to be distinct improvements over the previous techniques. First, there is no need to allocate units to the CCD before doing the allocation. Second, it is obvious that new units tend to cluster. Third, it more accurately reflects the characteristics of the parcels. It may be interesting to compare the initial period projection at the aggregated modified grid/TAZ level to that developed in the most recent period by modified grid/TAZ.

Summary of Independent Variables

COMLOT – A vacant lot with commercial zoning

CAT90N – Lots in year 2010 that were also lots in 1990. Many of these are lots that for some reason have not been built and in mapping these many are of very small size or are in floodplains or are in otherwise environmentally restricted.

INSUBDIV – New Castle County Tax Assessment files include a variable that lists a subdivision name. This subdivision name is available for any lots in established subdivisions but also is sometimes available for larger tracts of land indicating that it is part of a future plan for subdivision. This factor proved to be significant during the modeling process and could be further examined for accuracy and use in models.

SEWER – A factor indicating whether the lot was within an existing sewer system area. This variable could be altered for a projection time period if it was thought that sewer service was begin extended in parts of the County

NOTLOT – This is a designator for a synthetic lot. Lots that show on current tax parcel maps have a value of zero for this factor, synthetic lots have a value of one. In general an existing lot is expected to have a higher probability for development than one that would be created during a future subdivision of a large land tract.

TAZVAR0610 – Named for the 5 year period the variable refers to, this is a traffic zone level factor and is the ratio of the number of properties that were built in the previous 5 year period in the traffic zone the property is within, to the number of lots that were available in the previous 5 year period in the traffic zone the property is located. This is the factor that indicates current building activity.

Specification Of The Model

The probability that a lot will be developed in the first 5 year period is given as:

$$\text{PROB1115} = \frac{e^Z}{(1 + e^Z)}$$

Where

$$Z = -1.240 + \text{COMLOT} * -498 + \text{CAT90n} * -1.705 + \text{INSUBDIV} * 0.870 \\ + \text{SEWER} * -0.307 + \text{NOTLOT} * -1.883 + \text{TAXVAR0610} * 1.261$$

This probability was based on the building of 10,172 lots in the 5 year modeling period.

PART Four, Use and Examination of the Model

The section examines the process of using the allocation model to develop a projection for future building of lots.

Step One, Specification of the Model

Part Two of this report explains the development of a model that specifies the probability of lots being built. Given the time available for the research this was the best that could be determined but of course other models are possible that might use other factors. As more information is collected thru time the model could be updated or new models could be developed. The model was built on a database that categorized different types of properties, and developable land is seen as made up of either “Lots” which are actual subdivided single unit tax parcels that are currently visible in tax parcel maps, and as “Synthetic Lots” which are those potential housing units that could be developed from subdivision of larger tracts of land. The independent variables for the model are summarized on the preceding page. The first step is to update or correct all of these factors and to insure that land use classifications are correct.

Step Two, Update of the Master Property Table

The master table includes over 190,000 records for existing properties that are classified as shown in figure 1. With the time and data available this project established this classification but certainly there are corrections that could be made and each year classifications change. For instance updates could be made for lots that are created and built, properties that go from residential to commercial, properties that are classified as undevelopable, or large tracts of land believed to be preserved are subdivided. There are also about 37,800 synthetic lots that were created. Synthetic lots take on the factors (such as SEWER and INSUB) of the parent parcel they were made from. The model is applied to Lots and Synthetic Lots and the classification needs to best reflect what is known about the availability of properties for development. Working at the very detailed tax parcel level involves a continuous and detailed update process. This is facilitated greatly by GIS and continuous involvement of a number of sources for the information. Classifications of properties and model factors need to be updated in the master property table each time a projection is run. The factors used in the model also need to be updated. If sewer service has been extended or expected to be extended in the future then data for properties that are newly within services areas needs to be updated. Building activity in the prior 5 years and any new information that appears in the model factors needs to be updated

Step Three, Calculate modeled probabilities to be built and adjust probabilities based on expected growth

The probability that a lot or synthetic lot will be built is calculated by the model as

$$z1115 = -1.240 + \text{comlot} * -498 + \text{cat90n} * -1.705 + \text{insubdiv} * 0.870 + \text{sewer} * 0.307 + \text{notlot} * -1.883 + \text{blto610} * 1.261.$$

$$\text{prob1115} = \exp(z1115) / (1 + \exp(z1115)).$$

This is calculated for Lots and Synthetic Lots in 2010. As the model was built on 5 years of data where 10172 properties were built, the sum of the probabilities will equal 10,172. However if we are looking at the period between 2011 and 2015 the Delaware Population Consortium estimates that in New Castle County, 9,550 will be added/built so the probabilities to use for the 2011 to 2015 forecast will need to be adjusted to this control total. As less lots are being built the probability of lots being built is slightly less.

$$\text{Prob1115adj} = \text{Prob1115} * 9550 / 10172$$

Step Four, Selecting what lots will be built in the selected time period

To project what lots to select as built, the lots with the highest probability would be selected and this would be the best guess even though it is known that properties with a smaller probability of being built as specified by the model will be seen as built once we obtain the actual data for the time interval in the future. Selecting where lots will be built in this first stage for the year 2011 to 2015 projection period comes down to selecting the top 9550 lots (number of housing units projected from DPC) from a list ranked by highest probability.

Step Five, Examining Results

SPSS statistical software was used to do modeling and data table calculations in this project but other programs that work with tabular data would work. The master table including probability calculations was exported in a DBASE format and added to ArcMap which was the GIS platform used for the project. The current tax parcel polygon layer and the synthetic lots point file were both joined to the master table with probabilities and a thematic map was created to show the distribution of the modeled probabilities for lots being built. As the calculations are very straightforward master tables could be manipulated in GIS software such as ArcMap without the use of other software to manipulate tables. Maps of the resulting probabilities follow. The map layers shown and the master table are all in the project data collection for more detailed review. Tax parcels with no color are either built residential lots or non-residential.

The points are synthetic lots representing potential development and are colored by their estimated probability for becoming built lots. The number of synthetic lots in each large tax parcel they are within is the number estimated that can be supported by current zoning.

If a selection was made of the most probable 9550 that would become lots then those properties would be greater than a .46 probability and these are shown in orange or red in the maps. The highest probability for synthetic lots for this 5 year estimate was 0.24 and none would be selected for being built.

**Figure 28, Lots projected to be built between 2011 and 2015
(shown in orange)**



Figure 29, Distribution of Probabilities for Lot Construction in 2011 to 2015 with Synthetic Lots (points) included. Below and above the C&D Canal in New Castle County, (orange are projected lots to be built)



Step Six, Adjustments

Various adjustments can be made to the base data. Each year there is new information, and factors and property classifications can change. Putting the data together for New Castle County in this project was a very time consuming effort and serves as a good start but certainly there is a great deal of other information about properties at this tax parcel layers. Specific information will come to light from various sources that certain properties may have new or corrected classifications or have a much lower or much higher probability of development and new information can be added to make better predictions. Planners also are frequently involved in scenario analysis and will be interested in what future development patterns may take place in the future if a certain large scale development takes place or is encouraged in various parts of the county, and classifications, factors, and probabilities could be adjusted and new projections made. Probabilities of development in a particular projection period could be forced to lower or higher probabilities (like 1.0) to study effects. Use of GIS can greatly facilitate update of the model and examination of scenarios

New Castle County government tracks development activity through the subdivision process and this is very good source of information for what will be coming in the future and an adjustment that would be desirable to incorporate. This is a simple but important example. Figure 30 shows large tracts of land outlined in pink that are currently listing as places where there is a subdivision plan “PENDING” approval in the New Castle County. This represents close to 1000’s of new lots that have a high probability of being added in the next few years. Figure 31 also on the next page shows synthetic points and their probabilities, some of which are higher assuming subdivision plans were approved.

The following developments are listed as pending subdivisions:

| Development Name | Lots |
|---------------------------|-------------|
| Spring Oaks | 242 |
| Carter Farm | 36 |
| Deats Farm | 1381 |
| Church Town | 73 |
| Village of Scott Run | 273 |
| Ashby’s Place | 54 |
| Boyds Corner Farm | 287 |
| High Hook Farms | 390 |
| Wilchelsea | 618 |
| Windsor Commons at Hyetts | 316 |
| Lightkkkk | 54 |
| Port Penn Assemblage | 505 |
| Wrnkkk Tract | 143 |
| Oasis at Cypress Ridge | 29 |

The subdivision activity data was a few months older than the November 31, 2010 version of the tax parcel map some of these had been approved and lots are shown within and are expected to be developed in the first 5 year projection period.

Figure 30, Properties Shown as “PENDING” in New Castle County Development Activity Process (shown outlined in pink)

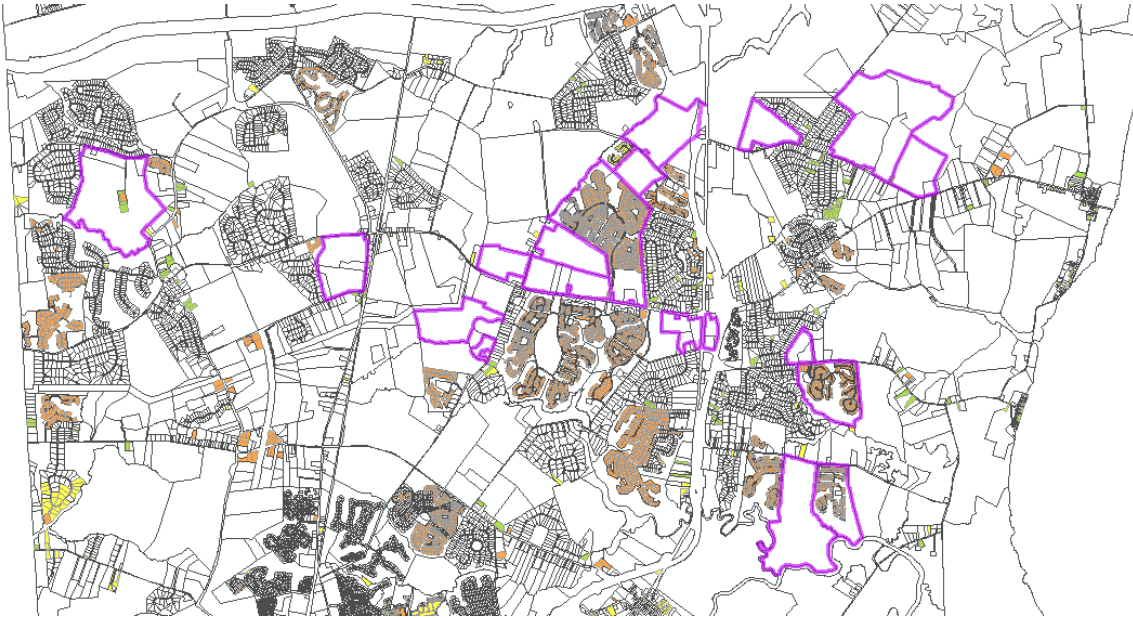


Figure 31, PENDING Subdivisions (outlined in pink) Shown With Lots and Synthetic Lots, Before Adjusting for Pending Subdivision Activity



An update to the data that would take into account the additional information known about subdivision activity and would involve first adjusting the number of synthetic lots currently estimated for the property to match the lots listed in the subdivision plan. The master table would be edited to add or delete synthetic parcel records and the GIS point file would be also edited to add or delete synthetic parcels. The inclusion of the factor NOTLOT in the model facilitates this kind of adjustment. As indicated before, NOTLOT is a factor that takes into account that a property that is an existing approved lot has roughly 4 times the probability of being built in 5 year period than a lot that would have to be created as part of a subdivision process and then built. Synthetic lots have a value of 1 for the NOTLOT factor. Changing this value to zero for the PENDING areas is expected to produce the desired adjustment. Figure 32 below shows how probabilities for synthetic lots have increased when compared to figure 31 on the previous page. Increased probabilities based on the knowledge of subdivision activity would project some synthetic lots to be built in the first 5 year projection period.

A similar adjustment could be made to examine various scenarios that look at the effect of large amounts of development in a particular area. Factors for synthetic lots could be changed through the NOTLOT and INSUBDIV values. New sewer service projected for currently unserved areas could be modeled by changing the SEWER factor. It is also possible to assign a probability of 1 to any lot to insure it is built in a projection period of interest. Part of the power of a tax parcel based approach is to be able to track and take advantage of detailed property level information. A careful review of the data each year and updates of categorizations could show improvements in estimates.



Figure 32, Probabilities for Development of Lots and Synthetic Lots Taking Into Account Pending Subdivision Activity, Synthetic Lots in Orange Now Projected To Be Built in 2011 to 2015

Ten Year Projections – Strict Application of the Model

The previous discussion showed how we can use the logistic regression to estimate the odds that one parcel becomes developed relative to another. Because we assume that these relative probabilities remain fixed over five years, they can be scaled to reflect how much the assumed amount of development that would occur in the next five years. This allows us to forecast which parcels are more likely to be developed in the next five years. In the following discussion, we briefly sketch out how such a model could be iterated so that the five year forecast is used to make predictions for the ten year forecast.¹

There are four steps in this iteration:

1. The analyst must predict the total amount of development that can be expected to occur between time periods $t+6$ and $t+10$.
2. The predicted amount of development between time periods $t+1$ and $t+5$ are used to update our expectations about the future characteristics of each parcel.
3. The expected future characteristics interact with the model's estimated parameters so that a new set of relative probabilities are created.
4. The new set of relative probabilities is scaled to reflect the total development that is assumed to occur between time periods $t+1$ and $t+10$.

The first step requires that an analyst use aggregate projections from outside sources to determine the total development that will occur in the future. Such projections might rely on demographic or macroeconomic forecasts. The projections could also come from scenario analyses. This is provided by Delaware Population Consortium estimates.

The second step uses the 2015 predictions to update the expected value of each variable. Six variables are updated based on the 2015 predictions: NOTLOT, INSUBDIV, CAT90, TAZVAR, COMLOT, and SEWER.

The NOTLOT variable needs to be updated because it indicates which parcels become lots, and therefore indicates that they are ready for development. However, as development occurs, properties that were not lots have a chance of becoming lots in the future. In fact, parcels that are most likely to be developed, are also likely to become lots.

The INSUBDIV variable indicates that an undeveloped property is planned to be turned into a subdivision. However, properties that are more likely to develop are also more

¹ We caution the reader that the model was designed for a five year-ahead forecast. Iterating this model necessarily compounds the forecast error. This reflects the fact that the greater extrapolation yields greater error.

likely to be given a subdivision name. This is similar to our reasoning behind updating the NOTLOT variable.

The CAT90 variable indicates which undeveloped properties were lots ready to be developed in 1990. Though less likely, some of these properties will be developed so CAT90 needs to be adjusted.

The TAZVAR indicates which other properties in a particular traffic analysis zone (TAZ) are developed. If we have estimates on which properties will likely be developed, then we would also have estimates on how many properties develop in a TAZ. Thus, this variable also requires updating based on our model results.

The SEWER and COMLOT variables are mostly controlled by policy makers. We have no prior beliefs as to how development will change the sewer districting and commercial zoning. Therefore, these variables do not change in the updates. Specific assumptions and details for each variable are made in an appendix.

To proceed with this estimate, we relied on our model parameters one more time so that we could estimate a new set of relative probabilities. This new set of probabilities was normalized to reflect chances that the property would be developed in between 2016 and 2020. Finally, we combined these new estimates with the probability that a property was developed between 2011 and 2015 to yield the ten year forecast. Details of this procedure are given in the appendix.

A map of probabilities for showing a 10 year projection is shown on the next page and are similar to what was provided in other methods discussed next. Estimating the probabilities and future independent variables is an involved process and more involved going out 20 or 30 years. It is suspected that algorithms could be developed for 20 or 30 year projections with this more rigorous approach to the calculation. In practice without such algorithms the calculation could be difficult.

Ten Year Projection – 5 year model on 10 year projection number

Another approach to extend the model would be to use the five year factors but apply a control total of housing units to be added that included 10 years of projected growth. This provides a simple means to extend the forecast past five years. For instance Delaware Population Consortium Figures estimate county housing units to be added in the period of years 2010 to 2050 to be 9550. In the period between 2010 to 2020, 17789 housing units are projected to be added to New Castle County. If about 17789 housing units are selected to be built from most probable lots and synthetic lots in the master table the picture would as shown in figure 34. The calculation of probabilities in that figure includes the adjustment for PENDING subdivision.

Figure 33, Probability Distribution For A 10 Year Projection Involving Re-estimation of Factors From Analysis of Probabilities.
(Polygons and points in orange and red projected to be built. Does not take into account pending subdivision.)



Figure 34, 10 year projection (2011 to 2020) produced by 10 year DPC projection on 5 year model
Orange and Red lots are expected to be built (Red – probability 0.4 to 0.67, Orange 0.15 to 0.4, Yellow 0.01 to 0.10)



Ten Year Projection – Removing Modeled Built Properties, Recalculating Factors and Applying Model

Another approach to the ten year or more forecast using the model would be to assume the projected housing units for the initial 5 year period are built and then remove them from consideration for the next 5 year period by reclassifying them as built, and then recalculate factors and re-estimate probabilities for the next 5 year period based on the assumption that they were built. This would have the advantage of a re-estimation of the traffic zone activity variable and does not involve a recalculation of factors based on a probability analysis. Time available for this project did not allow for examination of this approach, but it seems promising particularly for a 15 year projection. The first 10 years of any projection methodology is expected to be dominated by existing lots and pending subdivision activity. The first 10 years could be projected thru a rigorous application of the model involving algorithms taking into account a study of the probabilities of factors, or for simplicity, applying 10 year growth totals to the 5 year model. Once there was a 10 year projection, the projected 10 year growth could be assumed and properties selected as built could be removed a factors for remaining developable land could be calculated in an easier fashion. It is as if the process is starting over from the beginning after the first 10 year projection.

Comparison of Model Projection with Currently Used Traffic Zone Allocations

With an expected improved accuracy resulting from building the model from more specific data at the tax parcel level it is thought that these new models would be an improvement to methodologies used in the past. A more thorough construction of projections and a study of results is needed. It is interesting to make a comparison with current projections for the first 10 years. A 5 year and 10 year projection was generated using the project model after first taking into account pending subdivision activity. The number of housing units per traffic zone between year 2020 generated from the model was subtracted from the difference in the number of housing units between years 2020 and 2010 for the current projections and is mapped in figure 35. Big negative numbers in dark green are areas where the model projected more growth. The map shows the model putting more construction below the canal than the current methodologies. The bottom 5 of these ranging from -525 to -245 were investigated and it seems that pending developments* were not taken into account in the current methodologies. The current method shows in red a few traffic zones where there were 300 or more new lots built as compared to the modeled projection. Discussion with county land use planners referenced specific development activity not tabulated in this projects master table. Having the GIS mapping allows for study of particular results and maps for Traffic Zone 178, Traffic Zone 212, Traffic Zone 113, and Traffic Zone 340 are provided as examples in figures 38 thru 41 .

* Bayberry North, Port Penn Assemblage, Boyds Corner Farm, Carter Farm, and High Hock Farms

FIGURE 35 Comparison of Model Projection for 2020 Compared to Current Traffic Zone Projections. MODEL minus CURRENT

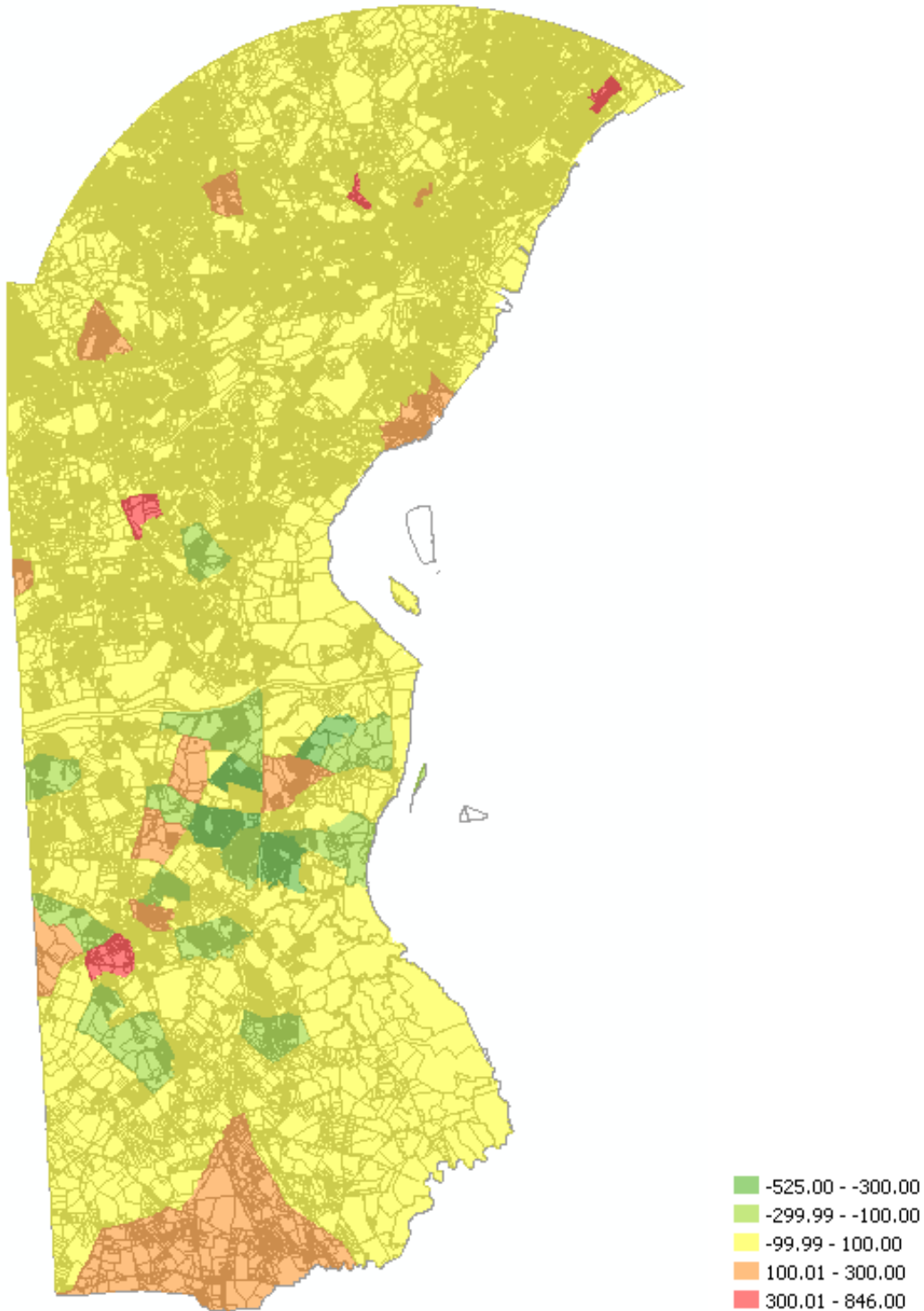


Figure 36, Projection Comparison by Traffic Zone of Current Allocation with Project Model Allocation, Records Showing Model Estimating More Construction (model preceded by “m”, current preceded by “w”

| taz | tazn | m2010 | m2015 | m2020 | w2010 | w2015 | w2020 | df10to20 | |
|-----|------|-------|-------|-------|-------|-------|-------|----------|--|
| 332 | 332 | . | . | . | 0 | 0 | 0 | . | |
| 335 | 335 | . | . | . | 0 | 0 | 0 | . | |
| 341 | 341 | . | . | . | 105 | 108 | 110 | . | |
| 280 | 280 | 82 | 82 | 1245 | 77 | 420 | 715 | -525.00 | bayberry north, windsor commons at hyett |
| 284 | 284 | 82 | 82 | 749 | 78 | 213 | 344 | -401.00 | Port Penn Assemblage |
| 274 | 274 | 52 | 697 | 1187 | 52 | 317 | 813 | -374.00 | Boyd's corner farm |
| 321 | 321 | 332 | 882 | 885 | 318 | 422 | 538 | -333.00 | High Hock Farms |
| 193 | 193 | 225 | 763 | 769 | 221 | 331 | 491 | -274.00 | Carter Farm |
| 197 | 197 | 887 | 1025 | 1220 | 902 | 952 | 990 | -245.00 | synthetic lots modeled to be built |
| 192 | 192 | 237 | 565 | 567 | 219 | 283 | 349 | -200.00 | |
| 191 | 191 | 435 | 763 | 764 | 531 | 597 | 663 | -197.00 | |
| 194 | 194 | 248 | 711 | 711 | 237 | 350 | 506 | -194.00 | |
| 302 | 302 | 416 | 829 | 829 | 394 | 505 | 620 | -187.00 | |
| 195 | 195 | 29 | 29 | 261 | 32 | 57 | 82 | -182.00 | |
| 190 | 190 | 185 | 609 | 614 | 180 | 303 | 429 | -180.00 | |

Figure 37, Projection Comparison by Traffic Zone of Current Allocation with Project Model Allocation, Records Showing Model Estimating Less Construction (model preceded by “m”, current preceded by “w”

| taz | tazn | m2010 | m2015 | m2020 | w2010 | w2015 | w2020 | df10to20 |
|-----|------|-------|-------|-------|-------|-------|-------|----------|
| 216 | 216 | 16 | 16 | 95 | 23 | 127 | 253 | 151.00 |
| 316 | 316 | 481 | 481 | 484 | 478 | 590 | 667 | 186.00 |
| 314 | 314 | 14 | 14 | 132 | 13 | 200 | 398 | 267.00 |
| 210 | 210 | 772 | 814 | 1006 | 978 | 1293 | 1481 | 269.00 |
| 339 | 339 | 314 | 314 | 592 | 350 | 626 | 916 | 288.00 |
| 340 | 340 | 6 | 6 | 6 | 75 | 219 | 381 | 306.00 |
| 212 | 212 | 1 | 1 | 2 | 2 | 169 | 330 | 327.00 |
| 178 | 178 | 91 | 91 | 92 | 256 | 456 | 656 | 399.00 |
| 113 | 113 | 785 | 818 | 825 | 776 | 1383 | 1662 | 846.00 |

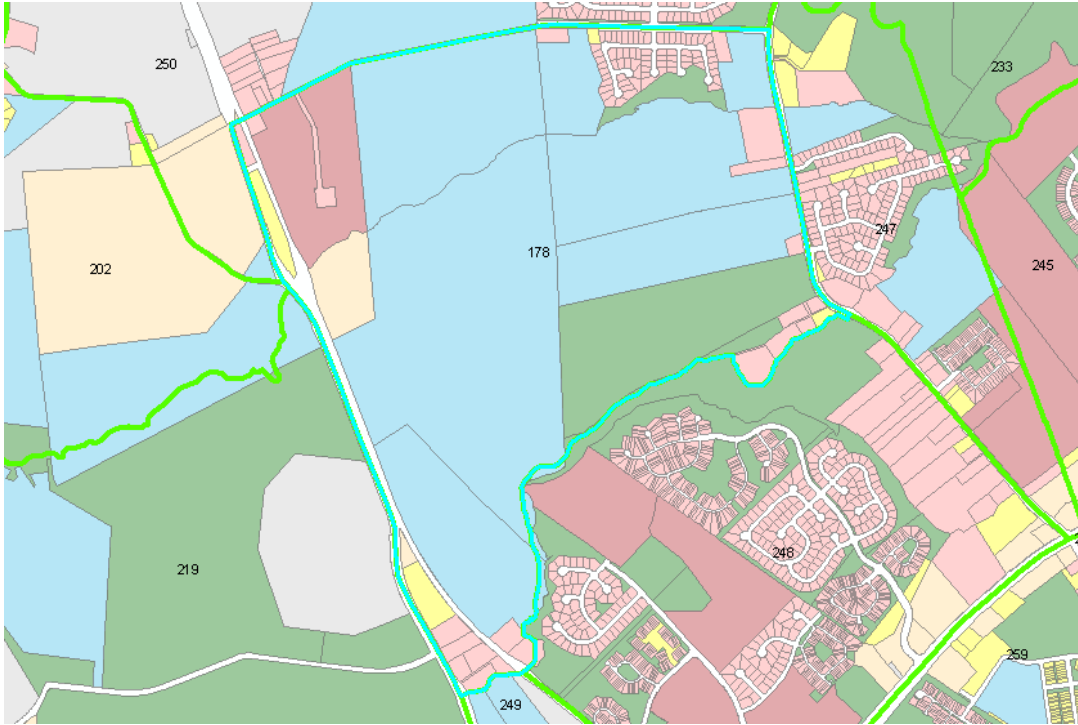
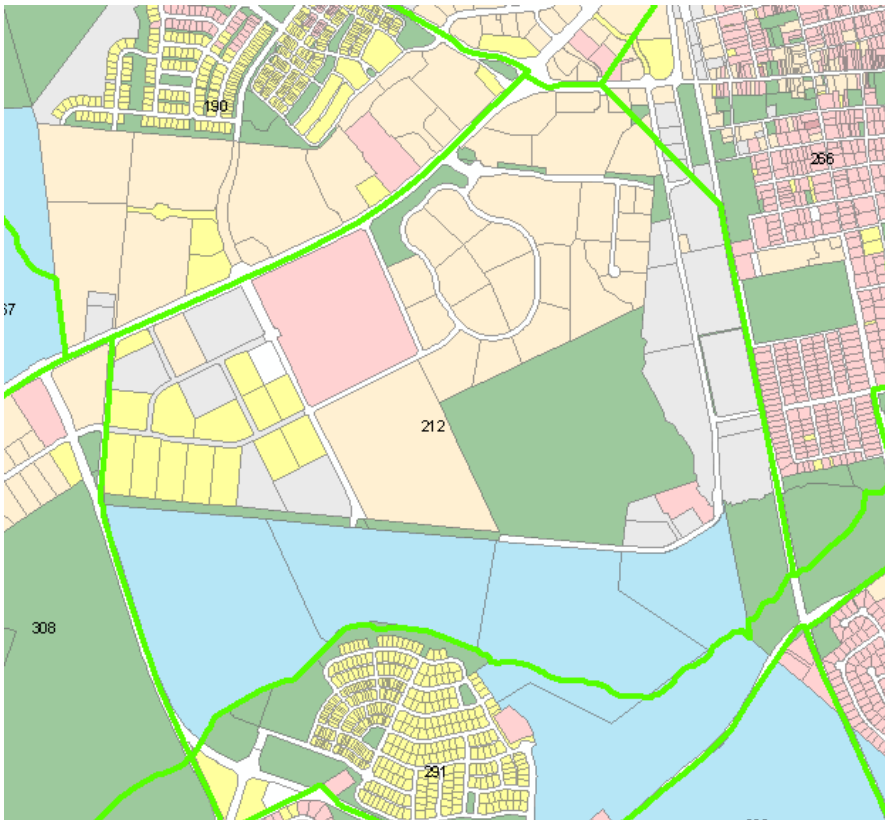
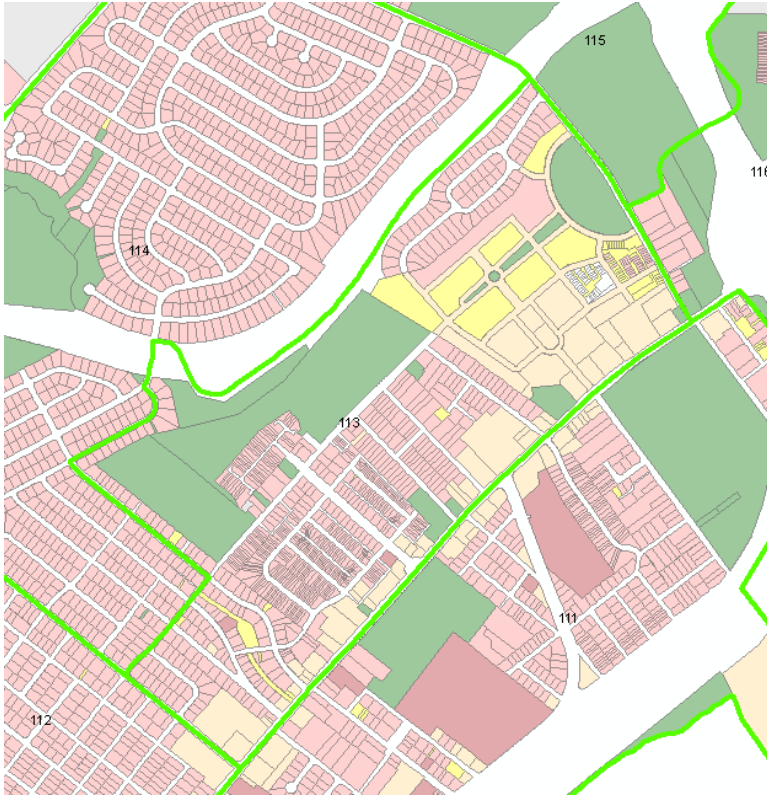
Figure 38, Land Use in Traffic Zone 170**Figure 39, Land Use in Traffic Zone 212**

Figure 40, Land Use in Traffic Zone 113**Figure 41, Land Use in Traffic Zone 330**

Part Five, Going Forward and Conclusions

Travel demand forecasting and land use tracking has moved to the very detailed tax parcel level and there is a need to have a resource that planners can work with. The tax parcel maps together with the master categorization and modeling table provide a powerful framework to capture data at this detailed level. There was a large effort to compile the base data that serves as a good starting point for future efforts.

There are some advantages to the model presented over current practices:

- * Much more detailed data and views to examine projections and drivers of growth are available.
- * Avoidance of steps that depend first on projections at the Planning District Level
- * The modeling process developed is more easily understood, modified, and implemented by Planners. Examination of growth scenarios is much easier to understand and implement
- * At the tax parcel level there are more possibilities to integrate information with other data sets across purposes. There is a large amount of addressed based land use information that can be incorporated.
- * Once projections are developed they are reviewed by several agencies and individuals and through various types of collaboration adjustments are made. This detailed level assists in making adjustments that can be more easily visualized and justified.
- * the model deals only with residential land uses but the overall data structure could support analysis and tracking of commercial uses, employment, and trip attractors.

The best test of the model is examine how it performs through time as data is updated from year to year. Perhaps other useful factors could be discovered to incorporate into the model. Other next steps for a better model include:

- * Review and update of all land use classifications and model factors
- * Further development of methods for associating information with land use at the tax parcel level.
- * Addressing multi-family housing better. The data includes location of multi-family housing in 2010 but does not model its creation in projections. With the down turn in the economy, some indications are that more multifamily housing will be created in the future and there could be significant effects that have not been considered.
- * The model does not deal with vacancy information but the datasets and modeling procedures could take advantage of vacancy classifications.
- * the model does not work with reconstruction of the housing base, perhaps there would be some usefulness in examining this.
- * the modeling process for 15, 20, and longer term projections could be facilitated by developing algorithms for estimating future factors in a way that is more true to the probabilities and expectations in the model. Initial indications are that it might be possible within a reasonable amount of effort to automate the projection process.

Appendix

Comparison of Model and Current Traffic Zone Projections

Model includes Pending development, Current 2/1/2011 Projections from WILMAPCO

TAZ=Traffic Zone M10 = Model 2010 M15=Model 2015 M20=Model 2020
W10 = Current Projections 2010 W15 – Current 2015 W20- Current 2020

TAZ M10 M15 M20 W10 W15 W20 (W20 – W10) – (H20 – H10)

| | | | | | | | |
|----|------|------|------|------|------|------|--------|
| 1 | | | | 87 | 87 | 87 | |
| 2 | 1 | 1 | 1 | 279 | 279 | 279 | .0 |
| 3 | 36 | 36 | 38 | 150 | 150 | 150 | -2.00 |
| 4 | 5 | 5 | 5 | 142 | 146 | 150 | 8.00 |
| 5 | | | | 1 | 1 | 1 | |
| 6 | 65 | 65 | 65 | 308 | 310 | 312 | 4.00 |
| 7 | 6 | 6 | 6 | 26 | 26 | 26 | .0 |
| 8 | | | | 33 | 33 | 33 | |
| 9 | | | | 28 | 33 | 38 | |
| 10 | | | | 12 | 12 | 12 | |
| 11 | 11 | 11 | 17 | 9 | 9 | 9 | -6.00 |
| 12 | 186 | 186 | 186 | 226 | 226 | 226 | .0 |
| 13 | 1 | 1 | 1 | 59 | 59 | 59 | .0 |
| 14 | 513 | 523 | 523 | 786 | 786 | 786 | -10.00 |
| 15 | 333 | 333 | 339 | 566 | 566 | 566 | -6.00 |
| 16 | 1117 | 1131 | 1170 | 1142 | 1149 | 1156 | -39.00 |
| 17 | 223 | 231 | 235 | 165 | 170 | 175 | -2.00 |
| 18 | 775 | 795 | 811 | 897 | 907 | 916 | -17.00 |
| 19 | 85 | 85 | 86 | 490 | 490 | 490 | -1.00 |
| 20 | 1152 | 1163 | 1163 | 1323 | 1323 | 1323 | -11.00 |
| 21 | 506 | 507 | 512 | 776 | 776 | 776 | -6.00 |
| 22 | 339 | 339 | 344 | 611 | 611 | 611 | -5.00 |
| 23 | 1113 | 1130 | 1130 | 1221 | 1221 | 1221 | -17.00 |
| 24 | 1068 | 1072 | 1082 | 1201 | 1201 | 1201 | -14.00 |
| 25 | 511 | 511 | 511 | 536 | 536 | 536 | .0 |
| 26 | 258 | 258 | 261 | 479 | 479 | 479 | -3.00 |
| 27 | 536 | 536 | 537 | 2383 | 2383 | 2383 | -1.00 |
| 28 | 719 | 723 | 723 | 827 | 961 | 971 | 140.00 |
| 29 | 317 | 317 | 320 | 310 | 319 | 329 | 16.00 |
| 30 | 579 | 582 | 582 | 791 | 791 | 791 | -3.00 |
| 31 | 114 | 117 | 117 | 114 | 114 | 114 | -3.00 |
| 32 | 225 | 225 | 232 | 678 | 678 | 679 | -6.00 |
| 33 | 921 | 939 | 939 | 1400 | 1408 | 1417 | -1.00 |
| 34 | 450 | 450 | 452 | 634 | 634 | 634 | -2.00 |
| 35 | 548 | 549 | 555 | 1065 | 1068 | 1069 | -3.00 |
| 36 | 894 | 897 | 914 | 921 | 921 | 921 | -20.00 |
| 37 | 760 | 771 | 771 | 928 | 931 | 934 | -5.00 |
| 38 | 915 | 927 | 931 | 1093 | 1094 | 1094 | -15.00 |

Comparison of Model and Current Traffic Zone Projections

Model includes Pending development, Current 2/1/2011 Projections from WILMAPCO

TAZ=Traffic Zone M10 = Model 2010 M15=Model 2015 M20=Model 2020
W10 = Current Projections 2010 W15 – Current 2015 W20- Current 2020

| TAZ | M10 | M15 | M20 | W10 | W15 | W20 | (W20 – W10) – (H20 – H10) |
|------------|------------|------------|------------|------------|------------|------------|-----------------------------------|
| 39 | 752 | 752 | 758 | 1075 | 1130 | 1135 | 54.00 |
| 40 | 1344 | 1350 | 1350 | 1333 | 1333 | 1333 | -6.00 |
| 41 | 1112 | 1112 | 1119 | 1268 | 1275 | 1281 | 6.00 |
| 42 | 63 | 63 | 63 | 147 | 188 | 192 | 45.00 |
| 43 | 216 | 231 | 231 | 319 | 328 | 338 | 4.00 |
| 44 | 208 | 208 | 211 | 169 | 170 | 172 | .0 |
| 45 | 0 | 0 | 1 | 0 | 0 | 0 | -1.00 |
| 46 | | | | 0 | 0 | 0 | |
| 47 | 842 | 842 | 856 | 785 | 785 | 785 | -14.00 |
| 48 | 604 | 613 | 613 | 1408 | 1411 | 1414 | -3.00 |
| 49 | 47 | 47 | 52 | 209 | 210 | 211 | -3.00 |
| 50 | | | | 0 | 113 | 116 | |
| 51 | 18 | 18 | 20 | 16 | 19 | 21 | 3.00 |
| 52 | 1 | 1 | 1 | 0 | 0 | 0 | .0 |
| 53 | | | | 0 | 0 | 0 | |
| 54 | 138 | 139 | 139 | 1441 | 1485 | 1518 | 76.00 |
| 55 | 546 | 551 | 553 | 780 | 793 | 806 | 19.00 |
| 56 | 1415 | 1423 | 1424 | 1707 | 1708 | 1710 | -6.00 |
| 57 | 234 | 234 | 236 | 921 | 921 | 922 | -1.00 |
| 58 | 495 | 496 | 496 | 474 | 474 | 474 | -1.00 |
| 59 | 425 | 427 | 427 | 410 | 410 | 410 | -2.00 |
| 60 | 592 | 599 | 599 | 717 | 718 | 718 | -6.00 |
| 61 | 8 | 12 | 14 | 70 | 71 | 72 | -4.00 |
| 62 | 254 | 256 | 256 | 452 | 452 | 452 | -2.00 |
| 63 | 1094 | 1101 | 1101 | 1343 | 1355 | 1366 | 16.00 |
| 64 | 1128 | 1134 | 1135 | 1089 | 1090 | 1090 | -6.00 |
| 65 | 845 | 847 | 847 | 809 | 810 | 810 | -1.00 |
| 66 | 1252 | 1257 | 1257 | 1203 | 1210 | 1217 | 9.00 |
| 67 | 1090 | 1090 | 1091 | 1187 | 1188 | 1188 | .0 |
| 68 | 1151 | 1164 | 1184 | 1172 | 1179 | 1185 | -20.00 |
| 69 | 158 | 158 | 158 | 152 | 152 | 153 | 1.00 |
| 70 | 908 | 963 | 965 | 890 | 917 | 945 | -2.00 |
| 71 | 452 | 459 | 459 | 443 | 443 | 443 | -7.00 |
| 72 | 28 | 28 | 29 | 36 | 40 | 44 | 7.00 |
| 73 | 9 | 9 | 9 | 627 | 647 | 667 | 40.00 |
| 74 | 162 | 166 | 168 | 174 | 176 | 177 | -3.00 |
| 75 | 272 | 274 | 281 | 272 | 276 | 279 | -2.00 |
| 76 | 105 | 106 | 107 | 265 | 269 | 274 | 7.00 |
| 77 | 71 | 71 | 73 | 80 | 81 | 83 | 1.00 |

Comparison of Model and Current Traffic Zone Projections

Model includes Pending development, Current 2/1/2011 Projections from WILMAPCO

TAZ=Traffic Zone M10 = Model 2010 M15=Model 2015 M20=Model 2020
W10 = Current Projections 2010 W15 – Current 2015 W20- Current 2020

| TAZ | M10 | M15 | M20 | W10 | W15 | W20 | (W20 – W10) – (M20 – M10) |
|------------|------------|------------|------------|------------|------------|------------|-----------------------------------|
| 78 | 504 | 508 | 513 | 502 | 504 | 505 | -6.00 |
| 79 | 29 | 29 | 29 | 506 | 506 | 506 | .0 |
| 80 | 373 | 377 | 377 | 356 | 361 | 365 | 5.00 |
| 81 | 338 | 359 | 360 | 338 | 338 | 339 | -21.00 |
| 82 | 436 | 473 | 473 | 418 | 446 | 471 | 16.00 |
| 83 | 1221 | 1229 | 1230 | 1206 | 1215 | 1220 | 5.00 |
| 84 | 781 | 783 | 794 | 779 | 780 | 781 | -11.00 |
| 85 | 763 | 763 | 764 | 736 | 737 | 737 | .0 |
| 86 | 414 | 424 | 424 | 401 | 401 | 402 | -9.00 |
| 87 | 118 | 119 | 120 | 121 | 122 | 123 | .0 |
| 88 | 565 | 571 | 582 | 801 | 802 | 802 | -16.00 |
| 89 | 263 | 270 | 272 | 432 | 441 | 450 | 9.00 |
| 90 | 591 | 591 | 591 | 705 | 706 | 708 | 3.00 |
| 91 | | | | 0 | 0 | 0 | |
| 92 | 786 | 787 | 789 | 1460 | 1462 | 1463 | .0 |
| 93 | 1388 | 1399 | 1399 | 1684 | 1688 | 1691 | -4.00 |
| 94 | 343 | 343 | 344 | 333 | 334 | 335 | 1.00 |
| 95 | 1012 | 1012 | 1012 | 1034 | 1034 | 1035 | 1.00 |
| 96 | 576 | 585 | 586 | 600 | 606 | 612 | 2.00 |
| 97 | 228 | 242 | 242 | 238 | 238 | 239 | -13.00 |
| 98 | 593 | 594 | 601 | 639 | 639 | 639 | -8.00 |
| 99 | 735 | 744 | 744 | 1027 | 1027 | 1028 | -8.00 |
| 100 | 207 | 220 | 221 | 199 | 203 | 208 | -5.00 |
| 101 | 1023 | 1055 | 1061 | 995 | 1003 | 1015 | -18.00 |
| 102 | 1081 | 1086 | 1091 | 1046 | 1052 | 1062 | 6.00 |
| 103 | 239 | 251 | 264 | 230 | 230 | 230 | -25.00 |
| 104 | 739 | 739 | 745 | 708 | 708 | 708 | -6.00 |
| 105 | 803 | 812 | 834 | 853 | 853 | 853 | -31.00 |
| 106 | 2038 | 2045 | 2045 | 2212 | 2212 | 2212 | -7.00 |
| 107 | 1255 | 1255 | 1261 | 1321 | 1325 | 1328 | 1.00 |
| 108 | 1397 | 1400 | 1401 | 1791 | 1791 | 1791 | -4.00 |
| 109 | 1708 | 1755 | 1755 | 1771 | 1827 | 1919 | 101.00 |
| 110 | 647 | 647 | 647 | 692 | 692 | 692 | .0 |
| 111 | 654 | 656 | 669 | 1663 | 1663 | 1663 | -15.00 |
| 112 | 865 | 866 | 872 | 1298 | 1298 | 1298 | -7.00 |
| 113 | 785 | 818 | 825 | 776 | 1383 | 1662 | 846.00 |
| 114 | 1109 | 1109 | 1109 | 1065 | 1065 | 1065 | .0 |
| 115 | 259 | 259 | 262 | 1932 | 1938 | 1944 | 9.00 |
| 116 | 326 | 345 | 345 | 331 | 333 | 334 | -16.00 |

Comparison of Model and Current Traffic Zone Projections

Model includes Pending development, Current 2/1/2011 Projections from WILMAPCO

TAZ=Traffic Zone M10 = Model 2010 M15=Model 2015 M20=Model 2020
W10 = Current Projections 2010 W15 – Current 2015 W20- Current 2020

| TAZ | M10 | M15 | M20 | W10 | W15 | W20 | (W20 – W10) – (M20 – M10) |
|------------|------------|------------|------------|------------|------------|------------|-----------------------------------|
| 117 | 34 | 34 | 34 | 133 | 152 | 171 | 38.00 |
| 118 | 574 | 578 | 578 | 860 | 860 | 860 | -4.00 |
| 119 | 1234 | 1242 | 1247 | 1185 | 1187 | 1188 | -10.00 |
| 120 | 1007 | 1008 | 1008 | 1035 | 1037 | 1038 | 2.00 |
| 121 | 814 | 816 | 816 | 803 | 815 | 826 | 21.00 |
| 122 | 886 | 891 | 892 | 856 | 860 | 863 | 1.00 |
| 123 | 688 | 690 | 690 | 746 | 755 | 764 | 16.00 |
| 124 | 650 | 651 | 651 | 889 | 893 | 896 | 6.00 |
| 125 | 1124 | 1128 | 1131 | 2139 | 2139 | 2139 | -7.00 |
| 126 | 933 | 937 | 937 | 960 | 963 | 967 | 3.00 |
| 127 | 219 | 219 | 240 | 237 | 267 | 296 | 38.00 |
| 128 | 83 | 83 | 84 | 96 | 100 | 104 | 7.00 |
| 129 | 95 | 95 | 104 | 108 | 112 | 115 | -2.00 |
| 130 | 128 | 129 | 130 | 139 | 141 | 143 | 2.00 |
| 131 | 252 | 252 | 265 | 264 | 266 | 267 | -10.00 |
| 132 | 145 | 145 | 146 | 155 | 156 | 158 | 2.00 |
| 133 | 222 | 379 | 379 | 213 | 261 | 296 | -74.00 |
| 134 | 599 | 600 | 600 | 581 | 598 | 614 | 32.00 |
| 135 | 360 | 360 | 362 | 457 | 474 | 490 | 31.00 |
| 136 | 613 | 619 | 619 | 600 | 604 | 607 | 1.00 |
| 137 | 1649 | 1665 | 1672 | 1610 | 1614 | 1619 | -14.00 |
| 138 | 1087 | 1094 | 1102 | 1067 | 1072 | 1077 | -5.00 |
| 139 | 1586 | 1588 | 1589 | 2110 | 2117 | 2124 | 11.00 |
| 140 | 1433 | 1441 | 1448 | 1621 | 1626 | 1631 | -5.00 |
| 141 | 1536 | 1536 | 1536 | 1925 | 1930 | 1935 | 10.00 |
| 142 | 1449 | 1463 | 1464 | 2919 | 2924 | 2929 | -5.00 |
| 143 | 2298 | 2394 | 2409 | 2703 | 2741 | 2770 | -44.00 |
| 144 | 2848 | 2963 | 2984 | 3125 | 3157 | 3186 | -75.00 |
| 145 | 1034 | 1040 | 1042 | 1763 | 1764 | 1765 | -6.00 |
| 146 | 1876 | 1877 | 1879 | 3089 | 3094 | 3100 | 8.00 |
| 147 | 2612 | 2733 | 2736 | 2596 | 2649 | 2689 | -31.00 |
| 148 | 1176 | 1191 | 1199 | 1472 | 1562 | 1602 | 107.00 |
| 149 | 13 | 13 | 13 | 13 | 13 | 13 | .0 |
| 150 | 183 | 183 | 183 | 1144 | 1144 | 1144 | .0 |
| 151 | 36 | 36 | 36 | 35 | 35 | 35 | .0 |
| 152 | 1482 | 1482 | 1495 | 2597 | 2597 | 2597 | -13.00 |
| 153 | 562 | 619 | 619 | 815 | 833 | 858 | -14.00 |
| 154 | 1288 | 1289 | 1289 | 2194 | 2194 | 2194 | -1.00 |
| 155 | 762 | 762 | 762 | 740 | 741 | 742 | 2.00 |

Comparison of Model and Current Traffic Zone Projections

Model includes Pending development, Current 2/1/2011 Projections from WILMAPCO

TAZ=Traffic Zone M10 = Model 2010 M15=Model 2015 M20=Model 2020
W10 = Current Projections 2010 W15 – Current 2015 W20- Current 2020

| TAZ | M10 | M15 | M20 | W10 | W15 | W20 | (W20 – W10) – (H20 – H10) |
|------------|------------|------------|------------|------------|------------|------------|-----------------------------------|
| 156 | 60 | 60 | 62 | 72 | 73 | 75 | 1.00 |
| 157 | 681 | 683 | 684 | 714 | 716 | 717 | .0 |
| 158 | 1875 | 1875 | 1875 | 3718 | 3745 | 3762 | 44.00 |
| 159 | 4 | 4 | 5 | 5 | 5 | 5 | -1.00 |
| 160 | 1 | 1 | 1 | 0 | 0 | 0 | .0 |
| 161 | 311 | 311 | 578 | 305 | 421 | 537 | -35.00 |
| 162 | 524 | 525 | 525 | 596 | 601 | 606 | 9.00 |
| 163 | 1786 | 1798 | 1799 | 3536 | 3543 | 3549 | .0 |
| 164 | 1461 | 1496 | 1496 | 2079 | 2112 | 2146 | 32.00 |
| 165 | 6 | 6 | 6 | 13 | 15 | 16 | 3.00 |
| 166 | 533 | 538 | 616 | 582 | 586 | 589 | -76.00 |
| 167 | 1368 | 1454 | 1455 | 2299 | 2346 | 2414 | 28.00 |
| 168 | 260 | 263 | 264 | 703 | 706 | 709 | 2.00 |
| 169 | 311 | 315 | 315 | 518 | 519 | 521 | -1.00 |
| 170 | 107 | 107 | 107 | 111 | 112 | 114 | 3.00 |
| 171 | 748 | 751 | 751 | 1002 | 1010 | 1023 | 18.00 |
| 172 | 1017 | 1019 | 1020 | 1353 | 1358 | 1363 | 7.00 |
| 173 | 618 | 620 | 624 | 681 | 709 | 744 | 57.00 |
| 174 | 18 | 81 | 84 | 317 | 358 | 406 | 23.00 |
| 175 | 1132 | 1139 | 1139 | 1217 | 1232 | 1245 | 21.00 |
| 176 | 679 | 682 | 693 | 664 | 669 | 674 | -4.00 |
| 177 | 116 | 116 | 116 | 112 | 113 | 115 | 3.00 |
| 178 | 91 | 91 | 92 | 256 | 456 | 656 | 399.00 |
| 179 | 582 | 652 | 656 | 581 | 625 | 656 | 1.00 |
| 180 | 970 | 972 | 973 | 2677 | 2684 | 2691 | 11.00 |
| 181 | 563 | 565 | 569 | 552 | 588 | 618 | 60.00 |
| 182 | 733 | 754 | 754 | 717 | 742 | 767 | 29.00 |
| 183 | 335 | 336 | 337 | 325 | 340 | 358 | 31.00 |
| 184 | | | | 1 | 8 | 14 | |
| 185 | 294 | 294 | 294 | 281 | 285 | 290 | 9.00 |
| 186 | 238 | 270 | 367 | 223 | 244 | 275 | -77.00 |
| 187 | 3 | 3 | 3 | 3 | 3 | 3 | .0 |
| 188 | 652 | 668 | 677 | 707 | 710 | 713 | -19.00 |
| 189 | 298 | 298 | 300 | 285 | 294 | 300 | 13.00 |
| 190 | 185 | 609 | 614 | 180 | 303 | 429 | -180.00 |
| 191 | 435 | 763 | 764 | 531 | 597 | 663 | -197.00 |
| 192 | 237 | 565 | 567 | 219 | 283 | 349 | -200.00 |
| 193 | 225 | 763 | 769 | 221 | 331 | 491 | -274.00 |
| 194 | 248 | 711 | 711 | 237 | 350 | 506 | -194.00 |

Comparison of Model and Current Traffic Zone Projections

Model includes Pending development, Current 2/1/2011 Projections from WILMAPCO

TAZ=Traffic Zone M10 = Model 2010 M15=Model 2015 M20=Model 2020
W10 = Current Projections 2010 W15 – Current 2015 W20- Current 2020

| TAZ | M10 | M15 | M20 | W10 | W15 | W20 | (W20 – W10) – (M20 – M10) |
|------------|------------|------------|------------|------------|------------|------------|-----------------------------------|
| 195 | 29 | 29 | 261 | 32 | 57 | 82 | -182.00 |
| 196 | 278 | 278 | 313 | 341 | 378 | 410 | 34.00 |
| 197 | 887 | 1025 | 1220 | 902 | 952 | 990 | -245.00 |
| 198 | 101 | 101 | 105 | 111 | 124 | 136 | 21.00 |
| 199 | 468 | 468 | 468 | 451 | 495 | 533 | 82.00 |
| 200 | 322 | 322 | 334 | 431 | 465 | 493 | 50.00 |
| 201 | 89 | 89 | 89 | 109 | 139 | 167 | 58.00 |
| 202 | 7 | 7 | 25 | 13 | 23 | 33 | 2.00 |
| 203 | 99 | 99 | 171 | 104 | 139 | 170 | -6.00 |
| 204 | | | | 0 | 0 | 0 | |
| 205 | 76 | 77 | 80 | 75 | 75 | 75 | -4.00 |
| 206 | 901 | 922 | 922 | 879 | 882 | 885 | -15.00 |
| 207 | 232 | 232 | 465 | 225 | 306 | 387 | -71.00 |
| 208 | 1110 | 1112 | 1112 | 1079 | 1082 | 1085 | 4.00 |
| 209 | 796 | 1019 | 1019 | 794 | 848 | 920 | -97.00 |
| 210 | 772 | 814 | 1006 | 978 | 1293 | 1481 | 269.00 |
| 211 | 1185 | 1205 | 1210 | 1484 | 1525 | 1548 | 39.00 |
| 212 | 1 | 1 | 2 | 2 | 169 | 330 | 327.00 |
| 213 | 353 | 399 | 400 | 342 | 357 | 369 | -20.00 |
| 214 | 66 | 66 | 70 | 71 | 116 | 160 | 85.00 |
| 215 | 154 | 154 | 156 | 145 | 162 | 176 | 29.00 |
| 216 | 16 | 16 | 95 | 23 | 127 | 253 | 151.00 |
| 217 | 156 | 156 | 159 | 152 | 163 | 172 | 17.00 |
| 218 | 112 | 112 | 112 | 105 | 128 | 149 | 44.00 |
| 219 | 126 | 126 | 128 | 122 | 124 | 126 | 2.00 |
| 220 | 403 | 464 | 467 | 392 | 400 | 409 | -47.00 |
| 221 | 849 | 851 | 855 | 849 | 851 | 853 | -2.00 |
| 222 | 119 | 119 | 122 | 113 | 115 | 116 | .0 |
| 223 | | | | 0 | 0 | 0 | |
| 224 | | | | 0 | 27 | 50 | |
| 225 | 35 | 63 | 64 | 36 | 40 | 43 | -22.00 |
| 226 | | | | 0 | 0 | 0 | |
| 227 | | | | 0 | 0 | 0 | |
| 228 | | | | 0 | 0 | 0 | |
| 229 | | | | 0 | 0 | 0 | |
| 230 | 917 | 921 | 924 | 1515 | 1539 | 1550 | 28.00 |
| 231 | 77 | 77 | 78 | 80 | 81 | 81 | .0 |
| 232 | 406 | 435 | 439 | 871 | 876 | 882 | -22.00 |
| 233 | 1656 | 1658 | 1658 | 1605 | 1605 | 1605 | -2.00 |

Comparison of Model and Current Traffic Zone Projections

Model includes Pending development, Current 2/1/2011 Projections from WILMAPCO

TAZ=Traffic Zone M10 = Model 2010 M15=Model 2015 M20=Model 2020
W10 = Current Projections 2010 W15 – Current 2015 W20- Current 2020

| TAZ | M10 | M15 | M20 | W10 | W15 | W20 | (W20 – W10) – (H20 – H10) |
|------------|------------|------------|------------|------------|------------|------------|-----------------------------------|
| 234 | 1204 | 1232 | 1237 | 2142 | 2146 | 2150 | -25.00 |
| 235 | 390 | 391 | 391 | 369 | 369 | 369 | -1.00 |
| 236 | 831 | 831 | 833 | 814 | 824 | 839 | 23.00 |
| 237 | 505 | 505 | 505 | 1458 | 1458 | 1459 | 1.00 |
| 238 | 74 | 77 | 84 | 73 | 80 | 88 | 5.00 |
| 239 | 461 | 513 | 513 | 423 | 441 | 458 | -17.00 |
| 240 | 315 | 315 | 318 | 762 | 767 | 772 | 7.00 |
| 241 | 1257 | 1265 | 1265 | 1625 | 1628 | 1632 | -1.00 |
| 242 | 874 | 881 | 883 | 843 | 863 | 893 | 41.00 |
| 243 | 136 | 1011 | 1013 | 1018 | 1475 | 1755 | -140.00 |
| 244 | 1782 | 1785 | 1848 | 2000 | 2002 | 2004 | -62.00 |
| 245 | 1509 | 1622 | 1623 | 2121 | 2142 | 2173 | -62.00 |
| 246 | 324 | 324 | 423 | 787 | 875 | 956 | 70.00 |
| 247 | 248 | 248 | 354 | 373 | 427 | 478 | -1.00 |
| 248 | 918 | 918 | 919 | 1686 | 1689 | 1691 | 4.00 |
| 249 | 12 | 13 | 14 | 17 | 19 | 21 | 2.00 |
| 250 | 263 | 478 | 478 | 252 | 308 | 370 | -97.00 |
| 251 | 904 | 938 | 940 | 1849 | 1918 | 1963 | 78.00 |
| 252 | 33 | 33 | 436 | 36 | 265 | 389 | -50.00 |
| 253 | 293 | 375 | 375 | 294 | 319 | 338 | -38.00 |
| 254 | 212 | 212 | 212 | 209 | 211 | 213 | 4.00 |
| 255 | 63 | 63 | 66 | 66 | 66 | 66 | -3.00 |
| 256 | 572 | 647 | 649 | 977 | 1012 | 1067 | 13.00 |
| 257 | 172 | 172 | 172 | 385 | 387 | 388 | 3.00 |
| 258 | 452 | 455 | 456 | 442 | 515 | 576 | 130.00 |
| 259 | 336 | 460 | 461 | 744 | 813 | 897 | 28.00 |
| 260 | 691 | 699 | 700 | 1205 | 1208 | 1212 | -2.00 |
| 261 | 490 | 492 | 496 | 476 | 486 | 496 | 14.00 |
| 262 | 197 | 245 | 245 | 188 | 226 | 254 | 18.00 |
| 263 | 370 | 429 | 435 | 358 | 368 | 382 | -41.00 |
| 264 | 219 | 219 | 220 | 219 | 221 | 223 | 3.00 |
| 265 | 225 | 234 | 234 | 215 | 229 | 241 | 17.00 |
| 266 | 643 | 652 | 655 | 643 | 679 | 707 | 52.00 |
| 267 | 12 | 12 | 14 | 21 | 92 | 161 | 138.00 |
| 268 | 61 | 61 | 87 | 62 | 67 | 72 | -16.00 |
| 269 | | | | 419 | 438 | 453 | |
| 270 | 329 | 330 | 339 | 316 | 330 | 340 | 14.00 |
| 271 | 100 | 100 | 312 | 86 | 115 | 142 | -156.00 |
| 272 | 23 | 23 | 205 | 19 | 111 | 199 | -2.00 |

Comparison of Model and Current Traffic Zone Projections

Model includes Pending development, Current 2/1/2011 Projections from WILMAPCO

TAZ=Traffic Zone M10 = Model 2010 M15=Model 2015 M20=Model 2020
W10 = Current Projections 2010 W15 – Current 2015 W20- Current 2020

| TAZ | M10 | M15 | M20 | W10 | W15 | W20 | (W20 – W10) – (M20 – M10) |
|------------|------------|------------|------------|------------|------------|------------|-----------------------------------|
| 273 | 177 | 177 | 180 | 172 | 195 | 216 | 41.00 |
| 274 | 52 | 697 | 1187 | 52 | 317 | 813 | -374.00 |
| 275 | 275 | 374 | 374 | 274 | 297 | 318 | -55.00 |
| 276 | 299 | 299 | 300 | 286 | 308 | 327 | 40.00 |
| 277 | 158 | 158 | 275 | 154 | 228 | 298 | 27.00 |
| 278 | 341 | 346 | 353 | 333 | 398 | 458 | 113.00 |
| 279 | 195 | 469 | 469 | 163 | 399 | 508 | 71.00 |
| 280 | 82 | 82 | 1245 | 77 | 420 | 715 | -525.00 |
| 281 | 40 | 40 | 271 | 29 | 90 | 149 | -111.00 |
| 282 | 39 | 40 | 41 | 37 | 38 | 38 | -1.00 |
| 283 | 85 | 85 | 140 | 77 | 87 | 97 | -35.00 |
| 284 | 82 | 82 | 749 | 78 | 213 | 344 | -401.00 |
| 285 | 9 | 9 | 9 | 12 | 14 | 16 | 4.00 |
| 286 | | | | 0 | 0 | 0 | |
| 287 | 21 | 21 | 24 | 17 | 19 | 20 | .0 |
| 288 | 106 | 106 | 112 | 101 | 116 | 128 | 21.00 |
| 289 | 171 | 392 | 403 | 164 | 209 | 252 | -144.00 |
| 290 | 3 | 3 | 3 | 3 | 13 | 23 | 20.00 |
| 291 | 4 | 9 | 380 | 6 | 292 | 362 | -20.00 |
| 292 | 34 | 109 | 109 | 32 | 89 | 145 | 38.00 |
| 293 | 153 | 395 | 395 | 147 | 220 | 288 | -101.00 |
| 294 | 42 | 43 | 44 | 54 | 62 | 70 | 14.00 |
| 295 | 1 | 1 | 4 | 1 | 5 | 9 | 5.00 |
| 296 | 150 | 153 | 175 | 144 | 189 | 230 | 61.00 |
| 297 | 186 | 186 | 189 | 205 | 217 | 227 | 19.00 |
| 298 | 22 | 22 | 24 | 22 | 40 | 58 | 34.00 |
| 299 | 16 | 16 | 16 | 28 | 44 | 60 | 32.00 |
| 300 | 139 | 238 | 239 | 141 | 172 | 201 | -40.00 |
| 301 | 101 | 104 | 105 | 75 | 103 | 129 | 50.00 |
| 302 | 416 | 829 | 829 | 394 | 505 | 620 | -187.00 |
| 303 | 413 | 703 | 704 | 420 | 555 | 716 | 5.00 |
| 304 | 328 | 328 | 328 | 315 | 355 | 391 | 76.00 |
| 305 | 99 | 99 | 100 | 98 | 119 | 138 | 39.00 |
| 306 | 27 | 27 | 30 | 32 | 48 | 63 | 28.00 |
| 307 | 299 | 299 | 299 | 309 | 332 | 350 | 41.00 |
| 308 | 2 | 5 | 5 | 11 | 25 | 40 | 26.00 |
| 309 | 93 | 93 | 543 | 89 | 381 | 615 | 76.00 |
| 310 | 88 | 88 | 239 | 129 | 158 | 184 | -96.00 |
| 311 | 146 | 146 | 147 | 140 | 146 | 150 | 9.00 |

Comparison of Model and Current Traffic Zone Projections

Model includes Pending development, Current 2/1/2011 Projections from WILMAPCO

TAZ=Traffic Zone M10 = Model 2010 M15=Model 2015 M20=Model 2020
W10 = Current Projections 2010 W15 – Current 2015 W20- Current 2020

| TAZ | M10 | M15 | M20 | W10 | W15 | W20 | (W20 – W10) – (M20 – M10) |
|------------|------------|------------|------------|------------|------------|------------|-----------------------------------|
| 312 | 11 | 11 | 284 | 11 | 78 | 142 | -142.00 |
| 313 | 115 | 115 | 116 | 108 | 135 | 159 | 50.00 |
| 314 | 14 | 14 | 132 | 13 | 200 | 398 | 267.00 |
| 315 | 223 | 227 | 236 | 590 | 616 | 642 | 39.00 |
| 316 | 481 | 481 | 484 | 478 | 590 | 667 | 186.00 |
| 317 | 137 | 137 | 137 | 139 | 147 | 155 | 16.00 |
| 318 | 56 | 56 | 61 | 70 | 77 | 84 | 9.00 |
| 319 | 0 | 0 | 245 | 673 | 839 | 985 | 67.00 |
| 320 | 366 | 427 | 429 | 361 | 382 | 393 | -31.00 |
| 321 | 332 | 882 | 885 | 318 | 422 | 538 | -333.00 |
| 322 | 295 | 295 | 324 | 350 | 418 | 480 | 101.00 |
| 323 | 76 | 76 | 77 | 80 | 81 | 83 | 2.00 |
| 324 | 626 | 626 | 628 | 608 | 610 | 612 | 2.00 |
| 325 | 109 | 109 | 109 | 525 | 527 | 528 | 3.00 |
| 326 | | | | 0 | 0 | 0 | |
| 327 | 2 | 2 | 4 | 10 | 12 | 13 | 1.00 |
| 328 | 242 | 242 | 245 | 595 | 621 | 657 | 59.00 |
| 329 | 1 | 1 | 1 | 1 | 1 | 1 | .0 |
| 330 | | | | 248 | 248 | 248 | |
| 331 | 12 | 12 | 12 | 11 | 13 | 14 | 3.00 |
| 332 | | | | 0 | 0 | 0 | |
| 333 | 1590 | 1592 | 1594 | 2149 | 2153 | 2151 | -2.00 |
| 334 | 79 | 257 | 257 | 75 | 120 | 161 | -92.00 |
| 335 | | | | 0 | 0 | 0 | |
| 336 | 89 | 337 | 340 | 81 | 175 | 232 | -100.00 |
| 337 | 284 | 284 | 323 | 296 | 318 | 336 | 1.00 |
| 338 | 398 | 402 | 425 | 401 | 460 | 513 | 85.00 |
| 339 | 314 | 314 | 592 | 350 | 626 | 916 | 288.00 |
| 340 | 6 | 6 | 6 | 75 | 219 | 381 | 306.00 |
| 341 | | | | 105 | 108 | 110 | |
| 342 | 125 | 127 | 131 | 128 | 130 | 132 | -2.00 |
| 343 | 10 | 10 | 10 | 10 | 10 | 10 | .0 |
| 344 | 426 | 431 | 476 | 541 | 570 | 598 | 7.00 |
| 345 | 139 | 139 | 140 | 132 | 133 | 133 | .0 |

APPENDIX B – A rigorous discussion of calculation of probabilities and factors for future time projection periods.

The logistic regression uses the characteristics the last five years to assign the probability to each piece of land that it was developed during this time. In other words, given the information we had between 2006 and 2010, we derived the absolute probability that a plot of land with specific characteristics was actually developed. Because the logistic regression tries to make as good a fit as possible, the sum of these absolute probabilities equals the total amount of development that actually occurred. In mathematical notation, the logistic regression estimated the following probability:

$$1) \quad P_{1i} (D_1(2010, i) = 1 | X_1(2006 - 2010, i) , D_1(2006, i) = 0)$$

The next step involved making a forecast of development in the next five years. To do this, we made two assumptions. The first is that the total amount of development that will occur in the next five years is known with certainty (estimated from Delaware's population and macroeconomic projections). For example, we assumed that 9,950 plots of land will be developed between 2011 and 2015. Then we assumed that the relative probability that a plot of land will be developed in the next five years equals the relative probability that it was developed in the last five years. In other words, the relative probability that the plot of land was developed between 2006 and 2010 was assumed to equal the relative probability that the plot of land was developed between 2011 and 2015.

To calculate this relative probability for each plot of land, we first limited the sample to those plots of land that were not developed as of 2011. Then we multiplied the lagged probability that each one would have been developed between 2006 and 2010 by a scalar. That scalar equaled the expected future development (9,950) divided by the sum of the original lagged probabilities. This operation normalized the probabilities in such a way to maintain our two assumptions. It also gave us the expected probability that development would occur for each plot of land between 2011 and 2015. The mathematical expression for this is:

$$2) \quad P_{1i} (D_1(2015, i) = 1 | X_1(2011 - 2015, i) , D_1(2011, i) = 0) = E[D_1(2015, i)] \approx \\ P_{1i} (D_1(2010, i) = 1 | X_1(2006 - 2010, i) , D_1(2006, i) = 0) \times (D_1(2010, i) \times \text{[Assumed Development]}) / \sum_i (D_1(2010, i) \times \text{[Assumed Development]})$$

To iterate the five year forecasts into the future, the same logic would imply the following mathematical equations:

$$3) \quad P_{1i} (D_1(2020, i) = 1 | X_1(2016 - 2020, i) , D_1(2015, i) = 0) \approx \\ P_{1i} (D_1(2015, i) = 1 | X_1(2011 - 2015, i) , D_1(2011, i) = 0) \times (D_1(2015, i) \times \text{[Assumed Development]}) / \sum_i (D_1(2015, i) \times \text{[Assumed Development]})$$

However, we cannot actually implement equation 3, because we do not know what independent variables will exist in the future ($X_{2011-2015,i}$) or what future development occurs ($D_{2015,i}$). However, we have an approximation for future development given by equation 2, ($E[D_{2015,i}]$), and we know that the future independent variables are affected by development that will occur. Thus, we use what development we think will occur to update what independent variables we will expect to see in the future.²

$$4) \quad P_{1i} (D_1(2020, i) = 1 | X_1(2016 - 2020, i) , D_1(2015, i) = 0) \approx \\ P_{1i} (D_1(2015, i) = 1 | E[X_1(2011 - 2015, i)] , D_1(2011, i) = 0) \times (E[D_1(2015, i)] \times \text{[Assumed Development]}) / \sum_i (E[D_1(2015, i)] \times \text{[Assumed Development]})$$

² One should keep in mind that an approximation is being approximated in this step, so any error in the original model will be compounded.

We assume that the probability of development in 2015 has the same relative probabilities predicted by the original model. We are being loose here with the mathematical notation for a reason. By saying that a probability is conditional on certain event, one implies that event is known with certainty. However, we chose this notation to show a comparison with equation 1, the probability derived from a logistic regression.

The major point of equation 4 is that left term is derived by updating our expectations for the independent variables and applying these new variables to the original logistic regression. In other words, the 2020 forecast is based on events that occurred between 2011 and 2015. Since it is currently 2011, we use our 2015 predictions to infer what those changes are likely to be.

To estimate the total probability that a parcel is developed over the next ten years, we would ideally like to use the formula:

5)

$$P(D_{12020} = 1 | X_1(2011 - 2020), D_{12011} = 0) = P(D_{12015} = 1 | X_1(2011 - 2015), D_{12011} = 0) + P(D_{12015} = 0 | X_1(2011 - 2015), D_{12011} = 0) \times P(D_{12020} = 1 | X_1(2015 - 2020), D_{12015} = 0)$$

As detailed earlier, all of these probabilities on the right hand side of the equation had to be approximated. Therefore, simply switching out each one with its appropriate approximation yields iterated ten year forecast.

Next, we detail how we updated the independent variables using our original predictions for 2015. There were 6 variables: NOTLOT, COMLOT, CAT90, SEWER, TAZDEV, and INSUBDIV. We now describe the assumptions and calculations behind the updates in each of these variables.

NOTLOT: This variable indicates that a parcel of land has not been turned into a developable lot. We think of development as generally following three stages:

- 1 – parcel not a developable lot (NOTLOT = 1)
- 2 – parcel becomes a developable lot (NOTLOT = 0)
- 3 – developable lot is developed (D=1)

Since we assume that parcels follow this path to development, only those parcels that have yet to become a developable lot are included in the discussion below. Second we assume that there always is always a constant number of developable lots at any time. This assumption implies that a parcel must become a developable lot (1→2) every time a parcel is developed (2→3). That is, actual development is assumed to pull parcels from the first stage to the second stage.

$$6. \quad \sum_{j=1}^N (NOTLOT_{2016,j}) = \sum_{j=1}^N (NOTLOT_{2011,j}) - \text{Assumed Development}_{2015-2011}$$

This also equals the sum of the probabilities that a parcel that is not ready to be developed in 2010 remains in the same state as of 2016.

7.

$$\sum_{i=1}^N (1) \times N \times ([NOTLOT]_{1(2016,j)}) = \sum_{i=1}^N (1) \times N \times [P_{1i} ([NOTLOT]_{1,2016} = 1 | [NOTLOT]_{1,2011})]$$

The only other factor to consider is which parcels are most likely to become a developable lot. We assumed that the probability that the land would remain an undevelopable parcel is proportional to the probability that land was not developed.

$$8. \quad P([NOTLOT]_{1,2016} = 1 | [NOTLOT]_{1,2011} = 1) = C \times P(D_{12016} = 0)$$

C is the constant of proportionality that needs to be determined.

Equations 6, 7, and 8 implies that

$$9. \quad \sum_{j=1}^N (NOTLOT_{2011,j}) - Assumed\ Development_{2015-2011} = C \times \sum_{i=1}^N (P(D_{2016} = 0))$$

Solving for C yielded the final equation:

$$10. \quad C = \frac{\sum_{j=1}^N (NOTLOT_{2011,j}) - Assumed\ Development_{2015-2011}}{\sum_{i=1}^N (P(D_{2016} = 0))}$$

This constant was inserted into equation 8 to estimate the probability that a parcel would not be a developable lot in 2015. Were this model to be further developed in the future, we would recommend that the process of parcels being turned into developable lots be modeled separately.

CAT90: This variable represents whether the observation was a lot in 1990. The purpose of this variable was to flag properties that have been prepared for development for a long time, but have not yet developed. The first assumption we made was that any piece of developable land that was unprepared for development in 1990 would not be flagged. The second assumption was that any piece of land that developed between 2011 and 2015 would no longer be flagged. Thus, the expected value of this variable was:

$$11. \quad E[CAT90_{2016}] = \begin{cases} 0 & \text{if } CAT90_{2010} = 0 \\ P(D_{2016} = 0) & \text{if } CAT90_{2010} = 1 \end{cases}$$

INSUBDIV: Next, we modeled whether a parcel was expected to be in a subdivision in the future. We assumed that any current subdivisions will remain subdivisions in the future. We also assumed that all parcels that become developable lots are given a subdivision. Thus, the expected value that an undeveloped parcel becomes a developable lot is equals the same probability that it gets a subdivision. Any other properties were assumed not to be in a subdivision.

$$12. \quad E[INSUBDIV_{2016}] = \begin{cases} 1 & \text{if } INSUBDIV_{2010} = 1 \\ P(NOTLOT_{2015} = 0) & \text{if } INSUBDIV_{2010} = 0 \text{ and } NOTLOT_{2010} = 1 \\ 0 & \text{else} \end{cases}$$

TAZDEV: This variable is intended to model the growth of development that occurred for all other parcels in the traffic analysis zone (TAZ). This was done by first estimating the potential predicted amount of development that was found to occur in each TAZ and dividing that number by the predicted amount of land that could be developed in each TAZ. The numerator was merely the sum of $E[D_{2015,t}]$ in each TAZ. The denominator was calculated as the sum of the following function over all parcels in a particular TAZ:

$$13. \quad DENOM = \begin{cases} 1 & \text{if } NOTLOT_{2010} = 0 \\ P(NOTLOT_{2015} = 0) & \text{if } NOTLOT_{2010} = 1 \end{cases}$$

COMLOT: We assume that the same commercial zoning patterns will exist in the future as they do today. That is, we do not assume that development over the next five years will influence the commercial zoning of particular lots. Future zoning proposals could easily be analyzed by updating the model with that hypothetical situation.

$$14. \quad E[COMLOT_{2016}] = COMLOT_{2011}$$

SEWER: Similar to COMLOT We assume that the same sewer districts will exist in the future as they do today. Again, modeling different scenarios would imply different development patterns.

$$15. \quad E[SEWER_{2016}] = SEWER_{2011}$$

APPENDIX C – Scripts used to classify properties

```

if (meanacre=0)size=9.
if (meanacre>0 and meanacre le .2)size=1.
if (meanacre>0.2 and meanacre le 1)size=2.
if (meanacre>1.0 and meanacre le 2)size=3.
if (meanacre>2 and meanacre le 5)size=4.
if (meanacre>5.0 and meanacre le 10)size=5.
if (meanacre>10 and meanacre le 20)size=6.
if (meanacre>20 and meanacre le 100)size=7.
if (meanacre> 100)size=8 .
EXECUTE.

```

comment replace year below to generate yearly profile.

```

IF ( ~( abegyear <= 1999 & aendyear >= 1999) ) CATEG1999='NOTEXIST'.
EXECUTE.
IF ( zoning01 = 'BP' or zoning01 = 'CN' or zoning01 = 'CR' or zoning01 = 'EX' or
zoning01 = 'HI' or zoning01 = 'T' or zoning01 = 'ON' or zoning01 = 'OR' & categ1999= "
) CATEG1999='COM'.
EXECUTE.
IF ( openpubprv = 'y' & categ1999= " ) CATEG1999='OPENSOURCE'.
EXECUTE.
IF ( agpdr = 'AGPM' | agdist = 'y' & categ1999= " ) CATEG1999='Ag Preservation'.
EXECUTE.
IF ( pclass = 'EC' & categ1999= " ) CATEG1999='Exempt C'.
EXECUTE.
IF ( pclass = 'T' & categ1999= " ) CATEG1999='Industrial'.
EXECUTE.
IF ( pclass = 'ER' & categ1999= " ) CATEG1999='Exempt R'.
EXECUTE.
IF ( pclass = 'U' & categ1999= " ) CATEG1999='Utility'.
EXECUTE.
IF ( pclass = 'C' & categ1999= " ) CATEG1999='Assessed Commercial'.
EXECUTE.
IF ( size = 1 & bldg01 > 0 & categ1999= " ) CATEG1999='BLT very small'.
EXECUTE.
IF ( size = 1 & bldg01 = 0 & categ1999= " ) CATEG1999='LOT very small'.
EXECUTE.
IF ( size = 2 & bldg01 = 0 & categ1999= " ) CATEG1999='LOT small'.
EXECUTE.
IF ( size = 2 & bldg01 > 0 & categ1999= " ) CATEG1999='BLT small'.
EXECUTE.
IF ( size = 3 & bldg01 = 0 & categ1999= " ) CATEG1999='LOT med'.
EXECUTE.

```

```

IF (size = 3 & bldg01 > 0 & categ1999= " ) CATEG1999='BLT med'.
EXECUTE.
IF (size = 4 & bldg01 = 0 & categ1999= " ) CATEG1999='LOT large'.
EXECUTE.
IF (size = 4 & bldg01 > 0 & categ1999= " ) CATEG1999='BLT large'.
EXECUTE.
IF (size = 5 & categ1999= " ) CATEG1999='PLOT very small'.
EXECUTE.
IF (size = 6 & categ1999= " ) CATEG1999='PLOT small'.
EXECUTE.
IF (size = 7 & categ1999= " ) CATEG1999='PLOT medium'.
EXECUTE.
IF ( size = 8 & categ1999= " ) CATEG1999='PLOT large'.
EXECUTE.

comment *****.

IF ( ~( abegyear <= 2000 & aendyear >= 2000) ) CATEG2000='NOTEXIST'.
EXECUTE.
IF ( zoning00 = 'BP' or zoning00 = 'CN' or zoning00 = 'CR' or zoning00 = 'EX' or
zoning00 = 'HI' or zoning00 = 'I' or zoning00 = 'ON' or zoning00 = 'OR' & categ2000= "
) CATEG2000='COM'.
EXECUTE.
IF ( openpubprv = 'y' & categ2000= " ) CATEG2000='OPENSOURCE'.
EXECUTE.
IF ( agpdr = 'AGPM' | agdist = 'y' & categ2000= " ) CATEG2000='Ag Preservation'.
EXECUTE.
IF ( pclass = 'EC' & categ2000= " ) CATEG2000='Exempt C'.
EXECUTE.
IF ( pclass = 'I' & categ2000= " ) CATEG2000='Industrial'.
EXECUTE.
IF ( pclass = 'ER' & categ2000= " ) CATEG2000='Exempt R'.
EXECUTE.
IF ( pclass = 'U' & categ2000= " ) CATEG2000='Utility'.
EXECUTE.
IF ( pclass = 'C' & categ2000= " ) CATEG2000='Assessed Commercial'.
EXECUTE.
IF (size = 1 & bldg00 > 0 & categ2000= " ) CATEG2000='BLT very small'.
EXECUTE.
IF (size = 1 & bldg00 = 0 & categ2000= " ) CATEG2000='LOT very small'.
EXECUTE.
IF (size = 2 & bldg00 = 0 & categ2000= " ) CATEG2000='LOT small'.
EXECUTE.
IF (size = 2 & bldg00 > 0 & categ2000= " ) CATEG2000='BLT small'.
EXECUTE.
IF (size = 3 & bldg00 = 0 & categ2000= " ) CATEG2000='LOT med'.

```

```

EXECUTE.
IF (size = 3 & bldg00 > 0 & categ2000= " ) CATEG2000='BLT med'.
EXECUTE.
IF (size = 4 & bldg00 = 0 & categ2000= " ) CATEG2000='LOT large'.
EXECUTE.
IF (size = 4 & bldg00 > 0 & categ2000= " ) CATEG2000='BLT large'.
EXECUTE.
IF (size = 5 & categ2000= " ) CATEG2000='PLOT very small'.
EXECUTE.
IF (size = 6 & categ2000= " ) CATEG2000='PLOT small'.
EXECUTE.
IF (size = 7 & categ2000= " ) CATEG2000='PLOT medium'.
EXECUTE.
IF ( size = 8 & categ2000= " ) CATEG2000='PLOT large'.
EXECUTE.

comment *****
IF ( ~( abegyear <= 2001 & aendyear >= 2001) ) CATEG2001='NOTEXIST'.
EXECUTE.
IF ( zoning01 = 'BP' or zoning01 = 'CN' or zoning01 = 'CR' or zoning01 = 'EX' or
zoning01 = 'HI' or zoning01 = 'I' or zoning01 = 'ON' or zoning01 = 'OR' & categ2001= "
) CATEG2001='COM'.
EXECUTE.
IF ( openpubprv = 'y' & categ2001= " ) CATEG2001='OPENSOURCE'.
EXECUTE.
IF ( agpdr = 'AGPM' | agdist = 'y' & categ2001= " ) CATEG2001='Ag Preservation'.
EXECUTE.
IF ( pclass = 'EC' & categ2001= " ) CATEG2001='Exempt C'.
EXECUTE.
IF ( pclass = 'I' & categ2001= " ) CATEG2001='Industrial'.
EXECUTE.
IF ( pclass = 'ER' & categ2001= " ) CATEG2001='Exempt R'.
EXECUTE.
IF ( pclass = 'U' & categ2001= " ) CATEG2001='Utility'.
EXECUTE.
IF ( pclass = 'C' & categ2001= " ) CATEG2001='Assessed Commercial'.
EXECUTE.
IF (size = 1 & bldg01 > 0 & categ2001= " ) CATEG2001='BLT very small'.
EXECUTE.
IF (size = 1 & bldg01 = 0 & categ2001= " ) CATEG2001='LOT very small'.
EXECUTE.
IF (size = 2 & bldg01 = 0 & categ2001= " ) CATEG2001='LOT small'.
EXECUTE.
IF (size = 2 & bldg01 > 0 & categ2001= " ) CATEG2001='BLT small'.
EXECUTE.
IF (size = 3 & bldg01 = 0 & categ2001= " ) CATEG2001='LOT med'.

```

```

EXECUTE.
IF (size = 3 & bldg01 > 0 & categ2001= " ) CATEG2001='BLT med'.
EXECUTE.
IF (size = 4 & bldg01 = 0 & categ2001= " ) CATEG2001='LOT large'.
EXECUTE.
IF (size = 4 & bldg01 > 0 & categ2001= " ) CATEG2001='BLT large'.
EXECUTE.
IF (size = 5 & categ2001= " ) CATEG2001='PLOT very small'.
EXECUTE.
IF (size = 6 & categ2001= " ) CATEG2001='PLOT small'.
EXECUTE.
IF (size = 7 & categ2001= " ) CATEG2001='PLOT medium'.
EXECUTE.
IF ( size = 8 & categ2001= " ) CATEG2001='PLOT large'.
EXECUTE.

comment *****.

IF ( ~( abegyear <= 2002 & aendyear >= 2002) ) CATEG2002='NOTEXIST'.
EXECUTE.
IF ( zoning02 = 'BP' or zoning02 = 'CN' or zoning02 = 'CR' or zoning02 = 'EX' or
zoning02 = 'HI' or zoning02 = 'I' or zoning02 = 'ON' or zoning02 = 'OR' & categ2002= "
) CATEG2002='COM'.
EXECUTE.
IF ( openpubprv = 'y' & categ2002= " ) CATEG2002='OPENSOURCE'.
EXECUTE.
IF ( agpdr = 'AGPM' | agdist = 'y' & categ2002= " ) CATEG2002='Ag Preservation'.
EXECUTE.
IF ( pclass = 'EC' & categ2002= " ) CATEG2002='Exempt C'.
EXECUTE.
IF ( pclass = 'I' & categ2002= " ) CATEG2002='Industrial'.
EXECUTE.
IF ( pclass = 'ER' & categ2002= " ) CATEG2002='Exempt R'.
EXECUTE.
IF ( pclass = 'U' & categ2002= " ) CATEG2002='Utility'.
EXECUTE.
IF ( pclass = 'C' & categ2002= " ) CATEG2002='Assessed Commercial'.
EXECUTE.
IF (size = 1 & bldg02 > 0 & categ2002= " ) CATEG2002='BLT very small'.
EXECUTE.
IF (size = 1 & bldg02 = 0 & categ2002= " ) CATEG2002='LOT very small'.
EXECUTE.
IF (size = 2 & bldg02 = 0 & categ2002= " ) CATEG2002='LOT small'.
EXECUTE.
IF (size = 2 & bldg02 > 0 & categ2002= " ) CATEG2002='BLT small'.
EXECUTE.

```

```

IF (size = 3 & bldg02 = 0 & categ2002= " ) CATEG2002='LOT med'.
EXECUTE.
IF (size = 3 & bldg02 > 0 & categ2002= " ) CATEG2002='BLT med'.
EXECUTE.
IF (size = 4 & bldg02 = 0 & categ2002= " ) CATEG2002='LOT large'.
EXECUTE.
IF (size = 4 & bldg02 > 0 & categ2002= " ) CATEG2002='BLT large'.
EXECUTE.
IF (size = 5 & categ2002= " ) CATEG2002='PLOT very small'.
EXECUTE.
IF (size = 6 & categ2002= " ) CATEG2002='PLOT small'.
EXECUTE.
IF (size = 7 & categ2002= " ) CATEG2002='PLOT medium'.
EXECUTE.
IF ( size = 8 & categ2002= " ) CATEG2002='PLOT large'.
EXECUTE .

```

```
comment *****.
```

```

IF ( ~( abegyear <= 2003 & aendyear >= 2003) ) CATEG2003='NOTEXIST'.
EXECUTE.
IF (zoning03a = 'BP' or zoning03a = 'CN' or zoning03a = 'CR' or zoning03a = 'EX' or
zoning03a = 'HI' or zoning03a = 'T' or zoning03a = 'ON' or zoning03a = 'OR' &
categ2003= " ) CATEG2003='COM'.
EXECUTE.
IF (openpubprv = 'y' & categ2003= " ) CATEG2003='OPENSOURCE'.
EXECUTE.
IF ( agpdr = 'AGPM' | agdist = 'y' & categ2003= " ) CATEG2003='Ag Preservation'.
EXECUTE.
IF ( pclass = 'EC' & categ2003= " ) CATEG2003='Exempt C'.
EXECUTE.
IF ( pclass = 'T' & categ2003= " ) CATEG2003='Industrial'.
EXECUTE.
IF ( pclass = 'ER' & categ2003= " ) CATEG2003='Exempt R'.
EXECUTE.
IF ( pclass = 'U' & categ2003= " ) CATEG2003='Utility'.
EXECUTE.
IF ( pclass = 'C' & categ2003= " ) CATEG2003='Assessed Commercial'.
EXECUTE.
IF (size = 1 & bldg03 > 0 & categ2003= " ) CATEG2003='BLT very small'.
EXECUTE.
IF (size = 1 & bldg03 = 0 & categ2003= " ) CATEG2003='LOT very small'.
EXECUTE.
IF (size = 2 & bldg03 = 0 & categ2003= " ) CATEG2003='LOT small'.
EXECUTE.
IF (size = 2 & bldg03 > 0 & categ2003= " ) CATEG2003='BLT small'.

```

```

EXECUTE.
IF (size = 3 & bldg03 = 0 & categ2003= " ) CATEG2003='LOT med'.
EXECUTE.
IF (size = 3 & bldg03 > 0 & categ2003= " ) CATEG2003='BLT med'.
EXECUTE.
IF (size = 4 & bldg03 = 0 & categ2003= " ) CATEG2003='LOT large'.
EXECUTE.
IF (size = 4 & bldg03 > 0 & categ2003= " ) CATEG2003='BLT large'.
EXECUTE.
IF (size = 5 & categ2003= " ) CATEG2003='PLOT very small'.
EXECUTE.
IF (size = 6 & categ2003= " ) CATEG2003='PLOT small'.
EXECUTE.
IF (size = 7 & categ2003= " ) CATEG2003='PLOT medium'.
EXECUTE.
IF ( size = 8 & categ2003= " ) CATEG2003='PLOT large'.
EXECUTE .

comment *****.

IF ( ~( abegyear <= 2004 & aendyear >= 2004) ) CATEG2004='NOTEXIST'.
EXECUTE.
IF ( zoning04 = 'BP' or zoning04 = 'CN' or zoning04 = 'CR' or zoning04 = 'EX' or
zoning04 = 'HI' or zoning04 = 'I' or zoning04 = 'ON' or zoning04 = 'OR' & categ2004= "
) CATEG2004='COM'.
EXECUTE.
IF ( openpubprv = 'y' & categ2004= " ) CATEG2004='OPENSOURCE'.
EXECUTE.
IF ( agpdr = 'AGPM' | agdist = 'y' & categ2004= " ) CATEG2004='Ag Preservation'.
EXECUTE.
IF ( pclass = 'EC' & categ2004= " ) CATEG2004='Exempt C'.
EXECUTE.
IF ( pclass = 'I' & categ2004= " ) CATEG2004='Industrial'.
EXECUTE.
IF ( pclass = 'ER' & categ2004= " ) CATEG2004='Exempt R'.
EXECUTE.
IF ( pclass = 'U' & categ2004= " ) CATEG2004='Utility'.
EXECUTE.
IF ( pclass = 'C' & categ2004= " ) CATEG2004='Assessed Commercial'.
EXECUTE.
IF (size = 1 & bldg04 > 0 & categ2004= " ) CATEG2004='BLT very small'.
EXECUTE.
IF (size = 1 & bldg04 = 0 & categ2004= " ) CATEG2004='LOT very small'.
EXECUTE.
IF (size = 2 & bldg04 = 0 & categ2004= " ) CATEG2004='LOT small'.
EXECUTE.

```

IF (size = 2 & bldg04 > 0 & categ2004= ") CATEG2004='BLT small'.
EXECUTE.

IF (size = 3 & bldg04 = 0 & categ2004= ") CATEG2004='LOT med'.
EXECUTE.

IF (size = 3 & bldg04 > 0 & categ2004= ") CATEG2004='BLT med'.
EXECUTE.

IF (size = 4 & bldg04 = 0 & categ2004= ") CATEG2004='LOT large'.
EXECUTE.

IF (size = 4 & bldg04 > 0 & categ2004= ") CATEG2004='BLT large'.
EXECUTE.

IF (size = 5 & categ2004= ") CATEG2004='PLOT very small'.
EXECUTE.

IF (size = 6 & categ2004= ") CATEG2004='PLOT small'.
EXECUTE.

IF (size = 7 & categ2004= ") CATEG2004='PLOT medium'.
EXECUTE.

IF (size = 8 & categ2004= ") CATEG2004='PLOT large'.
EXECUTE .

comment *****.

IF (~(abegyear <= 2005 & aendyear >= 2005)) CATEG2005='NOTEXIST'.
EXECUTE.

IF (zoning05b = 'BP' or zoning05b = 'CN' or zoning05b = 'CR' or zoning05b = 'EX' or
zoning05b = 'HI' or zoning05b = 'I' or zoning05b = 'ON' or zoning05b = 'OR' &
categ2005= ") CATEG2005='COM'.
EXECUTE.

IF (openpubprv = 'y' & categ2005= ") CATEG2005='OPENSOURCE'.
EXECUTE.

IF (agpdr = 'AGPM' | agdist = 'y' & categ2005= ") CATEG2005='Ag Preservation'.
EXECUTE.

IF (pclass = 'EC' & categ2005= ") CATEG2005='Exempt C'.
EXECUTE.

IF (pclass = 'I' & categ2005= ") CATEG2005='Industrial'.
EXECUTE.

IF (pclass = 'ER' & categ2005= ") CATEG2005='Exempt R'.
EXECUTE.

IF (pclass = 'U' & categ2005= ") CATEG2005='Utility'.
EXECUTE.

IF (pclass = 'C' & categ2005= ") CATEG2005='Assessed Commercial'.
EXECUTE.

IF (size = 1 & bldg05 > 0 & categ2005= ") CATEG2005='BLT very small'.
EXECUTE.

IF (size = 1 & bldg05 = 0 & categ2005= ") CATEG2005='LOT very small'.
EXECUTE.

IF (size = 2 & bldg05 = 0 & categ2005= ") CATEG2005='LOT small'.

```

EXECUTE.
IF (size = 2 & bldg05 > 0 & categ2005= " ) CATEG2005='BLT small'.
EXECUTE.
IF (size = 3 & bldg05 = 0 & categ2005= " ) CATEG2005='LOT med'.
EXECUTE.
IF (size = 3 & bldg05 > 0 & categ2005= " ) CATEG2005='BLT med'.
EXECUTE.
IF (size = 4 & bldg05 = 0 & categ2005= " ) CATEG2005='LOT large'.
EXECUTE.
IF (size = 4 & bldg05 > 0 & categ2005= " ) CATEG2005='BLT large'.
EXECUTE.
IF (size = 5 & categ2005= " ) CATEG2005='PLOT very small'.
EXECUTE.
IF (size = 6 & categ2005= " ) CATEG2005='PLOT small'.
EXECUTE.
IF (size = 7 & categ2005= " ) CATEG2005='PLOT medium'.
EXECUTE.
IF ( size = 8 & categ2005= " ) CATEG2005='PLOT large'.
EXECUTE .

comment *****.

IF ( ~( abegyear <= 2006 & aendyear >= 2006) ) CATEG2006='NOTEXIST'.
EXECUTE.
IF ( zoning06a = 'BP' or zoning06a = 'CN' or zoning06a = 'CR' or zoning06a = 'EX' or
zoning06a = 'HI' or zoning06a = 'I' or zoning06a = 'ON' or zoning06a = 'OR' &
categ2006= " ) CATEG2006='COM'.
EXECUTE.
IF ( openpubprv = 'y' & categ2006= " ) CATEG2006='OPENSOURCE'.
EXECUTE.
IF ( agpdr = 'AGPM' | agdist = 'y' & categ2006= " ) CATEG2006='Ag Preservation'.
EXECUTE.
IF ( pclass = 'EC' & categ2006= " ) CATEG2006='Exempt C'.
EXECUTE.
IF ( pclass = 'I' & categ2006= " ) CATEG2006='Industrial'.
EXECUTE.
IF ( pclass = 'ER' & categ2006= " ) CATEG2006='Exempt R'.
EXECUTE.
IF ( pclass = 'U' & categ2006= " ) CATEG2006='Utility'.
EXECUTE.
IF ( pclass = 'C' & categ2006= " ) CATEG2006='Assessed Commercial'.
EXECUTE.
IF (size = 1 & bldg06 > 0 & categ2006= " ) CATEG2006='BLT very small'.
EXECUTE.
IF (size = 1 & bldg06 = 0 & categ2006= " ) CATEG2006='LOT very small'.
EXECUTE.

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```

IF (size = 2 & bldg06 = 0 & categ2006= " ) CATEG2006='LOT small'.
EXECUTE.
IF (size = 2 & bldg06 > 0 & categ2006= " ) CATEG2006='BLT small'.
EXECUTE.
IF (size = 3 & bldg06 = 0 & categ2006= " ) CATEG2006='LOT med'.
EXECUTE.
IF (size = 3 & bldg06 > 0 & categ2006= " ) CATEG2006='BLT med'.
EXECUTE.
IF (size = 4 & bldg06 = 0 & categ2006= " ) CATEG2006='LOT large'.
EXECUTE.
IF (size = 4 & bldg06 > 0 & categ2006= " ) CATEG2006='BLT large'.
EXECUTE.
IF (size = 5 & categ2006= " ) CATEG2006='PLOT very small'.
EXECUTE.
IF (size = 6 & categ2006= " ) CATEG2006='PLOT small'.
EXECUTE.
IF (size = 7 & categ2006= " ) CATEG2006='PLOT medium'.
EXECUTE.
IF ( size = 8 & categ2006= " ) CATEG2006='PLOT large'.
EXECUTE .
comment *****.

IF ( ~( abegyear <= 2007 & aendyear >= 2007) ) CATEG2007='NOTEXIST'.
EXECUTE.
IF ( zoning07 = 'BP' or zoning07 = 'CN' or zoning07 = 'CR' or zoning07 = 'EX' or
zoning07 = 'HI' or zoning07 = 'I' or zoning07 = 'ON' or zoning07 = 'OR' & categ2007= "
) CATEG2007='COM'.
EXECUTE.
IF ( openpubprv = 'y' & categ2007= " ) CATEG2007='OPENSOURCE'.
EXECUTE.
IF ( agpdr = 'AGPM' | agdist = 'y' & categ2007= " ) CATEG2007='Ag Preservation'.
EXECUTE.
IF ( pclass = 'EC' & categ2007= " ) CATEG2007='Exempt C'.
EXECUTE.
IF ( pclass = 'I' & categ2007= " ) CATEG2007='Industrial'.
EXECUTE.
IF ( pclass = 'ER' & categ2007= " ) CATEG2007='Exempt R'.
EXECUTE.
IF ( pclass = 'U' & categ2007= " ) CATEG2007='Utility'.
EXECUTE.
IF ( pclass = 'C' & categ2007= " ) CATEG2007='Assessed Commercial'.
EXECUTE.
IF (size = 1 & bldg07 > 0 & categ2007= " ) CATEG2007='BLT very small'.
EXECUTE.
IF (size = 1 & bldg07 = 0 & categ2007= " ) CATEG2007='LOT very small'.
EXECUTE.

```

IF (size = 2 & bldg07 = 0 & categ2007= ") CATEG2007='LOT small'.
EXECUTE.

IF (size = 2 & bldg07 > 0 & categ2007= ") CATEG2007='BLT small'.
EXECUTE.

IF (size = 3 & bldg07 = 0 & categ2007= ") CATEG2007='LOT med'.
EXECUTE.

IF (size = 3 & bldg07 > 0 & categ2007= ") CATEG2007='BLT med'.
EXECUTE.

IF (size = 4 & bldg07 = 0 & categ2007= ") CATEG2007='LOT large'.
EXECUTE.

IF (size = 4 & bldg07 > 0 & categ2007= ") CATEG2007='BLT large'.
EXECUTE.

IF (size = 5 & categ2007= ") CATEG2007='PLOT very small'.
EXECUTE.

IF (size = 6 & categ2007= ") CATEG2007='PLOT small'.
EXECUTE.

IF (size = 7 & categ2007= ") CATEG2007='PLOT medium'.
EXECUTE.

IF (size = 8 & categ2007= ") CATEG2007='PLOT large'.
EXECUTE .

comment *****.

IF (~(abegyear <= 2008 & aendyear >= 2008)) CATEG2008='NOTEXIST'.
EXECUTE.

IF (zoning08 = 'BP' or zoning08 = 'CN' or zoning08 = 'CR' or zoning08 = 'EX' or
zoning08 = 'HI' or zoning08 = 'I' or zoning08 = 'ON' or zoning08 = 'OR' & categ2008= "
) CATEG2008='COM'.
EXECUTE.

IF (openpubprv = 'y' & categ2008= ") CATEG2008='OPENSOURCE'.
EXECUTE.

IF (agpdr = 'AGPM' | agdist = 'y' & categ2008= ") CATEG2008='Ag Preservation'.
EXECUTE.

IF (pclass = 'EC' & categ2008= ") CATEG2008='Exempt C'.
EXECUTE.

IF (pclass = 'I' & categ2008= ") CATEG2008='Industrial'.
EXECUTE.

IF (pclass = 'ER' & categ2008= ") CATEG2008='Exempt R'.
EXECUTE.

IF (pclass = 'U' & categ2008= ") CATEG2008='Utility'.
EXECUTE.

IF (pclass = 'C' & categ2008= ") CATEG2008='Assessed Commercial'.
EXECUTE.

IF (size = 1 & bldg08 > 0 & categ2008= ") CATEG2008='BLT very small'.
EXECUTE.

IF (size = 1 & bldg08 = 0 & categ2008= ") CATEG2008='LOT very small'.

EXECUTE.

IF (size = 2 & bldg08 = 0 & categ2008= ") CATEG2008='LOT small'.

EXECUTE.

IF (size = 2 & bldg08 > 0 & categ2008= ") CATEG2008='BLT small'.

EXECUTE.

IF (size = 3 & bldg08 = 0 & categ2008= ") CATEG2008='LOT med'.

EXECUTE.

IF (size = 3 & bldg08 > 0 & categ2008= ") CATEG2008='BLT med'.

EXECUTE.

IF (size = 4 & bldg08 = 0 & categ2008= ") CATEG2008='LOT large'.

EXECUTE.

IF (size = 4 & bldg08 > 0 & categ2008= ") CATEG2008='BLT large'.

EXECUTE.

IF (size = 5 & categ2008= ") CATEG2008='PLOT very small'.

EXECUTE.

IF (size = 6 & categ2008= ") CATEG2008='PLOT small'.

EXECUTE.

IF (size = 7 & categ2008= ") CATEG2008='PLOT medium'.

EXECUTE.

IF (size = 8 & categ2008= ") CATEG2008='PLOT large'.

EXECUTE .

comment *****.

IF (~(abegyear <= 2009 & aendyear >= 2009)) CATEG2009='NOTEXIST'.

EXECUTE.

IF (zoning09a = 'BP' or zoning09a = 'CN' or zoning09a = 'CR' or zoning09a = 'EX' or
zoning09a = 'HI' or zoning09a = 'I' or zoning09a = 'ON' or zoning09a = 'OR' &
categ2009= ") CATEG2009='COM'.

EXECUTE.

IF (openpubprv = 'y' & categ2009= ") CATEG2009='OPENSOURCE'.

EXECUTE.

IF (agpdr = 'AGPM' | agdist = 'y' & categ2009= ") CATEG2009='Ag Preservation'.

EXECUTE.

IF (pclass = 'EC' & categ2009= ") CATEG2009='Exempt C'.

EXECUTE.

IF (pclass = 'I' & categ2009= ") CATEG2009='Industrial'.

EXECUTE.

IF (pclass = 'ER' & categ2009= ") CATEG2009='Exempt R'.

EXECUTE.

IF (pclass = 'U' & categ2009= ") CATEG2009='Utility'.

EXECUTE.

IF (pclass = 'C' & categ2009= ") CATEG2009='Assessed Commercial'.

EXECUTE.

IF (size = 1 & bldg09 > 0 & categ2009= ") CATEG2009='BLT very small'.

EXECUTE.

```

IF (size = 1 & bldg09 = 0 & categ2009= " ) CATEG2009='LOT very small'.
EXECUTE.
IF (size = 2 & bldg09 = 0 & categ2009= " ) CATEG2009='LOT small'.
EXECUTE.
IF (size = 2 & bldg09 > 0 & categ2009= " ) CATEG2009='BLT small'.
EXECUTE.
IF (size = 3 & bldg09 = 0 & categ2009= " ) CATEG2009='LOT med'.
EXECUTE.
IF (size = 3 & bldg09 > 0 & categ2009= " ) CATEG2009='BLT med'.
EXECUTE.
IF (size = 4 & bldg09 = 0 & categ2009= " ) CATEG2009='LOT large'.
EXECUTE.
IF (size = 4 & bldg09 > 0 & categ2009= " ) CATEG2009='BLT large'.
EXECUTE.
IF (size = 5 & categ2009= " ) CATEG2009='PLOT very small'.
EXECUTE.
IF (size = 6 & categ2009= " ) CATEG2009='PLOT small'.
EXECUTE.
IF (size = 7 & categ2009= " ) CATEG2009='PLOT medium'.
EXECUTE.
IF ( size = 8 & categ2009= " ) CATEG2009='PLOT large'.
EXECUTE .

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IF (bldg99 > 0 & bldg98 = 0) builtyear=1999.
EXECUTE.

```

```

IF (bldg00 > 0 & bldg99 = 0) builtyear=2000.
EXECUTE.

```

```

IF (bldg01 > 0 & bldg00 = 0) builtyear=2001.
EXECUTE.

```

```

IF (bldg02 > 0 & bldg01 = 0) builtyear=2002.
EXECUTE.

```

```

IF (bldg03 > 0 & bldg02 = 0) builtyear=2003.
EXECUTE.

```

```

IF (bldg04 > 0 & bldg03 = 0) builtyear=2004.
EXECUTE.

```

```

IF (bldg05 > 0 & bldg04 = 0) builtyear=2005.
EXECUTE.

```

IF (bldg06 > 0 & bldg05 = 0) builtyear=2006.
EXECUTE.

IF (bldg07 > 0 & bldg06 = 0) builtyear=2007.
EXECUTE.

IF (bldg08 > 0 & bldg07 = 0) builtyear=2008.
EXECUTE.

IF (bldg09 > 0 & bldg08 = 0) builtyear=2009.
EXECUTE.

IF (CHAR.SUBSTR(cat99,1,3) = 'LOT') lot00='y'.
EXECUTE.

IF (CHAR.SUBSTR(cat00,1,3) = 'LOT') lot01='y'.
EXECUTE.

IF (CHAR.SUBSTR(cat01,1,3) = 'LOT') lot02='y'.
EXECUTE.

IF (CHAR.SUBSTR(cat02,1,3) = 'LOT') lot03='y'.
EXECUTE.

IF (CHAR.SUBSTR(cat03,1,3) = 'LOT') lot04='y'.
EXECUTE.

IF (CHAR.SUBSTR(cat04,1,3) = 'LOT') lot05='y'.
EXECUTE.

IF (CHAR.SUBSTR(cat05,1,3) = 'LOT') lot06='y'.
EXECUTE.

IF (CHAR.SUBSTR(cat06,1,3) = 'LOT') lot07='y'.
EXECUTE.

IF (CHAR.SUBSTR(cat07,1,3) = 'LOT') lot08='y'.
EXECUTE.

IF (CHAR.SUBSTR(cat08,1,3) = 'LOT') lot09='y'.
EXECUTE.

IF (largedev = 'y' & categ2001= ") CATEG2001=' FUTURE DEV'.
EXECUTE.

IF (pclass = 'ER' & categ2001= ") CATEG2001=' Exempt R'.
EXECUTE.

IF (pclass = 'EF' & categ2001= ") CATEG2001=' Exempt F'.
EXECUTE.

IF (yearcreate = 2001 & bldg01 = 0 & categ2001= ") CATEG2001='Empty lot created'.
EXECUTE.

IF (yearcreate = 2001 & bldg01 >= 10000 & categ2001= ") CATEG2001=' Lot created
and built'.
EXECUTE.

IF (bldg01 >= 10000 & bldg00 < 10000 & categ2001= ") CATEG2001=' Lot created'.
EXECUTE.

IF (bldg01 < 5000 & bldg00 < 5000 & categ2001= ") CATEG2001=' Open Lot'.
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'S') potunits=shapacr .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'SR') potunits=shapacr / 4 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'SE') potunits=shapacr / 3 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'ST') potunits=shapacr / 5 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC2a') potunits= 0.7 * shapacr
/ 2 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC40') potunits= 0.7 * shapacr
/ 1 .

EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC21') potunits= 0.7 * shapacr / .5 .

EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC15') potunits= 0.7 * shapacr / .66 .

EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NCpud') potunits= 0.7 * shapacr / .33 .

EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC10') potunits= 0.7 * shapacr / .25 .

EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC6.5') potunits= 0.7 * shapacr / .16 .

EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC5') potunits= 0.7 * shapacr / .125 .

EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NCmm') potunits= 0.7 * shapacr / .125 .

EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'Nga') potunits= 0.7 * shapacr / .05 .

EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NCap') potunits= 0.7 * shapacr / .025 .

EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) =) potunits = multiunit .

EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'S') potunits=shapacr .

EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'SR') potunits=shapacr / 4 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'SE') potunits=shapacr / 3 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'ST') potunits=shapacr / 5 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC2a') potunits= 0.7 * shapacr
/ 2 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC40') potunits= 0.7 * shapacr
/ 1 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC21') potunits= 0.7 * shapacr
/ .5 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC15') potunits= 0.7 * shapacr
/ .66 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NCpud') potunits= 0.7 *
shapacr / .33 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC10') potunits= 0.7 * shapacr
/ .25 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC6.5') potunits= 0.7 *
shapacr / .16 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NC5') potunits= 0.7 * shapacr /
.125 .
EXECUTE.

IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NCmm') potunits= 0.7 *
shapacr / .125 .
EXECUTE.

```
IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'Nga') potunits= 0.7 * shapacr /  
.05 .  
EXECUTE.
```

```
IF (CHAR.SUBSTR(cat10,1,4) = 'PLOT' & zoning10 = 'NCap') potunits= 0.7 * shapacr  
/ .025 .  
EXECUTE.
```