APPENDIX S
STROM THURMOND INSTITUTE ECONOMIC ANALYSIS – JST LAKE

Strom Thurmond Institute

South Carolina Water Resources Center

Regional Economic Analysis of Changing Lake Levels in Lake Thurmond

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I. Study Description

The purpose of this study is to answer the following questions:

- Do changing water levels in Lake Thurmond have a measurable impact on the economy and property values in surrounding counties in South Carolina and Georgia?
- Do different Duke Energy flow scenarios (Lake Keowee to Hartwell Lake and thereby to the remainder of the Savannah River Basin) affect water levels in Lake Thurmond sufficiently to have a measurable impact on the economy and property values in the surrounding counties?

The genesis of this analysis comes from an earlier study of the regional economic impact of changing water levels in Hartwell Lake on the six county region in South Carolina and Georgia surrounding the lake, as well as a subsequent study conducted on Lake Keowee. Understanding the economic impact of changing water levels in Lake Thurmond was considered an important next step, given the importance of Lake Thurmond to the Savannah River Basin.

The project examined selected lake, real estate, and economic data over a period of over 11 years from 1998 to 2009. The six counties bordering Lake Thurmond—McCormick County in South Carolina and Columbia, Elbert, Lincoln, McDuffie, and Wilkes Counties in Georgia—comprised the area of study. Lake Thurmond data includes monthly average lake level and air temperature. Real estate data are the number of monthly transactions (including sale price and property attributes) on all parcels in five of the six counties (Wilkes County is excluded as it has no residential properties bordering the lake). Economic data include monthly gross retail sales in selected sectors plus other measures of the local and regional economy. The period of study includes two extended droughts as well as periods of ample rainfall. Flow scenarios from Lake Keowee through Keowee Dam and simulations of the resulting changes in elevation in Lake Thurmond were supplied by Duke Energy consulting engineers.

Standard statistical techniques were used to assess the strength of the relationships between the water level in Lake Thurmond and the following variables: real estate sales, property sales prices, and selected categories of gross retail sales. The Regional Dynamics (REDYN) economic modeling engine generated estimates of the overall economic impact of changing lake levels on the study area, including those resulting from different flow scenarios.

II. PROJECT BACKGROUND

LAKE THURMOND

Lake Thurmond is located along the border between South Carolina and Georgia, within the Savannah River Basin; it is the southernmost lake within the basin. The lake was constructed by the U.S. Army Corps of Engineers (USACE) between 1946 and 1954. Its primary function is flood control, the production of hydropower, and navigation, although recreation use and real estate development have also become important roles for the lake since its completion.

Lake Thurmond has a surface area of over 71,000 acres and 1,200 miles of shoreline. It is bordered to the south by the Savannah River, which flows to the Atlantic port of Savannah, Georgia. The lake is bordered to the north by Richard B. Russell Lake, which is in turn bordered to the north by Hartwell Lake, both of which are also USACE lakes. Lake Keowee, a Duke Energy lake, borders Hartwell Lake to the north, such that releases from the Keowee Dam affect water levels in Lake Thurmond by way of lakes Hartwell and Russell.

III. DATA SOURCES AND METHODOLOGY

DATA SOURCES

The primary independent variable used is Lake Thurmond's average monthly water level, or elevation, measured in feet above mean sea level (MSL). Full pool for Lake Thurmond is 330 feet above MSL. Three dependent variables were used in the analysis:

- Lake-access real estate transactions
- Property value, as measured by sale price
- County gross retail sales

Economic and population data was collected from a variety of local, state, and federal government secondary source material. These variables capture both resident and nonresident economic activity as people from outside of the counties bordering Lake Thurmond buy homes on the lake, purchase goods and services on or near the lake, and visit lake sites for recreation.

Lake Elevation

Lake Thurmond's average monthly elevation for the years 1998 through 2009 was provided by USACE (Figure 1). The average monthly temperature at the Greenville-Spartanburg International Airport, the closest airport for which data was accessible, is used as a seasonal indicator (many boaters prefer warmer to colder air temperatures).

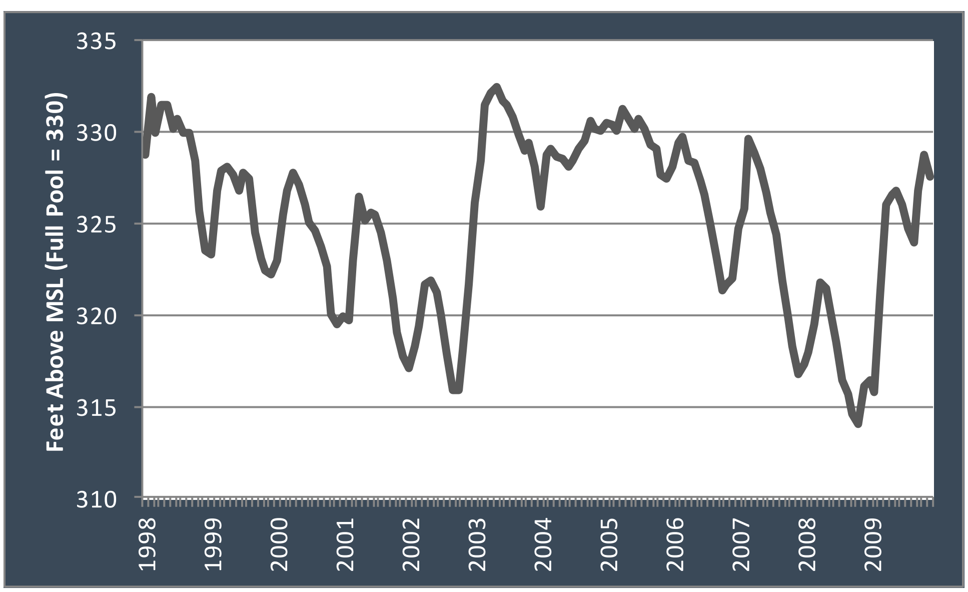

Figure 1 – Lake Thurmond Elevation (Monthly Average)

Real Estate Transactions

Real estate data was obtained by first identifying privately-owned parcels with direct access to Lake Thurmond within the surrounding counties (Wilkes County, Georgia was excluded from the real estate portion of this analysis, as that county has no residential properties adjacent to the lake). This data was collected from GIS (Geographical Information System) parcel maps obtained from each county's government.

Once lake-adjacent parcels were identified, county real property records were searched to determine the number of real estate transactions involving these parcels that occurred between January 1998 and May 2009, or for as many years as were available from each county's dataset.

Intuitively, a relationship between lake adjacent real estate transactions and average monthly water levels in Lake Thurmond is conceivable. However, the season, regional economic conditions, and other factors can also affect real estate activity. This is why ordinary least squares (OLS) regression analysis, which will be discussed presently, was used to isolate the effect of water level on lakefront property sales from these other factors.

County Gross Retail Sales

Data was collected on more than 25 categories of gross retail sales in each of the six counties bordering Lake Thurmond. These categories were restricted to business and industry sectors most likely to experience measurable economic impacts resulting from changing lake levels. Ultimately, our analysis focused on data from 12 SIC codes (Table 1).

Table 1: Gross Retail Sales Categories

SIC Code	Category
2099	Retail Trade
5331	General Merchandise
5399	Miscellaneous General Merchandise
5411	Groceries
5511	Cars
5541	Gas Stations
5551, 5599	Boating Stores
5812	Restaurants
5813	Drinking Establishments (Bars)
5921	Liquor Stores
5941	Sporting Goods Stores

Gross retail sales data for South Carolina were obtained from the state's Department of Revenue (DOR) for five years 2005 to 2009 (data from 1998 to 2004 was unavailable at the level of detail required). DOR provided the dollar value of total reported monthly sales of all businesses in each county, organized by SIC (Standard Industrial Classification) code.[1]

Sales tax revenue data for the Lake Thurmond counties located in Georgia were provided by Georgia DOR. Gross sales were derived from these data for all sectors except groceries, which are largely tax-exempt in the state. Georgia DOR reports sales tax revenues using its own industry classification code; this was converted into SIC codes to make it comparable to the South Carolina data.

Gross retail sales are a good measure of county economic activity, particularly at the consumer level. It encompasses spending increases (or declines) resulting from changes in income and employment, and also captures spending by visitors to the region. We expected that certain gross sales categories would be more likely than others to exhibit a statistically significant relationship with Lake Thurmond water levels. We also anticipated that these relationships might vary in direction and magnitude. For example, the dollar volume of boat sales might naturally vary with lake level—up when the lake is close to full pool and down when the lake is much lower. Other categories, such as groceries and general merchandise, were more difficult to predict.

ANALYTICAL TECHNIQUES

In this study, we first combined several statistical analysis techniques to analyze the strength of the relationship between water levels in Lake Thurmond and economic activity in the surrounding counties. Second, that information was used with the Regional Dynamics (REDYN) input-output model to estimate the total economic impact of different water levels in Lake Thurmond on the six-county region. Third, the Lake Thurmond-specific results were applied to Duke Energy's flow simulations to assess the regional economic impact of alternative flow scenarios on the six counties that border the lake.

The following techniques were applied to estimate the impact that changing elevations in Lake Thurmond have on the surrounding counties through gross retail sales, the number of real estate transactions, and changes in property value.

Regression Analysis

Ordinary least squares (OLS) regression analysis was used to directly estimate the strength of the relationship between the water level in Lake Thurmond and the following variables: real estate transactions on lakefront parcels, gross sales of goods and services in Oconee and Pickens Counties, and property values (as indicated by sale price) of lakefront parcels. The basic structure of an OLS linear regression model is as follows:

Model: $y_i = \beta 0 + \beta_1 x_i + \varepsilon_i$, $i = 1 \ldots n$

y_i = dependent variable

[1] In 1997 the federal government changed its industry classification system to the North American Industrial Classification System (NAICS), but South Carolina only recently changed its reporting from SIC to NAICS.

x_{i1} = independent variable

β_1 = estimate of change in dependent variable per unit increase in independent variable

i = month

ε_i = error term

One of the benefits of regression analysis is that it separates the effect of each dependent variable analyzed (real estate transactions, gross sales, property values) on the independent variable (water level). Thus, regression analysis can control for economic and seasonal variables that affect gross sales, or real estate sales, but may have no relationship to lake level.

In this study, it was important to remove the effect of seasonal temperature variations on lake-related activity. The variable chosen to remove seasonal variation was average monthly temperature from the Greenville/Spartanburg (GSP) weather reporting station.[2] As well, the nature of the dependent variables made it especially important to control for regional economic conditions, because some recent droughts occurred during periods of economic downturn.

A wide variety of data was collected to control for economic and seasonal factors.[3] Two state-level economic variables were collected: annual gross state product and quarterly state personal income. County level economic data collected included the following:

- population
- population over 16 years old
- labor force
- mean household income
- median household income
- per capita personal income
- percentage change in per capita personal income
- percentage of population poverty
- population density
- monthly county employment
- monthly annual employment percentage change

Many of these variables did not significantly affect the dependent variables or improve the overall statistical analysis and were therefore not incorporated into our models. The variable coefficients that result serve as inputs into the REDYN model. These coefficients estimate the impact of lake level on each dependent variable analyzed (real estate transactions, gross sales, or property values).

Linear regression analysis requires one to assume that the relationship between the independent variable (lake level) and the dependent variable (gross sales, property values, or real estate

[2] GSP was the closest weather-reporting station for which historical temperature data could be located. While GSP is located more than fifty miles north of the Strom Thrumond Dam, temperatures at the two locations tend to fluctuate closely together.
[3] All data collected are annual unless otherwise stated.

transactions) is linear and does not change over the period of analysis. But this assumption may or may not be reasonable. For this reason, linear regression analysis was used as a baseline technique before other approaches were tried.

Preliminary analyses of the relationships between lake level and real estate transactions, housing price, and some categories of gross retail sales suggested that these relationships were not linear. Thus, where appropriate, other model specifications were tested.

For example, these data were tested for the presence of structural breaks. Structural break regression models allow for the analysis of independent variables partitioned into different intervals, or clustered groups. These models are useful when it is hypothesized that there may be unique relationships with dependent study variables at different intervals of the independent variable. For example, one might expect to see a smaller effect on real estate transactions when lake levels are less than one foot below full pool than would be seen if levels were more than five feet below full pool. Our 2010 research on real estate transactions and water levels in Hartwell Lake supported this hypothesis (Allen et al. 2010).

We also tested these data using variable transformations such as quadratic terms to determine if nonlinear model forms better explained the relationships between lake elevation and real estate transactions, gross retail sales, and housing values.

Hedonic Regression Models

Hedonic modeling is often used to evaluate the impact of amenities (golf courses, green space, school quality, etc.) and disamenities (airport and highway noise, landfills, etc.) on the value of nearby housing. But it has also been used to measure the impact of water quality on property values (Brashares, 1985; David, 1968; Feenberg and Mills, 1980; Michael et al., 2000; and Young and Teti, 1984). Much of this research indicates that water quality variables which are physically observable to residents yield the strongest correlations with property values. Brashares (1985) concludes that when water quality characteristics are not physically observable they are less likely to be capitalized into property values.

Michael et al. (2000) discuss the importance of individual perceptions of water quality events and their impact on implicit housing prices. Historical water quality conditions may create stickiness in housing prices that may not be observed from characteristics at the time of sale. Additionally, events that are perceived as temporary may not be capitalized into property values when compared against events that are longer term or permanent. A recent study (Carey and Leftwich, 2007) found that a 1999 algal bloom event did not result in significant impacts on lake property values in the years following. It is hypothesized that when negative environmental events are deemed temporary, or isolated, they are not internalized in the market value of property.

A number of hedonic studies have evaluated the impact of water's aesthetic and recreational properties on local property values (Brown and Pollakowski, 1977; D'Arge and Shogren, 1989; Darling, 1973; David, 1968; Feather et al., 1992; Knetsch, 1964). A common finding among these studies is that proximity to water source and the size of lake (water) frontage increase property values.

Lansford and Jones (1995a) find that lake proximity is the most important contributor to a lake's aesthetic and recreation value. The lake's value falls rapidly as the distance from it increases. They estimate that approximately 87 percent of the recreation and amenity value of the lake can be captured in the sale price of homes that are within 2,000 feet of the shoreline. In another study, Lansford and Jones (1995b) confirm that scenic view, waterfront location and water level are all statistically significant contributors to enhanced property values. While proximity to the lake makes the most substantial impact on housing prices, consumers do appear to exhibit a positive preference for higher water levels as capitalized in the value of homes.

In a more recent analysis, Cho et al. (2006) uses spatial weights to evaluate the importance of distance to a water feature and its impact on property value. These results confirm that residential properties closer to specific types of water features will realize a price premium.

For example, if two lakefront homes are identical in every way except one area of the lake has more shoreline exposure due to declining lake levels, the price differential between these two homes reflects the marginal value associated with lake level, or effectively the value of "full pool." Thus, property on or near the lake, or with lake access, is bought and sold regularly and should reflect the intrinsic value of lake activity and amenities. Hedonic models are able to utilize housing markets as proxies for a wide range of environmental qualities or amenity values (Palmquist et al., 1997). It has been stated that "housing markets are one of the few places where environmental quality is traded" (Palmquist, Roka and Vukina, 1997, p.115).

The hedonic pricing technique, as applied to housing, is based on the idea that the value of a house is a function of the value of individual attributes that comprise the house, such as square footage, number of bedrooms, number of bathrooms, and proximity to such amenities as schools or parks. The price of a house (Ph) can be written as:

(1) $Ph = f(Sj, Nk, Qm)$

Where Sj, Nk, and Qm indicate vectors of structural, neighborhood, and other quality variables respectively. Quality variables can represent a range of relevant study features. In this analysis three variables were chosen to represent quality characteristics or water feature variables: Thurmond level, Hartwell level, and local average temperature. Given this, Equation 1 represents the hedonic, or implicit price, function for housing. The implicit price of any characteristic, for example Qm, a quality variable, can be estimated as:

(2) $\delta Ph / \delta Qm = PNk(Qm)$

This partial derivative gives the change in expenditures on housing that is required to obtain a house with one more unit of Qm, ceteris paribus. If the value of the partial derivative is positive, then the attribute is an amenity. If the value is negative then the attribute is a disamenity, such as air pollution or airport noise.

Economic Impact Analysis

A thorough economic impact analysis attempts to measure direct, indirect and induced economic impacts of a given economic activity. In this project:

> **Direct economic impacts** are spending by residents and visitors to the lake on lake-related activities (boat purchases, boat repairs, gasoline purchases, food purchases, etc.). Direct spending generates revenue for the recipients to pay wages, income, and taxes to individuals and government in the local economy.

Indirect economic impacts are the wages paid, income received, and tax revenues paid by the recipients of direct lake-related spending that are also spent in the local and regional economy. This spending creates indirect impacts that generate additional wage, income, and tax revenue in the economy.

Induced economic activity occurs as additional local and regional expenditures increase disposable income in the region that further enhances aggregate local and regional demand for goods and services.

Input-output (I/O) models such as REDYN are used to predict the impact of a change in one or more industries on other industries, consumers, and governments.[4] I/O models estimate direct, indirect, and induced economic impacts. Currently the largest model of the United States economy ever built, REDYN utilizes 7.6 terabytes of data to forecast a baseline level of activity within over 800 Standard Occupation Classification (SOC) and 703 North American Industry Classification System (NAICS) sectors. It also considers distance-to-market and transportation costs in determining the supply and demand of commodities across geographic regions. Changes to employment, income, or demand for products or services by either the private or the public sector can be input to the model. Based on these inputs, the model generates an estimate of the resulting variation from the projected baseline due to direct, indirect, and induced effects, as well as the effects on every industry.[5]

Results from the linear and nonlinear statistical models described above were used as inputs to the REDYN model to estimate the total economic impact of changing water levels on the six counties bordering Lake Thurmond. These statistical models yielded estimates of the marginal changes to the value of goods and services in selected industry sectors as a result of changing lake levels. When these estimates are entered into the REDYN model, it generates the predicted impact of changing water levels on the regional economy. Methodologically, this twofold approach to the analysis, along with the choice of variables used to estimate economic activity, provide for a thorough and instructive approach to estimating the impact of different lake water levels on overall economic activity.

[4] IMPLAN and REMI are other widely-used Input-Output modeling systems.
[5] In order to enter study data into the REDYN model, a detailed crosswalk was used to convert all gross sales figures from SIC codes used in the study to NAICS codes as used in REDYN.

VI. Estimated Economic Impact of Lake Elevations

The overall economic impact of changing water levels in Lake Thurmond was estimated for six county region using input-output (I/O) analysis. Results from the linear and nonlinear regression models for real estate transactions and gross retail sales (described earlier in this report) were input into the REDYN modeling system. These results were used by REDYN to estimate economic impacts on each county resulting from the income generated by real estate transactions and the changes in gross sales that could be attributed to changes in Lake Thurmond's water level.[6] The REDYN model provides an estimate of the total impact of changing lake levels on the broader economy, including direct, indirect, and induced effects.

Monthly Economic Impacts

The REDYN model generates estimated annual economic impacts as four measures: employment, output, disposable income, and net government revenue. In this analysis:

> **Employment** is the total number of jobs (including full and part time) gained or lost in the county associated with a one-foot increase in lake level;
>
> **Output** is the dollar value of all goods and services produced within the county in a given year associated with a one-foot increase in lake level;
>
> **Disposable income** is the change in aggregated (summed across all households) household after-tax income in a given year associated with a one-foot increase in lake level, and
>
> **Net government revenue** is the change in total revenue received by local (county and municipal) governments in each county, less expenses in a given year associated with a one-foot increase in lake level. These revenues are from all sources, including all taxes, licensing, and fees.

Because of the near-daily variation in Lake Thurmond's water level, analyzing the economic impact for an entire year would obscure a great deal of detail. Therefore, we converted results from the I/O model to monthly estimates based on correlation with average monthly lake levels.

No county is an island. Economic impacts from one county will naturally spill over into the surrounding counties, be they positive or negative. These cross-county effects are very important in estimating the overall impact of lake level changes on the regional economy. Therefore, effects in McCormick County, South Carolina from changing levels in Lake Thurmond impact the economy in Columbia County, Georgia, and vice versa. The REDYN model takes these factors into account when estimating the overall impact numbers.

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[6] Real estate income was quantified in terms of estimated real estate commissions and government revenue from taxes and fees.

VIII. CONCLUSION

This study was designed to estimate the amount by which changes in the elevation of Lake Thurmond affect county-level (or regional) economic activity. The economic impact of lake elevation was primarily evaluated in three ways:

- impact on gross retail sales of lake-related enterprises,
- impact on lakefront real estate sales, and
- impact on the value of lakefront property (as measured by sale price).

The evaluation of the impact on gross retail sales and real estate sales was carried out using a two-pronged approach. First, regression analysis was performed to estimate the marginal impact that lake elevation changes have on each, holding constant for seasonal variations, regional economic conditions, and other factors. Second, the estimated marginal impact generated by the regression analysis was input to the Regional Dynamics (REDYN) input-output modeling engine in order to approximate the total impact to the region resulting from changes in lake elevation.

The evaluation of the impact of changing lake levels on property values was carried out using a hedonic model, which estimates the effects on property values while again holding constant for seasonal and economic conditions, as well as property attributes, such as lot size, age of any structures on the property at time of sale, and square footage and number of rooms.

Some caveats should be considered with regards to this analysis. Because DOR only reports sales and sales tax data at the county level, it is not possible with these data to isolate effects from lake level changes on businesses within a certain distance from the lake; as such, some of these effects could be obscured by non-lake related economic activity in more distant portions of each county. Furthermore, some fine detail may be missed due to DOR not reporting data for sectors in which there are not a sufficient number of establishments to avoid identification of a specific establishment.

In light of these caveats, the methodology used in this report has a number of strengths. First, it has the ability to capture a broad swath of activity by businesses of all sizes affected by changes in lake elevation. Regardless of whether a business is small or large, its sales must be reported to its state's DOR for sales tax purposes, with the exception of services and goods for which sales taxes are not charged. It also allows us to take offsetting effects into account; for example, if fewer area residents are spending time at the lake, they may substitute shopping or dining out for that activity. Additionally, the use of Input-Output modeling captures "spillovers" that result from economic activity spurred (or suppressed) by the direct impact of lake level changes.

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