The Geospatial Small-Area Population Forecasting Model Methodology Used by the Southwest Florida Water Management District

Prepared For

Southwest Florida Water Management District
Agreement 19CN0002133
TWA 24TW0004444

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January 21, 2025

TABLE OF CONTENTS

INTRODUCTION 3

GEOSPATIAL SMALL-AREA POPULATION FORECASTING MODEL OVERVIEW 3

COUNTY BUILD-OUT SUBMODELS 5
- Parcels 5
- 2020 US Census Data 5
- Wetlands 5
- Future Land Use 6
- Administrative Boundaries 8
- Build-out Density Calculation 8
- Residential Development Plans 9

GROWTH DRIVERS SUBMODEL 9

GEOSPATIAL SMALL-AREA POPULATION FORECASTING MODEL 11
- Historic Growth Trends 11
- Growth Calculation Methodology 15

NON-RESIDENT POPULATION PROJECTIONS 15
- Peak Seasonal Population Cohort 15
- Functionalized Seasonal Population Cohort 17
- Tourist Population Cohort 17
- Net Commuter Population Cohort 18

UTILITY SERVICE AREA POPULATION SUMMARIES 19

PROJECTION DELIVERABLES 19

CONCLUSIONS 22

REFERENCES 22

LIST OF FIGURES

Figure 1. SWFWMD population projection process flowchart. 4

Figure 2. Example of inconsistencies between wetland delineation and residential parcels. 6

Figure 3. Future Land Use helps identify future residential areas. 7

Figure 4. Tampa Area Build-out Density Submodel shaded by maximum pop-ulation per acre. .. 8

Figure 5. Growth Drivers Submodel 10

Figure 6. Tampa area parcels shaded by projected 2050 population per acre........................... 21

LIST OF TABLES

Table 1. Wetland land cover codes and descriptions used in the County Build-out Submodels ... 6

Table 2. GIS datasets used in the Growth Drivers Submodel 9

Table 3. Utility service area population projection summaries table for Manatee County 20

INTRODUCTION

This document describes the methodologies used to develop small-area population projections for the Southwest Florida Water Management District (SWFWMD) in support of water supply planning and water use permitting. The county-level projections available from the Bureau of Economic and Business Research (BEBR) at the University of Florida are the official projections for the State of Florida and the generally accepted standard throughout the state, but accurately projecting future water demand for water utility potable service areas requires more precision than is offered by county-level projections. In addition, the Census Population Cohort projected by BEBR does not include important non-resident populations, such as seasonal, tourist, or commuter populations. For these reasons, SWFWMD contracted GIS Associates, Inc. (GISA) through WRA Engineering to provide small-area population projections for the 17 SWFWMD counties. (Note that there are only 16 counties located partly or entirely within SWFWMD, but forecasts were also made for two utility service areas in the northern part of Lee County that have water use permits with SWFWMD.) This was achieved by implementing GIS Associates' Geospatial Small-Area Population Forecasting Model ("Population Model"), which makes Census Population Cohort projections at the 2020 Census Tract level, and spatially distributes those projections to individual land parcels to facilitate aggregation by utility or other boundaries. In addition, GISA applied SWFWMD methods for projecting non-resident population to the Census Population Cohort projections derived from the Population Model. This document describes these projection methodologies and their use to project future populations. Ultimately, these small-area population projections are used as a basis for making future water demand projections for SWFWMD.

GEOSPATIAL SMALL-AREA POPULATION FORECASTING MODEL OVERVIEW

The geographic information system (GIS) based Population Model projected future Census Population Cohort population growth at the parcel level and controlled those projections to BEBR's latest county-level forecasts. Figure 1 on the following page is a process flow chart of the population projection and distribution methodology. First, County Build-out Submodels were developed using property parcel data for each of the 17 counties that are entirely or partly within SWFWMD. The purpose of the County Build-out Submodel is to develop maximum residential development potential at the parcel level. A detailed description of this model is included in the chapter titled "County Build-out Submodels". Current resident population was estimated and then the maximum population to which a county can grow was projected at the parcel level by the County Build-out Submodels. Areas which cannot physically or lawfully allow residential development (built-out areas, water bodies, public lands, commercial areas, etc.) were excluded from the County Build-out Submodel. Conversely, the model identified areas where growth is more likely to occur based on proximity to features that drive growth (e.g., roads). This is discussed in detail in chapter titled "Growth Drivers Submodel".

Next, population growth was modeled between the launch year population (2023) and the build-out population. Projections are based on a combination of historic growth trends and spatial constraints and influences, which both restrict and direct growth. This process is described in detail in the section titled "Geospatial Small-Area Population Estimation and Forecasting Model". Population growth calculations were controlled to BEBR's 2024 medium projections (BEBR's latest population forecasts for the years 2025 through 2050), which were available in five-year increments. The source of this data is the BEBR publication *Projections of Florida Population by County, 2025-2050, with Estimates for 2023.* (Florida Population Studies, Volume 57, Bulletin 198, January 2024).

The launch year for the version of the model described in this document was 2023, which was calibrated to the 2023 BEBR population estimates. Projections were made for April 1, 2025 to April 1, 2050 in five-year increments.

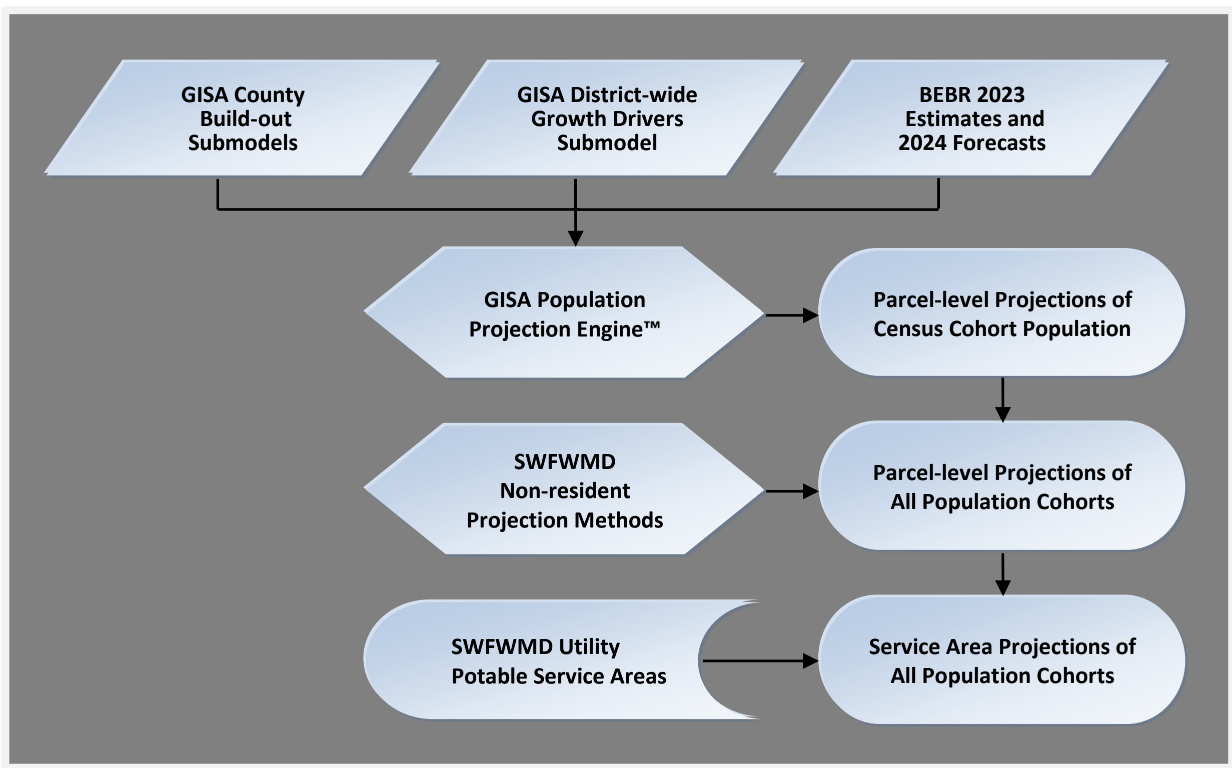

Figure 1. SWFWMD population projection process flowchart

Finally, the parcel level projections were summarized by water utility service area boundaries that SWFWMD maintains in a spatial (GIS) database. These summaries were exported to a Microsoft Excel spreadsheet with separate tabs for each county to facilitate the review and distribution of the results.

COUNTY BUILD-OUT SUBMODELS

The County Build-out Submodels were composed of multiple GIS data elements. Each model was based on each county property appraiser's GIS parcel database, including the associated tax roll information. Other GIS data elements included the 2020 Decennial Census data, local government future land use data, development plans, SWFWMD water/wetland data, and BEBR's official population estimates.

Parcels

GIS parcel layers and county tax roll databases were obtained from each county property appraiser's office. Parcel geometry was checked for irregular topology, particularly overlaps and fragments. Parcel tables were checked for errors, particularly non-unique parcel identifiers and missing values. Required tax roll table fields include actual year built, Florida Department of Revenue (DOR) land use code, and the total number of existing residential units for each parcel.

In cases where attribute data was missing or appeared to be in error, other data were used. For example, data reported by the State of Florida, military bases, and colleges and universities were used to identify the number of residential units (and population) in large group quarters facilities. In cases where mobile home parks without individually platted parcels did not appear to have the correct number of units within the property appraiser data, the number of residential units were estimated using other data from the county, information on the mobile home park websites, or even hand counts from recent imagery.

2020 US Census Data

Some of the essential data to translate parcels to population in the County Build-out Submodels were derived from the 2020 Decennial Census. Average housing unit occupancy and population per household by census tract were calculated for each census tract and then transferred to each county's parcel data. These were applied to our parcel-level housing units from property appraiser data and added to our estimates of population in group quarters (estimated using property appraiser bed counts, 2023 BEBR surveys of large group quarters, and 2020 Census counts). The resulting parcel-level population estimates were then controlled at county and place levels to the 2023 BEBR population estimates.

Wetlands

Wetlands (including surface water) are an important consideration when modeling a county's build-out. SWFWMD maintains a detailed wetlands GIS data layer. This data layer contains the location and spatial extent of the wetlands, as well as the specific types of wetlands as defined by SWFWMD land cover classifications. Certain wetland types were identified that would be difficult and expensive to convert to residential development. These areas were identified in the

SWFWMD wetland database and applied to the appropriate County Build-out Submodel. The wetland types are listed in Table 1.

Table 1. Wetland land cover codes and descriptions used in the County Build-out Submodels

Code	Description	Code	Description
5100	Streams and waterways	5600	Slough waters
5200	Lakes	6110	Wetland Hardwood Forests
5250	Marshy Lakes	6120	Mangrove swamp
5300	Reservoirs	6170	Mixed wetland hardwoods
5400	Bays and estuaries	6180	Cabbage palm wetland
6181	Cabbage palm hammock	6410	Freshwater marshes
6200	Wetland Coniferous Forest	6420	Saltwater marshes
6210	Cypress	6430	Wet prairies
6220	Pond pine	6440	Emergent aquatic vegetation
6250	Hydric pine flatwoods	6460	Mixed scrub-shrub wetland
6300	Wetland Forested Mixed	6500	Non-vegetated Wetland

Wetland GIS data (using the above classifications) were overlaid with a county's land parcels. The area of wetlands within parcels were calculated and recorded as the water area for that parcel. If the area covered by water within a parcel exceeded ½ acre, it was subtracted from the total area of the parcel feature to determine the relative developable area in that parcel. There were exceptions to this rule. In some cases, parcels with little or no developable area after wetlands were removed were already developed, thus the estimated unit total was not reduced by the wetland acreage. In other cases, inaccurate wetland delineations were overridden, such as when a newly platted residential parcel was shown to be covered by a wetland (Figure 2). In such a case, the parcel was considered developable by the submodel.

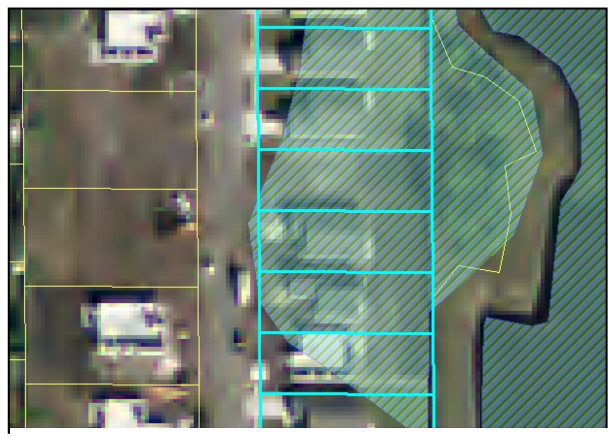

Figure 2. Example of inconsistencies between wetland delineation and residential parcels (outlined here in light blue)

Future Land Use

Future land use maps are essential elements of the County Build-out Submodels. These maps help guide where and at what density residential development could occur within a county. Future land use maps are a part of the local government comprehensive plans required for all local governments by Chapter 163, Part II, Florida Statutes. They are typically developed by the local government's planning department, or, in some cases, a regional planning council on behalf of the local government. The planning horizons for these are a minimum of 10 years, and they often extend for 15 to 20 years into the future. Although these future land use maps may be revised over time, they reflect the most up-to-date plan for future growth areas and densities. The latest available future land use maps were obtained and applied to the County Build-out Submodels.

Each land parcel in the County Build-out Submodels received a future land use designation. In places where parcels overlapped multiple future land use areas, the parcel was assigned the future land use class within which its centroid fell. Build-out population was modeled only for future land use classes that allow residential development, as shown in the yellow parcels in Figure 3. These include all residential uses, mixed use, and agricultural use, and in some cases institutional, commercial, and other uses, depending on the use type and jurisdiction's comprehensive plan.

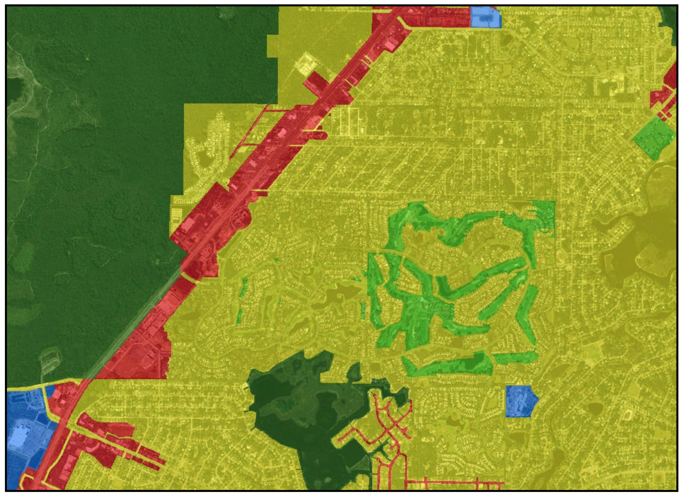

Figure 3. Future land use helps identify future residential areas (here shaded in yellow)

Development typically does not occur at the maximum densities allowed for each future land use category, so recent development densities were considered a better proxy for future densities than the maximum allowable density. For this reason, the County Build-out Submodels reflect the median density of recent development for each future land use category in the specific incorporated place. For example, if a city's medium density residential future land use designation allows up to 8 housing units per acre, but the median density of units built over the last 10 years is 5.7 housing units per acre, the submodel assumed future densities at 5.7 housing units per acre for that future land use designation in that city.

Typically, the median density calculation was limited to the last 10 years of development within each unique combination of land use and jurisdiction, as more recent development was deemed a better proxy for future densities than older development. In some cases, limiting the historical data to the last 10 years resulted in too small a sample, so either county average values were used (extended beyond the jurisdiction) or a longer base period was used (not limited to the last 10 years). In those cases, the determination of which sample to use depended upon the heterogeneity of the category across county jurisdictions, the heterogeneity of historical densities prior to the last 10 years, and our professional judgement. In some cases, where very few or no historical examples of residential parcels fell within a future land use category, a density from a similar future land use within the county (with sufficient historical samples) was used as a surrogate. Also, vacant or open parcels less than one acre in size but with sufficient developable area were typically considered single family residential, with one housing unit as the maximum allowable density.

Administrative Boundaries

Each parcel in the County Build-out Submodels was also attributed with administrative boundaries, including:

1. County and city name (or unincorporated area) from the 2023 boundaries from the U.S. Census Bureau,
2. Water management district boundaries (from SWFWMD's GIS data), and
3. SWFWMD water utility service area identifier.

These attributes enable queries and summaries of the county submodels by any combination of these boundaries.

Build-out Density Calculation

Using GIS overlay techniques, attributes of the census, political boundary, wetlands, future land use, and planned development data were attributed to each county's parcel map to develop the County Build-out Submodels. These submodels forecast the maximum residential population by parcel at build-out. Figure 4 depicts the Tampa area, showing lower densities at build-out in yellow and higher ones in brown. Non-residential uses are not shaded.

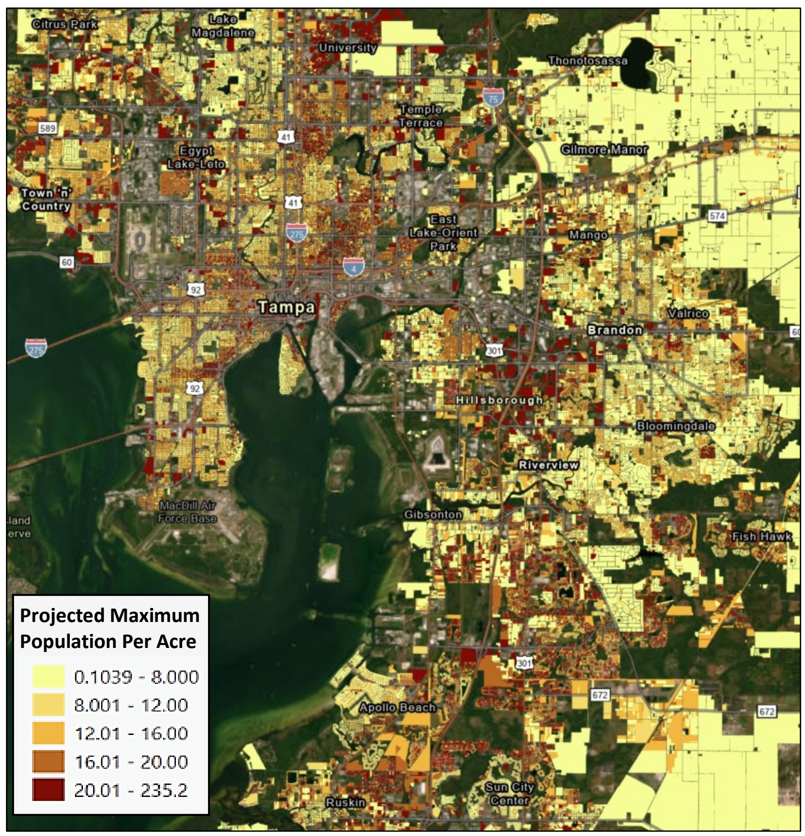

Figure 4. Tampa Area Build-out Density Submodel shaded by maximum population per acre

To estimate and project population from parcel-level housing units, the 2020 Census average household size was multiplied by the average housing unit occupancy rate at the tract level. In some cases, small group quarters population was included in the calculation by dividing the 2020 tract popualtion by its housing units. Also, if there were tracts with 2020 census values for persons per housing unit that were unusually high or low and based on a small number of homes (or no homes), the county's average persons per housing unit was typically used <u>for projected growth</u> in that tract. For group quarters facilities, population was based on annual BEBR surveys and bedroom counts, not average household size.

Residential Development Plans

The final step in the construction of the County Build-out Submodels was adjusting build-out densities within residential developments and redevelopments to correspond with approved development plans wherever their boundaries are available in a GIS format. Although developments may not develop as originally planned by the developer, the total number of units planned (regardless of timing) is likely to be a better forecast of the units at build-out than one based on the median historic densities. Therefore, in each of the County Build-out Submodels, parcels with centroids within a planned development were attributed with the name of the development. (Sometimes this included non-residential parcels.) The build-out densities for those parcels were adjusted so that the total housing units at build-out for the development was consistent with the development plan, and the build-out population for that area was recalculated.

GROWTH DRIVERS SUBMODEL

The Growth Drivers Submodel is a district-wide, raster (cell-based) GIS model representing development potential. The submodel is a continuous surface of 10-meter cells containing values of 0-100, with '100' having the highest development potential and '0' having the lowest development potential. It influences the Population Model by factoring in the attraction of certain spatial features, or growth drivers on development. These drivers were identified from transportation and land use/land cover data and included the following:

1. Proximity to roads and interchanges (with each road type modeled separately)
2. Proximity to water utility service areas
3. Proximity to existing commercial parcels (commercial parcels with land uses deemed an attractor to residential growth)
4. Proximity to existing residential parcels
5. Proximity to coastal and inland waters

Data used for generating the Growth Drivers Submodel are listed in Table 3 below.

Table 2. GIS datasets used in the Growth Drivers Submodel

Growth Driver	Data Source
Roads and Limited Access Road Interchanges	Florida Department of Transportation (FDOT) Major Roads: Functional Classification (FUNCLASS), and FDOT Limited Access Road Interchanges
Developments	Multiple sources, including Regional Planning Councils, local governments, SWFWMD, GIS Associates, and BEBR
Selected Existing Commercial Land Uses	County Property Appraiser Parcel Data
Water Utility Service Areas	SWFWMD, SFWMD, SJRWMD, and SRWMD
Coastal and Inland Waters	SWFWMD Land Cover Data, and Florida Geographic Data Library (FGDL) Coastline Data

Each of the drivers listed in Table 3 were used as independent variables in a logistic regression equation. Dependent variables included existing residential units built during or after 1995 as the measure of “presence”, and large undeveloped vacant parcels outside of large, planned developments were used to measure “absence”. The resulting equation could then be applied back to each of the regional grids resulting in a single regional grid with values 0 through 100, for which a value of 0 represented the lowest relative likelihood of development, and a value of 100 represented the highest relative likelihood of development.

Some adjustments were made to the default driver values. First, any parcels with vacant land uses that were developed during or after the launch year (2023) were assigned a driver value of 100 to ensure they would be built by 2025. Second, the driver values for any vacant platted residential parcels within a development were averaged with a higher value to boost their development potential. (This value was typically 99 but sometimes slightly varied by county.) Third, the driver values for vacant non-platted parcels within developments were averaged with a higher value to boost their development potential. (This value was typically 90 but sometimes slightly varied by county.)

This seamless, regional submodel covers all the counties that are all or partially within the Southwest Florida Water Management District, plus a one-county buffer to account for growth drivers outside the District that could influence growth within the District. It was then reclassified to stretch its mean driver values between 0 and 100, to better differentiate the relative probability of development.

Figure 5 depicts the Growth Drivers Submodel for SWFWMD, with high development potential in red, moderate development potential in yellow and low development potential in blue. This submodel was then used by the Population Model to rank undeveloped parcels based on their development potential, which is explained in the “Growth Calculation Methodology” section. Note that growth may still occur in areas assigned relatively low values from this model based on the historical growth trends. This submodel was used to rank undeveloped parcels based on their development potential, which is explained in the Growth Calculation Methodology section.

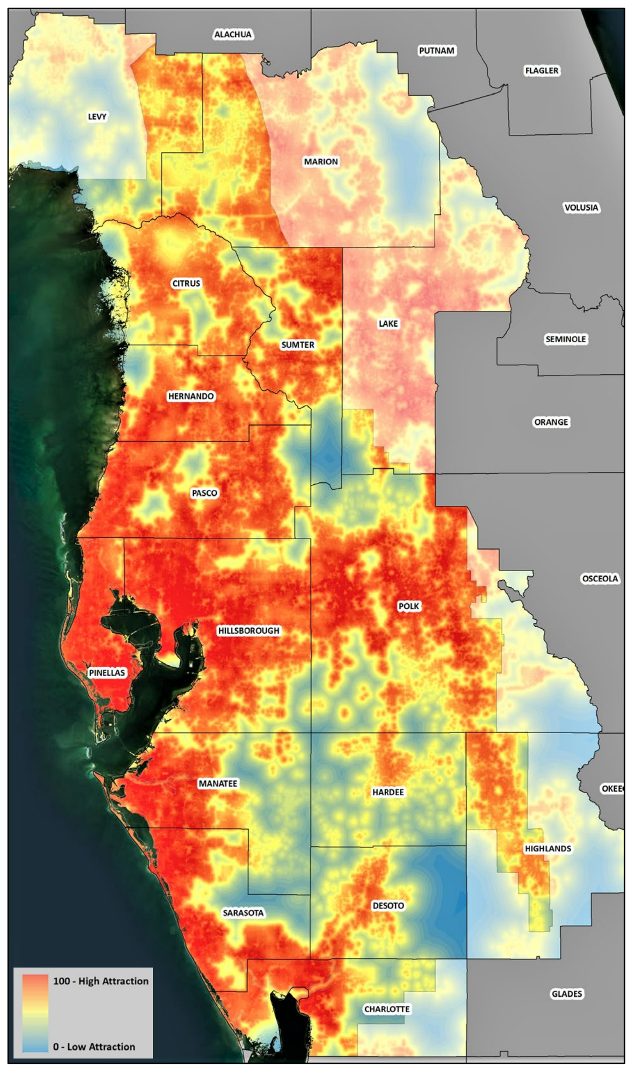

Figure 5. Growth Drivers Submodel

GEOSPATIAL SMALL-AREA POPULATION FORECASTING MODEL

GISA's Geospatial Small-Area Population Forecasting Model (Population Model) integrates the County Build-out Submodels and the Growth Drivers Submodel with the GISA Population Projection Engine, which makes the projection calculations using a combination of those submodels, historic growth trends, and growth controls from BEBR's county-level forecasts.

Historic Growth Trends

The historic growth trends were based on historic population counts from the 1990, 2000, 2010, and 2020 censuses. For 1990, 2000, and 2010, census block population counts were summarized at the 2020 tract level and combined with the 2020 tract population counts. These counts were used to produce twelve tract level projections using five different demographic extrapolation methods using multiple base periods. The length of the base was adjusted to roughly match the length of the projection horizon. For example, a 23-year historical period (2000-2023) was used to establish the growth trends for a 22-year projection horizon (2023-2045). The number of trend calculations varied based on the length of the base period used, and the highest and lowest calculations were discarded to moderate the effects of extreme projections. The remaining projections were then averaged.

The five demographic extrapolation methods for projecting population utilized by the model were Linear, Exponential, Constant Share, Share-of-Growth, and Shift-Share. The Linear and Exponential techniques employ a bottom-up approach, extrapolating the historic growth trends of each census tract with no consideration for the county's overall growth. The Constant Share, Share-of-Growth and Shift-Share techniques employ a ratio allocation, or top-down approach, allocating a portion of the total projected county population or growth to each census tract based on that census tract's percentage of county population or growth over the historical period. Each of the five methods is a good predictor of growth in different situations and growth patterns, so using a combination of all five and discarding the highest and lowest results was the best way to avoid the largest possible errors resulting from the least appropriate techniques for each census tract within the 17 counties. This approach is similar to BEBR's county population forecast methods, but the base periods and the number of projections are somewhat different because annual estimates are not available at the tract level.

The calculations associated with the five statistical methods are described on the following pages. The launch year was 2023, and the projections were made for 2025, 2030, 2035, 2040, 2045, and 2050. Note that for the 2023-2025 iteration, the typical five-year growth was reduced to reflect only a two-year change.

The calculations used are provided on the following pages.

1. **Linear Projection Method:** The Linear Projection Method assumes that the average annual change in the number of persons for each census tract will be the same as during the base period (Rayer and Comfort, 2024). Four linear growth rate calculations were made, 1990 to 2023, 2000 through 2023, 2010 through 2023, and 2020 through 2023. In the Linear methods (LIN), population growth was calculated using the following formulas:

$$LIN33 = \frac{(TractPop2023 - TractPop1990)}{33} * 5$$

$$LIN23 = \frac{(TractPop2023 - TractPop2000)}{23} * 5$$

$$LIN13 = \frac{(TractPop2023 - TractPop2010)}{13} * 5$$

$$LIN3 = \frac{(TractPop2023 - TractPop2020)}{3} * 5$$

2. **Exponential Projection Method:** The Exponential Projection Method assumes that population will continue to change at the same percentage rate as it did during the base period (Rayer and Comfort, 2024). One calculation was made from 2010 through 2023. In the Exponential method (EXP), population growth was calculated using the following formula:

$$EXP13 = (TractPop2023 * e^{5r}) - TractPop2023$$

$$Where, r = \frac{ln\frac{TractPop2023}{TractPop2010}}{13}$$

3. **Constant Share Projection Method:** The Constant Share Projection Method assumes that each census tract's percentage of the county's total population (CntyPop) will be the same as over the base year (Rayer and Comfort, 2024). One calculation was made using the 2023 share of county population. In the Constant Share method (CS), population growth was calculated using the following formula (using 2025–2030 as an example):

$$CS = \frac{TractPop2023}{CntyPop2023} * (CntyPop2030 - CntyPop2025)$$

4. **Share-of-Growth Projection Method**: The Share-of-Growth Projection Method assumes that each census tract's percentage of the county's total growth will be the same as over the base period (Rayer and Comfort, 2024). However, if population change is negative at the tract level and positive at the county level (or vice versa), higher county-level projections would result in larger declines in tract projections. This is counterintuitive, so the "Plus-minus" variant of the Share-of-Growth Method was used (Rayer, 2015). Three Share-of-Growth (SOG) calculations were made, 1990 through 2023, 2000 through 2023, and 2010 through 2023. Population growth was calculated using the following formulas <u>if</u> the changes in growth over the base period for the tract and county were both positive or both negative (using 2025–2030 as an example):

$$SOG33 = \frac{(TractPop2023 - TractPop1990)}{(CntyPop2023 - CntyPop1990)} * (CntyPop2030 - CntyPop2025)$$

$$SOG23 = \frac{(TractPop2023 - TractPop2000)}{(CntyPop2023 - CntyPop2000)} * (CntyPop2030 - CntyPop2025)$$

$$SOG13 = \frac{(TractPop2023 - TractPop2010)}{(CntyPop2023 - CntyPop2010)} * (CntyPop2030 - CntyPop2025)$$

If the changes in growth over the base period were negative at the tract level and positive at the county level or vice versa, the population growth was calculated using the following formulas (using 2025–2030 as an example):

$$SOG = \left[\frac{SOG}{CntyPop2030 - CntyPop2025}/5\right] * \left[\begin{matrix}\left[CntySum\left[\frac{ABS(SOG)}{CntyPop2030 - CntyPop2025}\right]\right] \\ + \left[1 - CntySum\left[\frac{SOG}{CntyPop2030 - CntyPop2025}\right]\right]\end{matrix}\right] \div \left[CntySum\left[\frac{ABS(SOG)}{CntyPop2030 - CntyPop2025}\right]\right] * (CntyPop2030 - CntyPop2025)$$

Where:

1) $SOG33 = \frac{(TractPop2023-TractPop1990)}{(CntyPop2023-CntyPop1990)} * (CntyPop2030 - CntyPop2025)$
2) $SOG23 = \frac{(TractPop2023-TractPop2000)}{(CntyPop2023-CntyPop2000)} * (CntyPop2030 - CntyPop2025)$
3) $SOG13 = \frac{(TractPop2023-TractPop2010)}{(CntyPop2023-CntyPop2010)} * (CntyPop2030 - CntyPop2025)$
4) $CntySum = County\ sum\ of\ the\ tract\ projections$
5) $ABS = Absolute\ Value$

5. **Shift-Share Projection Method:** The Shift-Share Projection Method assumes that each census tract's percentage of the county's population will change by the same annual amount as over the base period (Rayer and Comfort, 2024). Three Shift-Share calculations were made, 1990 through 2023, 2000 through 2023, and 2010 through 2023. In the three Shift-Share Projection Method (SSH) calculations, population growth was calculated using the following formulas (using the five years from 2025–2030 as an example):

$$SSH33 = \left[\frac{TractPop2023}{CntyPop2023} + \left[\frac{\left(\frac{TractPop2023}{CntyPop2023} - \frac{TractPop1990}{CntyPop1990} \right)}{33} * 5 \right] \right] * \begin{pmatrix} CntyPop2030 \\ -CntyPop2025 \end{pmatrix}$$

$$SSH23 = \left[\frac{TractPop2023}{CntyPop2023} + \left[\frac{\left(\frac{TractPop2023}{CntyPop2023} - \frac{TractPop2000}{CntyPop2000} \right)}{23} * 5 \right] \right] * \begin{pmatrix} CntyPop2030 \\ -CntyPop2025 \end{pmatrix}$$

$$SSH13 = \left[\frac{TractPop2023}{CntyPop2023} + \left[\frac{\left(\frac{TractPop2023}{CntyPop2023} - \frac{TractPop2010}{CntyPop2010} \right)}{13} * 5 \right] \right] * \begin{pmatrix} CntyPop2030 \\ -CntyPop2025 \end{pmatrix}$$

6. **Average of the Projection Extrapolations:** Because the number of trend calculations varied based on the length of the base period used, different combinations of projections were averaged for different forecast years.

   a. For the 2025, 2030, and 2035 projections, six calculations with base periods up to 13 years were used. The lowest and highest of the six were excluded to moderate the most extreme results of the census tracts throughout the 17 counties, and the remaining four were averaged.

   b. For the 2040 and 2045 projections, nine calculations with base periods up to 23 years were used. The two lowest and two highest of the nine were excluded, and the remaining five were averaged.

   c. For the 2050 projections, twelve calculations with base periods up to 33 years were used. The three lowest and three highest of the twelve were excluded, and the remaining six were averaged.

Growth Calculation Methodology

The Population Projection Model then automated growth calculations using the historic growth trends and queries of the County Build-out Submodels and the Growth Drivers Submodel. The methodology for calculating growth for each projection increment included the following steps:

1. Apply the tract-level projected growth to parcels within each tract, distributing growth to parcels with the highest driver values first.
2. Check growth projections against build-out population and reduce any projections exceeding build-out to equal the build-out numbers.
3. After projecting growth for all census tracts within a particular county, summarize the resulting growth and compare it against countywide BEBR target growth. For each model iteration, this step led to one of two scenarios:
    a. If the Small-Area Population Forecasting Model’s projections exceeded the BEBR target growth, reduce the projected growth for parcels with the lowest growth driver values until the county growth equaled the target.
    b. If the Small-Area Population projection model’s projections were less than the BEBR target, develop parcels with the highest growth driver values and available capacity until the BEBR target growth is reached.

Counties that are partially within another water management district were processed in their entirety and controlled to the BEBR-based target growth.

NON-RESIDENT POPULATION PROJECTIONS

In addition to the Census Population Cohort projections generated by the Population Model, projections of non-resident population were also made. Those projections include peak seasonal population, functionalized seasonal population, tourist population and net commuter population. The methods for projecting those population types were originally developed by SWFWMD and were implemented by GIS Associates are described in this section.

Peak Seasonal Population Cohort

Seasonal population was estimated by SWFWMD using a combination of 2010 census data and emergency room admissions data, both at the Zip Code Tabulation Area (ZCTA) level. Average 2009 - 2011 emergency room admissions data was utilized for the 45-74 age cohort, which is typical of seasonal population. A “Seasonal Resident Ratio” was calculated by ZCTA to estimate the proportion of peak (including seasonal) to resident population.

The Seasonal Resident Ratio was derived using the following steps:

1. Subtract the sum of the 2009 - 2011 third quarter (July, August, and September) hospital admissions from the sum of the 2009 - 2011 first quarter (January, February, and March) admissions.
2. Calculate the average annual difference between the first quarter and third quarter by dividing above result by three.
3. Calculate a seasonal population estimate for each ZCTA by dividing the above difference by the probability of the population in the 45-74 age cohort being admitted to the emergency room (approximately 2.23%).
4. Calculate the Seasonal Resident Ratio by adding the seasonal population to the resident population and dividing that total by the resident population.

The number of seasonal households was then estimated using the following steps:

1. Multiply the resident population in households (from the 2010 census) by the Seasonal Resident Ratio.
2. Subtract the resident population in households from above result.
3. Divide above result by the lesser of SWFWMD's seasonal persons per household (1.95) or the census resident persons per household for each ZCTA.

The ratio of seasonal to total households was then calculated by dividing seasonal households by the sum of seasonal and resident households. Seasonal peak population was then calculated using the following steps:

1. Subtract vacant housing units for reasons other than seasonal, recreational, or occasional use from total housing units (from the 2010 census).
2. Multiply above result times the seasonal to total household ratio.
3. Multiply above result times the lesser of SWFWMD's seasonal persons per household (1.95) or the census resident persons per household for each ZCTA.

Because the Census Population Cohort contains some non-residents who complete the census forms in Florida but reside for part of the year elsewhere, it was also necessary to calculate resident population. It was calculated using the following steps:

1. Subtract vacant housing units for reasons other than seasonal, recreational, or occasional use from total housing units (from the 2010 census).
2. Multiply above result times one minus the seasonal to total household ratio.
3. Multiply above result times the census resident persons per household for each ZCTA.

The ratio of total unadjusted peak population to total census population was then calculated by dividing the sum of the seasonal peak population, the resident population in households, and the group quarters population (from the 2010 census) by the total census population. This ratio was then applied by GISA to the future projections of the Census Population Cohort from the Population Model to derive parcel level peak population projections (which also includes residents).

Functionalized Seasonal Population Cohort

The functional population is the peak seasonal population reduced to account for the percentage of the year seasonal population typically reside elsewhere, and the absence of indoor water use during that time. It was calculated using the following generalized steps:

1. Utilize the following metrics previously derived by SWFWMD data and surveys:
   a. The estimated portion of the year seasonal residents spend in Florida, which varies from beach destination counties (44.2%) to non-beach destination counties (56.7%).
   b. The seasonal resident adjustment based on average per capita water use.
      i. The five-year District-wide average per capita use is 132 gallons per person per day, and 69.3 gallons is estimated indoor use and 62.7 gallons for outdoor use.
      ii. The adjustment calculation for "beach destination" counties (Charlotte, Manatee, Pinellas, and Sarasota) is:
      ((0.442 x 132 gpd) + ((1 – 0.442) x 62.7 gpd)) / 132 gpd = 0.707
      iii. The adjustment calculation for "non-beach destination counties" is:
      ((0.567 x 132 gpd) + ((1 – 0.567) x 62.7 gpd)) / 132 gpd = 0.773
2. Calculate "functionalized" seasonal population by multiplying the seasonal peak population by the appropriate seasonal resident adjustment factor for the particular county (0.707 or 0.773).

The ratio of total functional to total census population was then calculated by dividing the sum of the functionalized seasonal population, the resident population, and the group quarters population by the total census population. This ratio was then applied by GISA to the future projections of the Census Population Cohort from the Population Model to derive parcel level functionalized seasonal population projections (which also includes residents).

Tourist Population Cohort

The tourist population projections were based on 28 years (1996-2023) of county-level lodging room data from the Florida Department of Business and Professional Regulation (DBPR). The SWFWMD methodology for projecting future tourist rooms by county utilizes two different methods and averages the two results for each county.

The first method projects the increase in rooms by county by extrapolating the linear trend using the least squares method derived from the last 28 years of county total room estimates.

A second method projects future rooms based on projections of employment in the Accommodation and Food Services industries (from data from Woods and Poole). This is also an extrapolation of a linear trend using the least squares method, but rooms by county are projected as a function of a county's employment projections rather than time.

SWFWMD staff previously tested both methods by projecting values for the years 2007-2013 using room estimates from 1996-2006. Based on the differences between actual room estimates and projected values for 2007-2013, neither method was clearly superior to the other. For that reason, SWFWMD staff opted to use both methods. The results of both methods were averaged, but only after adjusting for the average 2007-2013 error for each projection in each county.

These projections of future rooms were then converted to "functionalized" tourist population by applying various county-level average unit occupancy and party size ratios derived from SWFWMD surveys. SWFWMD also updated the values associated with locations identified as short-term rentals for this projection set based on SWFWMD research.

These projections of tourist population were joined to the existing lodging facility locations, which were geocoded by SWFWMD. No attempt was made to forecast new locations of lodging facilities, as:

1. The precise locations would be highly speculative.
2. It was assumed that lodging facilities often are built in the general vicinity of existing lodging facilities, or at least in close enough proximity to be within the same utility service area.

Net Commuter Population Cohort

The net commuter population projections were based on net commuter data provided by SWFWMD. A census tract ratio was developed of net commuters to total census population. This ratio was then applied to the future projections of the Census Population Cohort from the Population Model to derive parcel level projections for net commuter population. That population was then "functionalized" with the following ratios:

1. 8 / 24 (typical working hours per day)
2. 5 / 7 (typical working days per week)

By applying both of these ratios to the net commuter population, the resulting functional net commuter population is 23.8% of the actual net commuter population. This functional number better reflects the water use that is expected for net commuters.

Note that the net commuter population projection summaries by utility service area were often negative, as many utilities serve "bedroom communities" and other areas where more residents work outside the utility service area than the population (residents and non-residents) employed within it. Only positive net commuter populations were included in a utility's total functional population.

UTILITY SERVICE AREA POPULATION SUMMARIES

The parcel level population projections for all population cohorts discussed above were then summarized by water utility service area boundaries for all utilities mapped by SWFWMD, which typically are those that average more than 0.1 million gallons per day (mgd) of total water use. These service areas, maintained by SWFWMD, were overlaid with each county's parcel level results, and each parcel within a service area was assigned a unique identifier for that service area. The projected population was then summarized by that identifier and joined to SWFWMD's public service area boundary database to produce tabular and spatial output. Note that these service areas change over time, so for any future use of these deliverables, it is important to match this projection set only with the service areas included in the GIS deliverables for this project.

PROJECTION DELIVERABLES

The final population projections were delivered in multiple formats, including:

1. GIS – Esri file geodatabases, with individual feature classes for each county containing parcel level results, and a single feature class districtwide of utility service areas and their population summaries.
2. Tabular – Excel spreadsheet summaries by utility service area

The summaries of population outside of service areas include population with private wells for potable use (considered to be domestic self-supply, or DSS) or small utilities without a service area boundary in SWFWMD's database. Small utilities are generally defined as those utilities permitted for less than 100,000 gallons per day (gpd). However, there are some small utilities in that category that are included here because their service area boundaries are in SWFWMD's database.

Also note that these service area population summaries may include some self-supplied populations (or populations with private wells) that reside within the service areas. The population projections utilized for SWFWMD's planning and permitting may vary from the raw functional population projections developed with the model due to service area boundary changes, self-supplied population, and current population served reported by utility using the required population estimation methodology in Part D of the Water Use Permitting Manual.

The tabular deliverables were parcel summaries at the utility level. Table 3 below includes the service area population projection summaries table for Manatee County as an example.

Table 3. Utility service area population projection summaries table for Manatee County

BEBR / Census Population (Permanent Resident Population)							
Utility Name	2023	2025	2030	2035	2040	2045	2050
OUTSIDE SERVICE AREAS	10,838	13,173	19,770	25,370	26,377	27,197	31,609
CITY OF BRADENTON PUBLIC WORKS	57,253	57,943	59,628	60,593	61,581	62,071	62,349
CITY OF PALMETTO PUBLIC WORKS	14,796	15,109	15,254	15,503	15,671	15,843	16,043
MANATEE COUNTY UTILITIES DEPARTMENT	353,808	370,362	405,535	435,722	461,558	484,177	501,686
TOWN OF LONGBOAT KEY	2,761	2,802	2,802	2,802	2,802	2,802	2,802
PALMETTO PARK	22	22	22	22	22	22	22
PINES TRAILER PARK	42	42	42	42	42	42	42
LAZY ACRES	46	46	46	46	46	46	46

Peak Seasonal Population (Includes BEBR / Census)							
Utility Name	2023	2025	2030	2035	2040	2045	2050
OUTSIDE SERVICE AREAS	11,141	13,636	20,686	26,641	27,664	28,502	33,217
CITY OF BRADENTON PUBLIC WORKS	61,006	61,724	63,482	64,488	65,515	66,025	66,313
CITY OF PALMETTO PUBLIC WORKS	16,464	16,812	16,973	17,250	17,438	17,628	17,852
MANATEE COUNTY UTILITIES DEPARTMENT	388,318	405,891	443,241	475,285	502,599	526,532	544,735
TOWN OF LONGBOAT KEY	5,887	5,976	5,976	5,976	5,976	5,976	5,976
PALMETTO PARK	25	25	25	25	25	25	25
PINES TRAILER PARK	79	79	79	79	79	79	79
LAZY ACRES	51	51	51	51	51	51	51

Functionalized Seasonal Population (Includes BEBR / Census)							
Utility Name	2023	2025	2030	2035	2040	2045	2050
OUTSIDE SERVICE AREAS	11,043	13,499	20,437	26,302	27,318	28,149	32,789
CITY OF BRADENTON PUBLIC WORKS	59,829	60,533	62,257	63,244	64,251	64,751	65,034
CITY OF PALMETTO PUBLIC WORKS	16,004	16,342	16,499	16,768	16,950	17,136	17,352
MANATEE COUNTY UTILITIES DEPARTMENT	380,242	397,530	434,202	465,661	492,522	516,055	533,978
TOWN OF LONGBOAT KEY	5,472	5,555	5,555	5,555	5,555	5,555	5,555
PALMETTO PARK	24	24	24	24	24	24	24
PINES TRAILER PARK	75	75	75	75	75	75	75
LAZY ACRES	49	49	49	49	49	49	49

Functionalized Tourist Population							
Utility Name	2023	2025	2030	2035	2040	2045	2050
OUTSIDE SERVICE AREAS	6	9	10	11	13	14	16
CITY OF BRADENTON PUBLIC WORKS	1,419	2,095	2,391	2,706	3,039	3,390	3,760
CITY OF PALMETTO PUBLIC WORKS	17	24	28	32	35	40	44
MANATEE COUNTY UTILITIES DEPARTMENT	9,221	13,606	15,533	17,580	19,742	22,021	24,423
TOWN OF LONGBOAT KEY	717	1,059	1,209	1,368	1,536	1,713	1,900
PALMETTO PARK	-	-	-	-	-	-	-
PINES TRAILER PARK	-	-	-	-	-	-	-
LAZY ACRES	-	-	-	-	-	-	-

Functionalized Net Commuter Population							
Utility Name	2023	2025	2030	2035	2040	2045	2050
OUTSIDE SERVICE AREAS	(645)	(789)	(1,207)	(1,569)	(1,645)	(1,710)	(1,986)
CITY OF BRADENTON PUBLIC WORKS	2,372	2,564	2,908	2,935	2,933	2,922	2,909
CITY OF PALMETTO PUBLIC WORKS	(394)	(400)	(405)	(412)	(420)	(430)	(442)
MANATEE COUNTY UTILITIES DEPARTMENT	(8,475)	(8,770)	(9,154)	(9,322)	(10,160)	(10,877)	(11,130)
TOWN OF LONGBOAT KEY	139	141	141	141	141	141	141
PALMETTO PARK	(1)	(1)	(1)	(1)	(1)	(1)	(1)
PINES TRAILER PARK	0	0	0	0	0	0	0
LAZY ACRES	(0)	(0)	(0)	(0)	(0)	(0)	(0)

Total Functional Population (Functionalized Seasonal + Tourist + Positive Net Commuter)							
Utility Name	2023	2025	2030	2035	2040	2045	2050
OUTSIDE SERVICE AREAS	11,049	13,508	20,447	26,314	27,331	28,164	32,805
CITY OF BRADENTON PUBLIC WORKS	63,620	65,192	67,557	68,885	70,223	71,063	71,703
CITY OF PALMETTO PUBLIC WORKS	16,020	16,367	16,527	16,800	16,986	17,175	17,396
MANATEE COUNTY UTILITIES DEPARTMENT	389,464	411,136	449,735	483,240	512,263	538,076	558,402
TOWN OF LONGBOAT KEY	6,329	6,754	6,904	7,064	7,232	7,409	7,596
PALMETTO PARK	24	24	24	24	24	24	24
PINES TRAILER PARK	76	76	76	76	76	76	76
LAZY ACRES	49	49	49	49	49	49	49

The GIS outputs are useful for quality assuring the results and inputs, for maintaining the projection inputs over time, and for graphically depicting projected patterns of future population growth. Figure 6 below is an example of this data in the Tampa area. Projected 2050 population per acre is depicted with lower densities in blue, medium densities in yellow, and high densities in red. Non-residential uses are not shaded.

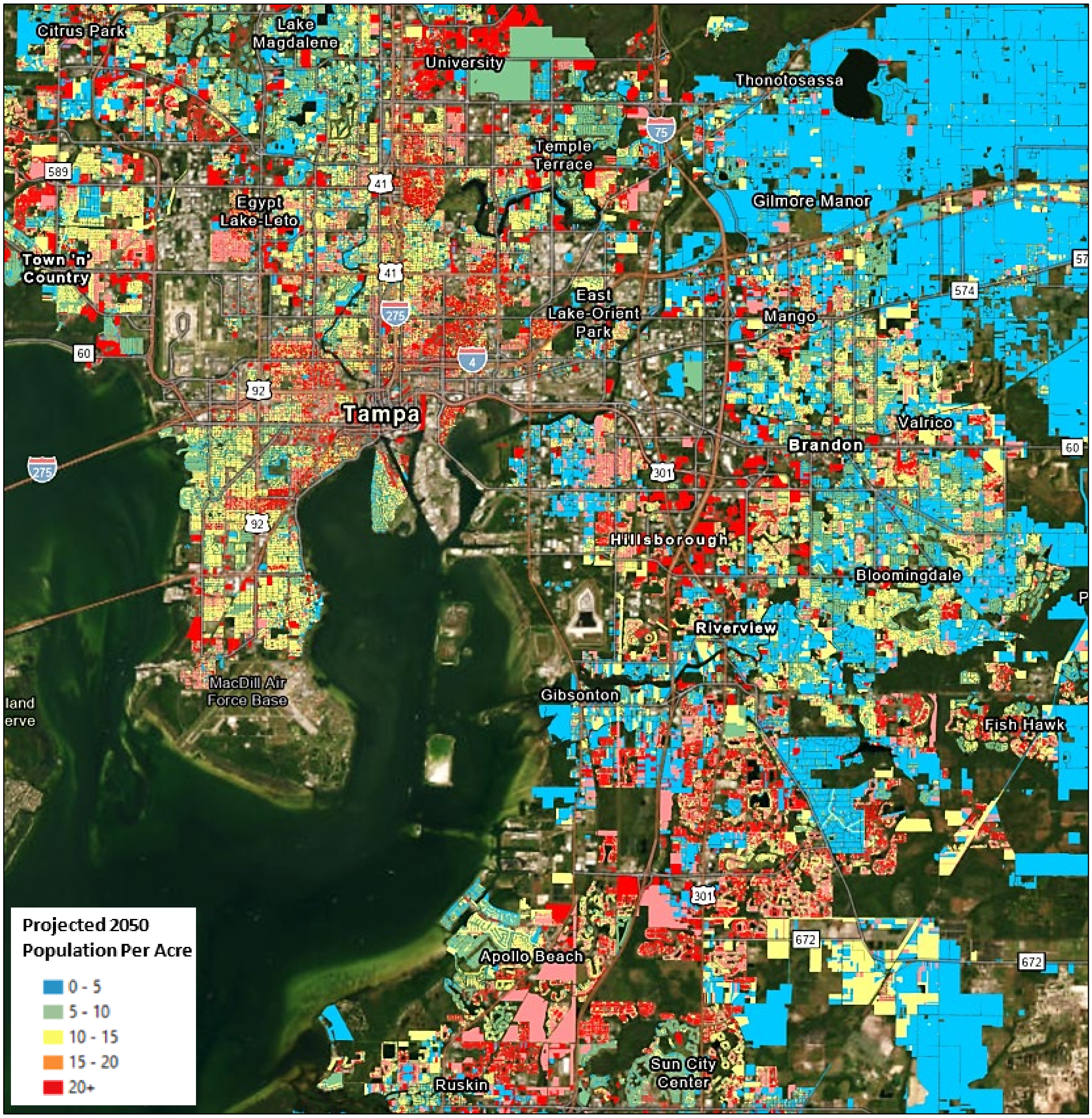

Figure 6. Tampa area parcels shaded by projected 2050 population per acre

CONCLUSIONS

Small area population projections have become increasingly important for planning and permitting, particularly in an area experiencing rapid growth. With ever changing population dynamics and requirements for water supply planning and permitting, it is critical for SWFWMD to be able to accurately forecast population and water demand for small areas, and to be able to update these projections regularly and in a consistent and cost-effective manner. For these reasons, GIS Associates updated and implemented its Geospatial Small-Area Population Forecasting Model and implemented SWFWMD methods for projecting seasonal, tourist and net commuter populations. The Population Model was updated with current data to project population in an efficient and consistent manner throughout the entire 17-county region. Controlling the projections to BEBR's county-level forecasts provided consistency with other projections made by state and local governments, while at the same time providing the spatial precision needed for water supply planning, water use permitting and groundwater modeling.

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