

SPECIAL PUBLICATION SJ2009-SP7

**THE SMALL AREA POPULATION PROJECTION
AND DISTRIBUTION METHODOLOGY OF
THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
FOR THE 2008 DISTRICT WATER SUPPLY ASSESSMENT
AND THE 2010 DISTRICT WATER SUPPLY PLAN**



Special Publication SJ2009-SP7

**THE SMALL AREA POPULATION PROJECTION AND
DISTRIBUTION METHODOLOGY
OF
THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
FOR THE 2008 DISTRICT WATER SUPPLY ASSESSMENT
AND THE 2010 DISTRICT WATER SUPPLY PLAN**

by



**GIS Associates, Inc.
806 NW 16th Avenue, Suite A
Gainesville, Florida 32601**

**Prepared for
The Division of Water Supply Management
Department of Resource Management
The St. Johns River Water Management District
Palatka, Florida**

2009

CONTENTS

INTRODUCTION	1
SMALL AREA POPULATION PROJECTION AND DISTRIBUTION MODEL OVERVIEW	2
COUNTY BUILD-OUT MODELS.....	4
Parcels	4
2000 US Census Block Data.....	5
2000 U.S. Census Place Data.....	5
Water Management District Boundaries.....	5
Wetlands	6
Future Land Use.....	7
Build-out Density Calculation	8
Developments of Regional Impact.....	9
GROWTH DRIVERS MODEL.....	10
SMALL AREA POPULATION PROJECTION AND DISTRIBUTION MODEL	12
Historic Growth Trends	13
Growth Calculation Methodology	15
UTILITY SERVICE AREA POPULATION SUMMARIES	16
Spatial Incongruity of Boundaries	16
ADJUSTMENTS TO BASELINE MODEL PROJECTIONS	16
FINAL POPULATION PROJECTIONS	17
CONCLUSIONS.....	18
REFERENCES	19

LIST OF FIGURES

Figure 1. Population projection and distribution model process flowchart.	3
Figure 2. Property parcel boundaries.	4
Figure 3. Population density for census blocks in St. Johns County in the year 2000.	5
Figure 4. Example of inconsistencies between wetland delineation and residential parcels.	6
Figure 5. Future Land Use helps identify future residential areas.	7
Figure 6. Example of Build-out Density Model shaded by dwelling units per acre.	8
Figure 7. Example of DRI data used by County Build-out Models.	10
Figure 8. Northeast Florida sample area of the Growth Drivers Model.	11
Figure 9. Parcel centroids used in summarizing parcels to public water supply service area boundaries.	16
Figure 10. New development master plan.	16
Figure 11 Screen capture of table showing utility service area population projection summaries	17
Figure 12. Dot density symbolization of parcel level population growth in St. Johns County. ...	18

LIST OF TABLES

Table 1. Parcel database attribute fields used in the County Build-out Models	4
Table 2. SJRWMD wetland land cover codes and descriptions used in the County Build-out Models.....	6
Table 3. Generalized future land use classes allowed by the County Build-out Model to project future residential development.....	7
Table 4. Build-out calculations of a hypothetical census block in the city of Sanford.....	9
Table 5. GIS datasets used in the Growth Drivers Model	11
Table 6. Growth Drivers Model values with associated distances between drivers and residential growth from 1995 to 2005	112

St. Johns River Water Management District
The Small Area Population Projection and Distribution Methodology

INTRODUCTION

The purpose of this document is to describe the methodologies used by the St. Johns River Water Management District (SJRWMD) to project and spatially distribute population for water supply planning purposes in support of development of the 2008 District Water Supply Assessment (WSA 2008) and 2010 District Water Supply Plan (DWSP 2010). Because accurately projecting future water demand for public water supply utility service areas requires more precision than is offered by county-level projections available from the Bureau of Economic and Business Research (BEBR) at the University of Florida, the generally accepted standard throughout the State of Florida, SJRWMD contracted with GIS Associates, Inc., to provide small-area population projections for the 18 counties located partly or entirely within SJRWMD. This was achieved by developing a small area population projection and distribution model. The present document describes the Small Area Population Projection and Distribution Model methodology and its use to project and distribute future populations. Ultimately, these small-area population projections were used as a basis for making future water demand projections for SJRWMD.

Paragraph 373.0361(2)(a)1., Florida Statutes (F.S.), requires that:

Population projections used for determining public water supply needs must be based upon the best available data. In determining the best available data, the district shall consider the University of Florida's Bureau of Economic and Business Research (BEBR) medium population projections and any population projection data and analysis submitted by a local government pursuant to the public workshop described in subsection (1) if the data and analysis support the local government's comprehensive plan. Any adjustment of or deviation from the BEBR projections must be fully described, and the original BEBR data must be presented along with the adjusted data.

For WSA 2008, SJRWMD chose to use a projection methodology that was not strictly based on BEBR medium projections but which controlled projections within the range of BEBR low to high projections. This methodology was chosen for the following reasons.

- BEBR's projection methodology does not provide for effectively projecting short-term economic and housing fluctuations.
- BEBR projections are more likely to err on the low side than the high side, an undesirable scenario, which could result in planning for too little water.

BEBR's 2001 projections, which SJRWMD used to control the projections for the *2003 District Water Supply Assessment (WSA 2003)*, significantly underestimated the growth to date. Although the *WSA 2003* projections were originally tied to 2001 BEBR medium, other data (BEBR's own estimates, utility meter growth, etc.) compelled SJRWMD to depart from use of BEBR medium projections in nine counties. Although *WSA 2003* projections were always within the low to high range of the BEBR projections, *WSA 2003* projections proved to be a more accurate predictor of current population for every county where medium was not used. For those counties, the 2001 BEBR medium projection was 5% lower in 2005 than BEBR's own 2005 estimate, while SJRWMD's *WSA 2003* projections were less than 2% lower.

In addition to SJRWMD's experience with *WSA 2003*, BEBR's annually updated projected growth rose steadily each year from its 2001 version to its 2007 version. SJRWMD's projections for WSA 2008 were controlled to BEBR's 2006 or 2007 projections, depending on the county. The supporting data (BEBR's annual population estimates, utility meters, other planning assessments and development plans) also indicated higher than medium trends. BEBR's 2008 projections were the first to show a decline due to the depressed housing market. For this reason, the WSA 2008 projections may err on the high side, particularly in the shorter term (2010 and 2015). The longer-term growth projections (2020 to 2030) may prove to be more accurate, depending on future changes in the housing market and the economy in general.

SJRWMD projects future water demand for the six water use categories defined by the Water Demand Protection Subcommittee (WDPS 1998), a subcommittee of the Water Planning Coordination Group. These are public supply, domestic self-supply and other small public supply, agricultural irrigation self-supply, recreational self-supply, commercial/industrial/institutional self-supply, and thermoelectric power generation self-supply.

Water demand projections for the public supply and domestic self supply and other small public supply water use categories require population projections at a small enough geographic scale to be easily aggregated by public water supply service area boundaries¹. SJRWMD accounts for public supply water use for water utilities with an average annual water use of at least 100,000 gallons per day. Water demand projections for commercial/industrial/institutional self-supply and recreational self-supply were made based on population projections at the county level. However, spatial population projection distribution was still required to be able to apply methodologies of population growth to project future water demand in these categories. Public water supply service area boundaries as of August 2006 and August 2008 were used for population and water demand projections respectively. A detailed description of how these small area population projections were used to derive SJRWMD's future water demand projections for various water use categories is provided in the document titled *The Water Demand Projection Methodology of the St. Johns River Water Management District for the 2008 District Water Supply Assessment and the 2010 District Water Supply Plan* (Doty, Fortich and Saarinen, 2009).

SMALL AREA POPULATION PROJECTION AND DISTRIBUTION MODEL OVERVIEW

The geographic information system (GIS) based Small Area Population Projection and Distribution Model used by SJRWMD projected future permanent population growth at the parcel level, and normalized those projections to BEBR's county projections. Figure 1 shows a process flow chart of the population projection and distribution methodology. First, a County Build-out Model was developed by GIS Associates, Inc., from the base parcel data. The purpose of the County Build-out Model 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 Models*. Current permanent population was estimated and then the maximum population to

¹ A Public Water Supply Service Area Boundary (PWSAB) outlines an area where water is currently provided, or might reasonably be provided in the future, according to adopted plans and proposed future amendments to adopted plans of the public supply water utility companies or the respective local governments within which they operate.

which a county can grow was modeled by the County Build-out Models. Areas which cannot physically or lawfully sustain residential development (built-out areas, water bodies, public lands, commercial areas, etc.) were excluded from the County Build-out Model. Conversely, the model identified areas where growth is more likely to occur based on proximity to existing infrastructure. This is discussed in detail in chapter titled Growth Drivers Model.

Next, population growth was modeled between the current estimated population and the build-out population. Projections are based on a combination of historic growth trends (using an approach similar to that used by BEBR for its county-level projections), and spatial constraints and influences, which restrict or direct growth. This process is described in detail in the chapter titled Population Projection and Distribution Model. Population growth calculations were limited by BEBR’s latest available projections (either 2006 or 2007) of population for the years 2010 through 2030, which were available in five-year increments. The process for limiting growth is described in the chapter titled Population Projection and Distribution Model. BEBR bracketed its “medium” forecast with “high” and “low” projections. SJRWMD projections always fell within the range from low to high. In some cases, projection revisions were made based on credible data from local planners or utilities, but the county projection totals were always within BEBR’s range of low to high.

The base year for the version of the model described in this document was 2005. Projections were made through the year 2030 in the following five-year increments:

1. April 2, 2005 through April 1, 2010
2. April 2, 2010 through April 1, 2015
3. April 2, 2015 through April 1, 2020
4. April 2, 2020 through April 1, 2025
5. April 2, 2025 through April 1, 2030

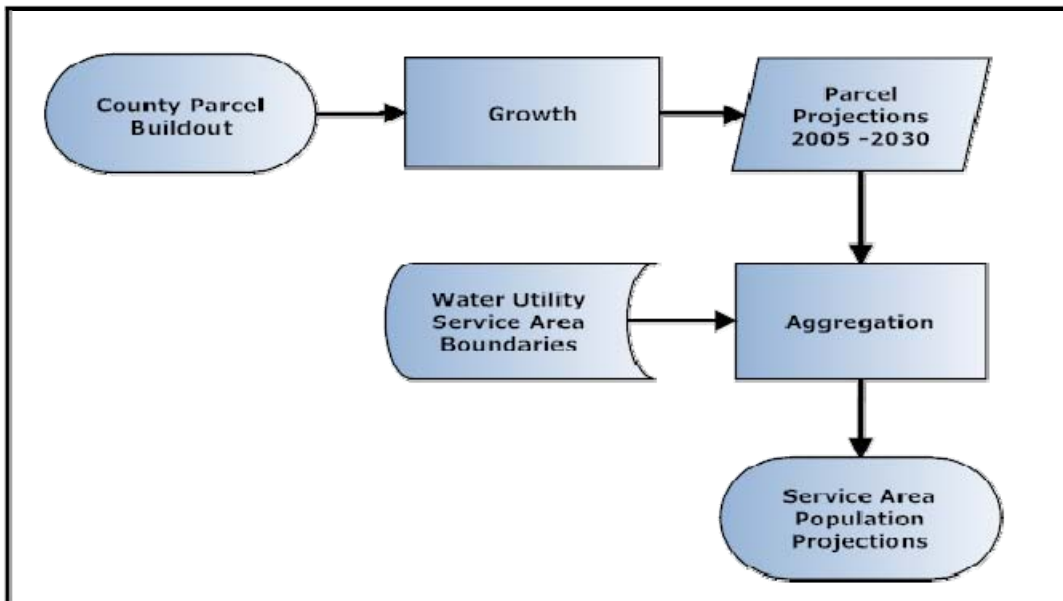


Figure 1. Population projection and distribution model process flowchart

Finally, the parcel level projections were easily aggregated by any set of boundaries desired (utility service areas, municipalities, watersheds, etc.). For SJRWMD planning efforts, parcel projections were summarized by public water supply service area boundaries that SJRWMD maintains in a spatial (GIS) database. Figure 2 shows the level of detail associated with the property parcel boundaries to which population projections were assigned.



Figure 2. Property parcel boundaries

COUNTY BUILD-OUT MODELS

The County Build-out Models are composed of multiple GIS data elements. Each model is based on each county property appraiser’s GIS parcel database, including the associated tax roll information. Other elements incorporated into each build-out model include the 2000 US Census block data, SJRWMD wetland data, local government future land use maps, and Development of Regional Impact (DRI) plans for the county of interest.

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. Table 1 lists the information extracted from the parcel data and used in the County Build-out Models. In cases where values or fields were missing, other relevant information was extrapolated and used as a surrogate. For example, when data identifying the number of dwelling units per multi-family parcel were absent, multi-family unit totals were determined using building data specific to each county’s property appraiser.

Table 1. Parcel database attribute fields used in the County Build-out Models

S No.	Attribute field	Build-out model use
1.	Parcel Geometry	Area (Acreage)
2.	DOR Use Code	Residential land use type
3.	Multiple dwellings	Dwelling unit density per parcel
4.	Actual Year Built	Year parcel was developed

2000 US Census Block Data

Some of the essential attribute information to translate parcels to population in the County Build-out Models was derived from the Block level Census 2000 data. Figure 3 depicts population density for census blocks in St. Johns County in the year 2000. Census blocks are the smallest geographic unit for which the Census Bureau tabulates population data (as small as a city block in urban areas), but these entities are usually larger than individual land parcels. Therefore, average population per dwelling unit data were transferred from block level census data to each county's parcel data. Average dwelling unit occupancy data were transferred from the Zip Code Tabulation



Figure 3. Population density for census blocks in St. Johns County in the year 2000

Area-level census data to each county's parcel data. The combination of average population per dwelling unit and average dwelling unit occupancy enabled parcel level estimation of population from parcel based dwelling unit estimates. In cases where property appraiser data were missing or incomplete, block-level Census 2000 data were used. For example, Census 2000 block data includes the number of mobile homes within a block. The number of mobile homes within parcels identified as mobile home parks can then be estimated using block level data.

2000 U.S. Census Place Data

Each parcel in the County Build-out Models was also attributed with the Incorporated Place or Census Designated Place in which it is located in the year 2000. Incorporated Place includes cities or towns, and the Census Designated Places are “the statistical counterparts of incorporated places. Census Designated Places are delineated to provide census data for concentrations of population, housing, and commercial structures that are identifiable by name but are not within an incorporated place.” (U.S. Census Bureau website 2008, <http://www.census.gov/geo/www/tiger/glossry2.pdf>). These are from the U.S. Census Bureau, and they were used by the models to aggregate parcels for density calculations by future land use code. (See section titled Build-out Density Calculation for more detail). They can also be used for quality assurance of population estimates from BEBR, as they are available for both County and Incorporated Place.

Water Management District Boundaries

Each parcel in the County Build-out Models was also attributed with water management district boundaries (from SJRWMD), which enabled the county models for any counties split between two or more water management districts to be summarized for the respective district.

Wetlands

Wetlands (including surface water) are an important consideration when modeling a county’s build-out. SJRWMD maintains a detailed GIS database of wetlands within its boundaries. This database contains the location and spatial extent of the wetlands, as well as the specific types of wetlands as defined by SJRWMD 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 SJRWMD wetland database and applied to the appropriate County Build-out Model. The wetland types are listed in Table 2.

Table 2. SJRWMD wetland land cover codes and descriptions used in the County Build-out Models

S. No.	Code	Description	S. No.	Code	Description
1.	5100	Streams and waterways	6.	5600	Slough waters
2.	5200	Lakes	7.	6110	Wetland Hardwood Forests
3.	5250	Marshy Lakes	8.	6120	Mangrove swamp
4.	5300	Reservoirs	9.	6170	Mixed wetland hardwoods
5.	5400	Bays and estuaries	10.	6180	Cabbage palm wetland
11.	6181	Cabbage palm hammock	17.	6410	Freshwater marshes
12.	6200	Wetland Coniferous Forest	18.	6420	Saltwater marshes
13.	6210	Cypress	19.	6430	Wet prairies
14.	6220	Pond pine	20.	6440	Emergent aquatic vegetation
15.	6250	Hydric pine flatwoods	21.	6460	Mixed scrub-shrub wetland
16.	6300	Wetland Forested Mixed	22.	6500	Non-vegetated Wetland

Using spatial analysis (GIS) techniques, wetland polygons (using the above classifications) were overlaid with a county’s land parcels in a GIS. 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 0.5 acres, 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 4). In such a case, the parcel was considered developable by the model.

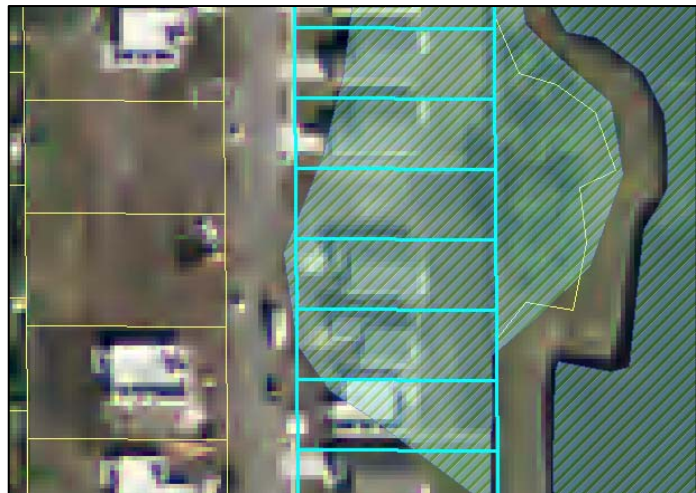


Figure 4. Example of inconsistencies between wetland delineation and residential parcels (outlined here in light blue)

Future Land Use

Future land use maps were essential elements of the County Build-out Models. These maps helped guide where and at what density residential development could occur within a county (Figure 5). Future land use maps are a part of the local government comprehensive plans required for all local governments by Chapter 163, Part II, F.S. They are typically developed by the local government's planning department, or, in some cases, a regional planning council. The latest available future land use maps were obtained and applied to the build-out model. The planning horizons for these are a minimum of 10 years, and they often extend for 15 to 20 years into the future. Table 3 shows which future land use map classes were assigned residential densities in the County Build-out Models. Future land use map classifications for residential land uses are assigned maximum dwelling unit densities (per acre) or density ranges. These ranges were intended to guide the type and density of development. However, development does not always occur at densities consistent with future land use maps.



Figure 5. Future land use helps identify future residential areas (here shaded in yellow)

Table 3. Generalized future land use classes allowed by the County Build-out Model to project future residential development

S. No.	Generalized Future Land Use Classes	Residential Development Allowed by the Model
1.	Agricultural	Yes
2.	Low Density Residential	Yes
3.	Medium Density Residential	Yes
4.	High Density Residential	Yes
5.	Mixed Use	Yes
6.	Commercial	No
7.	Recreation / Open Space	No
8.	Conservation / Preservation	No
9.	Industrial	No
10.	Institutional	No
11.	Right of Way	No
12.	Water	No

For this reason, County Build-out Models reflect the densities of recent development (from 1995 to 2005) of the specific incorporated place or Census Designated Place instead of the maximum density described on future land use maps. For example, the City of Sanford's future land use allows up to 15 dwelling units per acre, but the average medium density residential density built

in Sanford from 1995 to 2005 is 9.7 dwelling units per acre. It was assumed that densities of recent development are a better indicator of future densities than the maximum allowable density. For this reason, future residential development in the City of Sanford's medium density residential land use category was projected to be built at 9.7 dwelling units per acre in the County Build-out Models for Seminole County.

As an exception, some future land use and Incorporated Place or Census Designated Place combinations had insufficient sample size to create average density values. In such cases, countywide average density was applied for that future land use class. Vacant or open parcels less than one acre in size were considered single family residential and calculated with a population of 1 dwelling unit.

Each land parcel in the County Build-out Models 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 center fell. Build-out population was modeled only for residential future land use types.

Build-out Density Calculation

For each county, the census, political boundary, wetlands, and future land use data were overlain with the parcel data in a GIS to make the build-out calculations. In the County Build-out Models, the build-out population represented the total permanent residential population (existing and future) that could inhabit a parcel (Figure 6). Permanent population was calculated by multiplying the parcel-level dwelling units by average persons-per-dwelling unit (from the block level Census 2000 data). The result was then multiplied by the average housing unit occupancy (from the Zip Code Tabulation Area-level Census 2000 data).



Figure 6. Example of Build-out Density Model shaded by dwelling units per acre

For census blocks developed after the 2000 census, and where the Census 2000 average persons-per-dwelling unit was zero, the county’s average persons-per-dwelling unit was used. Also, if there were blocks with Census 2000 values for persons-per-dwelling unit greater than zero that were based on a small number of homes with unusually high or low persons per dwelling unit values, the county’s average persons-per-dwelling unit was used.

Table 4 provides an example of the data used to calculate the build-out population for a hypothetical census block in the City of Sanford composed of parcels with medium density residential and high density residential future land use classifications.

Table 4. Build-out calculations of a hypothetical census block in the city of Sanford

S. No.	Future Land Use	Existing Land Use (from Parcel Data)	Buildable Acres	Dwelling Units Per Acre at Build-out	Dwelling Units at Build-out	Average Persons per Dwelling Unit	Average Dwelling Unit Occupancy	Parcel-level Population at Build-out
1.	MDR	Single Family	0.10	9.68	1	2.37	0.91	2.16
2.	MDR	Single Family	0.09	9.68	1	2.37	0.91	2.16
3.	MDR	Single Family	0.11	9.68	1	2.37	0.91	2.16
4.	MDR	Vacant Residential	0.10	9.68	1	2.37	0.91	2.16
5.	HDR	Vacant Residential	1.01	11.94	12	2.37	0.91	25.88
6.	HDR	Multi-Family	4.52	11.94	54	2.37	0.91	116.46
7.	BLOCK TOTALS		5.93		70	2.37	0.91	150.97

Note: MDR – medium density residential
HDR – high density residential

Developments of Regional Impact

Developments of Regional Impact (DRI) are defined by Section 380.06(1), F.S., as “any development that, because of its character, magnitude or location, would have a substantial effect on the health, safety or welfare of citizens in more than one county.” DRI plans are another component of Florida’s growth management legislation required by Chapter 380, F.S. The final step in the development of the County Build-out Models was adjusting build-out densities to correspond with approved DRIs, or other large development plans (where available). The state annually updates population-based thresholds by county to determine when a development must undergo the DRI review process. For residential DRIs, dwelling unit thresholds range from 250 units (in counties with fewer than 25,000 people) to 3,000 units (in counties with more than 500,000 people). A DRI plan delineates the boundaries of a DRI, the number of dwelling units within the boundaries, and the projected timing of when these units will be built. Figure 7 shows an example of a DRI with the planned units at build-out. Although DRIs often do not develop as originally planned by the developer, the total number of units planned (regardless of timing) is likely to be a more accurate control for the build-out of that DRI than the average historic densities. Therefore, in each of the build-out models, parcels that were within a DRI were attributed with the name of the DRI. The build-out densities for parcels

within a particular DRI were adjusted, if necessary, to be consistent with the DRI development plan, and the build-out population for that area was recalculated.



Figure 7. Example of DRI data used by County Build-out Models

GROWTH DRIVERS MODEL

The Growth Drivers Model is a districtwide, raster (cell-based) GIS model representing development potential. The model is a continuous surface of 10-meter cells containing values of 1-10, with '10' having the highest development potential and '1' having the lowest development potential. It influences the Small Area Population Projection and Distribution 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. They included the following:

1. Access to roads prioritized by level of use (with each road type modeled separately, but then combined into a single model)
2. Proximity to existing residential development
3. Proximity to existing commercial development (based on parcels with commercial land use codes deemed attractors to residential growth)
4. Proximity to coastal and inland waters

Figure 8 depicts the Northeast Florida portion of the SJRWMD Growth Drivers Model, with high development potential in red, moderate development potential in yellow, and low development potential in green. Data used for generating the Growth Drivers Model and their sources are listed below in Table 5.

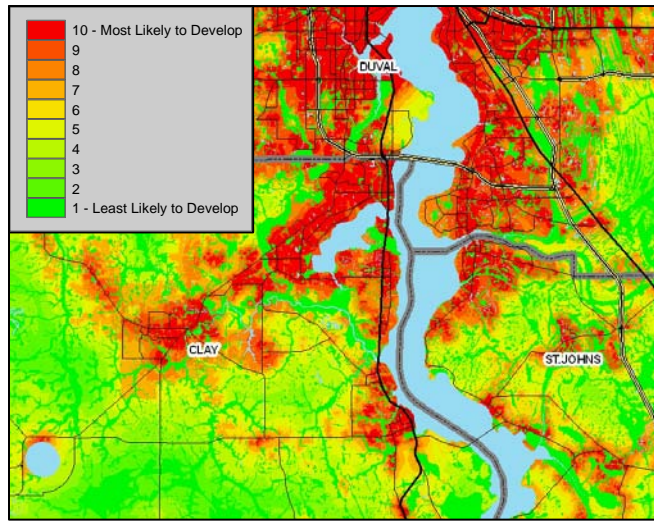


Figure 8. Northeast Florida sample area of the Growth Drivers Model

Table 5. GIS datasets used in the Growth Drivers Model

S. No.	Growth Driver	Data Source
1.	Roads and Limited Access Road Interchanges	Florida Department of Transportation (FDOT) Major Roads: Functional Classification (FUNCLASS), and FDOT Limited Access Road Interchanges
2.	Existing Residential Land Uses	County Property Appraiser Parcel Data
3.	Existing Commercial Land Uses	County Property Appraiser Parcel Data
4.	Coastal and Inland Waters	SJRWMD Land Cover Data, and Florida Geographic Data Library (FGDL) Coastline Data

Each of the drivers listed in Table 5 were modeled individually to determine its spatial relationship with historic residential development. Results of each model were then reclassified into values of 1-10. Values were then assigned based on 10% increments of post-1995 residential development that occurred within a range of distances from a driver. For each distance increment containing 10% of the post-1995 residential development, a growth driver value was assigned. The first distance increment containing 10% of the post-1995 residential development is assigned a value of 10, the next increment containing between 10% and 20% of the post-1995 residential development is assigned a value of 9, and so on.

Table 6. Growth Drivers Model values with associated distances between drivers and residential growth from 1995 to 2005

S. No.	Driver Value	Maximum Distance (in Feet) for each Growth Driver Value								
		Residential Land Uses	Commercial Land Uses	Coastal & Inland Waters	Interstate Highways (Interchanges)	Other Principal Arterial Roads	Minor Arterial Roads	Major Collector Roads	Minor Collector Roads	Local Roads
1.	10	60	220	440	4,260	520	350	240	540	980
2.	9	80	400	1,140	6,680	920	700	520	1,300	1,840
3.	8	100	600	2,120	8,340	1,440	1,100	980	2,020	2,780
4.	7	140	880	3,000	10,000	2,120	1,600	1,720	3,160	3,760
5.	6	200	1,040	3,860	11,600	2,880	2,200	2,560	4,980	4,620
6.	5	300	1,300	4,980	14,320	4,080	3,250	3,460	6,300	5,280
7.	4	440	1,700	6,340	16,260	5,960	4,800	4,400	7,560	6,040
8.	3	660	2,200	8,200	19,600	8,480	7,950	5,660	9,400	6,860
9.	2	1,200	3,800	10,880	28,960	15,240	12,050	8,500	11,800	7,980
10.	1	>1,200	>3,800	>10,880	>28,960	>15,240	>12,050	>8,500	>11,800	>7,980

The six driver sub-models associated with roads and interchanges were combined into a single transportation sub-model. The transportation sub-model was then combined with the remaining three driver sub-models (Residential Land Uses, Commercial Land Uses, and Coastal & Inland Waters) into the Growth Drivers Model. The values for this combined model were derived by averaging the four raster inputs. No weights were applied to any single driver, and each influenced the model equally. The model was then overlaid with each of the County Build-out Models, and each vacant, developable land parcel within the build-out models was assigned the mean growth driver value of the 10-meter cells intersecting it.

This model was used by the Small Area Population Projection and Distribution Model to rank parcels in undeveloped Census blocks based on their development potential. The Small Area Population Projection and Distribution Model decided which undeveloped blocks to begin developing first by selecting parcels in those blocks with the highest values from the Growth Drivers Model. How this process is incorporated into the overall Small Area Population Projection and Distribution Model is explained in the Growth Calculation Methodology section. This districtwide Growth Drivers Model encompasses all counties that are entirely or partially within SJRWMD. An additional one-county buffer was applied to eliminate any “edge effects.”

SMALL AREA POPULATION PROJECTION AND DISTRIBUTION MODEL

The Small Area Population Projection and Distribution Model integrates the County Build-out Models and the Growth Drivers Model with historic growth trends and county-level population controls from BEBR.

Historic Growth Trends

The historic growth trends were derived from historic population estimates at the 2000 US Census block level. Census block population estimates for 1990 and 2000 were from the Florida House of Representatives Redistricting Data website (<http://www.floridaredistricting.org/FredsData.html>, 2002), and 2005 population estimates were derived from property parcel data summarized by census block. These estimates were used to produce six block level projections using four different methods. The minimum and maximum calculations were discarded to moderate the effects of extreme projections (Smith and Rayer 2004). The remaining four projections were then averaged.

The four statistical methods for population projection utilized by the model were the Linear Projection Method, the Exponential Projection Method, the Share of Growth Projection Method, and the Shift Share Projection Method. The Linear and Exponential projection techniques employ a bottom-up approach, extrapolating the historic growth trends of each census block with no consideration for the county's overall growth. The Share of Growth and Shift Share techniques employ a top-down approach, allocating a portion of the total projected county growth to each census block based on that census block's percentage of county growth over the historical period. Each of the four methods is a good predictor of growth in different situations and growth patterns, so using all four was the best way to avoid the largest possible errors resulting from the least appropriate techniques for each census block within the 18-county area (Sipe and Hopkins 1984). This methodology is based on BEBR's population projection methodology and is well suited for small area population projections.

1. **Linear Projection Method:** The Linear Projection Method assumes that future population change for each census block will be the same as over the historic period (Sipe and Hopkins 1984). Two linear growth rate calculations were made, one from 1990 through 2005 (15-year period), and one from 2000 through 2005 (5-year period). In the two Linear methods (LIN), five-year population growth was calculated using the following formulas (using the 2005–2010 growth projections as an example):

$$LIN_1 = \frac{(BlockPop2005 - BlockPop1990)}{15} * 5$$

$$LIN_2 = BlockPop2005 - BlockPop2000$$

2. **Exponential Projection Method:** The Exponential Projection Method assumes that population will continue to change at the same annual growth rate as over the historic period. In the Exponential method (EXP), five-year population growth was calculated using the following formula (using the 2005–2010 growth projections as an example):

$$EXP = (BlockPop2005 * e^{5r}) - BlockPop2005$$

where,

$$r = \frac{\ln \frac{BlockPop2005}{BlockPop1990}}{15}$$

3. **Share of Growth Projection Method:** The Share of Growth Projection Method assumes that each census block’s percentage of the county’s total growth will be the same as over the historic period (Sipe and Hopkins 1984). Two growth rate calculations were made, one from 1990 through 2005 (15-year period), and one from 2000 through 2005 (5-year period), based on the Share of Growth Projection Method. In the two Share of Growth calculations (SOG), five-year population growth was calculated using the following formulas (using the 2005–2010 growth projections as an example):

$$SOG_1 = \frac{(BlockPop2005 - BlockPop1990)}{(CountyPop2005 - CountyPop1990)} * (CountyPop2010 - CountyPop2005)$$

$$SOG_2 = \frac{(BlockPop2005 - BlockPop2000)}{(CountyPop2005 - CountyPop2000)} * (CountyPop2010 - CountyPop2005)$$

4. **Shift Share Projection Method:** The Shift Share Projection Method assumes that each census block’s percentage of the county’s total annual growth will change by the same annual amount as over the historic period (Sipe and Hopkins 1984). In the Shift Share Projection Method (SSH), five-year population growth was calculated with the following formula (using the 2005–2010 growth projection as an example):

$$\begin{aligned} SSH = & \\ & \frac{(BlockPop2005 - BlockPop2000)}{(CountyPop2005 - CountyPop2000)} * (CountyPop2010 - CountyPop2005) \\ & + \\ & \frac{(BlockPop2005 - BlockPop2000)}{(CountyPop2005 - CountyPop2000)} * (CountyPop2010 - CountyPop2005) \\ & - \\ & \frac{(BlockPop2005 - BlockPop1990)}{(CountyPop2005 - CountyPop1990)} * (CountyPop2010 - CountyPop2005) \end{aligned}$$

By their definitions, the “Share of Growth” and the “Shift Share” methods projected census block population that added up to the BEBR projected county totals.

5. **Average of the Projection Extrapolations:** The minimum and maximum of the six extrapolations for each census block were dropped to reduce errors resulting from the least appropriate techniques. The four remaining extrapolations were averaged to account for the considerable variation in growth rates and patterns over all of the census blocks within the 18-county area (Sipe and Hopkins 1984). All four remaining methods were weighted equally. The average was calculated using the following formula:

$$AVG = \frac{(LIN_1 + LIN_2 + EXP + SOG_1 + SOG_2 + SSH - MIN - MAX)}{4}$$

where,

MIN = method resulting in minimum growth for each block

and,

MAX = method resulting in maximum growth for each block

Growth Calculation Methodology

After the development of the County Build-out Models, the Growth Drivers Model, and the historic growth trends, the growth calculations could be made. The methodology for calculating growth within the Small Area Population Projection and Distribution Model for each five-year increment included the following steps:

1. Applying census block-level average historical growth rate to parcels within a particular block.
2. Checking growth projections against build-out population, and reducing any projections exceeding build-out to the build-out numbers.
3. After projecting growth for all census blocks within a particular county, summarizing the resulting growth and comparing it against countywide BEBR target growth. This step led to two scenarios:
 - a. If the Small Area Population Projection and Distribution Model's projections exceeded the BEBR target, projected growth for all blocks was reduced by the percentage that the projections exceeded the BEBR target.
 - b. If the Small Area Population Projection and Distribution Model's projections were less than the BEBR target (which is more common due to high growth areas building out), the model would continue growing the county using the Growth Drivers Model until the BEBR target growth for each five-year increment was reached. This process involved selecting parcels in undeveloped census blocks with the highest growth driver value and developing them. (Note that most parcels were projected to completely 'build out' in this step, which represents a five-year interval. However, some large parcels may require two or more five-year intervals to 'build out'.)
4. Summarizing growth and checking against build-out.
5. Continuing this process until the county growth target was met. (Note that this BEBR-based target growth was a countywide number. Counties that are partially within another water management district were processed in their entirety and controlled to the BEBR-based target growth. The proportion of the county population within SJRWMD was dictated by the Small Area Population Projection and Distribution Model, not by BEBR.)

UTILITY SERVICE AREA POPULATION SUMMARIES

The parcel-level population projections generated from the population projection model discussed above were then summarized by public water service area boundaries (PWSABs) for all utilities in SJRWMD that averaged more than 0.1 million gallons per day (mgd) of total water use. These PWSABs, maintained by SJRWMD, were overlain 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 SJRWMD’s public service area boundary database to produce tabular and spatial output. This output was then used as input into the SJRWMD’s Water Demand Projection and Distribution Model.

Spatial Incongruity of Boundaries

Due to mapping errors, the service area boundaries often bisect parcel boundaries (Figure 9). In the present modeling activity, parcels were deemed to be within a given service area if their center points (or “centroids”) fell inside the service area boundaries. The error associated with this spatial incongruity at the parcel level was much smaller than would be the case with census block level data. This is one of the main reasons for disaggregating census block-level data to the parcel level. The percentage of parcels erroneously attributed or excluded from a service area by this process is insignificant.

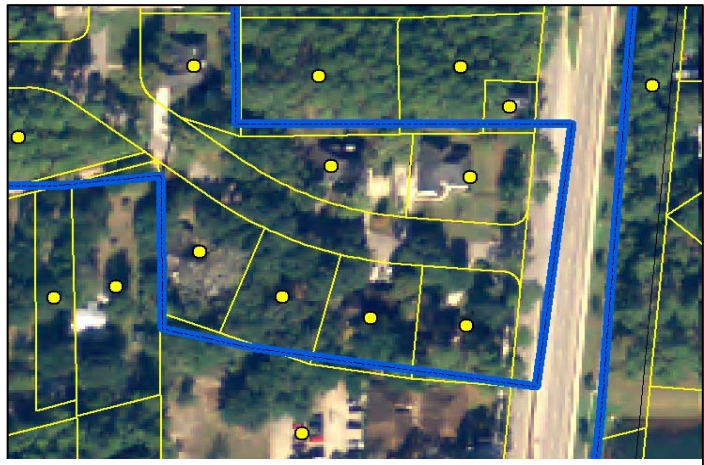


Figure 9. Parcel centroids (yellow points) used in summarizing parcels (yellow) to public water supply service area boundaries (blue)

ADJUSTMENTS TO BASELINE MODEL PROJECTIONS

The model produced a “baseline” set of projections for the 18 counties partly or entirely within SJRWMD. These baseline projections were then compared with other projections made by utilities and local planning agencies. Projections made by utilities and local planning agencies are typically not spatial, but they were still useful for comparison and possible adjustments. Figure 10 shows a typical master plan and a build-out scenario from a local planning agency, which was used to update model densities and projections to be in agreement with new development plans.

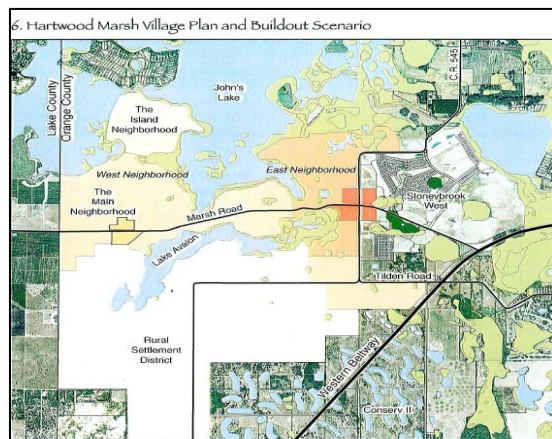


Figure 10. New development master plan

To fully understand any differences between projections, a dialogue was opened with utilities and local and regional planners via meetings and conference calls. An important part of this effort was to solicit information from these “local” stakeholders to leverage their knowledge of factors influencing future growth at the local level. Available data were collected on factors that could cause future projections to deviate significantly from historic trends. Typical factors were:

1. Recent changes to public service area boundaries
2. Number of residential utility meters by year (used to distinguish publicly supplied from self-supplied population)
3. Recent changes to large development plans (such as DRIs)

This input from local stakeholders provided valuable information, which resulted in important adjustments to model results, and enabled local planners and utilities to participate and reach an agreement with SJRWMD regarding the population projections and the methodology used to make these projections.

FINAL POPULATION PROJECTIONS

The final population projections were summarized in tabular (Microsoft Access database or Excel spreadsheet) and GIS formats (ESRI’s geodatabase or shapefile). Population projections are available in the form of parcel-level population geodatabase for each county. Figure 11 shows a screen capture of a population projection summaries table by utility service area.

PROJECTED POPULATION BY SERVICE AREA									
UTILITY IDENTIFIER				POPULATION PROJECTIONS					
OWNER	SUBGROUP	STATUS	WMD	2005	2010	2015	2020	2025	2030
ST JOHNS COUNTY UTILITIES	Eagle Creek	EXISTING	SJRWMD	529	529	529	529	529	529
ST JOHNS COUNTY UTILITIES	Eagle Creek	PROPOSED	SJRWMD	0	0	0	0	0	0
ST JOHNS COUNTY UTILITIES	Eagle Creek	SERVED	SJRWMD	529	529	529	529	529	529
ST JOHNS COUNTY UTILITIES	Harmony Village	EXISTING	SJRWMD	85	89	89	89	89	89
ST JOHNS COUNTY UTILITIES	Harmony Village	PROPOSED	SJRWMD	0	0	0	0	0	0
ST JOHNS COUNTY UTILITIES	Harmony Village	SERVED	SJRWMD	85	89	89	89	89	89
ST JOHNS COUNTY UTILITIES	Mainland and Anastasia Island	EXISTING	SJRWMD	41,860	56,232	61,536	69,320	79,645	94,283
ST JOHNS COUNTY UTILITIES	Mainland and Anastasia Island	PROPOSED	SJRWMD	2,050	2,152	3,533	5,175	6,451	8,153
ST JOHNS COUNTY UTILITIES	Mainland and Anastasia Island	SERVED	SJRWMD	33,907	48,631	55,566	65,243	77,094	93,683
ST JOHNS COUNTY UTILITIES	Northwest Utilities (WGV)	EXISTING	SJRWMD	2,075	8,946	11,048	15,149	17,168	18,966

Figure 11. Screen capture of table showing utility service area population projection summaries

These 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 (Figure12). However, the primary products were generated at the utility level in the form of output tables, which were incorporated into SJRWMD’s spreadsheet-based future Water Demand Projection and Distribution Model. These population projections by utility were available in SJRWMD’s Draft 2008 District Water Supply Assessment at the time of completion of this document.

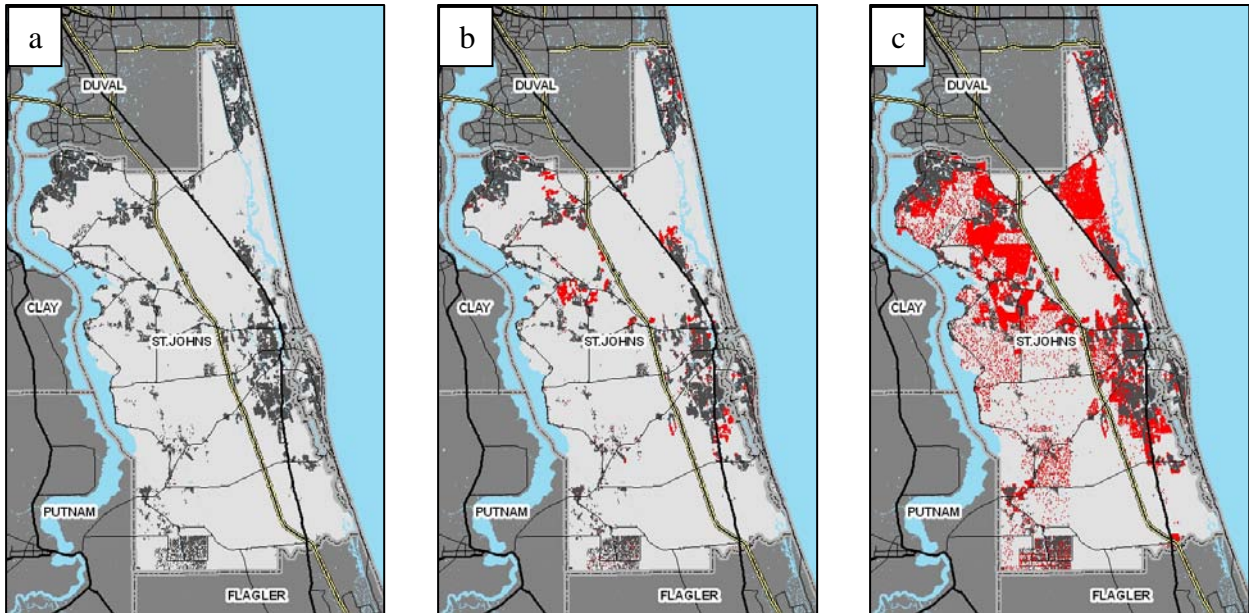


Figure 12. Dot density symbolization of parcel level population growth in St. Johns County a) 2005 base year population (dark grey), b) 2005-2010 population growth (red) and c) 2005-2030 population growth (red)

CONCLUSIONS

Small area population projections have become increasingly important for various regional planning efforts. With ever changing population dynamics and requirements for water supply planning, SJRWMD must accurately forecast water demand based on population projections at a much finer resolution than at the county level. To achieve this, SJRWMD adopted a GIS based Small Area Population Projection and Distribution Model developed by GIS Associates, Inc. This model incorporated the best available spatial data to project population at the parcel level, which could then be summarized by utility. This enabled SJRWMD to estimate future water demand by utility in an efficient and consistent manner throughout the entire 18 county region. Controlling the projections to BEBR's county level projections 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.

REFERENCES

Doty, Richard L., Carlos M. Fortich, and Justin A. Saarinen (2009) Draft. The Water Demand Projection Methodology of the St. Johns River Water Management District for the 2008 District Water Supply Assessment and the 2010 District Water Supply Plan. GIS Associates, Inc. Gainesville, Florida.

Florida House of Representatives Redistricting Committee (2002). "Florida Redistricting Data", <http://www.floridaredistriking.org/FredsData.html> (Accessed 10/07/2002), Florida House of Representatives, Tallahassee, Florida.

Sipe, Neil G., and Robert W. Hopkins (1984), "Microcomputers and Economic Analysis: Spreadsheet Templates for Local Government", BEBR Monographs, Bureau of Economic and Business Research, University of Florida, Gainesville, Florida.

Smith, Stanley K., and Stefan Rayer (2004). Methodology for Constructing Projections of Total Population for Florida and Its Counties: 2003-2030, June 2004, Bureau of Economic and Business Research, University of Florida, Gainesville, Florida.

U.S. Census Bureau (2008). "Appendix A. Census 2000 Geographic Terms and Concepts", Census 2000 Geography Glossary, <http://www.census.gov/geo/www/tiger/glossry2.pdf>, Accessed 11/04/2008, 2:53 PM, U.S. Census Bureau, Washington, DC.

WDPS (1998). "Final Report: Developing and Reporting of Water Demand Projections in Florida's Water Supply Planning Process." St. Johns River Water Management District, Palatka, Florida.