Original Article

Unaccounted infrastructure needs for transit-oriented developments

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ABSTRACT

Increasingly, U.S. cities are focusing on transit-oriented development (TOD) policies to expand the stock of higher-density, mixed-use development near public transit stations within the context of a transit corridor and, in most cases, a regional metropolis. A TOD zone relies on a regulatory and institutional environment, public and private participation and investment, and development incentives to create vibrant, people-oriented communities and mobility options and to support business development. TODs provide local governments with more tax revenues due to increased property values (and, as applicable, income and sales tax revenues), but most planning for TODs ignores the non-transit infrastructure costs of increasing development density. This study focused on determining the water and sewer infrastructure costs for TOD zones along a rail line in southeast Florida. The finding was that millions of dollars in funds are needed to meet those water and sewer needs and that few are currently planned as a part of community capital improvement programs.

Keywords: transit; transit-oriented development; infrastructure; water; sewer; development

1. Introduction

This project was developed to evaluate the economic impacts and infrastructure requirements of creating a series of transit-oriented development (TOD) zones along the Florida East Coast (FEC) Railway corridor from Jupiter, north of the city of West Palm Beach, through downtown Fort Lauderdale, to downtown Miami. The plan calls for 27 stations to be located at various points, most in downtown areas of small communities, such as Dania Beach, Hallandale Beach, Boca Raton, North Miami and Lake Worth Beach. The plan proposes building upon 77,262 existing units with a projected 115,738 new housing units, primarily due to residential infill along the corridor (see Figure 1). This level of infill development is lower than the projected goal of 15 dwelling units (DU)/acre because many local governments face opposition to increased density and greater building heights. Based on these projections, a value capture model was created, which determined that the property tax revenue for all land-use types along the corridor is $438 million in property valuation using the low growth rates from a study provided to Miami-Dade County by Government Services Group
(GSG) and Clary Consulting Corp (CCC).

The projection indicated that infill residential development distributed equally over a 30-year period could capture as much as $30 billion across the three counties of Broward, Miami-Dade and Palm Beach. Tax increment financing (TIF) revenues could be the source of financing horsepower to design, build, operate and maintain the infrastructure. Moreover, a portion of these funds, which is dedicated to affordable housing, could offset transit-induced gentrification created by the train system. However, most planning for TODs ignores the non-transit infrastructure costs of increasing development density. This study focused on determining the water and sewer infrastructure costs for TOD zones along a rail line in southeast Florida. Without appropriate consideration for non-transportation infrastructure needs, TOD implementation to achieve transportation-related goals is likely to be compromised.

2. Review of literature

After World War 2, Congress funded highways that facilitated the migration of people from the inner cities to the suburbs, causing considerable density drop. Shortly afterward, Congress approved legislation to reduce the amount of time corporations could depreciate commercial properties. The results included more use of automobiles, more road-building costs, more traffic congestion and more energy use (Newman and Kenworthy, 1999; Burchell et al., 2002). The desire to reduce these issues had given rise to the concept of transit-oriented developments (TODs) (Renne et al., 2016).
TODs most often entail a significant investment of locally derived funds in the form of general or specific-purpose funds, such as tax increment financing (TIF) and community redevelopment agencies (CRAs), as means to pay for transportation improvements including landscaping, pedestrian walkways, bicycling lanes and bus circulation around rail stations. Salat and Ollivier (2017) noted that TODs are a means to transform urban spaces to increase efficiency in development, reduce power use and improve traffic congestion.

Over the last 20 years, the concept has been implemented in cities across the globe. The goal is to encourage higher-density development close to transportation systems (Warren, 2014). Suzuki et al. (2015) outlined the World Bank’s recommendations for creating and financing TODs. Multi- and mixed-use developments encourage people to live and shop in the same neighborhood, which generates more accessibility, while reducing energy costs (Levine et al., 2019). Compact neighborhoods generate more accessible job opportunities, mixed land uses and diverse activities at the street level and encourage pedestrian traffic, stimulating the local economy (Calthorpe, 1993). Locating affordable housing in transit corridors allows households to reduce expenses, while increasing access to employment, educational opportunities and services (Renne et al., 2016; Hamidi et al., 2016).

Although most TODs include both bus transit and rail, comparisons between bus rapid transit and rail systems were made by Currie (2006) after noting that most TOD zones focused only on rail. The U.S. Environmental Protection Agency (EPA) (2015) noted that the costs for TOD developments are significant—specifically with respect to sidewalks, on-street parking, bike lanes, transit and trains, but there has been little consideration related to the cost for other infrastructure systems. Schlossberg and Brown (2004) outlined additional requirements for TOD zones for walkability indicators. Pedestrian integration is a key to TOD success.

When the principles of multi-modal transportation options are in place, the results of a TOD zone can be significant with respect to economic development and property values. While the benefits to local governments include an increase in tax revenues, a national study revealed that it is increasingly expensive to live near public transit (American Public Transportation Association, 2019). House prices and rents within a half-mile of transit facilities are increasing at a faster rate than those in neighborhoods farther away. Public transit zones can increase property values near high-capacity rail stations by as much as 150%, and office spaces per square foot in transit-proximate areas in Boston, Hartford, Los Angeles and Phoenix are 5% to 43% more expensive than offices in non-transit locations. In Boston, office sales prices increased by 38% in the transit zone compared with the region, which only increased by 3%. Similar patterns were found in Hartford, Los Angeles and Phoenix (American Public Transportation Association, 2019).

Recent studies assessing the implementation of TOD zones as achieving truly equitable, mixed and economically accessible transit neighborhoods have found that a new market-rate development in station areas is not usually affordable to very low-, low- or even moderate-income households, unless developers take advantage of affordable housing subsidies. Locating affordable housing in transit corridors allows households to reduce expenses, while increasing access to employment, educational opportunities and services (Renne et al., 2019).

A TOD zone is often more expensive than a comparable suburban development due to the expense of upgrading local infrastructure, where a suburban development is not designed to handle
higher-density housing or offices. Parking, for example, is often constructed in surface lots in
suburbs, whereas in TOD zones, parking is expected to be underground or in a structure. The cost to
build underground or structured parking is typically 20–30 times more expensive than a parking lot,
which is passed along to residents in the form of higher rents or more expensive housing units.

Utility upgrades, such as water and sewer upgrades, can be very expensive, and in growing
suburbs, municipalities are often more willing to subsidize these expenses to encourage growth
compared with retrofitting infill TOD zone locations where local governments are dominated by
an anti-development mindset and thus less willing to subsidize the costs of new developments
(Arrington and Cervero, 2008).

In the U.S., such TOD funds provide catalytic, risk-tolerant private capital that aligns objectives
to maximize impact and leverage. A shifting paradigm for financing equitable TOD funding means
federal dollars are no longer the driving catalyst. Increasingly, the model of structured, multi-
investor loan funds has proliferated for acquiring strategic properties in transit corridors to create
and preserve affordable housing. The creation of TOD funds provides a novel investment vehicle
that pools capital from a cross-sector coalition of public, private and philanthropic investors with
different risk profiles to provide low-interest sub-loans and largely non-recourse, revolving lines of
credit (Renne et al., 2019).

3. Methodology

The purpose of evaluating the South Florida Transit-Oriented Development project for the
South Florida Regional Planning Council was to evaluate water and sewer utility infrastructure to
determine if the infrastructure is sufficient within a one-half-mile radius around the proposed station
site. The types of potential train station area (station) enhancements considered as a part of this
study were City Centers (12,500 units), Town Centers (5,000–8,000 units) and Neighborhood Zones
(4,000 units). Three City Center stations already exist but could be developed beyond the current
conditions (Downtown West Palm Beach, Broward Blvd. in Fort Lauderdale and Government
Center in downtown Miami). The remainder were proposed stations. The goal of this study was to
review the utilities around each of the 27 stations to determine the potential for development, and
the limitations each site might face if the development were to move forward.

To conduct the assessment, the methodology included developing data from a series of public
sources, including:

- Raw water supplies: Data were generated from permit data from the South Florida Water
  Management District (SFWMD) permit files and the most recent draft of the Lower East
  Coast Water Supply Plan.
- Water treatment plant capacity: Data were generated from the most recent draft of the Lower
  East Coast Water Supply Plan and Florida Department of Health files for each plant.
- Average daily water demands: Data were from the most recent draft of the Lower East Coast
  Water Supply Plan and Florida Department of Health monthly operating reports (now with
  the Florida Department of Environmental Protection (FDEP))
- Wastewater capacity: Note that several of these stations are connected to regional utilities;
  data were gathered from utility websites and monthly operating reports filed with the Florida
Department of Environmental Protection.

- Wastewater demands: Note that the capacity in regional stations is harder to analyze, especially if a regional plant serves more than one of the potential station enhancement sites. Data were gathered from monthly operating reports filed with the Florida Department of Environmental Protection or directly from the utilities.

For each of these station areas, the utilities were asked to provide geographic information system (GIS) data for their water and sewer piping to allow evaluation of the ability to provide service based on pipe size and looping. Each station area was analyzed based on the assumption that either a City Center site or a smaller station size (either a Town Center or Neighborhood Zone station) would be constructed to determine the magnitude of needed improvements.

For water treatment plant capacity, the current demand plus the new TOD demands were combined. If this value exceeded 90 percent of the plant capacity, added capacity was assumed to be necessary based on water resources best practices. This capacity was estimated at a cost of $8 million per million gallons per day (MGD) or $8 per gallon. Likewise, for raw water supply, the existing demand plus the added projected demand were multiplied by 1.04 to account for lost water during the treatment process at an estimated cost of $7 million per MGD or $7 per gallon. The same analysis for wastewater treatment was performed with an estimated projected cost of $7 million per MGD or $7 per gallon. Underground water and sewer piping needs were determined with assumptions as follows:

- If the water distribution piping was 12 inches or less and/or not looped, new piping was suggested.
- Based on the distance to the water plant or large piping, a looped pipe length was created.
- The estimated cost per foot was $275 for water distribution piping.
- Likewise, for sewer pipes, it was assumed that large force mains and lift stations were needed.
- If these were not present, lift stations and force mains were estimated at $250/ft.

For each of the stations, the same analysis was made and a table was created based on the City Center station plus either a Town Center or Neighborhood Zone station based on the prior corridor analysis of the proposed station size. Cost data were developed based on the personal knowledge of the industry by author Bloetscher. The results were then peer-reviewed by two utility managers familiar with the systems. Reviewer feedback was collected during two utility group phone calls with additional utility staff in May 2019. Each county was represented, and the reviewers had direct knowledge of at least eight of the systems involved, which encompassed nearly all the stations (for example, West Palm Beach serves three stations with water and six with sewer; Fort Lauderdale is similar). Finally, tables were created to develop the following:

- Current development limitations (units).
- Restrictions to current development.
- Needs and costs for future development, noting that the costs are a magnitude of scale, not detailed costs estimates, based on two scenarios of TOD development.
- County-level needs.
To define the characteristics that might limit TOD development, statistical techniques of principal component analysis, linear regression and logistic regression were used with the goal of identifying those variables most likely to predict costs or challenges. It should be noted that a critical component of the statistical analysis used in this effort was the need for a complete dataset. Linear regression and logistic regression models were run on the complete dataset using the XLSTAT® statistical software. With linear regression, the goal is to develop a series of weights for the independent variables (all but the outcome variable defined for success) to determine which variables impact the outcome of success the most. For this analysis, linear regression can be used as a tool to predict the limiting factors for TOD development. Logistic regression was preferred when the dependent variable was used to predict whether there are challenges for the development at the TOD zone. More discussion can be found in Bloetscher et al. (2014) and Bloetscher (2019).

4. Results

Based on the analysis of GIS pipelines for the area, most stations require piping infrastructure to some degree. Several sites will need water supply, water treatment capacity or wastewater treatment capacity. Note that water systems were deemed to need expansion if the station brought total use above 90% of capacity. Wastewater was 80% of capacity based on FDEP guidelines and industry best practices. The anticipated needs outlined in Table 1 were estimated.

There are four stations with current limitations that restrict development: Riviera Beach, Pompano Beach, Dania Beach and Hallandale Beach. The latter has to do with the water supply. All four involve wastewater treatment plant capacity issues. The total cost for the infrastructure for the proposed stations is just over $400 million based on the proposed station type, as shown in Table 1. The highlighted areas are those where capacity issues arise with TOD development. Note that for all stations served by Miami-Dade County, adequate water treatment and wastewater treatment capacity exists, although raw water is a concern (the volume exceeds 90% capacity although the system size is huge). Hence, while the 90% threshold is exceeded in Miami-Dade County, this does not prevent any particular station from being developed.

Table 2 shows the cost for each site based on the proposed station location (also illustrated in Figure 2). Figure 3 shows the cost by county. The regional system in Miami-Dade County resolves many issues that are present in Broward County. Miami-Dade has a large, well-developed, large-capacity system that is fully interconnected between sites. The southeast region of Broward County is particularly challenged due to saltwater intrusion that limits raw water supplies and due to the outfall issues with the Hollywood’s wastewater plant. However, the penny sales tax for transportation may be a source of funds to address some of these needs.

Table 3 outlines the current potential for development. While many of the sites have the water supply, water treatment capacity and wastewater capacity to serve the area, piping and other limitations may prove to be a challenge. Those with current challenges were noted. The Miami-Dade numbers are large because there is a lot of capacity in the system. Other utilities are smaller but raw water and sewer disposal options are likely large expenditures that need to be planned by the affected utilities.

In reviewing the variable analysis, the highest correlation (0.922) indicated that wastewater
| Sta. No. | 1 | 2 | 3 | 4 | 5 |
|----------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Station Location | TONEY PENNA | PGA BLVD PALM BEACH GARDENS | PARK AVE LAKE PARK | 13TH ST RIVIERA BEACH | 45TH ST WEST PALM BEACH |
| City | JUPITER | PALM BEACH | LAKE PARK | RIVIERA BEACH | WEST PALM BEACH |
| Station Location | TONEY PENNA | PGA BLVD PALM BEACH GARDENS | PARK AVE LAKE PARK | 13TH ST RIVIERA BEACH | 45TH ST WEST PALM BEACH |
| City | JUPITER | PALM BEACH | LAKE PARK | RIVIERA BEACH | WEST PALM BEACH |
| City | JUPITER | PALM BEACH | LAKE PARK | RIVIERA BEACH | WEST PALM BEACH |
| City | JUPITER | PALM BEACH | LAKE PARK | RIVIERA BEACH | WEST PALM BEACH |
| City | JUPITER | PALM BEACH | LAKE PARK | RIVIERA BEACH | WEST PALM BEACH |
| City | JUPITER | PALM BEACH | LAKE PARK | RIVIERA BEACH | WEST PALM BEACH |
| Station Goal | TC | TC | NC | NC | TC |
| Potential Units For Planning Purposes | 6500 | 6500 | 4000 | 4000 | 6500 |
| Restrictions for WTP, WWTP or Raw Water Capacity | yes | yes | yes | yes | yes |
| Raw W (MDG) | 24.41 | 26.92 | 26.92 | 9.08 | 41.2 |
| Raw Source | Floridan | Surficial Aq | Surficial Aq | Surficial Aq | Surface Water |
| WTP Cap (MGD) | 26 | 30.5 | 30.5 | 17.5 | 47 |
| WTP Demand (MGD) | 16.13 | 18.02 | 18.02 | 7.81 | 29.49 |
| WWTP Cap (MGD) | 11 | 12 | 12 | 70 | 70 |
| WWTP Demand (MGD) | 6.5 | 8 | 8 | 41.45 | 41.45 |
| Disposal Method | Reuse | Reuse/Inj Well | Reuse/Inj Well | Reuse/Inj Well | Reuse/Inj Well |
| # of Existing Residential Units within Half-Mile of Station (2018) | 1474 | 1660 | 1066 | N/a | 2178 |
| Max Density Scenario within Half-Mile of Station | -1474 | -1660 | -1066 | N/a | -2178 |
| Add Water Demand | -0.442 | -0.498 | -0.320 | N/a | -0.653 |
| Add WW Demand | -0.295 | -0.332 | -0.213 | N/a | -0.436 |
| Available Capacity Water | 9.87 | 12.48 | 12.48 | 9.69 | 17.51 |
| Available Capacity Raw Water | 8.28 | 8.9 | 8.9 | 1.27 | 11.71 |
| Available Capacity Wastewater | 4.5 | 4 | 4 | 28.55 | 28.55 |
| % Capacity Water Treatment | 0.60 | 0.57 | 0.58 | N/a | 0.61 |
| % Capacity Water Supply | 0.67 | 0.68 | 0.68 | N/a | 0.73 |
| % Capacity Needed Wastewater Treatment | 0.56 | 0.64 | 0.65 | N/a | 0.59 |
| Capacity Needed Water MGD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Water Supply Capacity Needed MGD | 0.00 | 0.00 | 0.00 | n/a | 0.00 |
| Wastewater Treatment Plant Capacity Needed MGD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16+ WM - LF | 0 | 0 | 0 | 20000 | 8000 |
| Force Main LF | 2500 | 0 | 0 | 10000 | 5000 |
| Sewer Lift Station | 1 | 0 | 0 | 4 | 4 |
| Gravity Sewer Revisions | 0 | 0 | 0 | 0 | 0 |
| Lift Station Upgrades | 1 | 0 | 0 | 1 | 1 |
| Capacity Water (per MGD) | $7,000,000 | $7,000,000 | $7,000,000 | $7,000,000 | $7,000,000 |
| Raw Water (per MGD) | $6,000,000 | $6,000,000 | $6,000,000 | $6,000,000 | $6,000,000 |
| Capacity Sewer (per MGD) | $8,000,000 | $8,000,000 | $8,000,000 | $8,000,000 | $8,000,000 |
| 16" or More Water Main - $/LF | $275 | $275 | $275 | $275 | $275 |
| Force Main $/LF | $200 | $200 | $200 | $200 | $200 |
| Sewer Lift Station Cost | $500,000 | $500,000 | $500,000 | $500,000 | $500,000 |
| Gravity Sewer Installation /LF | $250 | $250 | $250 | $250 | $250 |
| Lift Station Upgrades Cost | $250,000 | $250,000 | $250,000 | $250,000 | $250,000 |
| Capacity Water | $- | $- | $- | $- | $- |
| Water Supply | $- | $- | $- | $- | $- |
| Capacity Sewer | $- | $- | $- | $- | $- |
| 16+ WM /LF | $- | $- | $- | $5,500,000 | $2,200,000 |
| Force Main / LF | $500,000 | $- | $- | $2,000,000 | $1,000,000 |
| Sewer Lift Station | $500,000 | $- | $- | $2,000,000 | $2,000,000 |
| Gravity Cost | $- | $- | $- | $- | $- |
| Lift Station Upgrades | $250,000 | $- | $- | $250,000 | $250,000 |
| Total Cost | $1,250,000 | $- | $- | $9,750,000 | $5,450,000 |
| Total Cost Millions | $1.25 | $- | $- | $9.75 | $5.45 |

Table 1. Summary of infrastructure data for each proposed station.
Table 1. (Continued)

| Sta. No. | 6 | 7 | 8 | 9 | 10 |
|----------|---|---|---|---|----|
| Station Location | EVERNIA ST/DOWNTOWN WEST PALM BEACH | GREGORY RD WEST PALM BEACH | LAKE AVE LAKE WORTH | BOYNTON BEACH BLVD Boynton Beach | ATLANTIC AVE DELRAY BEACH |
| City | WEST PALM BEACH | WEST PALM BEACH | LAKE WORTH | BOYNTON | BEACH |
| Station Goal | CC | NC | TC | TC | TC |
| Potential Units For Planning Purposes | 12500 | 4000 | 6500 | 6500 | 6500 |
| Restrictions for WTP, WWTP or Raw Water Capacity | | | | | |
| Raw W (MDG) | 41.2 | 41.2 | 41.2 | 20.86 | 19.1 |
| Raw Source | Surface Water | Surface Water | Surficial Aq | Surficial Aq | Surficial Aq |
| WTP Cap (MGD) | 47 | 47 | 17.4 | 34 | 24 |
| WTP Demand (MGD) | 29.49 | 29.49 | 5.31 | 13.51 | 16.15 |
| WWTP Cap (MGD) | 70 | 70 | 70 | 24 | 24 |
| WWTP Demand (MGD) | 41.45 | 41.45 | 41.45 | 9.5 | 6.7 |
| Disposal Method | Reuse/Inj Well | Reuse/Inj Well | Reuse/Inj Well | Reuse/Inj Well | Reuse/Inj Well |
| # of Existing Residential Units within Half-Mile of Station (2018) | 5111 | 852 | 3695 | 2944 | 2740 |
| Max Density Scenario within Half-Mile of Station | -5111 | -852 | -3695 | -2944 | -2740 |
| Add Water Demand | -1.533 | -0.256 | -1.109 | -0.883 | -0.822 |
| Add WW Demand | -1.022 | -0.170 | -0.739 | -0.589 | -0.548 |
| Available Capacity Water | 17.51 | 17.51 | 12.09 | 20.49 | 7.85 |
| Available Capacity Raw Water | 11.71 | 11.71 | 35.89 | 7.35 | 2.95 |
| Available Capacity Wastewater | 28.55 | 28.55 | 28.55 | 14.5 | 17.3 |
| % Capacity Water Treatment | 0.59 | 0.62 | 0.24 | 0.37 | 0.64 |
| % Capacity Water Supply | 0.71 | 0.74 | 0.11 | 0.63 | 0.83 |
| % Capacity Needed Wastewater Treatment | 0.58 | 0.59 | 0.58 | 0.37 | 0.26 |
| Capacity Needed Water MGD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Water Supply Capacity Needed MGD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Wastewater Treatment Plant Capacity Needed MGD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16+ WM - LF | 0 | 0 | 8000 | 0 | 0 |
| Force Main LF | 0 | 8000 | 0 | 0 | 0 |
| Sewer Lift Station | 0 | 2 | 1 | 1 | 0 |
| Gravity Sewer Revisions | 0 | 10000 | 20000 | 500 | 0 |
| Lift Station Upgrades | 0 | 1 | 1 | 1 | 0 |
| Capacity Water (per MGD) | $7,000,000 | $7,000,000 | $7,000,000 | $7,000,000 | $7,000,000 |
| Raw Water (per MGD) | $6,000,000 | $6,000,000 | $6,000,000 | $6,000,000 | $6,000,000 |
| Capacity Sewer (per MGD) | $8,000,000 | $8,000,000 | $8,000,000 | $8,000,000 | $8,000,000 |
| 16” or More Water Main - $/LF | $275 | $275 | $275 | $275 | $275 |
| Force Main $/LF | $200 | $200 | $200 | $200 | $200 |
| Sewer Lift Station Cost | $500,000 | $500,000 | $500,000 | $500,000 | $500,000 |
| Gravity Sewer Installtion /LF | $250 | $250 | $250 | $250 | $250 |
| Lift Station Upgrades Cost | $250,000 | $250,000 | $250,000 | $250,000 | $250,000 |
| Capacity Water | $- | $- | $- | $- | $- |
| Water Supply | $- | $- | $- | $- | $- |
| Capacity Sewer | $- | $- | $- | $- | $- |
| 16+ WM /LF | $- | $- | $- | $- | $- |
| Force Main/ LF | $- | $3,600,000 | $4,000,000 | $100,000 | $- |
| Sewer Lift Station | $- | $1,000,000 | $500,000 | $500,000 | $- |
| Gravity Cost | $- | $2,500,000 | $5,000,000 | $125,000 | $- |
| Lift Station Upgrades | $- | $250,000 | $250,000 | $250,000 | $- |
| Total Cost | $- | $7,350,000 | $11,950,000 | $975,000 | $- |
| Total Cost Millions | $- | $7.35 | $11.95 | $0.98 | $- |
Table 1. (Continued)

| Sta. No. | 11 | 12 | 13 | 14 | 15 |
|----------|----|----|----|----|----|
| Station Location | NE 2ND ST | HILLSBORO BLVD | ATLANTIC BLVD | 38TH ST | 26TH ST |
| City | BOCA RATON | DEERFIELD BEACH | POMPANO BEACH | OAKLAND PARK | WILTON MANORS |
| Station Goal | TC | TC | TC | TC | TC |
| Potential Units For Planning Purposes | 6500 | 6500 | 6500 | 6500 | 6500 |
| Restrictions for WTP, WWTP or Raw Water Capacity | yes |
| Raw W (MDG) | 51.54 | 14.74 | 17.75 | 61.19 | 61.19 |
| Raw Source | Biscayne | Biscayne | Biscayne | Biscayne | Biscayne |
| WTP Cap (MGD) | 70 | 34.8 | 50 | 82 | 82 |
| WTP Demand (MGD) | 35.02 | 10.42 | 15.71 | 40.89 | 40.89 |
| WWTP Cap (MGD) | 17 | 7 | 15.71 | 55.7 | 55.7 |
| WWTP Demand (MGD) | 14 | 6.5 | 16.1 | 37.5 | 37.5 |
| Disposal Method | Reuse/Inj Well | Outfall/Reuse | Outfall/Reuse | Inj Well | Inj Well |
| # of Existing Residential Units within Half-Mile of Station (2018) | 3401 | 2011 | 3682 | 2272 | 3978 |
| Max Density Scenario within Half-Mile of Station | -3401 | -2011 | N/a | -2272 | -3978 |
| Add Water Demand | -1.020 | -0.603 | N/a | -0.682 | -1.193 |
| Add WW Demand | -0.680 | -0.402 | N/a | -0.454 | -0.796 |
| Available Capacity Water | 34.98 | 24.38 | 35.44 | 41.11 | 41.11 |
| Available Capacity Raw Water | 16.52 | 4.32 | 3.19 | 20.3 | 20.3 |
| Available Capacity Wastewater | 3 | 0.5 | -0.39 | 18.2 | 18.2 |
| % Capacity Water Treatment | 0.49 | 0.28 | N/a | 0.49 | 0.48 |
| % Capacity Water Supply | 0.69 | 0.69 | N/a | 0.68 | 0.67 |
| % Capacity Needed Wastewater Treatment | 0.78 | 0.87 | N/a | 0.67 | 0.66 |
| Capacity Needed Water MGD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Water Supply Capacity Needed MGD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Wastewater Treatment Plant Capacity Needed MGD | -0.28 | 0.50 | N/a | 0.00 | 0.00 |
| 16" or More Water Main - LF | 0 | 5000 | 3000 | 2000 | 2000 |
| Force Main LF | 1000 | 5000 | 500 | 2500 | 2500 |
| Sewer Lift Station | 2 | 2 | 2 | 2 | 2 |
| Gravity Sewer Revisions | 0 | 10000 | 5000 | 2500 | 1000 |
| Lift Station Upgrades | 1 | 1 | 1 | 1 | 1 |
| Capacity Water (per MGD) | $7,000,000 | $7,000,000 | $7,000,000 | $7,000,000 | $7,000,000 |
| Raw Water (per MGD) | $6,000,000 | $6,000,000 | $6,000,000 | $6,000,000 | $6,000,000 |
| Capacity Sewer (per MGD) | $8,000,000 | $8,000,000 | $8,000,000 | $8,000,000 | $8,000,000 |
| 16" or More Water Main - $/LF | $275 | $275 | $275 | $275 | $275 |
| Force Main $/LF | $200 | $200 | $200 | $200 | $200 |
| Sewer Lift Station Cost | $500,000 | $500,000 | $500,000 | $500,000 | $500,000 |
| Gravity Sewer Installation /LF | $250 | $250 | $250 | $250 | $250 |
| Lift Station Upgrades Cost | $250,000 | $250,000 | $250,000 | $250,000 | $250,000 |
| Capacity Water | $- | $- | $- | $- | $- |
| Water Supply | $- | $- | $- | $- | $- |
| Capacity Sewer | $(2,241,600) | $3,982,400 | $- | $- | $- |
| 16+ WM / LF | $- | $1,375,000 | $825,000 | $550,000 | $550,000 |
| Force Main/ LF | $200,000 | $3,000,000 | $1,100,000 | $1,000,000 | $700,000 |
| Sewer Lift Station | $1,000,000 | $1,000,000 | $1,000,000 | $1,000,000 | $1,000,000 |
| Gravity Cost | $- | $2,500,000 | $1,250,000 | $625,000 | $250,000 |
| Lift Station Upgrades | $250,000 | $250,000 | $250,000 | $250,000 | $250,000 |
| Total Cost | $(791,600) | $12,107,400 | $4,425,000 | $3,425,000 | $2,750,000 |
| Total Cost Millions | $(0.79) | $12.11 | $4.43 | $3.43 | $2.75 |
Table 1. (Continued)

| Sta. No. | 16 | 17 | 18 | 19 |
|----------|----|----|----|----|
| Sta. No. | BROWARD BLVD | FLL INTERNATIONAL AIRPORT | DANIA BEACH | HOLLYWOOD BLVD |
| City     | FT. LAUDERDALE | Broward Co/Hollywood | DANIA BEACH | HOLLYWOOD |
| Station Location | BROWARD BLVD | FLL INTERNATIONAL AIRPORT | DANIA BEACH | HOLLYWOOD BLVD |
| City     | FT. LAUDERDALE | Broward Co/Hollywood | DANIA BEACH | HOLLYWOOD |
| Station Goal | CC | P&R | TC | TC |
| Potential Units For Planning Purposes | 12500 | 0 | 6500 | 6500 |
| Restrictions for WTP, WWTP or Raw Water Capacity | yes |
| Raw W (MDG) | 61.19 | 61.19 | 2.58 | 39.38 |
| Raw Source | Biscayne/ Floridan | Biscayne/ Floridan | Biscayne | Biscayne/ Floridan |
| WTP Cap (MGD) | 82 | 46 | 5.04 | 46 |
| WTP Demand (MGD) | 40.89 | 23.22 | 2.18 | 23.22 |
| WWTP Cap (MGD) | 55.7 | 3.5 | 4.15 | 48.75 |
| WWTP Demand (MGD) | 37.5 | 2.5 | 2.9 | 41.5 |
| Disposal Method | Inj Well | Inj Well | Outfall | Outfall |
| # of Existing Residential Units within Half-Mile of Station (2018) | 6136 | 2332 | 5648 |
| Max Density Scenario within Half-Mile of Station | -6136 | 0 | N/a | -5648 |
| Add Water Demand | -1.841 | 0 | N/a | -1.694 |
| Add WW Demand | -1.227 | 0 | N/a | -1.130 |
| Available Capacity Water | 41.11 | 22.78 | 2.86 | 22.78 |
| Available Capacity Raw Water | 20.3 | 37.97 | 0.4 | 16.16 |
| Available Capacity Wastewater | 18.2 | 1 | 1.25 | 7.25 |
| % Capacity Water Treatment | 0.48 | 0.50 | N/a | 0.47 |
| % Capacity Water Supply | 0.66 | 0.39 | N/a | 0.57 |
| % Capacity Needed Wastewater Treatment | 0.65 | 0.71 | N/a | 0.83 |
| Capacity Needed Water MGD | 0.00 | 0.00 | 0.00 | 0.00 |
| Water Supply Capacity Needed MGD | 0.00 | 0.00 | n/a | 0.00 |
| Wastewater Treatment Plant Capacity Needed MGD | 0.00 | 0.00 | n/a | 1.37 |
| 16+ WM - LF | 0 | 0 | 0 | 0 |
| Force Main LF | 0 | 0 | 5000 | 0 |
| Sewer Lift Station | 0 | 0 | 1 | 1 |
| Gravity Sewer Revisions | 0 | 0 | 0 | 5000 |
| Lift Station Upgrades | 0 | 0 | 0 | 0 |
| Capacity Water (per MGD) | $7,000,000 | $7,000,000 | $7,000,000 | $7,000,000 |
| Raw Water (per MGD) | $6,000,000 | $6,000,000 | $6,000,000 | $6,000,000 |
| Capacity Sewer (per MGD) | $8,000,000 | $8,000,000 | $8,000,000 | $8,000,000 |
| 16” or More Water Main - $/LF | $275 | $275 | $275 | $275 |
| Force Main $/LF | $200 | $200 | $200 | $200 |
| Sewer Lift Station Cost | $500,000 | $500,000 | $500,000 | $500,000 |
| Gravity Sewer Installtion /LF | $250 | $250 | $250 | $250 |
| Lift Station Upgrades Cost | $250,000 | $250,000 | $250,000 | $250,000 |
| Capacity Water | $- | $- | $- | $- |
| Water Supply | $- | $- | $- | $- |
| Capacity Sewer | $- | $- | $- | $10,963,200 |
| 16+ WM /LF | $- | $- | $- | $- |
| Force Main/ LF | $- | $- | $1,000,000 | $1,000,000 |
| Sewer Lift Station | $- | $- | $500,000 | $500,000 |
| Gravity Cost | $- | $- | $- | $1,250,000 |
| Lift Station Upgrades | $- | $- | $- | $- |
| Total Cost | $- | $- | $1,500,000 | $13,713,200 |
| Total Cost Millions | $- | $- | $1.50 | $13.71 |
| Sta. No. | 20   | 21   | 22   | 23   |
|---------|------|------|------|------|
| Station Location | SE 4TH ST | 192ND ST | 163RD ST | 125TH ST |
| City | HALLANDALE BEACH | AVENTURA | NORTH MIAMI BEACH | NORTH MIAMI |
| Station Goal | TC | NC | TC | NC |
| Potential Units For Planning Purposes | 6500 | 4000 | 6500 | 4000 |
| Restrictions for WTP, WWTP or Raw Water Capacity | yes |
| Raw W (MDG) | 6.5 | 386.07 | 38.38 | 17.27 |
| Raw Source Biscayne | Biscayne | Biscayne | Biscayne | Biscayne |
| WTP Cap (MGD) | 10 | 464 | 32 | 16 |
| WTP Demand (MGD) | 6.07 | 338.12 | 20.55 | 7.82 |
| WWTP Cap (MGD) | 9.2 | 376 | 376 | 376 |
| WWTP Demand (MGD) | 9.2 | 195.8 | 195.8 | 195.8 |
| Disposal Method | Outfall | Outfall | Outfall | Outfall |
| # of Existing Residential Units within Half-Mile of Station (2018) | 2613 | 1281 | 1492 | 3048 |
| Max Density Scenario within Half-Mile of Station | N/a | -1281 | -1492 | -3048 |
| Add Water Demand | N/a | -0.384 | -0.448 | -0.914 |
| Add WW Demand | N/a | -0.256 | -0.298 | -0.610 |
| Available Capacity Water | 3.93 | 125.88 | 11.45 | 8.18 |
| Available Capacity Raw Water | 0.43 | 47.95 | 17.83 | 9.45 |
| Available Capacity Wastewater | 0 | 180.2 | 180.2 | 180.2 |
| % Capacity Water Treatment | N/a | 0.73 | 0.63 | 0.43 |
| % Capacity Water Supply | N/a | 0.91 | 0.54 | 0.42 |
| % Capacity Needed Wastewater Treatment | N/a | 0.52 | 0.52 | 0.52 |
| Capacity Needed Water MGD | 0.00 | 0.00 | 0.00 | 0.00 |
| Water Supply Capacity Needed MGD | n/a | 0.00 | 0.00 | 0.00 |
| Wastewater Treatment Plant Capacity Needed MGD | n/a | 0.00 | 0.00 | 0.00 |
| 16+ WM - LF | 0 | 0 | 0 | 5000 |
| Force Main LF | 0 | 1000 | 1500 | 1500 |
| Sewer Lift Station | 0 | 1 | 4 | 4 |
| Gravity Sewer Revisions | 0 | 0 | 0 | 0 |
| Lift Station Upgrades | 0 | 0 | 1 | 1 |
| Capacity Water (per MGD) | $7,000,000 | $7,000,000 | $7,000,000 | $7,000,000 |
| Raw Water (per MGD) | $6,000,000 | $6,000,000 | $6,000,000 | $6,000,000 |
| Capacity Sewer (per MGD) | $8,000,000 | $8,000,000 | $8,000,000 | $8,000,000 |
| 16” or More Water Main - $/LF | $275 | $275 | $275 | $275 |
| Force Main$/LF | $200 | $200 | $200 | $200 |
| Sewer Lift Station Cost | $500,000 | $500,000 | $500,000 | $500,000 |
| Gravity Sewer Installation /LF | $250 | $250 | $250 | $250 |
| Lift Station Upgrades Cost | $250,000 | $250,000 | $250,000 | $250,000 |
| Capacity Water | $- | $- | $- | $- |
| Water Supply | $- | $- | $- | $- |
| Capacity Sewer | $- | $- | $- | $- |
| 16+ WM /LF | $- | $- | $- | $- |
| Force Main/ LF | $- | $200,000 | $300,000 | $300,000 |
| Sewer Lift Station | $- | $500,000 | $2,000,000 | $2,000,000 |
| Gravity Cost | $- | $- | $- | $- |
| Lift Station Upgrades | $- | $250,000 | $250,000 | $250,000 |
| Total Cost | $- | $700,000 | $2,550,000 | $3,925,000 |
| Total Cost Millions | $- | $0.70 | $2.55 | $3.93 |
| Sta. No. | 24 | 25 | 26 | 27 | 28 |
|----------|----|----|----|----|----|
| Station Location | 79TH ST | 55TH ST | 36TH ST | 11TH ST | GOVERNMENT CENTER |
| City | MIAMI | MIAMI | MIAMI | MIAMI | MIAMI |
| Station Goal | TC | TC | CC | CC | CC |
| Potential Units For Planning Purposes | 6500 | 6500 | 12500 | 12500 | 12500 |
| Restrictions for WTP, WWTP or Raw Water Capacity | | | | | |
| Raw W (MDG) | 386.07 | 386.07 | 386.07 | 386.07 | 386.07 |
| Raw Source | Biscayne | Biscayne | Biscayne | Biscayne | Biscayne |
| WTP Cap (MGD) | 464 | 464 | 464 | 464 | 464 |
| WTP Demand (MGD) | 338.12 | 338.12 | 338.12 | 338.12 | 338.12 |
| WWTP Cap (MGD) | 376 | 376 | 376 | 376 | 376 |
| WWTP Demand (MGD) | 195.8 | 195.8 | 195.8 | 195.8 | 195.8 |
| Disposal Method | Outfall | Outfall | Outfall | Outfall | Outfall |
| # of Existing Residential Units within Half-Mile of Station (2018) | 3514 | 2429 | 2336 | 3299 | 4902 |
| Max Density Scenario within Half-Mile of Station | -3514 | -2429 | -2336 | -3299 | -4902 |
| Add Water Demand | -1.054 | -0.729 | -0.701 | -0.990 | -1.471 |
| Add WW Demand | -0.703 | -0.486 | -0.467 | -0.660 | -0.980 |
| Available Capacity Water | 125.88 | 125.88 | 125.88 | 125.88 | 125.88 |
| Available Capacity Raw Water | 47.95 | 47.95 | 47.95 | 47.95 | 47.95 |
| Available Capacity Wastewater | 180.2 | 180.2 | 180.2 | 180.2 | 180.2 |
| % Capacity Water Treatment | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 |
| % Capacity Water Supply | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 |
| % Capacity Needed Wastewater Treatment | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 |
| Capacity Needed Water MGD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Water Supply Capacity Needed MGD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Wastewater Treatment Plant Capacity Needed MGD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16+ WM - LF | 0 | 10000 | 10000 | 5000 | 1500 |
| Force Main LF | 1000 | 0 | 0 | 2000 | 0 |
| Sewer Lift Station | 1 | 0 | 0 | 2 | 0 |
| Gravity Sewer Revisions | 0 | 0 | 0 | 5000 | 0 |
| Lift Station Upgrades | 0 | 0 | 0 | 1 | 0 |
| Capacity Water (per MGD) | $7,000,000 | $7,000,000 | $7,000,000 | $7,000,000 | $7,000,000 |
| Raw Water (per MGD) | $6,000,000 | $6,000,000 | $6,000,000 | $6,000,000 | $6,000,000 |
| Capacity Sewer (per MGD) | $8,000,000 | $8,000,000 | $8,000,000 | $8,000,000 | $8,000,000 |
| 16” or More Water Main - S/LF | $275 | $275 | $275 | $275 | $275 |
| Force Main $/LF | $200 | $200 | $200 | $200 | $200 |
| Sewer Lift Station Cost | $500,000 | $500,000 | $500,000 | $500,000 | $500,000 |
| Gravity Sewer Installation /LF | $250 | $250 | $250 | $250 | $250 |
| Lift Station Upgrades Cost | $250,000 | $250,000 | $250,000 | $250,000 | $250,000 |
| Capacity Water | $- | $- | $- | $- | $- |
| Water Supply | $- | $- | $- | $- | $- |
| Capacity Sewer | $- | $- | $- | $- | $- |
| 16+ WM /LF | $- | $2,750,000 | $2,750,000 | $1,375,000 | $412,500 |
| Force Main/ LF | $200,000 | $- | $- | $1,400,000 | $- |
| Sewer Lift Station | $500,000 | $- | $- | $1,000,000 | $- |
| Gravity Cost | $- | $- | $- | $1,250,000 | $- |
| Lift Station Upgrades | $- | $- | $- | $250,000 | $- |
| Total Cost | $700,000 | $2,750,000 | $2,750,000 | $5,275,000 | $412,500 |
| Total Cost Millions | $0.70 | $2.75 | $2.75 | $5.28 | $0.41 |
Table 2. Costs by proposed station

| Sta. No. | Station Location       | City               | Station Goal | Potential Units For Planning Purposes | Capacity Water | Water Supply | Sewer Capacity | 16+ WM / LF |
|----------|------------------------|--------------------|--------------|--------------------------------------|----------------|--------------|----------------|-------------|
| 1        | TONEY PENNA            | JUPITER            | Town Center  | 6500                                 | $-             | $-           | $-             | $-          |
| 2        | PGA BLVD               | PALM BEACH GARDENS| Town Center  | 6500                                 | $-             | $-           | $-             | $-          |
| 3        | PARK AVE               | LAKE PARK          | Neigh. Center| 4000                                 | $-             | $-           | $-             | $-          |
| 4        | 13TH ST                | RIVIERA BEACH      | Neigh. Center| 4000                                 | $-             | $-           | $5,003,904     | $5,500,000  |
| 5        | 45TH ST                | WEST PALM BEACH    | Town Center  | 6500                                 | $-             | $-           | $-             | $2,200,000  |
| 6        | EVERNIA ST/ DOWNTOWN   | WEST PALM BEACH    | City Center  | 12500                                | $-             | $-           | $-             | $-          |
| 7        | GREGORY RD             | WEST PALM BEACH    | Neigh. Center| 4000                                 | $-             | $-           | $-             | $-          |
| 8        | LAKE AVE               | LAKE WORTH         | Town Center  | 6500                                 | $-             | $-           | $-             | $2,200,000  |
| 9        | BOYNTON BEACH/BONTONY BEACH | Town Center  | 6500                                 | $-             | $-           | $-             | $-          |
| 10       | ATLANTIC AVE           | DELRAY BEACH       | Town Center  | 6500                                 | $-             | $-           | $-             | $-          |
| 11       | NE 2ND ST              | BOCA RATON         | Town Center  | 6500                                 | $-             | $-           | $8,158,400     | $-          |
| 12       | HILLSBORO BLVD         | DEERFIELD BEACH    | Town Center  | 6500                                 | $-             | $-           | $14,382,400    | $1,375,000  |
| 13       | ATLANTIC BLVD          | POMPANO BEACH      | Town Center  | 6500                                 | $-             | $-           | $32,764,800    | $825,000    |
| 14       | 38TH ST                | OAKLAND PARK       | Town Center  | 6500                                 | $-             | $-           | $-             | $550,000    |
| 15       | 26TH ST                | WILTON MANORS      | Town Center  | 6500                                 | $-             | $-           | $-             | $550,000    |
| 16       | BROWARD BLVD           | FT. LAUDERDALE     | City Center  | 12500                                | $-             | $-           | $-             | $-          |
| 17       | FLL INTERNATIONAL AIRPORT | BROWARD CO/HOLLYWOOD | P&R       | 0                                    | $-             | $-           | $-             | $-          |
| 18       | DANIA BEACH            | DANIA BEACH        | Town Center  | 6500                                 | $-             | $7,473,696   | $3,308,800     | $-          |
| 19       | HOLLYWOOD BLVD         | HOLLYWOOD          | Town Center  | 6500                                 | $-             | $-           | $21,363,200    | $-          |
| 20       | SE 4TH ST              | HALLANDALE BEACH   | Town Center  | 6500                                 | $-             | $10,053,264  | $20,939,200    | $-          |
| 21       | 192ND ST               | AVENTURA           | Neigh. Center| 4000                                 | $-             | $-           | $-             | $-          |
| 22       | 163RD ST               | NORTH MIAMI BEACH  | Town Center  | 6500                                 | $-             | $-           | $-             | $-          |
| 23       | 125TH ST               | NORTH MIAMI        | Neigh. Center| 4000                                 | $-             | $-           | $-             | $1,375,000  |
| 24       | 79TH ST                | MIAMI              | Town Center  | 6500                                 | $-             | $-           | $-             | $-          |
| 25       | 55TH ST                | MIAMI              | Town Center  | 6500                                 | $-             | $-           | $-             | $2,750,000  |
| 26       | 36TH ST                | MIAMI              | City Center  | 12500                                | $-             | $-           | $-             | $2,750,000  |
| 27       | 11TH ST                | MIAMI              | City Center  | 12500                                | $-             | $-           | $-             | $1,375,000  |
| 28       | GOVERNMENT CENTER      | MIAMI              | City Center  | 12500                                | $-             | $-           | $-             | $412,500    |
| Sta. No. | Station Location      | City             | Force Main/ LF | Sewer lift station | Gravity Cost | Lift station upgrades | Total cost  |
|---------|-----------------------|------------------|----------------|-------------------|--------------|----------------------|-------------|
| 1       | TONEY PENNA           | JUPITER          | $500,000       | $500,000          | $-           | $250,000             | $1,250,000  |
| 2       | PGA BLVD              | PALM BEACH       | $-             | $-                | $-           | $-                   | $-          |
| 3       | PARK AVE              | LAKE PARK        | $-             | $-                | $-           | $-                   | $-          |
| 4       | 13TH ST               | RIVIERA BEACH    | $2,000,000     | $2,000,000        | $-           | $250,000             | $14,753,904 |
| 5       | 45TH ST               | WEST PALM BEACH  | $1,000,000     | $2,000,000        | $-           | $250,000             | $5,450,000  |
| 6       | EVERNIA ST/ DOWNTOWN  | WEST PALM BEACH  | $-             | $-                | $-           | $-                   | $-          |
| 7       | GREGORY RD            | WEST PALM BEACH  | $3,600,000     | $1,000,000        | $2,500,000   | $250,000             | $7,350,000  |
| 8       | LAKE AVE              | LAKE WORTH       | $4,000,000     | $500,000          | $5,000,000   | $250,000             | $11,950,000 |
| 9       | BOYNTON BEACH BLVD    | BONTYON BEACH    | $100,000       | $500,000          | $125,000     | $250,000             | $975,000    |
| 10      | ATLANTIC AVE          | DELRAY BEACH     | $-             | $-                | $-           | $-                   | $-          |
| 11      | NE 2ND ST             | BOCA RATON       | $200,000       | $1,000,000        | $-           | $250,000             | $9,608,400  |
| 12      | HILLSBORO BLVD        | DEERFIELD BEACH  | $3,000,000     | $1,000,000        | $2,500,000   | $250,000             | $22,507,400 |
| 13      | ATLANTIC BLVD         | POMPANO BEACH    | $1,100,000     | $1,000,000        | $1,250,000   | $250,000             | $37,189,800 |
| 14      | 38TH ST               | OAKLAND PARK     | $1,000,000     | $1,000,000        | $625,000     | $250,000             | $3,425,000  |
| 15      | 26TH ST               | WILTON MANORS    | $700,000       | $1,000,000        | $250,000     | $250,000             | $2,750,000  |
| 16      | BROWARD BLVD          | FT. LAUDERDALE   | $-             | $-                | $-           | $-                   | $-          |
| 17      | FLL INTERNATIONAL AIRPORT | BROWARD CO/HOLLYWOOD | $- | $- | $- | $- | $- |
| 18      | DANIA BEACH           | DANIA BEACH      | $1,000,000     | $500,000          | $-           | $-                   | $12,282,496 |
| 19      | HOLLYWOOD BLVD        | HOLLYWOOD        | $1,000,000     | $500,000          | $1,250,000   | $-                   | $24,113,200 |
| 20      | SE 4TH ST             | HALLANDALE BEACH | $-             | $-                | $-           | $-                   | $30,992,464 |
| 21      | 192ND ST              | AVENTURA         | $200,000       | $500,000          | $-           | $-                   | $700,000    |
| 22      | 163RD ST              | NORTH MIAMI BEACH| $300,000       | $2,000,000        | $-           | $250,000             | $2,550,000  |
| 23      | 125TH ST              | NORTH MIAMI      | $300,000       | $2,000,000        | $-           | $250,000             | $3,925,000  |
| 24      | 79TH ST               | MIAMI            | $200,000       | $500,000          | $-           | $-                   | $700,000    |
| 25      | 55TH ST               | MIAMI            | $-             | $-                | $-           | $-                   | $2,750,000  |
| 26      | 36TH ST               | MIAMI            | $-             | $-                | $-           | $-                   | $2,750,000  |
| 27      | 11TH ST               | MIAMI            | $1,400,000     | $1,000,000        | $1,250,000   | $250,000             | $5,275,000  |
| 28      | GOVERNMENT CENTER     | MIAMI            | $-             | $-                | $-           | $-                   | $412,500    |
Figure 2. Cost by station.

Figure 3. Cost by county.
### Table 3. Potential development and limitations

| Sta. No. | 1       | 2       | 3       | 4       | 5       | 6       |
|----------|---------|---------|---------|---------|---------|---------|
| Station Location | TONEY PENNA | PGA BLVD | PARK AVE | 13TH ST | 45TH ST | EVERNIA ST/ DOWNTOWN |
| City | JUPITER | PALM BEACH GARDENS | LAKE PARK | RIVIERA BEACH | WEST PALM BEACH | WEST PALM BEACH |
| Station Goal | TC | TC | NC | NC | TC | CC |
| Potential Units For Planning Purposes | 6500 | 6500 | 4000 | 4000 | 6500 | 12500 |
| Restrictions for WTP, WWTP or Raw Water Capacity | | | | | | **1207** |
| Raw W (MDG) | 24.41 | 26.92 | 26.92 | 9.08 | 41.2 | 41.2 |
| Raw Source | Floridan | Surficial Aq | Surficial Aq | Surficial Aq | Surface Water | Surface Water |
| WTP Cap (MGD) | 26 | 30.5 | 30.5 | 17.5 | 47 | 47 |
| WTP Demand (MGD) | 16.13 | 18.02 | 18.02 | 7.81 | 29.49 | 29.49 |
| WWTP Cap (MGD) | 11 | 12 | 12 | 70 | 70 | 70 |
| WWTP Demand (MGD) | 6.5 | 8 | 8 | 41.45 | 41.45 | 41.45 |
| Disposal Method | Reuse | Reuse/Inj Well | Reuse/Inj Well | Reuse/Inj Well | Reuse/Inj Well | Reuse/Inj Well |
| # of Existing Residential Units within Half-Mile of Station (2018) | 1474 | 1660 | 1066 | 1168 | 2178 | 5111 |
| Potential Units - Water Supply | 26220 | 28183 | 28183 | 4022 | 37082 | 37082 |
| Net to Add Water Supply | 18246 | 20023 | 23117 | -1146 | 28404 | 19471 |
| Potential Units - Treatment | 32900 | 41600 | 41600 | 32300 | 58367 | 58367 |
| Net to Add Water Treatment | 24926 | 33440 | 36534 | 27132 | 49689 | 40756 |
| Potential Units - Wastwater Treatment | 18000 | 16000 | 16000 | 114200 | 114200 | 114200 |
| Net to Add Wastwater Supply | 10026 | 7840 | 10934 | 109032 | 105522 | 96589 |
| Water Piping | no | no | no | yes | no | no |
| Sewer Piping/Pumping | no | no | no | yes | no | no |
| Added Units to Exceed A Parameter | | | | | | water supply, piping |
| Sta. No. | 7      | 8      | 9      | 10     | 11     | 12      |
|---------|--------|--------|--------|--------|--------|---------|
| Station Location | GREGORY RD | LAKE AVE | BOYNTON BEACH BLVD | ATLANTIC AVE | NE 2ND ST | HILLSBORO BLVD |
| City | WEST PALM BEACH | LAKE WORTH | Boynton Beach | DELRAY BEACH | BOCA RATON | DEERFIELD BEACH |
| Station Goal | NC | TC | TC | TC | TC | TC |
| Potential Units For Planning Purposes | 4000 | 6500 | 6500 | 6500 | 6500 | 6500 |
| Restrictions for WTP, WWTP or Raw Water Capacity | 0 | 5200 | 0 |
| Raw W (MDG) | 41.2 | 41.2 | 20.86 | 19.1 | 51.54 | 14.74 |
| Raw Source | Surface Water | Surficial Aq | Surficial Aq | Surficial Aq | Biscayne | Biscayne |
| WTP Cap (MGD) | 47 | 17.4 | 34 | 24 | 70 | 34.8 |
| WTP Demand (MGD) | 29.49 | 5.31 | 13.51 | 16.15 | 35.02 | 10.42 |
| WWTP Cap (MGD) | 70 | 70 | 24 | 24 | 17 | 7 |
| WWTP Demand (MGD) | 41.45 | 41.45 | 9.5 | 6.7 | 14 | 6.5 |
| Disposal Method | Reuse/Inj Well | Reuse/Inj Well | Reuse/Inj Well | Reuse/Inj Well | Reuse/Inj Well | Outfall/Reuse |
| # of Existing Residential Units within Half-Mile of Station (2018) | 852 | 3695 | 2944 | 2740 | 3401 | 2011 |
| Potential Units - Water Supply | 37082 | 113652 | 23275 | 9342 | 52313 | 13680 |
| Net to Add Water Supply | 32230 | 103457 | 13831 | 102 | 42412 | 5169 |
| Potential Units - Treatment | 58367 | 40300 | 68300 | 26167 | 116600 | 81267 |
| Net to Add Water Treatment | 53515 | 30105 | 58856 | 16927 | 106699 | 72756 |
| Potential Units - Wastewater Treatment | 114200 | 114200 | 58000 | 69200 | 12000 | 2000 |
| Net to Add Wastewater Supply | 109348 | 104005 | 48556 | 59960 | 2099 | -6511 |
| Water Piping | no | yes | no | no | no | no |
| Sewer Piping/Pumping | no | yes | no | no | no | no |
| Added Units to Exceed A Parameter | piping | | | | | WWTP |
### Table 3. (Continued)

| Sta. No. | 13 | 14 | 15 | 16 | 17 | 18 |
|----------|----|----|----|----|----|----|
| **Station Location** | ATLANTIC BLVD | 38TH ST | 26TH ST | BROWARD BLVD | FLL INTERNATIONAL AIRPORT | DANIA BEACH |
| **City** | POMPANO BEACH | OAKLAND PARK | WILTON MANORS | FT. LAUDERDALE | Broward Co/ Hollywood | DANIA BEACH |
| **Station Goal** | TC | TC | TC | CC | P&R | TC |
| **Potential Units For Planning Purposes** | 6500 | 6500 | 6500 | 12500 | 0 | 6500 |
| **Restrictions for WTP, WWTP or Raw Water Capacity** | 0 | | | | | 473 |
| **Raw W (MDG)** | 17.75 | 61.19 | 61.19 | 61.19 | 61.19 | 2.58 |
| **Raw Source** | Biscayne | Biscayne | Biscayne | Biscayne/ Floridan | Biscayne/ Floridan | Biscayne |
| **WTP Cap (MGD)** | 50 | 82 | 82 | 82 | 46 | 5.04 |
| **WTP Demand (MGD)** | 14.56 | 40.89 | 40.89 | 40.89 | 23.22 | 2.18 |
| **WWTP Cap (MGD)** | 15.71 | 55.7 | 55.7 | 55.7 | 3.5 | 4.15 |
| **WWTP Demand (MGD)** | 16.1 | 37.5 | 37.5 | 37.5 | 2.5 | 2.9 |
| **Disposal Method** | Outfall/Reuse | Inj Well | Inj Well | Inj Well | Inj Well | Outfall |
| **# of Existing Residential Units within Half-Mile of Station (2018)** | 3682 | 2272 | 3978 | 6136 | 0 | 2332 |
| **Potential Units - Water Supply** | 10102 | 64283 | 64283 | 64283 | 0 | 1267 |
| **Net to Add Water Supply** | -80 | 55511 | 53805 | 45647 | 0 | -7565 |
| **Potential Units - Treatment** | 118133 | 137033 | 137033 | 137033 | 0 | 9533 |
| **Net to Add Water Treatment** | 107951 | 128261 | 126555 | 118397 | 0 | 701 |
| **Potential Units - Wastewater Treatment** | -1560 | 72800 | 72800 | 72800 | 0 | 5000 |
| **Net to Add Wastewater Supply** | -11742 | 64028 | 62322 | 54164 | 0 | -3832 |
| **Water Piping** | no | no | no | no | 0 | no |
| **Sewer Piping/Pumping** | no | no | no | no | 0 | no |
| **Added Units to Exceed A Parameter** | WWTP | | | | | land space | water supply, WWTP |
### Table 3. (Continued)

| Sta. No. | 19 | 20 | 21 | 22 | 23 | 24 |
|----------|----|----|----|----|----|----|
| Station Location | HOLLYWOOD BLVD | SE 4TH ST | 192ND ST | 163RD ST | 125TH ST | 79TH ST |
| City | HOLLYWOOD | HALLANDALE BEACH | AVENTURA | NORTH MIAMI BEACH | NORTH MIAMI | MIAMI |
| Station Goal | TC | TC | NC | TC | NC | TC |
| Potential Units For Planning Purposes | 6500 | 6500 | 4000 | 6500 | 4000 | 6500 |
| Restrictions for WTP, WWTP or Raw Water Capacity | 0 | 0 | | | | |
| Raw W (MDG) | 39.38 | 6.5 | 386.07 | 38.38 | 17.27 | 386.07 |
| Raw Source | Biscayne/ Floridan | Biscayne | Biscayne | Biscayne | Biscayne | Biscayne |
| WTP Cap (MDG) | 46 | 10 | 464 | 32 | 16 | 464 |
| WTP Demand (MGD) | 23.22 | 6.07 | 338.12 | 20.55 | 7.82 | 338.12 |
| WWTP Cap (MDG) | 48.75 | 9.2 | 376 | 376 | 376 | 376 |
| WWTP Demand (MGD) | 41.5 | 9.2 | 195.8 | 195.8 | 195.8 | 195.8 |
| Disposal Method | Outfall | Outfall | Outfall | Outfall | Outfall | Outfall |
| # of Existing Residential Units within Half-Mile of Station (2018) | 5648 | 2613 | 1281 | 1492 | 3048 | 3514 |
| Potential Units - Water Supply | 51173 | 1362 | 151842 | 56462 | 29925 | 151842 |
| Net to Add Water Supply | 39025 | -7751 | 146561 | 48470 | 22877 | 141828 |
| Potential Units - Treatment | 75933 | 13100 | 419600 | 38167 | 27267 | 419600 |
| Net to Add Water Treatment | 63785 | 3987 | 414319 | 30175 | 20219 | 409586 |
| Potential Units - Wastewater Treatment | 29000 | 0 | 720800 | 720800 | 720800 | 720800 |
| Net to Add Wastewater Supply | 16852 | -9113 | 715519 | 712808 | 713752 | 710786 |
| Water Piping | no | no | no | no | no | no |
| Sewer Piping/Pumping | no | no | no | no | no | no |
| Added Units to Exceed A Parameter | potentially SS | Wastewater | potentially SS | potentially SS | potentially SS | potentially SS |
Table 3. (Continued)

| Sta. No. | 25 | 26 | 27 | 28 |
|----------|----|----|----|----|
| **Station Location** | 55TH ST | 36TH ST | 11TH ST | GOVERNMENT CENTER |
| **City** | MIAMI | MIAMI | MIAMI | MIAMI |
| **Station Goal** | TC | CC | CC | CC |
| **Potential Units For Planning Purposes** | 6500 | 12500 | 12500 | 12500 |
| **Restrictions for WTP, WWTP or Raw Water Capacity** | | | | |
| **Raw W (MDG)** | 386.07 | 386.07 | 386.07 | 386.07 |
| **Raw Source** | Biscayne | Biscayne | Biscayne | Biscayne |
| **WTP Cap (MGD)** | 464 | 464 | 464 | 464 |
| **WTP Demand (MGD)** | 338.12 | 338.12 | 338.12 | 338.12 |
| **WWTP Cap (MGD)** | 376 | 376 | 376 | 376 |
| **WWTP Demand (MGD)** | 195.8 | 195.8 | 195.8 | 195.8 |
| **Disposal Method** | Outfall | Outfall | Outfall | Outfall |
| **# of Existing Residential Units within Half-Mile of Station (2018)** | 2429 | 2336 | 3299 | 4902 |
| **Potential Units - Water Supply** | 151842 | 151842 | 151842 | 151842 |
| **Net to Add Water Supply** | 142913 | 137006 | 136043 | 134440 |
| **Potential Units - Treatment** | 419600 | 419600 | 419600 | 419600 |
| **Net to Add Water Treatment** | 410671 | 404764 | 403801 | 402198 |
| **Potential Units - Wastewater Treatment** | 720800 | 720800 | 720800 | 720800 |
| **Net to Add Wastewater Supply** | 711871 | 705964 | 705001 | 703398 |
| **Water Piping** | no | no | no | no |
| **Sewer Piping/Pumping** | no | no | no | no |
| **Added Units to Exceed A Parameter** | | | | |

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capacity is the major limitation to TOD development. Water supply is also correlated, but not nearly as high as wastewater capacity. PCA analysis indicated that 85% of the variability is consumed in the first four factors (see Figure 4), which were the current density of the neighborhood, existing units/sewer needs, piping costs and water supply needs. The linear regression modeled confirmed that wastewater capacity is the major limitation to TOD development, followed by water supply and piping (see Figure 5).

In performing logistic regression, eliminating co-linearity, the model was able to predict a restriction on services 100% of the time based on:

- population,
- total cost in millions of needs,
- station goal,
- number of existing residential units within a half-mile of the station (in 2018), and
- maximum density scenario within a half-mile of the station.

The major issue affecting the infrastructure is the existing density in the vicinity of the station versus the proposed buildout. Hence, deliberations on the stations’ location need to consider the water and sewer infrastructure needs when deciding and prioritizing sites.

Figure 4. Scree plot showing that 80% of variance is the first four factors.
Unaccounted infrastructure needs for transit-oriented developments

4.1. Example analysis

Tables and graphs outlining the overall costs and costs by station and county were developed for the region based on the analysis of each node. The following is an example of one such analysis.

4.1.1. Water treatment plant, pumps and capacity

The City of Dania Beach (“City”) operates a 5.04 MGD water treatment plant. 3.04 MGD of this capacity is for lime softening. The remaining 2 MGD is for nanofiltration. Disinfection is via chloramination. Raw water comes from the Biscayne aquifer. Capacity is limited to 2.58 MGD, with an application for 2.88 MGD. The City is in the process of developing additional supplies. Water treatment is adequate to supply the needed water. Water supplies are not adequate at this time.

High-service pumps are rated over 12 MGD. A new 20-inch pipeline, with 16/12-inch connections to downtown, and new 12-inch looped pipelines were constructed in anticipation of 4,000 added residential units in 2008, along with a new storage tank; so piping capacity appears adequate for the anticipated growth to 4,000 units. Distribution capacity appears to be adequate.

4.1.2. Wastewater treatment plant, disposal method and capacity

Gravity sewer lines are available throughout the City except Melaleuca Gardens (which is not a potential site for the TOD). 8-inch pipelines exist throughout the City. Major vertical growth may require added sewer line capacity and lift stations. Lift station pump upgrades will be required.

Figure 5. Sewer treatment and water supply as major limitations for TOD zone development.
However, the nature of the community may limit growth. The contract with the City of Hollywood includes 4.15 MGD of capacity. Flow capacity is less than this today. Collaboration is needed with the City of Hollywood on the wastewater capacity.

The City of Hollywood treats the wastewater. The City of Hollywood currently uses an ocean outfall for wastewater disposal and two deep-injection wells. The outfall needs to be discontinued by 2025 and a solution has yet to be found. The FDEP and the SFWMD desire to have a 60% reuse goal but this is not achievable. As a result, although added deep wells are in place, there is no other solution.

### 4.1.3. Additional demands

Additional demands for a TOD zone depend on the type of train station area that is planned and the development anticipated as a result. The largest stations are City Center stations, which include 12,500 units (column 6 of Table 1). Based on such a station, the demands for the TOD of Station 18 site include 3.05 MGD of water supply and treatment and 2.03 MGD of wastewater treatment for a City Center station. Inadequate raw water supply, treated water capacity and wastewater capacity exist for a City Center station (see highlights in Table 3). The Southern Regional Wastewater Treatment Plant in Hollywood, which treats the wastewater, is currently operating at over 80% capacity, and so any station from any large user will be an issue.

However, this station is anticipated to be a Town Center station, which is a smaller station that is more in keeping with what the area can support. If an assumed 5,000 to 8,000 (assume 6,500 for planning) units are anticipated, the demands for this site include 1.25 MGD of water supply and treatment and 0.83 MGD of wastewater treatment (column 2). Inadequate raw water and wastewater capacity exist for a Town Center station.

This station should probably be a Neighborhood Zone station, not a Town Center station, but raw water supply remains an issue. The current utility infrastructure with respect to raw water and wastewater capacity is insufficient for the proposed station, but the piping system poses no restriction.

### 5. Conclusion

Many communities are attempting to resolve their transportation congestion issues by developing
transit-oriented development corridors that link rail, bus, bicycle and pedestrian mobility in one place. One means to do this is to use tax increment financing (TIF) to develop higher-density, mixed-use development near public transit stations. This could also include the use of federal loans from the U.S. Department of Transportation, such as the Transportation Infrastructure Finance and Innovation Act (TIFIA) and the Railroad Rehabilitation and Improvement Financing (RRIF) programs, which allow local infrastructure, including water and wastewater, to be financed. The success of a TOD zone relies on a conducive regulatory and institutional environment, public and private participation and investment, and development incentives to create vibrant, people-oriented communities and mobility options and to support business development. The ability to incorporate affordable and workforce housing in TOD zones increases the potential for meeting the needs of the working community.

In most cases, the focus of TOD developments consists of providing the needed transportation infrastructure and paying those costs back with TIF or other local tax funds. However, few TOD projects consider the costs for water and sewer infrastructure, which can be a major expense in creating TOD zones and may be limiting, as found in this study. Water and sewer infrastructure is buried and is rarely part of the consideration for development until the development is ready to begin. Then, requests for availability are normally submitted to the utility. Unfortunately, just because water and sewer lines are present, that does not mean they will meet future needs. They may be old or undersized (Bloetscher et al., 2014). Areas served with septic tanks are severely limiting. If piping is in place, treatment capacity, along with disposal options, weighs into the problem. Adding capacity, finding new water supplies or addressing the increased need for disposal (reuse, more treatment, etc.) can take three to five years (Bloetscher, 2011; 2019). New water supplies take even longer. As a result, it is important to ensure that the capital needs for utility operation are included when considering a TOD so that plans are not delayed due to the lack of utility infrastructure.

This study focused on determining the water and sewer infrastructure costs for TOD zones along the FEC Railway corridor in southeast Florida. All of the concerns with piping, pumping, treatment capacity and water supplies exist in the corridor. Different station sites have different problems. Larger stations, at points that are currently heavily developed, are more likely to support the TOD than smaller stations. As a result, the finding was that over $400 million is needed to meet those water and sewer needs and that few are currently planned into community capital improvement programs. Those costs represent a total of over $13,000 per residential unit, which is unaccounted for in the pricing. It was noted that the costs vary by site/community and that most of the large communities have sufficient infrastructure to address water sewer needs, but not the smaller ones. Given that these units also need to pay impact fees that are often at least this amount, considerations of solutions for addressing these infrastructure costs at the local level are needed for regional solutions to work.

**Author contributions**

All three authors were major contributors to writing this paper. Dr. Bloetscher developed the infrastructure costs. Dr. Renne and Ms Hoermann conducted the housing/TOD development analysis. All participated in writing the paper.
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