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THE ECONOMIC IMPACT OF THE ST JOHNS RIVER WATER QUALITY ON PROPERTY VALUES

A STUDY TO EXAMINE THE PROXIMITY EFFECTS OF WATER QUALITY ON HOUSE PRICES IN A FLORIDA RIVER SYSTEM

V Seidel, C Diamond, P Yacobellis, A Barker, C Cortez

ABSTRACT

The Balmoral Group undertook research to estimate the economic impact of the St Johns River and associated river water quality on property values for the Lower St Johns Basin in Florida in the US. A Hedonic model was used to estimate the economic value of the river based on more than 23,000 property sales fronting or near the river over the period 2003 to 2013.

The modelling found that riverfront properties in the four counties studied had a combined price premium of US$944 million due solely to river frontage. Tributary frontage properties had a US$117 million price premium over properties that lacked water frontage but were otherwise similar in other property characteristics. The value attributable to the river extends to the surrounding neighbourhoods, with an additional US$837 million of value for 23,494 properties with proximity to the river. The increased property values would equate to a theoretical increase in property tax revenues of US$45.3 million over 20 years. This study clearly demonstrates that a case for investment in water quality improvements can be made not only from a public amenity perspective, but also from a monetary perspective.

INTRODUCTION

The St Johns River is located on the east coast of north Florida, US. It is approximately 500km long and 5km wide at its widest point.

The river flows through 12 counties and about 3.5 million people live within its catchment of approximately 23,000 square km. The Lower St Johns Basin – the study area – comprises Duval, Clay, Putnam and St Johns Counties.

Following a workshop convened by the University of North Florida to examine the economic value of the St Johns River to the State of Florida, The Balmoral Group (TBG) was engaged to conduct research that addressed the impacts of the river and its floodplain on property values.

Public values for aesthetics, access and open space enjoyment of the river are reflected in property values and ad valorem taxes (rates), and this economic value can be estimated through hedonic pricing models (Palmquist, 2005).

Published research affirms that water resources, and changes in water quality, contribute to property values in Florida at varying distances from the water resource, based on attributes of "edge" (representing waterfront premiums) and "proximity" (representing distances to the waterfront or access point).

The economic impact brought about by lower water quality, such as reduced clarity, toxic algal blooms and other effects on the ecological health of the river, can be recognised through reduced property values and, in turn, reduced tax revenue.

Forty years of literature has found that lower water quality reduces nearby property values, and recent work has measured the effects of regulation of nutrient loadings on economic values in Florida. In work published in *Land Economics* using Hedonic pricing models, Walsh (2011) found that the value of improved water quality from reduced nutrient loads depends on property location and proximity to the waterfront.

Walsh suggested that the economic benefits to non-waterfront homes near a water body with high water quality might even exceed those realised by waterfront homes with diminished water quality.

This study examined the proximity effects of water quality on house prices in the St Johns River system.

METHODS

Publicly available data was collated on properties, demographics and water quality for the period 2003 through 2013. The literature (e.g. Rosen, 1974; Boyle and Kiel, 2001) supports the view that most economic value attributable to natural amenities dissipates by 1,500 metres separation from the resource.

This study included properties within 1,500 metres of the river.

Using GIS (geographic information systems), a dataset was built for regression analysis, quantifying proximity effects of the river on property values in the four counties of the study area.

The regression equation accounted for lot size, building size, existing land use, access – for example, distance to boat ramps – and neighbourhood effects, which account for nearby amenities such as parks, as well as potential disamenities such as landfills.

Hedonic Model

The Balmoral Group developed an econometric model that specifies the sale price as a function of the structural and spatial attributes of the property. The basic Hedonic specification is shown in Equation 1.

$$(1)\ \ln(p) = \beta_0 + \beta_1 (WF) + \beta_2 (RS) + \beta_3 (WF)*\ln(WQ) + \beta_4 \ln(dist) + \beta_5 \ln(dist)*\ln(WQ) + \beta_6 \ln(area)*\ln(WQ) + \beta_7 Low + \beta_8 Low*\ln(WQ) + \beta_s S + \beta_L L + \beta_T T + \varepsilon$$

where *p* represents housing sales price, *WF* is a waterfront indicator, *RS* is a dummy value representing the respective river segment closest to the subject property, *WQ* is a water quality indicator, *dist* is the distance to the river, *area* is the size of the parcel, *Low* is a threshold value for water quality, *S* is a vector of structural attributes, *L* is a vector of location attributes, *T* is a vector of time dummy values, and β represents a vector of the parameters to be estimated.

Several functional forms were tested, including log transformation, following similar approaches detailed in the literature (Walsh, 2011). It was concluded that a model with the dependent variable in a natural log form, and other variables in normal and quadratic forms, was statistically superior.

Housing Data Selection

To determine price for the regression analysis, parcel-specific spatial data (from each county's property appraiser) were selected if the property was within 1,500 metres of the river or a tributary of the river. This data was identified using GIS. Figure 1 shows the general subject area, the 1,500m buffer and residential parcels within the buffer. Sales of housing were reviewed for the period between January 1, 2003 and December 31, 2013.

Properties were excluded if (a) the sale price was less than US$15,000, (b) the land area was more than twice the standard deviation from the mean for the county (representing lands that appeared to be improperly coded as single family residential), (c) the land area was less than 500m^2, (d) the sales price was more than US$2,500,000, and (e) the dwelling living area was less than 46.5m^2.

The resulting dataset included 23,494 records, skewed heavily toward Duval County, which has the highest population. Sales prices (in 2013 $US) ranged from an average of US$160,000 to just under US$440,000 by county. Table 1 reflects the composition of housing within the dataset. The effects of the housing boom and bust cycle are evident. Sales counts by county, by year, as shown in Figure 2, show the decline in activity during the bottom of the recession, gradually recovering in recent years. Figure 3 provides a graphical distribution of sales price in log form by county, by year.

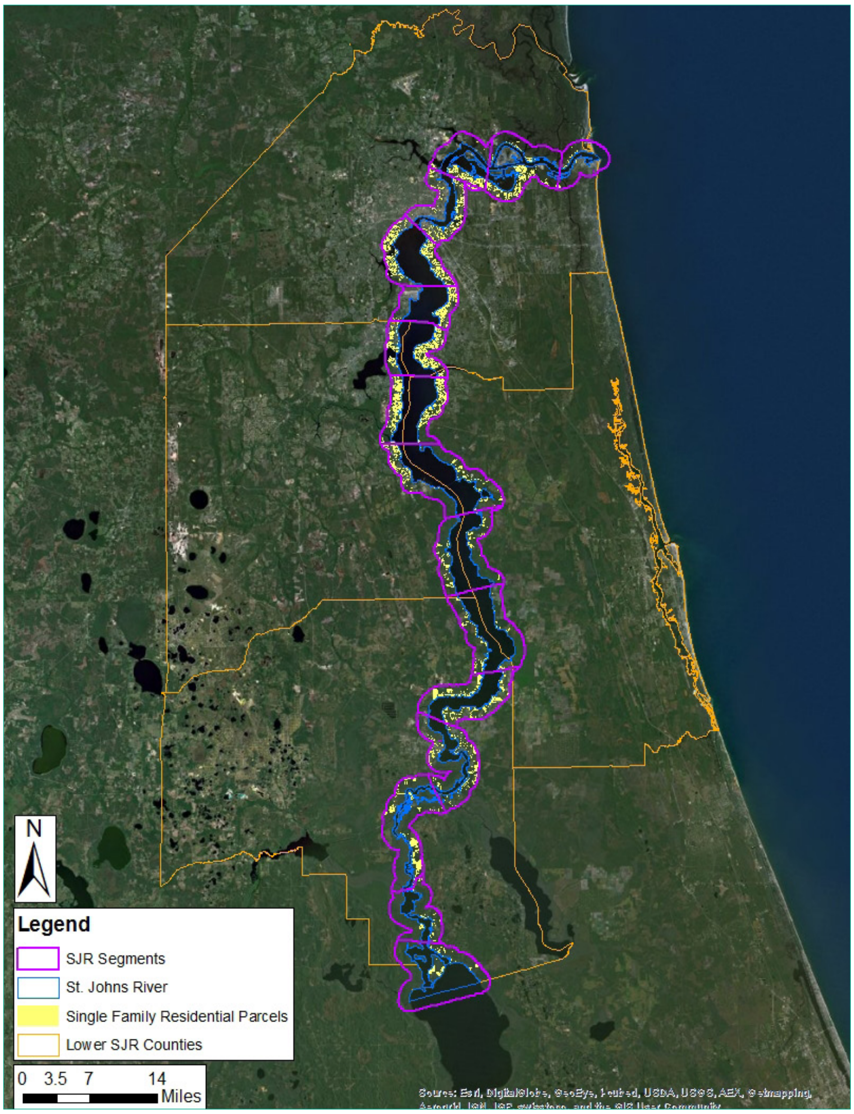

Figure 1. Residential properties along St Johns River.

Virtually all of the parcels in the dataset are located on the flood plain.

Flood maps changed during the period of analysis; since the designation of flood zone determines the requirements for flood insurance (which can affect housing costs by thousands of dollars annually), there may be effects on housing prices for properties that were newly identified as being located in a floodplain.

For some portions of the study area, new floodplain designations came into effect in 2004, while for other areas new floodplain designations came into effect in 2013. However, the effects of changes in the (flood risk) maps were assessed and produced no meaningful result; the vast majority of properties in the dataset require flood insurance, and the small amount of variation around this variable produced no explanatory value.

Water Quality Data Selection

To specify the dimensions of water quality for the regression, water quality data was partitioned spatially by 'Water Body Identification Number' (WBID), as assigned by the Florida Department of Environmental Protection. *(cont'd p5)*

Table 1. Housing characteristics in the four counties examined in the St Johns River segments.

Variable Description	Unit	Study Area (N = 23,494)			
		Mean	Std Deviation	Min	Max
Property Characteristics					
Sales price	2013 USD	243,615	216,064	15,500	2,408,000
Total living area	m^2	195	82	48	836
Area of allotment	m^2	1,302	1,102	400	15,554
Home age	Years	40	25	1	153
Water quality interaction (DRSD)	-	535	350	0	2,600
% riverfront (within 50m)	-	4.01	-	-	-
% tributary front (within 15m)	-	1.32	-	-	-
Spatial characteristics					
Distance to Central Business District	m	17,208	19,194	1,127	7,568
Distance to St Johns river	m	736	418	0	1,501
Distance to access points	m	2,699	1,840	0	7,568
Latitudinal coordinate	km	691.96	21.92	598.46	714.71
Longitudinal coordinate	km	627.44	5.52	618.91	647.07
Neighbourhood characteristics					
% of population Caucasian	-	75.20	-	-	-
% of population black	-	18.59	-	-	-
% of population senior	-	14.56	-	-	-
Persons per household	Persons	2.55	0.37	0.00	6.13
Median household income	2013 USD	59,429	24,399	0	125,461
Distribution of sales % by year					
2003	-	16.21	-	-	-
2004	-	17.35	-	-	-
2005	-	17.89	-	-	-
2006	-	14.37	-	-	-
2007	-	9.89	-	-	-
2008	-	3.79	-	-	-
2009	-	3.43	-	-	-
2010	-	4.06	-	-	-
2011	-	3.23	-	-	-
2012	-	3.82	-	-	-
2013		5.96			

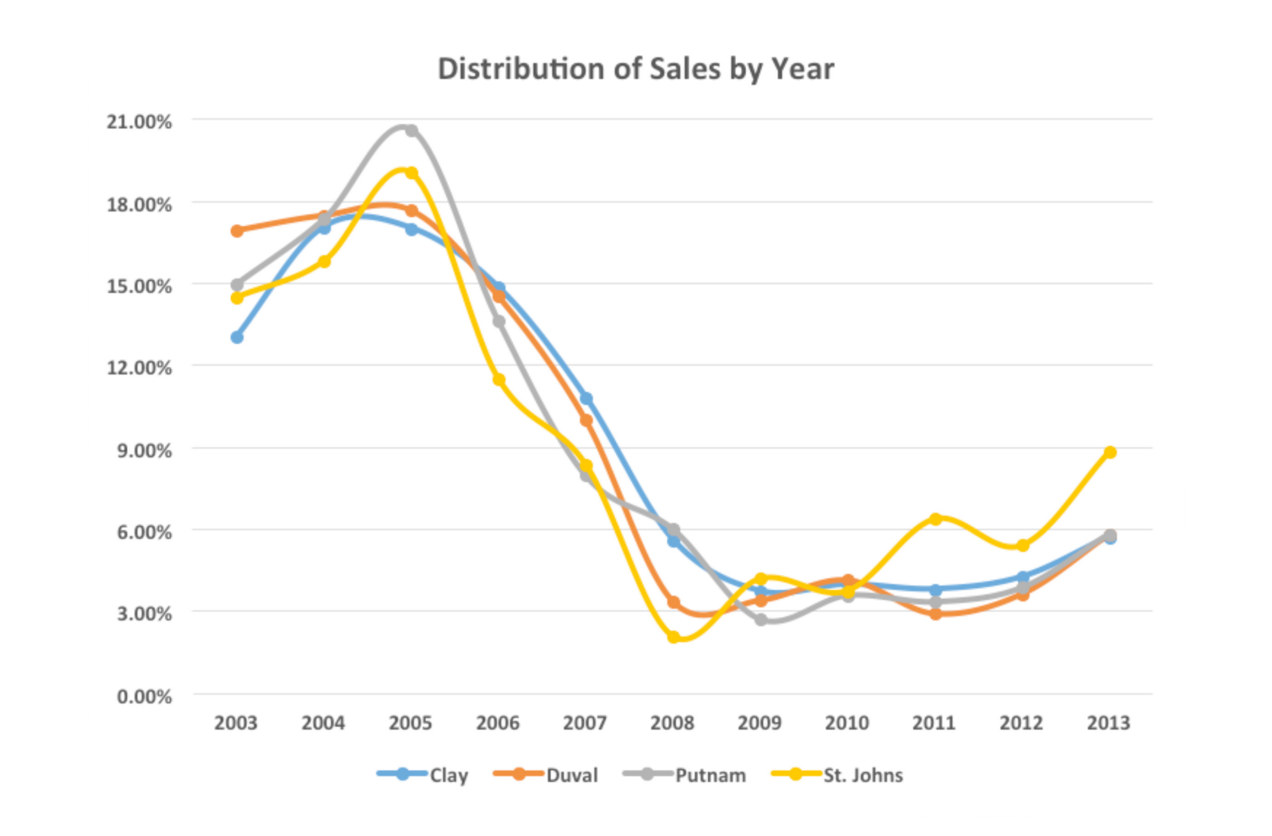

Figure 2. Sales count by year by county.

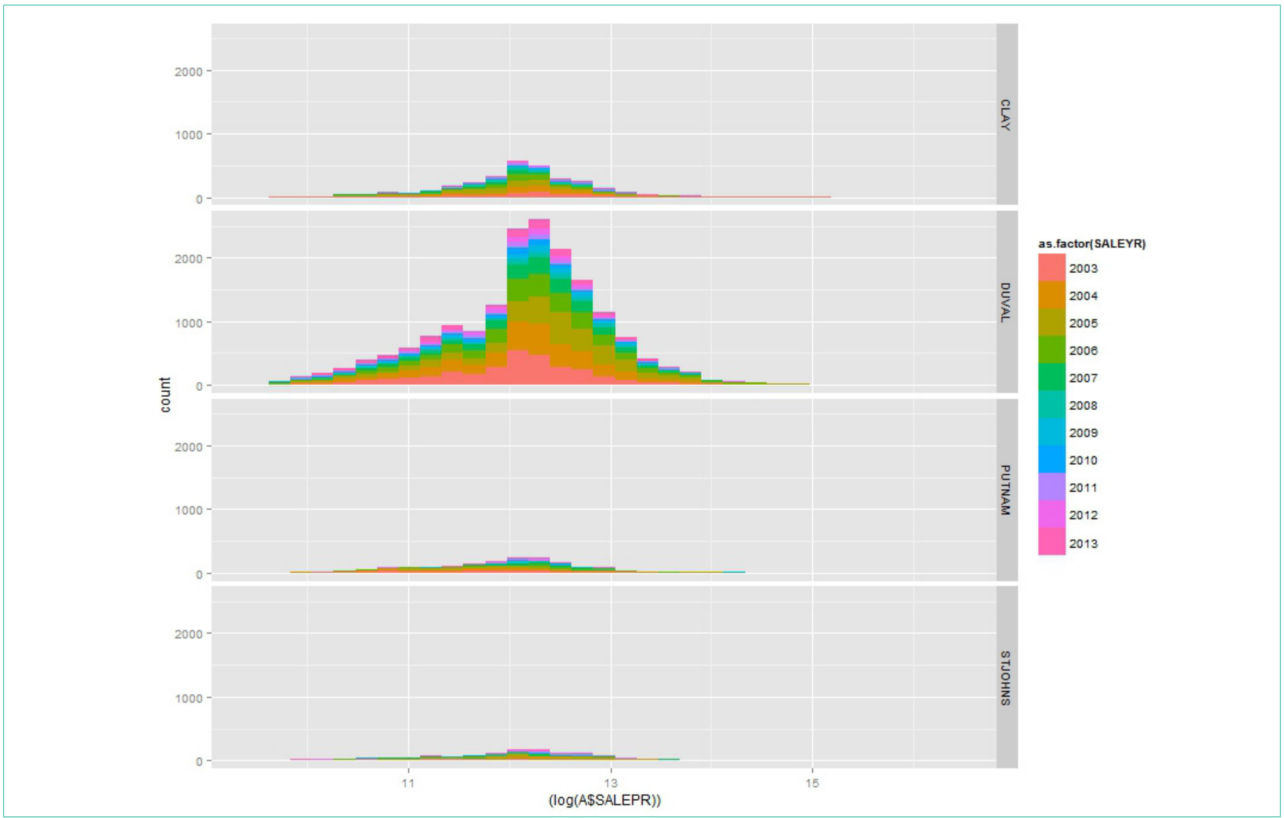

Figure 3. Log sales price by year by county.

This spatial partition allowed for analysis of data in specific sections of the river system. The Lower St Johns River includes 16 separate WBIDs, as shown in Figure 4. In order to assign water quality attributes within the analysis, a number of indicators were assessed for their suitability.

Water quality is defined by a variety of parameters, including field measurements (such as dissolved oxygen, specific conductance, pH or turbidity), and laboratory assessments (such as bacteria, nutrients or toxins). For this study, a general indicator of water quality was desired. The 'Trophic State Index' (TSI), an indicator of biomass within the water column, provides one such measure.

Historically applied to lakes, the TSI can be applied to slow-flowing systems such as the St Johns River. Harmful Algal Blooms (HABs) data were also evaluated, but the data was collected in a manner that did not allow consistent statistical treatment across all years and river segments.

The TSI (based on Carlson, 1997) is constructed from one or more of the following variables: Secchi Disk (SD) depth (water clarity); Chlorophyll concentration (CHLa); Total Nitrogen concentration (TN); and Total Phosphorus concentration (TP). The TSI based on SD is described by Equation 2:

(2) $TSI_{SD} = 60 - 14.41 * \ln(SD)$

where *SD* is the Secchi Disk depth in metres, and *ln* is the natural logarithm.

Variables for TSI measures did not produce meaningful results. As noted in the description of the variables, the researchers speculate that the inherent log transformation within TSI imputed distributions that were not compatible with the other data.

The tests of wet and dry years produced no explanatory value. The time dummy values and SD values presumably captured the variation that this attribute was attempting to quantify; namely, whether particularly high or low flows affected property values. Lagging the variables had no effect either.

The effects of changes in the flood maps were carefully assessed and produced no meaningful result; the vast majority of properties in the dataset require flood insurance, and the small amount of variation around this variable produced no explanatory value.

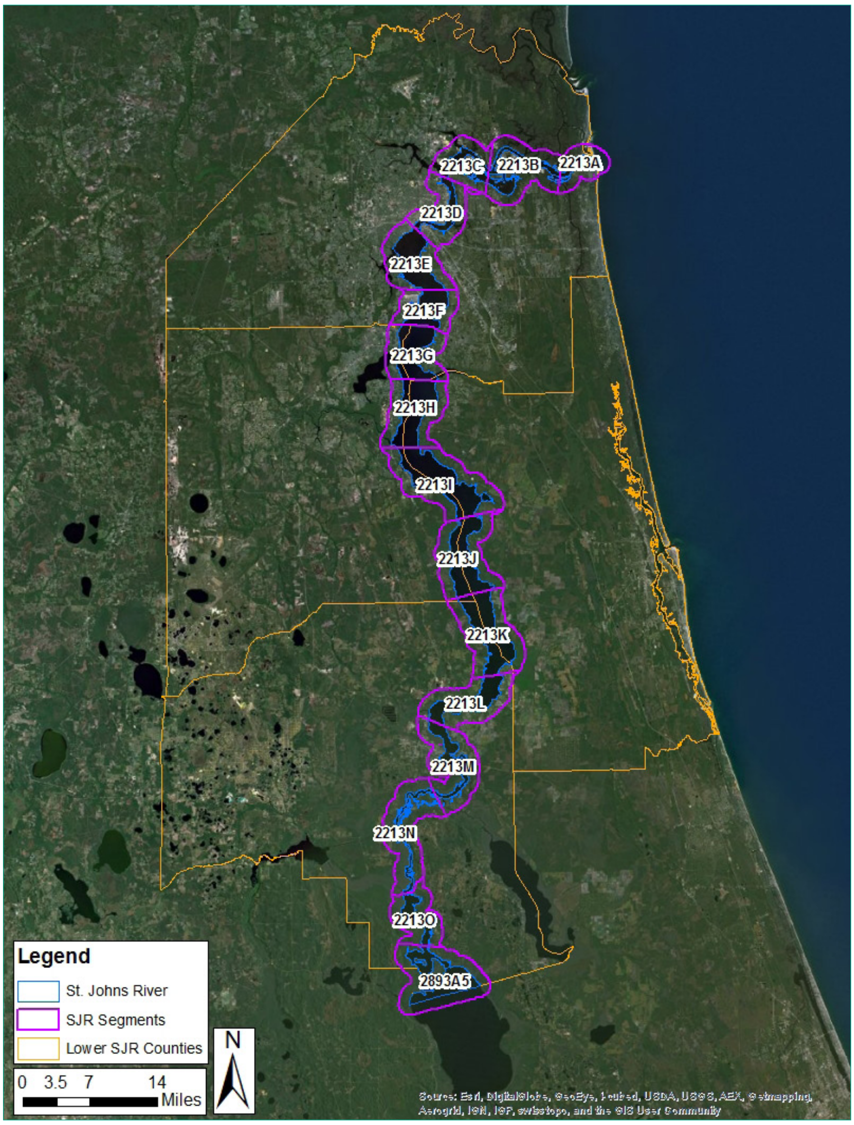

Figure 4. WBIDs (Water Body Identification Numbers) along St. Johns River.

Secchi Disk (SD) readings were available at 15 of the 16 river segments for all 10 years of this study, while observations for TN, TP and CHLa were unavailable in several river segments, and only for select years.

The broad availability of SD data lends itself to a longitudinal study and was chosen as the principal comparative indicator for the study. Secchi Disk measurements were averaged by year and by WBID. Figure 5 shows the average SD by year for each river reach: water quality deterioration – and then recovery – in the middle segments of the river, while the southernmost (most rural) and northernmost (most urban) segments showed steady improvement over the time period in question.

Figure 6 shows the readings when restricted to those measurements within one standard deviation from the mean for that segment. With this filter applied, patterns emerged that reflect intuitive trends: rural areas reflect higher measures of clarity, while segments closer to urbanised centres show changes in both directions. Grey areas represent areas with no data under this restriction. Figure 7 shows the averaged SD measurements by WBID, over all years. For each WBID, statistical analysis was undertaken to highlight housing sales that took place during periods of intense wet or dry weather. Years in which rainfall exceeded 1.5 standard deviations above mean annual rainfall for each WBID were identified as "wet" years and assigned a dummy value.

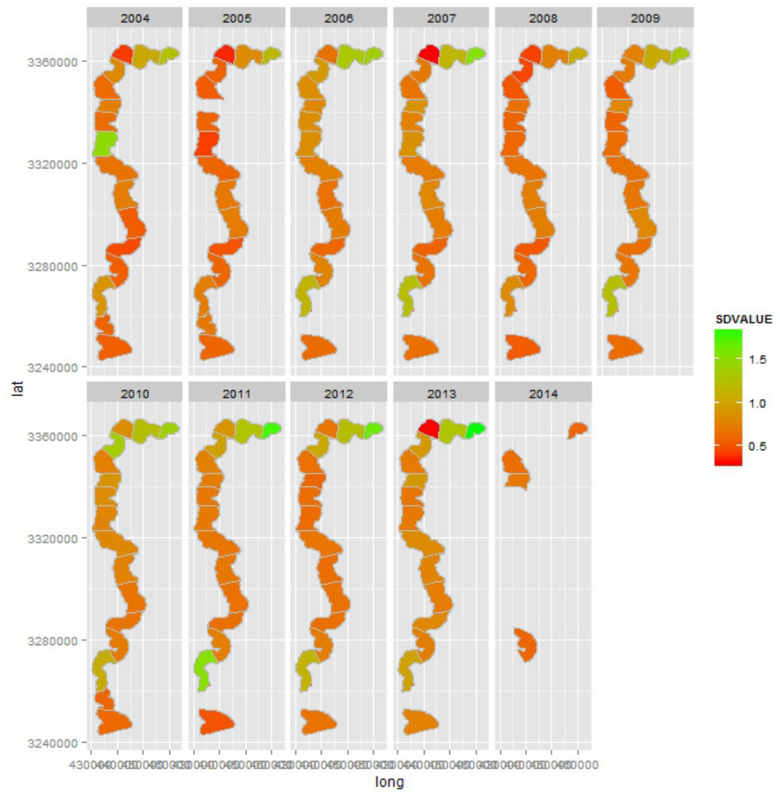

Figure 5. Average Secchi Disk measure by WBID by year.

Dry years in which rainfall fell more than two standard deviations below the mean were also assigned a dummy value. The outcomes of this analysis were that no statistical significance was found. Testing of a lag variable for the delayed effects of intense rain or drought was incorporated into the econometric modelling.

RESULTS

Hedonic Regression

A Hedonic regression or Hedonic demand theory is a revealed preference method of estimating (in this case): "does water quality influence house prices?" – which is being researched in this paper.

The following discussion decomposes the environmental factors and the housing market into its constituent attributes, and obtains estimates of the contributory value of each of these attributes. A full set of variables was considered and estimated in the research, as discussed. The final dataset included 23,494 records (n = 23,494), with an R^2 of 0.63. Selected Hedonic Estimation Results are shown in Table 3.

Housing Characteristics

Differences in lot size and dwelling size add about US$14,000 per 0.1 hectare and US$150 per $0.1m^2$ respectively and are statistically significant.

The age of housing stock was also significant, with a reduction of US$1,475 for each additional year between the home's construction and sale date.

Values between the counties reflect the greater demand for homes in the most urbanised county, Duval, which achieved a 12% premium over the mean, while Putnam generates an 8% premium and Clay a 15% discount, relative to the base for St Johns County.

Demographic variables reflect a sales premium for higher income census tracts, with a 12% increase in sale value for every US$54,176.36 in increased median household income; changes in value for increased percentages for minorities and senior citizens were as expected and statistically significant, but larger in magnitude than anticipated.

This appears to be largely driven by three segments of the river, which average 38% minority populations and sale prices of approximately US$150,000, compared to the overall dataset's average 19% minority population and a sale price of US$180,000. Price is negatively related to the distance to the central business district (downtown Jacksonville) and is significant, with a value of about US$3,300 lost for each additional metre from downtown.

Proximity Amenity Values

Proximity effects measure the decline in property values associated with increased distance to the amenity; the further from the river, the less valuable an equivalent property would be.

Proximity effects were estimated for properties that were not riverfront but were within 1,500m of the river's edge. The coefficient of proximity is negative and significant. For each additional metre from the river, a loss in value of approximately US$30 is shown.

The premium drops quickly after riverfront homes, as reflected in Table 4, which shows the proximity effects at a variety of gradients. The value declines about US$30 for each metre away from the river (the average distance is 735m). *(cont'd p8)*

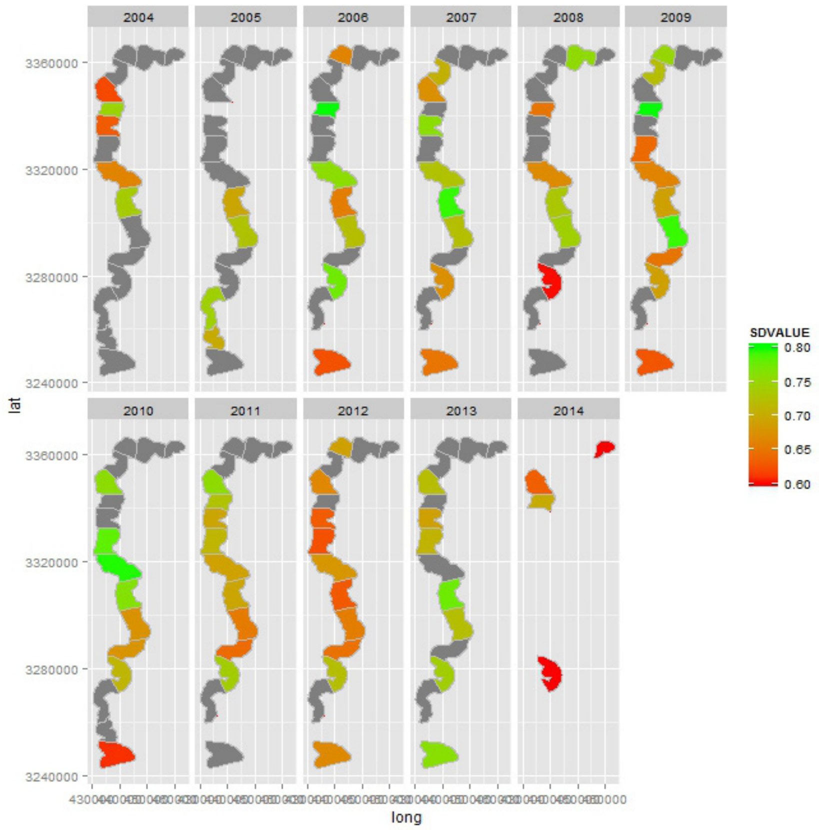

Figure 6. Secchi Disk measure by WBID by year, restricted to measures within one standard deviation.

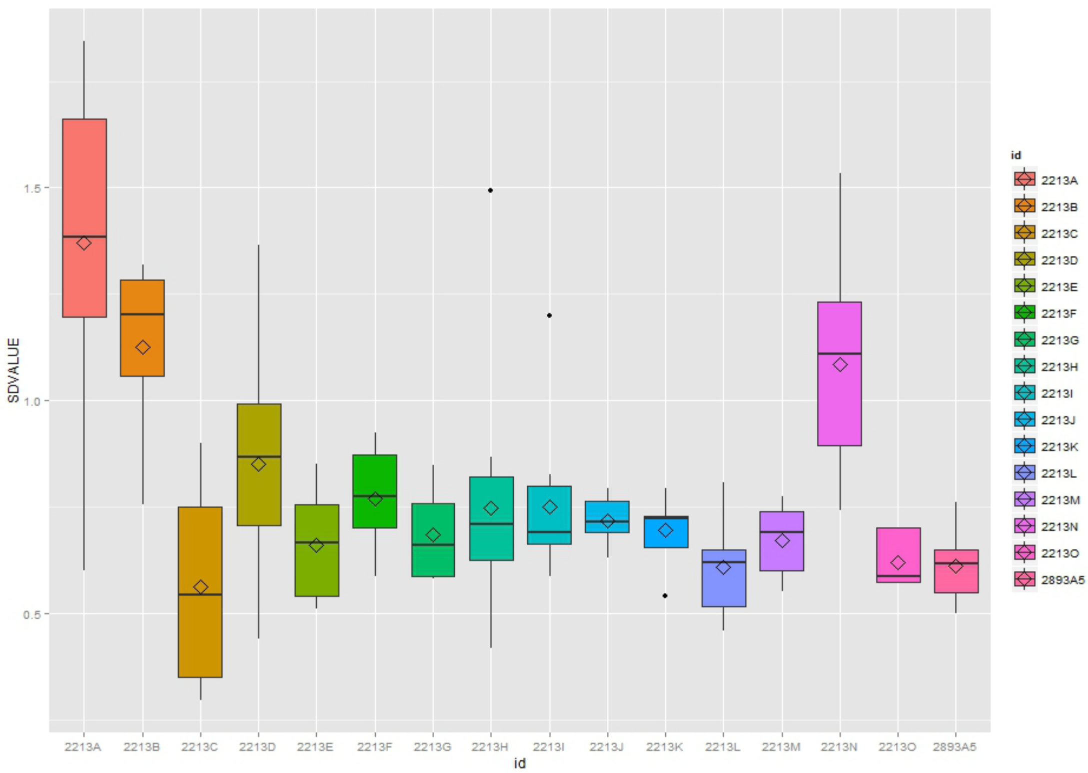

Figure 7. Average Secchi Disk measures by WBID over all years.

Table 3. Selected hedonic estimation results.

Variable Name	Variable Description	Regression Coefficient	Standard Error	Mean
Dependent Variable				
LNSALEP	Natural log of sale price	-	-	12.11
Independent Variables				
RVFRNT	Indicator if home is riverfront (1 is positive, 0 otherwise)	0.461 **	0.055	0.04
TRFRNT	Indicator if home is tributary-front	0.304 **	0.107	0.01
RVRFSD	Interaction of riverfront indicator and Secchi Disk	0.137 **	0.068	0.03
TRFSD	Interaction of tributary-front indicator and Secchi Disk	0.214	0.148	0.01
DRSD	Interaction of distance to St Johns River and Secchi Disk	(0.000)	0.000	535.15
DISTRVTW	Distance to river in m	(0.000) **	0.000	735.71
CLAY	Dummy variable for Clay County (Base is St Johns County)	(0.160) **	0.020	0.12
DUVAL	Dummy variable for Duval County (Base is St Johns County)	0.126 **	0.021	0.75
PUTNAM	Dummy variable for Putnam County (Base is St Johns County)	0.086 **	0.041	0.07
LVGAREA	Living area in square m	0.001 **	0.000	195
LIVARSQ	Living area squared	(0.000) **	0.000	481,273
LNDAREA	Property area in m^2	0.000 **	0.000	1,302
LANARSQ	Land area squared	(0.000) *	0.000	31,311,489
AGE	Age of home	(0.008) **	0.001	39.72
AGESQ	Age of home squared years	0.000 **	0.000	2,218
LNMHHI	Natural log of median household income	0.128 **	0.013	10.90
PERBLA	Per cent of black population	(1.027) **	0.029	0.19
PERSEN	Per cent of senior population	(1.580) **	0.086	0.15
DISTCBD	Distance to central business district in m	(0.000) **	0.000	17,208

*** denotes significance at the 0.05 level; * at the 0.10 level*

Figure 8 illustrates the proximity effect on property values for a selected stretch of the river. The legend shows the decline in property values that is reflected in each successive distance gradient from the river. The proximity effect ranges from a US$2,948 decline in value for non-waterfront properties closest to the river (within 1,000m), and up to a US$23,500 decline in value for properties between 1,000m and 1,500m from the river.

Waterfront Amenity Values

The coefficients on riverfront location (at 46.2% of sales price) and tributary frontage (at 30.4% of sales price) are significant, and consistent with the literature – for example, 152 properties that sold with Secchi Disk measures between 1.0 and 1.5, with an average sales price of US$555,673. The regression analysis showed that of this sales price, US$90,800, or about 16%, was attributable to the Secchi Disk/ water quality premium (calculated as the coefficient on SD, 0.13712 times the natural sales prices, times the SD reading at time of sale, times the riverfront dummy).

The premiums associated with river and tributary frontage generate substantial economic value for their respective counties. Of the total US$5.2 billion in property sales evaluated, approximately US$650 million related to waterfront homes, of which US$300 million in value is attributable solely to river and tributary frontage, all else being equal. The effects of this premium on the entire community can be calculated by extrapolating the riverfront dummy value coefficient to the entire set of riverfront properties in the four-county area. The coefficient is applied to the Just Value records provided by the Property Appraiser's office (in Florida, Just Values reflect approximate market value).

Table 4. Proximity values by county for non-riverfront properties						
	100m from river's edge			250m from river's edge		
County	Count	Property market value*	Approximate decline in property value due to increased distance	Count	Property Just Value*	Approximate decline in property value due to increased distance
Clay	151	24,662,079	-325,042	639	107,164,203	-3,126,379
Duval	819	216,810,573	-2,759,892	3,793	934,481,516	-27,531,597
Putnam	161	15,333,683	-193,970	575	57,228,885	-1,645,455
St Johns	209	53,260,020	-660,456	478	129,239,091	-3,656,072
Total	1,340	310,066,355	-3,950,236	5,485	1,228,113,695	-35,516,130
	500m from river's edge			1,000m from river's edge		
County	Count	Property Just Value*	Approximate decline in property value due to increased distance	Count	Property Just Value*	Approximate decline in property value due to increased distance
Clay	1,183	181,575,556	-11,273,271	2,445	334,093,239	-40,577,257
Duval	7,334	1,346,800,324	-83,233,754	14,825	1,883,878,904	-230,783,577
Putnam	668	55,778,055	-3,324,163	886	55,355,276	-6,797,334
St Johns	642	151,169,498	-9,397,429	1,119	247,095,050	-29,882,746
Total	9,827	1,735,323,433	-106,569,707	19,275	2,520,422,469	-307,296,389

**Note, in Florida, Market Value is legally synonymous with 'Just Value'. This is the appraised price of a property and may not reflect the sale price when a property is sold.*

Table 5 provides a breakdown of the premium associated with current waterfront properties attributable solely to the river or tributary frontage of these properties. There is a public benefit associated with this premium in the form of tax revenues (rates). This benefit can be estimated by applying the county millage rate (the amount per US$1,000 that is used to calculate taxes on property). The expressed millage rate is multiplied by the total taxable value of the property to arrive at the property taxes due. Table 6 provides an estimate of the tax revenue benefit.

Water Quality Amenity Values

The variation in Secchi Disk (SD) measurement at the time of sale is reflected in the selling price of riverfront homes. The contribution of value increases as the SD measurement increases, following a response that reflects the improved value associated with the highest SD readings – 1.8 metres. Table 7 shows that for riverfront properties with SD measurements greater than 1.5m (1.86 was the maximum in the dataset), up to 24% of the premium associated with river frontage could be attributable to the clearer water conditions. For riverfront properties that sold at times when the water clarity was lower (32 sales at < 0.5m and 748 sales at less than 1.0 metres), the premium drops to 6–9%. The value of water quality, as reflected in measurements of SD depth monitoring, is significant for waterfront properties. For the properties studied, SD (water clarity) measurements ranged from less than 0.3m to values of more than 2.0m. Waterfront properties with the highest clarity enjoyed an increased value premium of close to 24% for river frontage properties, while properties with the lowest clarity saw this premium reduced to only 6% of sales price.

For properties with tributary frontage, the change in sales price is more pronounced. Properties with a high SD measurement (1.5m+) had a greater share of their tributary frontage premium attributable to water quality, as did properties at the high end of water quality measurement. The overall sales price for properties with river frontage versus tributary frontage in the dataset was similar, at US$589,000 versus US$577,000. Table 8 provides estimates. For properties without any water frontage, the interaction term for proximity to the river and the effect of water quality was not statistically significant.

DISCUSSION

An implication of the value for improved water clarity can be found in the difference between the high and low Secchi Disk measurements.

The implicit price for improved water clarity across all riverfront properties can be estimated by extrapolating the effects of improved water clarity to all riverfront properties in the four counties. If all segments improved water clarity to 1.5 metres, other things being equal, the hypothetical increase in property value is reflected in Table 9. The associated property tax revenues were also calculated to be US$45.3m. An implication of the different impacts of water quality on property values can be calculated using hypothetical values.

If all riverfront properties saw their water quality increase to the highest category observed in this model (1.86 metres clarity), the hypothetical improvement in economic value attributable to the water quality improvement alone would total $346.1 million. The property tax revenue associated with this hypothetical improvement would total $45.3 million over 20 years.

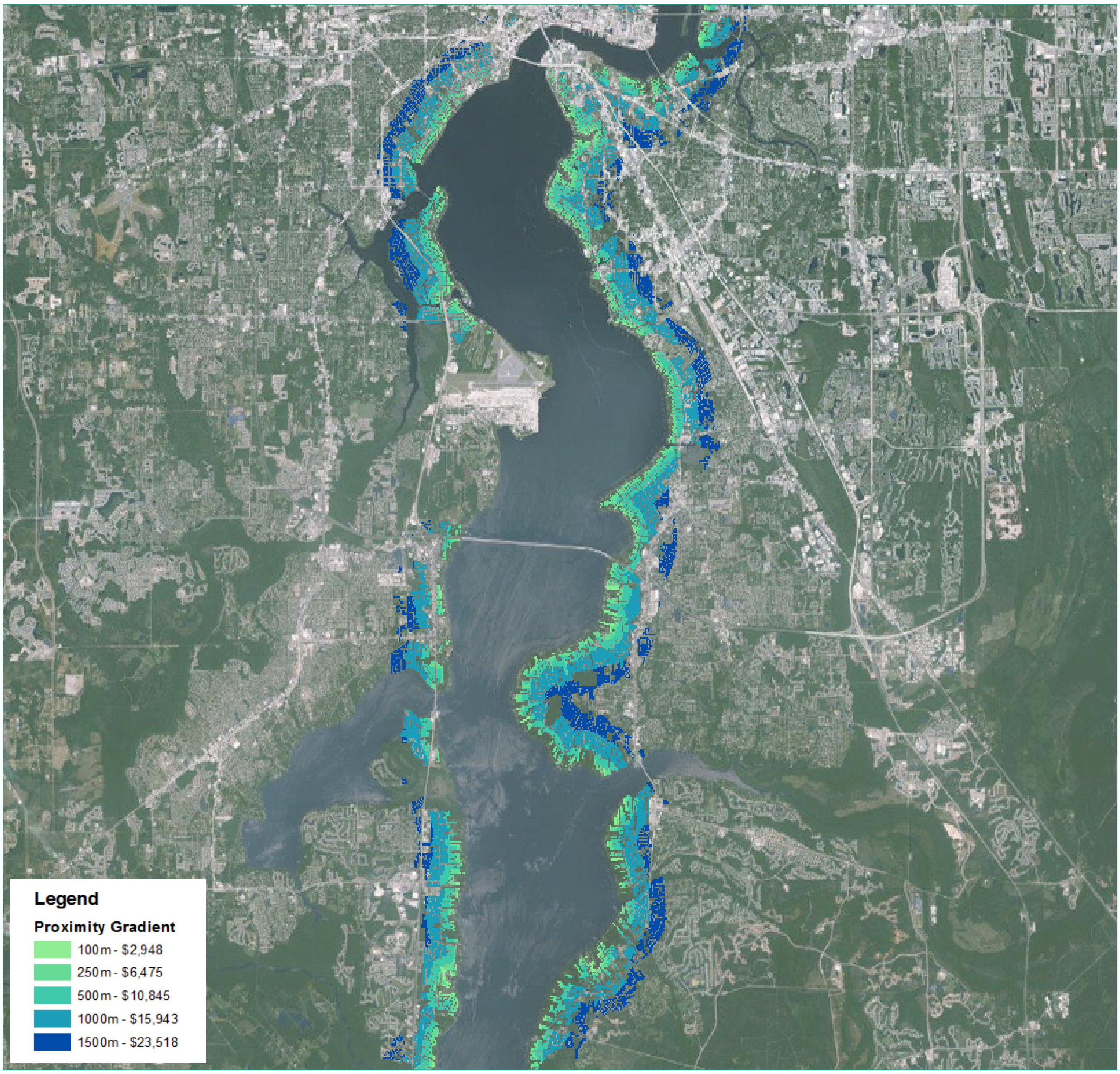

Figure 8. Property value effects of water frontage amenity.

CONCLUSION

The modelling found that riverfront properties in the four counties were priced at a premium of $944 million in value due solely to river frontage, with tributary frontage properties having a $117 million premium over properties that lack frontage, all other property characteristics being equivalent. The value attributable to the river extends to the surrounding neighbourhoods, with a general spillover effect of $837 million value for proximity (< 1500m) to the river.

The value of water quality, as reflected in measurements of SD depth, is significant for waterfront properties. Waterfront properties with the highest clarity enjoyed an increased value premium of close to 24% for river frontage, while properties with the lowest clarity saw this premium reduced to only 6% of the sales price. The increased property values would equate to a theoretical increase in property tax revenues of $45.3 million over 20 years.

This study clearly demonstrates that a case for investment in water quality improvements can be made, not only from a public amenity perspective, but also from a monetary perspective.

For more information on this study please contact Grant Leslie, General Manager, The Balmoral Group – Australia on gleslie@balmoralgroup.com.au

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Table 5. Waterfront premium values by county, 2013.				
County	Total No. of Riverfront Properties	Riverfront Premium ($mil.)	Total No. of Tributary Frontage Properties	Tributary Frontage Premium ($mil.)
Clay	603	$102	112	$11
Duval	1,808	$573	715	$88
Putnam	1,130	$111	124	$5
St. Johns	903	$159	111	$14
Total	4,444	$944	1,062	$117

Table 6. Property tax revenue associated with riverfront and tributary frontage premiums.			
		20-year Tax Revenue*	
County	Millage Rate [a]	Riverfront Premium ($M)	Tributary Frontage Premium ($M)
Clay	11.4	23.10	2.42
Duval	5.2	59.35	9.07
Putnam	5.4	11.79	0.49
St. Johns	8.9	27.91	2.41
Total		122.15	14.39

[a] assumes 3% annual inflation and 4% discounting over 20 years.

Table 7. Implicit price for Secchi Disk (SD) measurement improvement (riverfront).				
Secchi Disk measurement (m)	**< 0.5**	**0.5–1**	**1.0–1.5**	**1.5+**
Number of property sales	32	748	152	9
Premium associated with SD measurement ($)	23,626	56,210	90,857	107,572
Average sales price ($)	420,933	605,225	555,673	452,895
Percentage of premium	6	9	16	24

Table 8. Implicit price for Secchi Disk (SD) Measurement Improvement (tributary frontage)				
Secchi Disk measurement (m)	**< 0.5**	**0.5–1**	**1.0–1.5**	**1.5+**
Number of property sales	13	277	18	2
Premium associated with SD measurement	25,843	87,575	93,492	34,838
Average sales price ($)	307,070	608,191	361,884	95,750
Percentage of premium	8	14	26	36

Table 9. Implicit price for improved water clarity across all riverfront properties, by county.

County	Total no. of riverfront properties	Riverfront premium with current water quality ($m)	Hypothetical riverfront premium with SD improved to 1.5m ($m)	Difference ($m)	Hypothetical 20-year tax revenue after improvements to water quality ($m)
Clay	603	24.3	64.8	40.5	9.2
Duval	1,808	145.5	351.5	206.0	21.3
Putnam	1,130	29.1	68.2	39.2	4.2
St Johns	903	36.2	96.6	60.4	10.6
Total	4,444	235.1	581.1	346.1	45.3

THE AUTHORS

Valerie Seidel is President and Principal Economist of The Balmoral Group. She has a Masters in Commerce from Sydney University, with post-graduate work in environmental economics at the University of Central Florida. Her experience has focused on infrastructure and natural resource valuation, GIS/statistical models of resource allocation and optimisation, and cost-benefit analysis.

Craig Diamond is a Senior Economist with The Balmoral Group. He has been a water resources planner and graduate faculty of water resources. He has an MS in Environmental Engineering.

Paul Yacobellis is a Research Economist and GIS Specialist of The Balmoral Group. He has a Masters in Statistics and a Bachelors in Economics from the University of Central Florida.

Alicia Barker is a Research Analyst and GIS Specialist of The Balmoral Group. She holds a Bachelors in Economics, with emphasis on statistics, from the University of Central Florida.

Cortney Cortez is a Research Assistant at The Balmoral Group. She holds a Bachelors in Business Administration and Economics from the University of Central Florida.

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