Under Pressure: Developing a Residential Reuse System

Teri Pinson and Teri L. Shoemaker

The St. Johns County (county) integrated water resources plan (IWRP) recommends water conservation and reuse as the most cost-effective and beneficial way to manage a sustainable water supply in the rapidly growing county. In response to this objective, St. Johns County Utility Department (SJCUD) recommends utilization of reuse for irrigation purposes in new developments to offset irrigation demands from the potable water system. The recommendations have been largely well-received, and the 2040 projections indicate a potential offset to the potable water supply of approximately 5 mil gal per day (mgd).

In anticipation of this new growth, SJCUD constructed a new regional 3-mgd 100 percent beneficial reuse advanced wastewater treatment facility with APRICOT backup discharge located in a high-development area. The Florida APRICOT Act of 1994 was enacted as a result of Project APRICOT (A Prototype Realistic Innovative Community of Today. Project), developed in the late 1980s, which made it possible for the city of Altamonte Springs to fund and integrate reuse into its water resource management landscape.

Historically, SJCUD's treated wastewater effluent was reused by interruptible discharges to golf course irrigation ponds; however, the reuse system in the northwest (NW) area of SJCUD now needed to accommodate pressurized residential reuse customers as well. Therefore, SJCUD began a capital program to upgrade the existing facilities and encumbered over $12 million for reuse capital improvement project construction.

This article presents the planning, construction, and commissioning components of the NW pressurized residential reuse system throughout the various implementation phases of the project.

Background

St. Johns County is a high-growth area, with many new developments in the NW SJCUD service area. Installing reuse infrastructure in new neighborhoods is much more feasible than retrofitting established areas, and SJCUD needed to take advantage of this opportunity and align the residential reuse program with developer timing. This made for an aggressive timeline to have all aspects operational in 2017.

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The following is a timeline of SJCUD's reuse implementation in the NW service area:

- 1998: Reuse used for golf course irrigation from SR 16 wastewater treatment plant (WWTP)
- 2006: Committed to residential reuse in NW
- 2011: Completed reuse master plan
- 2012: Completed NW water reclamation facility (WRF) final design
- 2015: Finalized integrated water resources plan
- 2015: Implemented pressurized reuse capital improvement plan (CIP)
- 2016: Hired reuse coordinator
- 2017: Commenced residential reuse program

Current Population Projections

Due to its 28 percent population growth since 2010, the United States Census Bureau ranked the county as the third and 14th fastest-growing county in Florida and the United States, respectively. Figure 1 shows population projections completed in 2017. As identified in the graph, the NW sector is experiencing the most growth within the county.

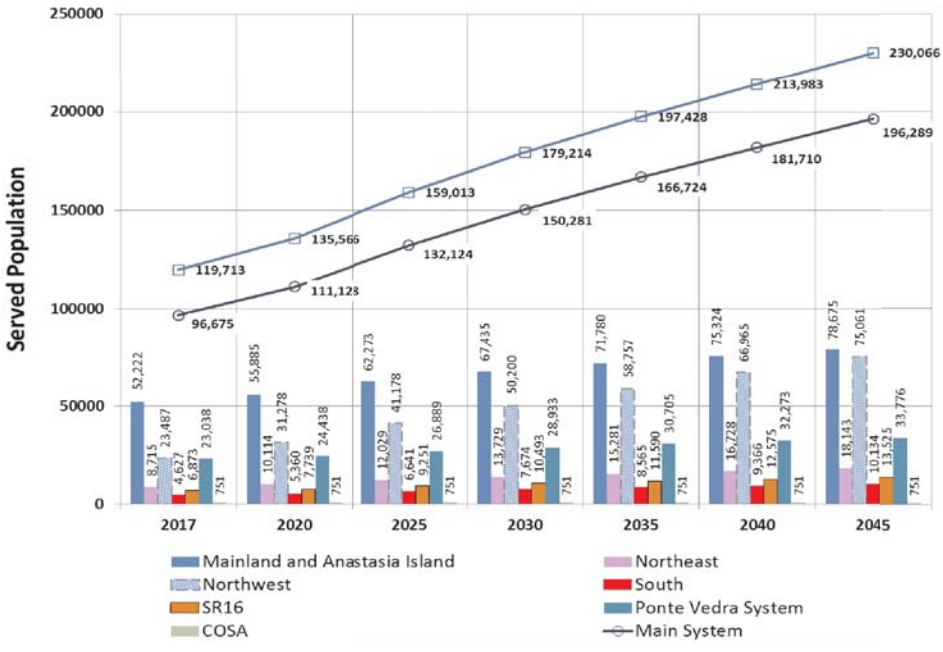

Figure 1. 2017 Population Projections for St. Johns County

Service Area and Existing System Description

The NW reuse system service area is presented in Figure 2. Prior to any improvements, the SR 16 WWTP was serving the entire service area with both sewer treatment and reuse. Wastewater from the NW portion of the service area was collected in an above grade 0.5 mil gal (MG) wet well and pumped through a

master pump station to the SR 16 WWTP. The reuse effluent was pumped from this facility through an inline booster pump station in the middle of the service area and discharged to the golf course pond on the northern side of the service area.

When construction of the new NW WRF was completed, wastewater flow from the northern portion of the service area was redirected from the master pump station to the new facility. Reuse effluent was interconnected through a new 20-in. reuse pipeline to the existing SR 16 reuse system, providing a combined reuse service area. At this time, all reuse was delivered to the golf course and one pressurized customer on the downstream side of the inline booster pump station.

The SR 16 WWTP wetland discharge has operational issues, so the limited wet weather discharge use is minimized. The backup discharge for the NW WWTP allows for 30 percent of the annual average daily flow to be discharged per year.

Figure 2 also shows the development and capital improvement projects that are projected to build out the reuse system through 2040. An "existing" status was noted, if online as of December 2018. Although the Silverleaf area was the original driver in 2006, economic conditions delayed that development. Meanwhile, SJCUD moved forward with the long-term reuse plan. When conditions improved, other developments were poised and SJCUD was in a position to serve reuse with a new colocated WRF and other improvements.

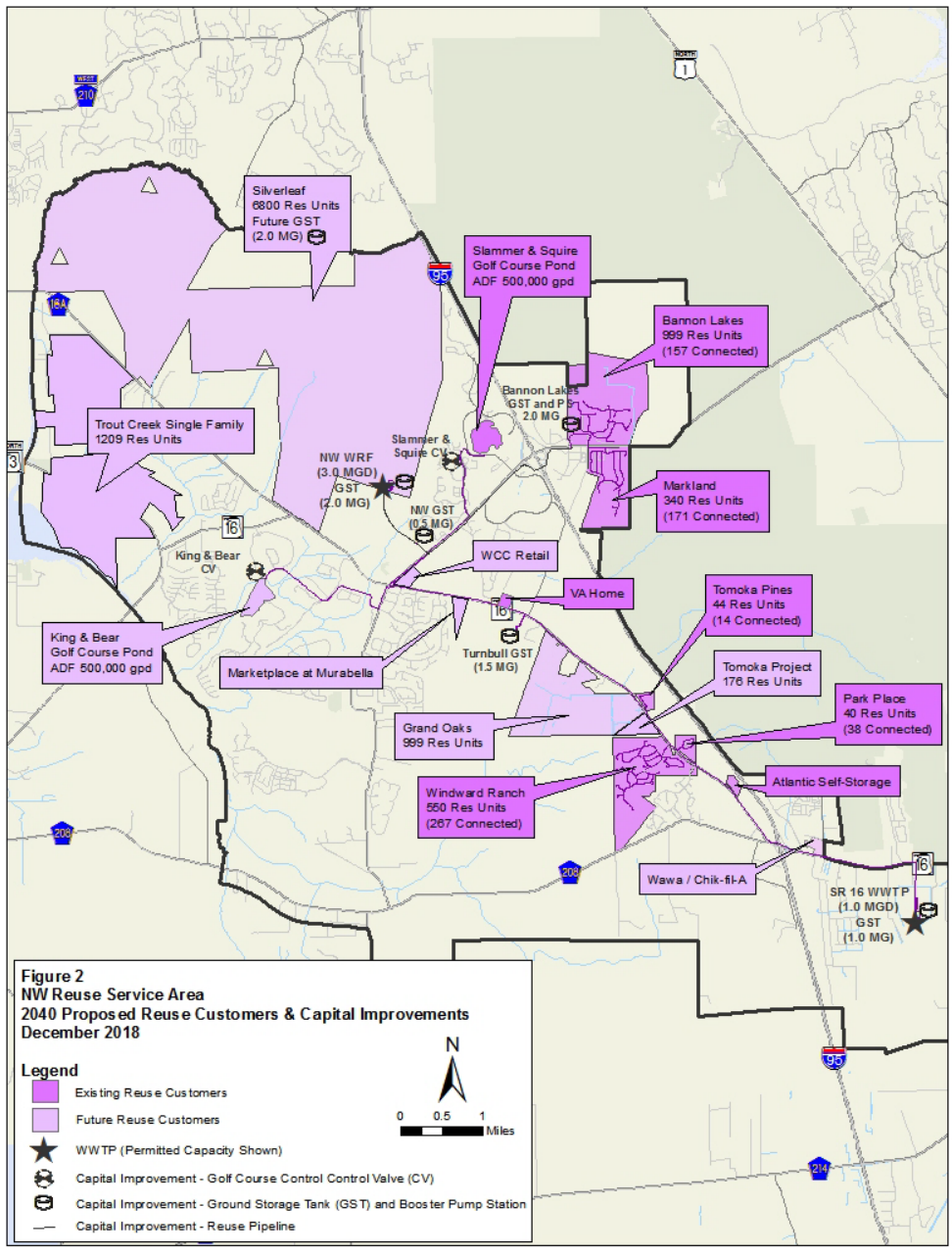

Figure 2. The Northwest Reuse System Service Area

Planning

In 2014, SJCUD implemented the CIP to pressurize the NW reuse system. The CIP was refined by detailing wastewater and reuse flow projections from the latest available development plans and calculating the water balance projections. Ultimately, a hydraulic model was created to validate the design of the required improvements.

2014 Reuse Supply And Demand Projections

The population projections were updated by SJCUD in 2013 through 2040, which were documented in internal technical bulletins. The wastewater flow projections were developed using the average daily flow (ADF) of 280 gal per day (gpd) per equivalent residential unit (ERU). The reuse demand projections were developed using the ADF of 300 gpd/ERU. This ADF is higher than the 250 gpd/ERU used in the 2030 reclaimed water system master plan (RWMP) prepared by CH2M HILL in January 2011 and was updated to be more aligned with industry standards. The reuse ADF for the commercial/office customers was assumed to be 0.5 in. of irrigation over 10 percent of the commercial/office lot coverage, consistent with the RWMP. The reuse ADF for the golf courses was assumed to be 0.5 mgd for each course. Approximately 22 percent of the developable property (as defined in an internal bulletin) was assumed to be built in 2040. This percentage was selected to best match the population projections.

It was assumed that the monthly irrigation demand varies throughout the year based on rainfall and evapotranspiration rates. The factors presented in the RWMP were used for planning. Each factor was used to calculate the peak-month irrigation demand rate in the water balance and in combination with the daily demand rates for calculating the peak-day demand rate for the residential and commercial reuse customers. It was assumed that the golf courses will receive the same ADF throughout the year and that they will be considered an interruptible user, consistent with the existing service.

These projections used the RWMP daily

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irrigation demand rates, which were developed based on the mandatory watering restrictions for potable water established by the St. Johns River Water Management District (SJRWMD). The golf course demand was assumed to be consistent throughout the day, as it's under the existing conditions with no peak-month factor. It was assumed that half of the residential units would be irrigating at a time. The hours between 10 a.m. and 4 p.m. are restricted irrigation hours for both residential and commercial users.

Table 1. Implemented Projects From the Capital Improvement Plan

Project Title/Description	Storage Capacity	Design Capacity	Completion Date
Turnbull GST and Booster Pump Station (BPS)	1.5 MG	580 gpm at 207 ft TDH 2 (1 Duty/1 Standby)	Oct 2015
NW Water Reclamation Facility – 3-mgd AADF Advanced Wastewater Treatment with Backup APRICOT Discharge to Surface Water	2 MG	866 gpm at 200 ft TDH 3 (3 Duty/1 Future)	Feb 2016
IGP* and CR2209 Pipelines	-	14,900 LF 16-in. and 20-in. Reuse Main	2014/2016
SR 16 WWTP GST*	1 MG	350 gpm at 220 ft TDH (1 Duty/1 Standby)	March 2017
Northwest Reuse and Flushing Pump Station	0.5 MG	320 gpm at 185 ft TDH 2 (1 Duty/1 Standby)	March 2017
Slammer and Squire Golf Course Pressure-Sustaining Valve	-	20-90 psi	March 2017
Master Reclaimed Water System Supervisory Controls	-	(Described below)	Aug 2017
King and Bear Gold Course Pressure-Sustaining Valve	-	20-90 psi	March 2019
Bannon Lakes GST and BPS*	2 MG	Jockey Pumps 1,200 gpm at 160 ft TDH 2 (1 Duty/1 Standby) Booster Pumps 2,000 gpm at 137 ft TDH 2 (1 Duty/Standby)	July 2019

Table 2. Monthly Irrigation Factors

Month	Percent of ADF Irrigation		
	RWMP	2017	2018
January	42	48	52
February	57	59	59
March	113	50	84
April	184	75	98
May	206	111	124
June	121	148	75
July	99	143	127
August	89	125	107
September	73	108	117
October	89	114	160
November	82	123	126
December	42	97	72

Water Balance

The planning wastewater flow and reuse demand rates were used to develop an annual water balance. The water balances were prepared assuming no discharge to the SR 16 WWTP wetland. The projected annual reuse demand exceeds the projected annual wastewater influent flow in 2020 by 0.155 mgd, requiring use of an augmentation system or reduction of golf course reuse demand. The SJCUD used Florida Department of Environmental Protection (FDEP) guidance, which recommended that storage capacity be the volume equal to three times that portion of the ADF for which no alternative reuse or disposal system is permitted, although it's not required since both WWTPs have a backup discharge. The resulting recommended minimum storage volume was 7.1 MG.

Water balances were also calculated using the daily peak-demand factors and peak-month factors for the months of May and November, selected as a representative month from the Eastern Standard Time (EST) and Daylight Saving Time (DST) irrigation demand periods, respectively. The 2020 reuse system requires a minimum 1.9 MG of storage to handle the daily supply/demand fluctuation. The combined required and recommended storage requirement from the annual and daily water balances is 9 MG.

Reuse Model

A hydraulic model of the NW reuse system was created using Innovyze InfoWater Suite 9.0 software to review reuse pumping and demand scenarios for 2016 and 2018 and help identify the best location and capacities for the proposed storage and pumping facilities.

The pressure-sustaining valves at the golf courses and ground storage tanks (GSTs) were also modeled as flow control valves to limit the flow to golf courses and direct the flow to reuse storage for future use. The pressure boundary conditions in the system ranged between 20 and 90 pounds per sq in. (psi), with a minimum of 40 psi reuse distribution pressure delivered to customers.

Reuse main velocities were reviewed for maximum allowable velocity. The highest observed velocity in the 2016 and 2018 scenarios was 6.17 ft per second (fps). The reuse main velocity will be exceeded in 2020, at which time the 8-in. reuse main along SR 16 would require an upgrade.

Construction

Implementation of the CIP immediately followed, with upgrades to effluent treatment,

storage, and pumping systems at two existing WWTPS, and three satellite storage and pump station sites totaling 7 MG, with pressure-sustaining valves, four mi of reuse transmission pipe, and a comprehensive supervisory control and data acquisition (SCADA) system.

The CIP presented in Table 1 was recommended for completion to meet the 2016 and 2018 projections. The pressurized system was commissioned in 2017 with the connections of the first noninterruptible residential reuse customers.

Master Reclaimed Water System Supervisory Controls

The master reclaimed water system (MRWS) can be monitored at three locations: SR16 WWTP, NW WRF, and the county master human machine interface. The goal of the MRWS was to develop an integration system that would manage and deliver all of the reuse water being treated in the NW on a daily basis. Each of the facilities with storage would have three modes of operation: fill, booster, or standby. The mode of operation is based on storage tank levels and pressure in the system. In addition, each site is given a ranking or priority to be used if two sites are attempting to be in a mode of operation that will be contradictory to the overall goal of delivering reuse to customers or golf course ponds. The pressure-sustaining valve sites each have two modes of operation: valve open or valve closed. As long as the pond high-level float switch is not energized, the valve will be available to be called open.

The county has received cost-share funding from SJRWMD for three projects that have expanded the SJCUD reuse system infrastructure in the NW (these projects are highlighted in Table 1). In addition to conservation, reuse protects waterways by decreasing nutrient loading through the reduction of surface water discharge. These measurable benefits of conservation and water quality made these projects eligible to receive the alternative water supply program cost-share funding.

The following projects are recommended for the 2020 capital improvements:

- *Upgrade 8-in.-diameter pipe between SR 16 WWTP and CR 2209.* This project is being closely coordinated with the planning and construction of new developments in this corridor, as they trigger state roadway improvements and utility relocation.
- *2-MG storage tank and pump station in Silverleaf development of regional impact.* This project is development-driven and will be timed accordingly with the construction of the development.

Commissioning

Internal Collaboration

The expedited implementation of residential reuse required regular in-house coordination meetings among the planning, development, capital, operations, compliance, billing, customer service, and information technology divisions of SJCUD. In addition, a reuse coordinator was hired to schedule and facilitate cross connection inspections for new homeowners. As part of these meetings, the following standard operating procedures and standards were created to ensure consistency with implementation:

- Flushing Reclaimed Water Main Infrastructure
- Residential Reuse Development Walk-Through Inspection and Checklist
- Residential Site Inspection and Survey
- Common-Area Inspection

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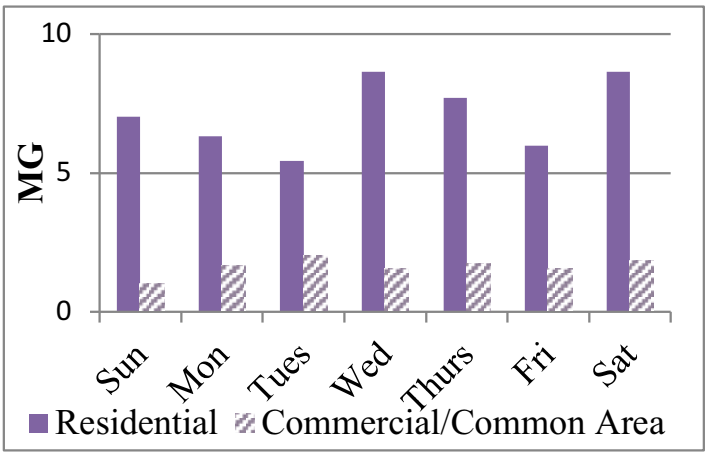

Figure 3. 2018 Residential and Commercial Reuse Flow per Day of Week

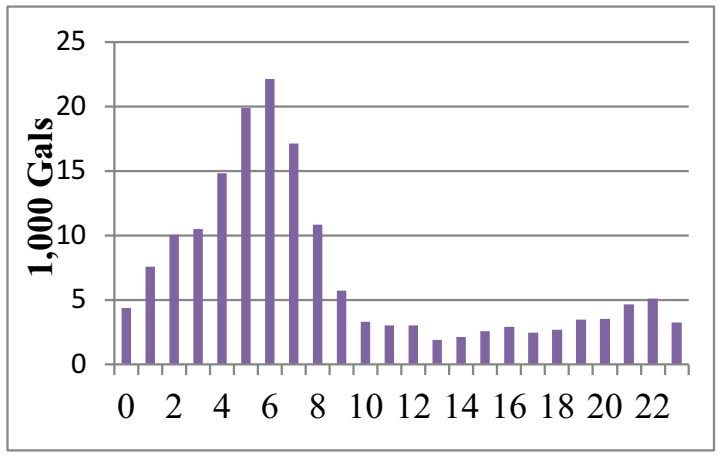

Figure 4. 2018 Combined Residential and Commercial Reuse Flow per Hour of Day

Table 3. Residential Reuse Average Day Flow

Source	ADF (gpd)
SJCUD Planning ADF	300
2017 Flow Data	415
2018 Flow Data	328
2017-2018 Flow Data	282

Table 4. Peak-Demand Factors

Type	RWMP	2018
Commercial	9.6	13.6
Residential	7.2	9.1
Overall	N/A	8.3

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- Repair and Spill Unpermitted Discharge
- Cross Connection Response
- New Reuse Customer Connection/Transfer/Disconnect (Billing System)
- Reuse Signage Details

Three developers were starting to build homes prior to the reuse system being fully pressurized and ready to serve, and SJCUD coordinated temporary potable jumpers to be used until conversion to reuse; however, the time frame was minimal. When the system was ready, the reuse coordinator scheduled cross connection inspections for the conversion to reuse. As a standard protocol, each reuse meter had to be locked until the inspection was completed, so SJCUD assigned as many inspectors as needed during this conversion to minimize inconvenience to customers.

Another challenge during implementation was determining the new operational responsibilities for the reuse system among the existing departments. During this internal collaboration, each division had assigned roles and staff to integrate the new program.

Public Outreach

With 650 residential accounts connected in less than three years in the NW area, public education was imperative to success. The SJCUD created a brochure, move-in packet, website, and mapping application to welcome customers to the program and describe reuse and its use. With this information, customers should understand the critical need to use nonpotable water on lawns and feel safe using this valuable resource.

The website includes information, such as:

- Overview and video
- How to connect
- Landscaping (salt-tolerant plants)
- Watering schedule (recommended)
- Schedule an inspection
- Service map
- Printable brochure with frequently asked questions

The SJCUD worked with developers from the planning phase to ensure a smooth transition and that homeowners were educated as soon as possible.

2019 Planning Update

Continued evaluation of flow projections was necessary to manage the adjustments to the operation strategy, as the larger proportion of the demand shifts from golf course (lower peak, interruptible service) to residential and commercial (higher peak, noninterruptible service), and to schedule the implementation of the remaining improvements. Having over two years of reuse meter data and significant growth of the new system, SJCUD was able to review the usage rates to verify the initial assumptions for sizing the pressurized system. The SJCUD's billing software, Microsoft Dynamics GP Cogsdale CSM Module and Sensus advanced metering infrastructure (AMI), was used to analyze the actual usage rates of reuse customers. The actual demand factors were compared to the planning demand factors, and the flow projections were updated as a result of this analysis.

Seasonal Variations

To compare the monthly irrigation rates to the rates used for planning from the RWMP, SJCUD analyzed the residential, commercial, and common-area flow rates for 2017 and 2018 and compared each month's average to the annual average flow for each year. The results of this analysis are presented in Table 2. The maximum month rate for these two years was 160 percent compared to 206 percent in the RWMP, and the minimum month rate was 50 percent compared to 42 percent in the RWMP. Additionally, the irrigation did not show as significant of a decline during the winter months as compared to the RWMP. Finally, the totals for each year were compared to the total rainfall for each year and month,

and no correlation was found between the two trends.

Demand Patterns

The RWMP assumed irrigation patterns similar to those required by SJRWMD for potable water users. The patterns were used to determine the peak-demand factors for the reuse system. The SJCUD analyzed the residential and commercial- and common-area flow categories to determine if the customer usage had a notable pattern. Figure 3 presents the flow data for 2018 distributed by day of the week. The reuse water is being used fairly consistently through the week. Figure 4 presents the flow data for 2018 distributed by hour of the day. The most significant use is between the hours of 1 a.m. and 8 a.m.

Residential Average Day Demand

The reuse flow from the residential meters with 12 full months of data for each year was used to determine the annual average day flow for each year per residential unit. In 2017, there were 178 meters with 12 months of data and an average day flow of 415 gpd; in 2018, there were 334 meters with 12 months of data and an ADF of 328 gpd. Influencing factors on these rates could be new customers watering their lawns, annual rainfall, and model homes. The rainfall was higher in 2017 than 2018 and did not show a decrease in ADF due to increased rainfall. To consider the impacts of watering on a new lawn, only the accounts that had been in service for the full 24-month period were reviewed. The ADF for these 178 meters in 2017 and 2018 was 282 gpd. The SJCUD will continue to use the planning ADF of 300 gpd/ERU. Table 3 presents the ADF for each year.

Peak-Demand Factor

The peak-hour demand factors (PDF) were analyzed by reviewing the hourly AMI data for 2018. The commercial- and common-area meters showed a peak-hour flow of 13.6 times their ADF, and the residential meters had a peak-hour flow of 9.1 times their ADF. Since the daily flow variations shows a fairly consistent spread throughout the week for each user type, SJCUD also reviewed an overall peak-hour flow for all noninterruptible users. This provided a peak-hour flow for the system of 8.3 times the ADF. The overall PDF will be used for planning purposes. Table 4 summarizes these factors.

Common-Area Irrigation Demand

When analyzing the metered flow data for the planning versus metered flow factor comparison, it was noted that common-area irrigation was not accounted for in initial 2014 planning projections in either ADF per residential unit or by commercial flow. It was found that between 17 and 59 percent of the total annual flow per development was used for common-areas. A new user category has been added to the projections to account for this use.

Because the flow rate depends on the open areas and amenities offered by each development, a high and low reuse growth curve has been provided in the new projections. The high growth curve assumes a percentage of common-area irrigation per proposed development consistent with these percentages; the low reuse growth curve assumes no additional flow for the common area as a boundary condition. The SJCUD will continue to monitor the rate at which common areas are irrigated and make necessary planning adjustments.

Use of Stormwater Pond for Irrigation

Some developments have proposed utilizing the stormwater system for irrigation, in addition to the SJCUD reuse supply. There have been two proposed methods: use stormwater irrigation for common areas, and receive SJCUD reuse through a master meter that would discharge to a stormwater pond and be distributed to residences through a private irrigation system. The reuse flow demands for the developments utilizing these alternate delivery methods have been adjusted in the 2019 projections.

Updated Flow Projections

Figure 5 presents the comparison between the revised 2014 and 2019 flow projections utilizing the updated 2017 population projections for the sewer flow projections and the adjustments noted previosuly for the reuse demand projections.

Conclusion

Even though the residential reuse system was in the long-term plan to colocate with impending NW area developments, the timeline was unpredictable until developers began construction. The SJCUD succeeded in meeting the expedited timeline for completing the capital infrastructure projects and providing pressurized reuse service to the new developments with minimal reliance on potable water jumpers. The SJCUD overcame the challenges associated with adding 650 accounts in less than three years and meeting the goals of potable water offset and nutrient reduction to surface water by utilizing 94 percent of the 1,112 MG of wastewater effluent in 2017 and 2018. Looking forward, SJCUD will continue to grow the residential reuse system and manage a sustainable water supply.

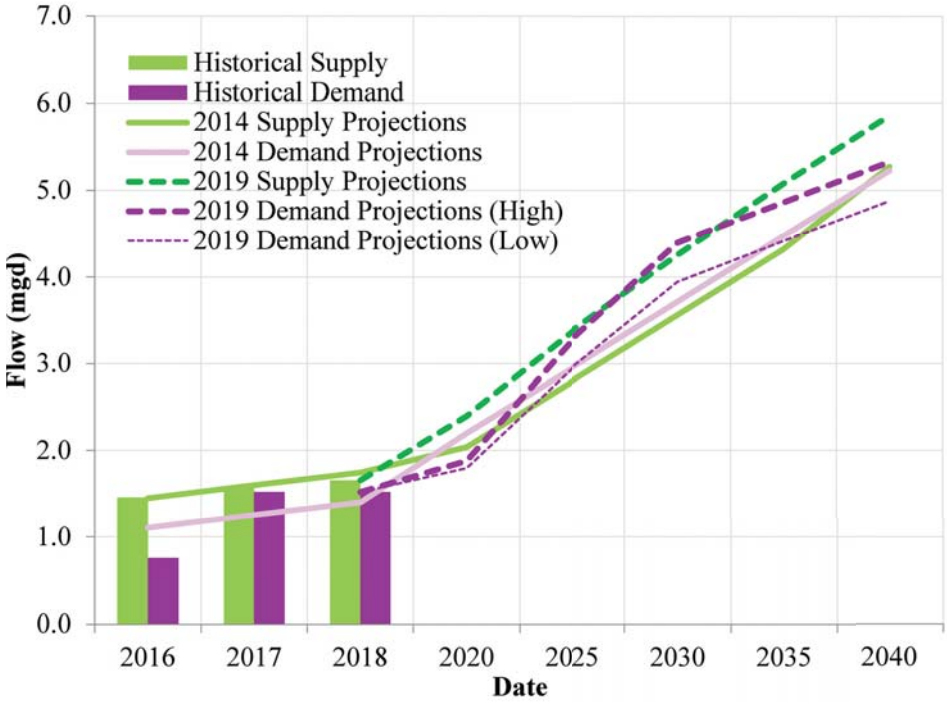

Figure 5. Historical, 2014, and 2019 Reuse Supply and Demand Projections