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# LOW-IMPACT WASTEWATER COLLECTION SYSTEM REDUCES NUTRIENT LOADS IN VERO BEACH

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## Background

The city of Vero Beach is located adjacent to the Indian River Lagoon (or the "IRL") along the Atlantic Coast of Florida. According to the IRL National Estuary Program, this area "is home to a rich array of plants and animals whose existence depends on the quality of water within the Lagoon. More than 2,000 species of plants, 600 species of fish, 300 species of birds, and 53 threatened or endangered species inhabit the IRL for at least some portion of their lives, and scientists have shown the IRL to be one of the most biologically diverse estuaries in North America, with approximately 4,000 species documented to occur" (IRLNEP 2017). The environmental health of the lagoon is also essential to the economy of Florida's east coast.

The lagoon's ecosystem is under increased threat from pollution. In 2013, more than 160 manatees, 300 pelicans, and 76 bottlenose dolphins in the IRL system died of unknown causes (Gibbs 2015). Another major die-off occurred in 2014, and others continue to this day. Inadequate wastewater treatment has been identified as one of many culprits in the degradation of the lagoon's water quality and health.

In the city of Vero Beach, septic systems serve most of the older homes in barrier island neighborhoods, the majority of which were built under antiquated regulatory codes. Homes constructed before 1983 were likely installed with inadequate septic drainfield separation to groundwater, which is unsuitable for proper septic system performance and contaminant removal.

About 900 septic systems are installed on the barrier island and 600 along open drainage systems on the mainland in Vero Beach. Nutrient discharge from various sources, including poorly designed and installed septic systems, negatively affects seagrass beds, the biological foundation of the ecosystem. Nitrogen and phosphorus inputs also distress mangroves, oyster reefs, algae, and wetlands, all of which influence lagoon and ocean fisheries as well as habitat for birds and other wildlife. Reversing this trend was of utmost importance to the City and its constituents.

## Preliminary Evaluation

As with any infrastructure project, financial considerations were paramount. Cost was the primary obstacle to effectively launching a new wastewater management system in Vero Beach. The four main cost considerations were:

- Capital costs
- Operations and maintenance (O&M) costs
- Social costs
- Availability costs

Until proven otherwise by affordability and implementation challenges, gravity sewers (because of their perceived lower O&M costs) were the initial preference for the Vero Beach project. In 2004, through voluntary assessment projects, around sixty additional homes were connected to the City's gravity sewer network. At the time, costs ranged from $6,200 to nearly $20,000 per gravity sewer connection.

In 2007, the City attempted to expand the gravity sewer network on a more extensive basis than before into more sensitive areas around the lagoon. However, this project was eventually suspended due to lackluster support from the community. The proposed state funding stream supporting the planned expansion needed approval from the public to pass. Due to the disruptions caused by the expansion in 2004 – as well as the high costs involved – only 14% of the residents supported the project. This was far below the required 60% level of community support required.

Concerns about social costs (or "indirect construction costs") were critical to the City's decision-making process. Disruption to vehicular traffic, road and pavement damage, potential damage to adjacent utilities, air pollution, risks to pedestrian safety, higher tendency for citizen complaints, and increased environmental impact were all major considerations. Stately live oak trees form a canopy throughout much of the narrow streets and densely populated neighborhoods in Vero Beach. Due to their past experiences, the construction impact of gravity sewers – which require large-diameter (eight-inch minimum) pipe, installed at a constant slope, often with the aid of major lift stations (USEPA 2002, 1) – generated tremendous alarm among the city's residents. Any sewer project that jeopardized the health or life of the community's live oak trees was not an option.

**Figure 1. Typical street in Vero Beach.**

The ability to implement a sewer solution without requiring mandatory connections was also vital. To effectively launch the sewer project, the City needed an affordable option that didn't require each household to connect to the new sewer. It needed a solution that allowed residents with properly functioning onsite systems to opt out of the city sewer project initially, while requiring future connection if the onsite systems failed.

Because of the construction impact and high costs of mainlines, Vero Beach embarked on a research initiative to identify gravity sewer alternatives. Robert Bolton, P.E., the City's Director of Water and Sewer, recalled that the nearby City of Palm Bay, along with other General Development Corporation communities in Florida, had implemented effluent sewer systems in the 1970s and 1980s. After quickly reaching a dead-end with the gravity sewer option, Bolton thoroughly investigated effluent sewers, a type of pressure sewer. He solicited information from other communities utilizing this technology, as well as from manufacturers in the industry.

**Effluent Sewer Technology**

Effluent sewers (also known as Septic Tank Effluent Pumping or "STEP" systems) for residential applications usually consist of an on-lot portion and a right-of-way (ROW) portion. Typically, the on-lot components are a short (10-30ft) building sewer, a 1,000-gallon tank, a pump package with a 1/8-inch mesh filter, and a 1-inch-diameter service lateral that connects to the ROW portion of the system. The on-lot tanks provide the following:

- Passive anaerobic digestion
- Solids separation and removal (excellent primary clarification)
- Reserve storage for 24-48 hours (minimizing the need for after-hours service calls)
- Surge capacity for daily flow modulation to the wastewater treatment facility
- Long-term sludge digestion (Crites and Tchnobanoglous 1988, 317)

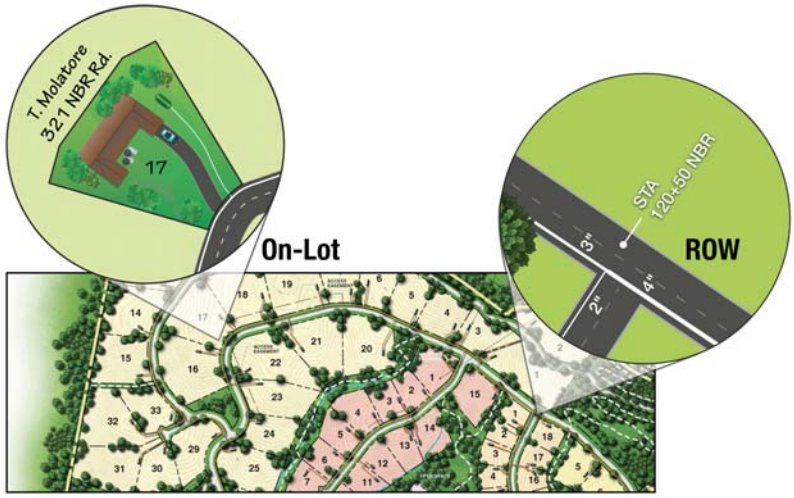


**Figure 2. Overview of a typical effluent sewer collection system.**

The right-of-way portion consists of small-diameter, low-pressure force mains (typically 2- to 4-inch diameter, depending on population, distance, and static head) that are shallowly buried, in the right-of-way adjacent to the road surface, and following the contour of the land. This eliminates the manholes and lift stations common to gravity sewers (USEPA 2002, 1). Figure 2 (above) illustrates an overview of an effluent sewer collection system, and Figure 3 illustrates typical on-lot STEP components.

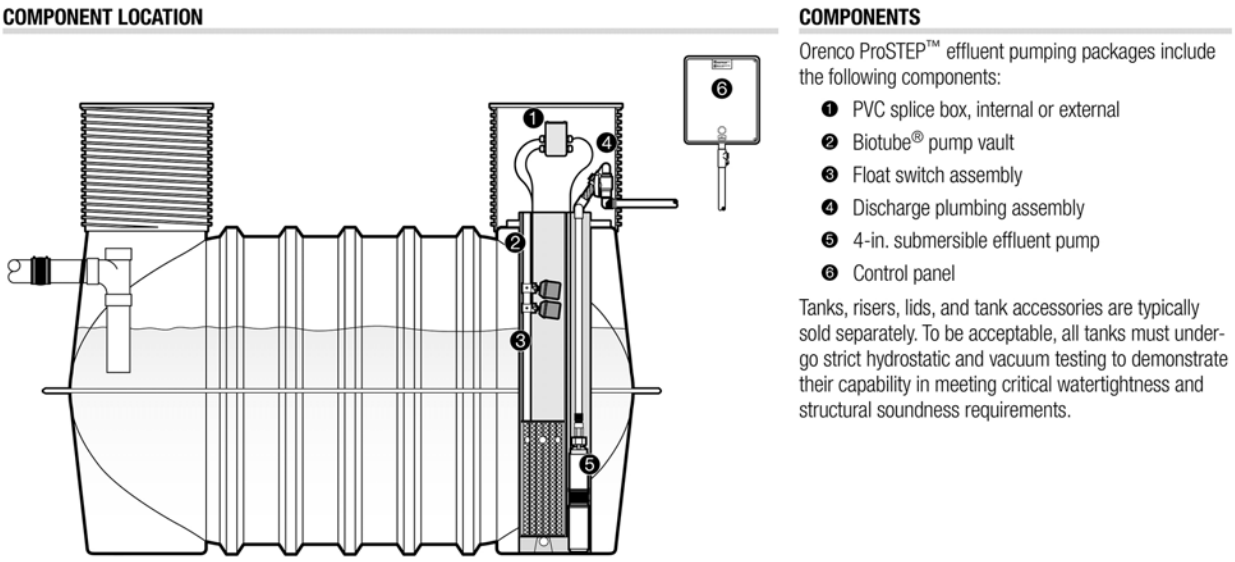


**Figure 3. Effluent sewer STEP package.**

Unlike other collection systems, effluent sewers modulate flows at the source. At the same time, they capture and digest over two-thirds of gross solids, grease, and oils, producing effluent that is primary-clarified, treated, and fine-screened before it is conveyed to the wastewater facility (Crites and Tchobanoglous 1998, 183). Table 1 lists the wastewater characteristics for various types of collection systems.

**Table 1. Typical wastewater loading rates for Orenco Effluent Sewer, grinder sewer, and gravity sewer.**

| Constituent Loading Assumptions | Effluent Sewer | Grinder Sewer | Gravity Sewer |
|---|---|---|---|
| Design Average Flow | 50 gpcd | 50 gpcd | 120 gpcd |
| Biochemical Oxygen Demand ($BOD_5$) | 150 mg/L | 450 mg/L | 200 mg/L |
| Chemical Oxygen Demand (COD) | 381 mg/L | 1143 mg/L | 508 mg/L |
| Total Suspended Solids (TSS) | 40 mg/L | 500 mg/L | 210 mg/L |
| Total Kjeldahl Nitrogen (TKN) | 65 mg/L | 70 mg/L | 35 mg/L |
| Ammonia ($NH_3$-N) | 40 mg/L | 55 mg/L | 21 mg/L |
| Total Phosphorus | 16 mg/L | 17 mg/L | 7 mg/L |
| Fats, Oils, Greases (FOG) | 15 mg/L | 164 mg/L | 80 mg/L |

[1]*Adapted from Metcalf & Eddy 2003; Crites and Tchobanoglous 1998; USEPA 2002; Winneberger 1984.*
[2]*Use of garbage grinders increases both settleable and floatable solids to septic tank solids accumulation rates by about 37% (USEPA 1980; Public Health Service 1967).*

With the high groundwater prevalent throughout the coastal community, a pressure sewer provides distinct benefits. Mainlines are watertight and largely resistant to infiltration. Effluent sewers experience minimal infiltration and inflow (I&I) throughout the collection system because service laterals and mainlines are pressurized, mains are shallowly buried, and manholes are eliminated. As reported in the EPA's "*Alternative Wastewater Collection Systems*" manual, "At this time, thousands of flow measurements have been made on pressure sewer systems with wide demographic spread. The result of these measurements has

corroborated findings of the earlier studies: that flows are typically 40-60 gallons/capita/day, with little weekly or seasonal variation" (USEPA 1991, 41).

**Capital Cost Estimates**

Expanding the existing gravity sewer in Vero Beach would have been unreasonably expensive. The streets are narrow, the area is plagued with high groundwater, and the terrain is very flat. The gravity sewer design required deep excavations, elaborate and costly dewatering infrastructure, numerous manholes, and extensive road replacement. Robert Bolton ultimately estimated that extending the gravity sewer to critical areas of unsewered residents would cost around $22.5 million. In contrast, the effluent sewer was estimated to cost around $11 million.

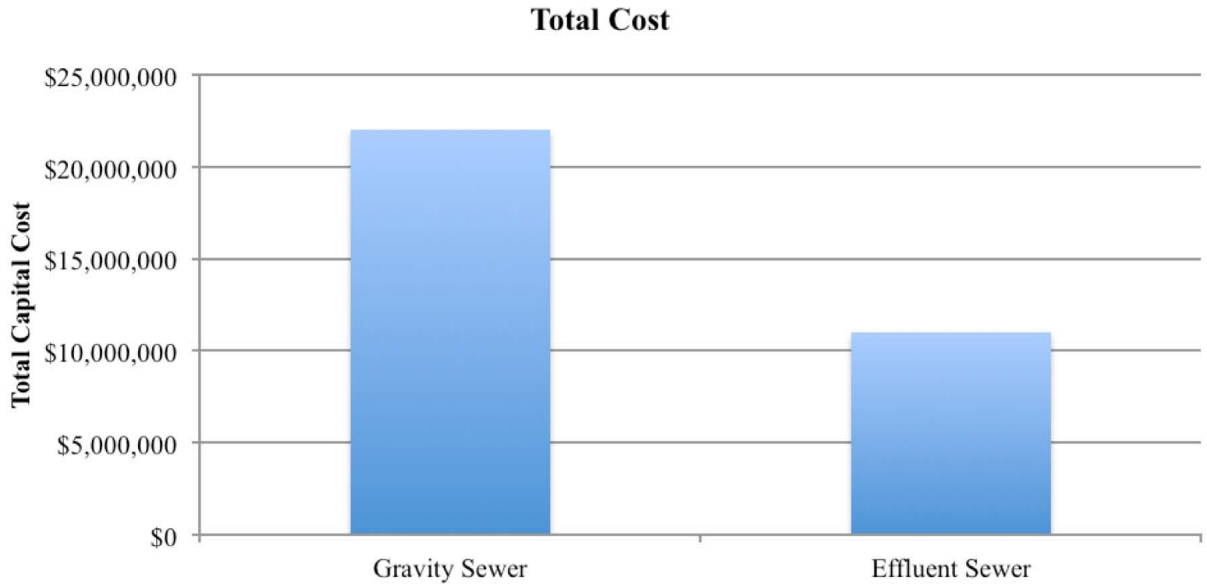


**Chart 1. Capital cost of gravity sewer vs. effluent sewer.**

**O&M Cost Estimates**

Due to a sewer system's anticipated lifespan of thirty or more years, its operation and maintenance costs are generally more important than up-front capital costs. Long-term costs of collection systems can overshadow up-front capital costs (USEPA 1978, 1-2). Bolton referenced historical gravity sewer expenditures and personal experience to extrapolate gravity sewer O&M costs. Vero Beach owns and operates an existing gravity sewer system, which includes 123 miles of gravity sewer lines, 48 miles of force mains, 118 electrical panels, 236 lift stations, and 2,660 manholes. Bolton estimated a monthly O&M cost for the City's existing gravity sewer system at $13.99 per connection, per month. This included the solids-handling cost of the wastewater treatment process.

To calculate O&M estimates for the effluent sewer, Bolton solicited real-world operational data from existing effluent sewers, specifically looking for systems that had been operational for more than thirty years. The estimated monthly O&M cost, which conservatively included tank pump-outs every eight years, was $12.91 per connection, per month for properties utilizing existing septic tanks and $15.26 per connection, per month for properties installing completely new systems. This evaluation included full replacement or rehabilitation of all components based on individual component life cycles over a seventy-five-year time frame. (Monthly costs were updated in December 2016.)

With reasonably similar O&M costs between gravity sewers and effluent sewers, and considering the significantly lower capital costs associated with effluent sewers, Bolton concluded that the overall long-term cost of ownership for effluent sewers was a fraction of gravity sewer costs.

**Social Cost Considerations**

Many residents were sensitive to how the installation of the sewer system would impact established oak trees, landscaping, and roads. The city's prior experience with gravity sewers had been negative, which resulted in widespread opposition. Roads had been totally destroyed. Traffic had been disrupted. Trees and landscapes had been altered. The gravity sewer construction process had been highly intrusive and unanimously unwelcome.


**Figure 4. Gravity sewer main excavation.**

The principal advantage of effluent sewers is the ability to convey primary-treated effluent through small-diameter mainlines that are shallowly buried and follow the contour of the land, much like a water distribution system. With effluent sewer, all of the mainlines are installed using trenchless construction, where pipes are pulled through bores and can be easily navigated around existing utilities. Also, the time required to install the effluent sewer was estimated at less than one-eighth of the time required for a gravity sewer.

**Figure 5. Directional drilling of two-inch main.**

**Figure 6. Two-inch main installed.**

## Availability Cost Estimates

The original gravity sewer proposal – the aforementioned $22.5 million gravity sewer expansion – was highly controversial, especially considering the requirement that everyone had to connect. Gravity sewers almost always require mandatory connections. This is due to a municipality's need for cash flow to retire the debt associated with the high cost of installing the necessary infrastructure, including large-diameter mainlines, manholes, and lift stations. While some residents supported new sewers, dissent was rampant among those whose onsite systems were functioning properly. Other residents were opposed to the expected disruption during installation, and still others were concerned about the cost. To successfully launch a sewer system, a non-mandatory approach was critical.

Effluent sewers provide options by enabling non-mandatory connections, a pivotal tool for eliciting political support for sewer projects. Vero Beach provides incentives for connections, but residents with properly performing onsite systems are not required to connect. The City developed an inspection process to monitor the performance of the existing septic systems, where all existing septic systems that do not connect to the effluent sewer system are inspected every five years. If the City determines, based on established criteria, that the existing system is deficient, the homeowner is required to connect to the effluent sewer system in accordance with state law.

Costs of effluent sewers are segmented into two main categories: on-lot and ROW. The majority of effluent sewer system costs, usually about 90% of the total, are associated with the on-lot equipment. Conversely, only 10% of the costs are related to the mainlines. Bolton coined the term "availability cost," which he defined as the cost of the effluent mainlines, excluding the on-lot components. The availability cost, or the cost to make sewer service available to the residents, was estimated at $885,000 for the effluent sewer but nearly $18 million for the gravity sewer (see Chart 2). The low availability cost of the effluent sewer facilitated non-mandatory connections, allowing properly functioning onsite systems to remain in service until determined otherwise.

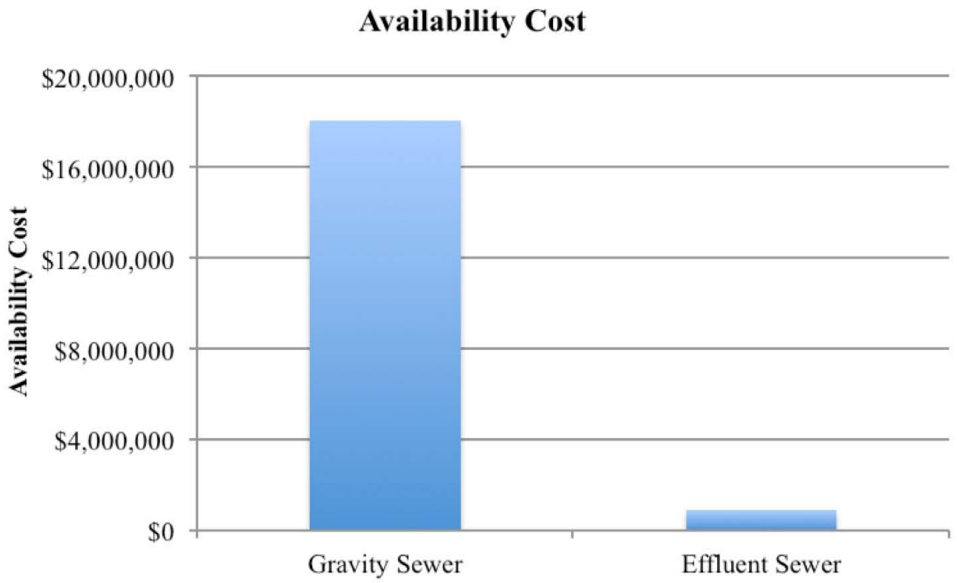


**Chart 2. Availability cost of gravity sewer vs. effluent sewer.**

**Funding**

To construct the effluent mainlines and service laterals, the St. Johns River Water Management District, a branch of the State of Florida Department of Environmental Protection, issued two cost-share agreements totaling approximately $493,000. The cost-share agreements provided 33% funding for the effluent mainlines ($885,000) and 26% funding for the individual lateral taps ($750,000) and immediately provided sewer availability to the residents.

The majority of the homes in Vero Beach will be equipped with an on-lot 1,000-gallon tank and 500-gallon STEP package plus a service lateral, estimated to cost a total of about $7,500 per connection after incentives. The costs of the on-lot equipment are privately funded; incentives are designed to encourage residents to connect by not charging for the ROW costs and providing credits for wastewater impact fees. For all residents who sign up within the first

twelve months of sewer availability, the City designed a “STEP Up and Save” program that offers a $2,290 credit. The credit offsets the wastewater impact fee that is normally required for new sewer customers. The second incentive for residents to connect is a “Wastewater Utility Extension Credit” of $1,100. This credit is available only to homeowners who pay in full for their equipment at the time of the application.

Costs are lower for homes with a recently constructed onsite system that may include components that are adaptable to the effluent sewer system. If the City, through a series of inspections, declares the existing tank to be watertight and structurally sound, the tank will be retained and the total cost of construction at the home would be reduced to about $6,000. In this case, the existing tank is followed by a 500-gallon STEP package plus a service lateral.

**Effluent Sewer Service Areas**

Neighborhoods were prioritized for STEP installation based on the age of the homes and other factors including depth to groundwater, soil conditions, proximity to surface water, and lot size. Because of the use of small-diameter mainlines and a low availability cost, an effluent sewer allowed the City to deliberately cherry-pick the critical areas that would result in the greatest elimination of nutrient loading into the lagoon ecosystem. In contrast, gravity sewers, because of the inherently high costs associated with mainline construction, prohibit the winnowing out of properly functioning onsite systems. Gravity systems indiscriminately require residents with all types of onsite systems to connect, whether the system is six months old or thirty years old. This inability to differentiate based on the type of system triggers automatic dissent and public opposition and can delay or halt projects.

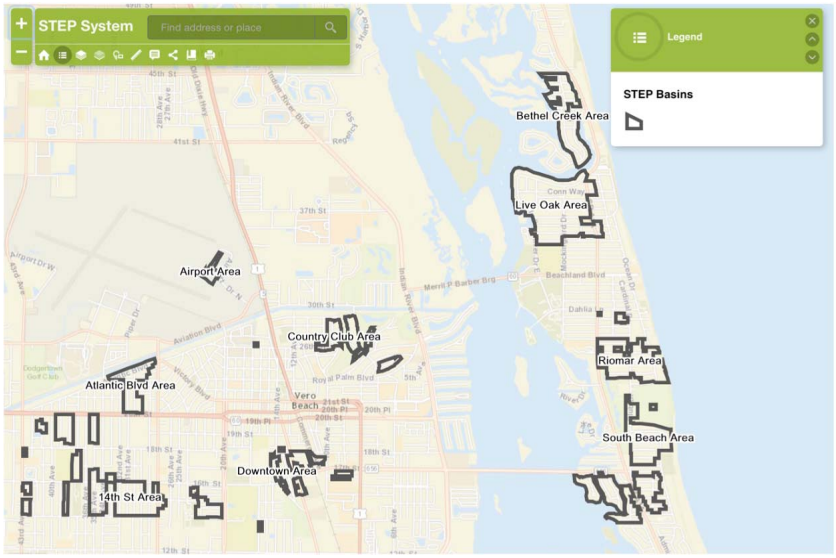


**Figure 7. Effluent sewer (STEP) system areas in Vero Beach.**

Within each sewer service zone, the City’s interactive map lists properties that are eligible to connect to the effluent sewer mains (see Figure 7). Sites that have already connected to the effluent sewer are shown in green. For redundancy purposes, mainly to provide uninterrupted service during hurricane events, some sites have the option of keeping their existing drainfield in service, to enable discharge in the event of an extended power outage. The properties with drainfields that have been left in place are shown as dark green parcels (see Figure 8).

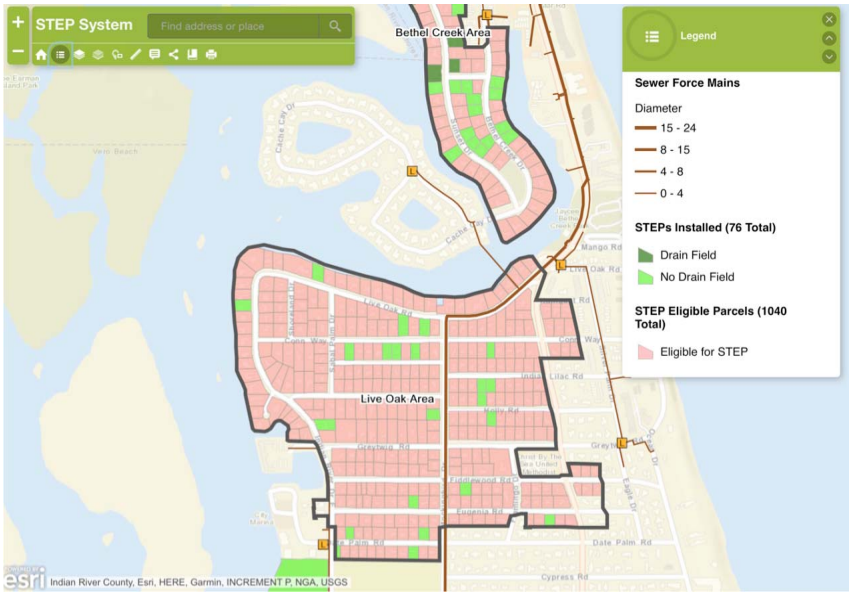


**Figure 8. STEP system availability in Vero Beach.**

## Construction

Approximately 93,000 linear feet of 2-inch diameter effluent mainlines needed to be installed within the service areas. The City started installing effluent mainlines in March 2015 and in March 2017 had effluent mains available to 1,189 of the 1,550 lots that were on septic systems. During this time, 86 homes connected because of failed septic systems, new construction, or remodeling of existing homes. The City has a list of 43 additional households with homeowners who want to connect.

In May 2017, the City is expected to launch its formal “Sign Up and Save Program” by sending letters to residents that will start the one (1) year clock. The City expects a lot of interest from residents at that time since the savings will be approximately 33% of the total cost.

The majority of the residences will use a 1,000-gallon tank along with a 500-gallon pump tank equipped with an Orenco STEP package. Commercial and multi-residential applications will use larger tanks and duplex pump packages.

For quality control and consistency purposes, all contractors undergo a certification process to become eligible to install STEP packages within the city. Installer trainings occur twice per year, all in coordination with the equipment manufacturer.

Residents are encouraged to navigate the installation process by using the City’s cell phone application, available for download from iTunes or Android. The mobile app provides an overview of the project, FAQs, diagrams, homeowner guides, area maps, a list of certified installers, installation photos, and links to important documents.

## Operation and Maintenance

The City owns and operates the entire effluent sewer system, including the on-lot tanks and associated equipment, through a utility easement. Monthly costs for residents include a base fee of $19.89/month per home, plus a usage charge of $3.59 per 1,000 gallons of wastewater. The maximum monthly user charge is set at $55.79.

O&M requirements for effluent sewer systems are relatively simple and despite an anticipated 1,550 connections, will likely not require full-time oversight. The on-lot equipment is specifically designed to allow infrequent maintenance activities, typically one site visit every three to five years.

The pumps are the most important mechanical component of the system and are designed to last more than 25 years. These pumps are high-head effluent pumps that only convey filtered and clarified effluent, and customarily operate just ten to twenty minutes per day. Unlike low-pressure sewers that require discharge to a gravity sewer system or a re-pump system, effluent sewers with their high-head pumps allow the City to connect the effluent mains directly to their force main network. The high-head pump is equipped with a flow controller plate that operates the pump at 8 gpm @ 150 ft. of head.

The City installed the first STEP System on April 4, 2015, and currently has 86 connections. Over the last two years the City has had nine (9) trouble calls. Six (6) of the calls were immediately after installation and were a result of loose electrical connections or improper float settings, two (2) were pump issues, and one (1) was a customer who disconnected the power supply to the STEP System. On October 6, 2016, Hurricane Matthew hit the east coast of Florida including Vero Beach. The City experienced a power outage for three (3) days but did not get any calls for backups of the STEP System. Unlike low-pressure grinder systems that have small collection basins (usually 50 to 80 gallons), the City's STEP system was designed with a minimum of 200 gallons of capacity at each residence to allow for a 3- to 4-day power outage. In addition, the City required an electrical panel equipped with an emergency generator receptacle (115V) at each address. Since the Orenco STEP pump is a 115V, ½-hp unit, any 2,500-watt generator will power the STEP pump.

**Conclusion**

At full build-out, an estimated 1,550 homes will connect to the effluent sewer system. By diverting up to 300,000 gpd of wastewater from the lagoon to the wastewater treatment facility, water quality in the lagoon is expected to improve. Through the use of small-diameter mainlines and by designing and implementing a non-mandatory connection approach, the City was able to obtain public support for the project. The low availability cost of the effluent sewer system enabled the City to install the mains for a fraction of what gravity sewer would have cost. The small-diameter mainlines allowed trenchless construction, a non-intrusive approach that preserved roads, landscapes, and old oak trees. Today, Vero Beach is completing the expansion of sewer availability to critical areas. Residents are pleased with the flexible options as well as the progress towards cleaning up the lagoon.

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