Achieving Nitrogen Loading Reduction through Onsite Wastewater Treatment Technologies
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About FOWA

FOWA is the state's largest organization for the onsite wastewater industry. Its mission is to promote the science and art of manufacturing and installing onsite sewage treatment and disposal systems (OSTDS). Furthermore, FOWA seeks to advance the standards of manufacturing, installing, repairing, and maintaining onsite treatment receptacles by working toward a uniformly enforced state code containing stringent standards for the design, installation, and service of OSTDS. It does so with a commitment to protecting public health, water resources, and the environment, including the reduction in nutrient loading to Florida's waters.

Decentralized vs. Centralized Wastewater Treatment Systems

Decentralized wastewater treatment systems, also referred to as "septic" or "onsite" systems, are named based on the location of the system, as they treat wastewater proximal to its generation source. The Florida Legislature and Florida state regulatory agencies refer to these systems collectively as OSTDS. "Onsite" systems are located on the property where a single-family home, apartment, business, or other source of domestic wastewater originates. The term "decentralized" includes wastewater treatment systems serving multiple sources of domestic wastewater, large-capacity septic systems, and small collection and treatment systems (United States Environmental Protection Agency [USEPA], 2005). Like onsite systems, decentralized systems also treat wastewater proximal to the generation source, but not necessarily on the property where it originates, as a localized piped collection system may be present, leading to a single point of treatment. Both onsite and decentralized wastewater treatment systems receive periodic maintenance, but do not require full-time staffing for effective and reliable function.

In contrast with decentralized wastewater treatment systems, centralized wastewater treatment facilities typically collect wastewater from hundreds to thousands of individual sources spread across a far more expansive municipality or urban or suburban area. Collected wastewater is typically processed in a multi-stage industrial-type facility operated by full-time staff. Centralized wastewater treatment systems typically discharge treated wastewater to surface water bodies.

USEPA Report to Congress

In April 1997, the USEPA developed its "Response to Congress on Use of Decentralized Wastewater Treatment Systems". In this document, the USEPA states "adequately managed decentralized wastewater systems are a cost-effective and long-term option for meeting public health and water quality goals". USEPA also states that decentralized systems can protect public health and the environment, typically have lower capital and maintenance costs for rural communities, are appropriate for varying site conditions, and are suitable for ecologically sensitive areas when adequately managed (USEPAa and b, 2017). USEPA states (2005) that decentralized systems protect human health and water quality when they are properly sited, designed, installed, operated and maintained.

Nationally, decentralized systems serve 25% of the U.S. population, and are used in about one-third of all new housing and commercial development. In Florida, approximately 30% of residents are served by decentralized systems. While decentralized systems are typically utilized in rural areas, more than half of the 25 million systems in the United States are found in suburban areas (USEPA, 2005). The Florida Department of Health (FDOH) estimates that over 2.7 million OSTDS are currently operating in the State of Florida (Hazen and Sawyer, 2015a).

Onsite Nitrogen-Reducing Technologies

Decentralized wastewater treatment systems can include varying levels of scale and complexity. The simplest design approved by the FDOH, referred to herein as a "conventional" OSTDS, includes a septic tank and subsurface soil dispersal system. Solids are removed from sewage in the septic tank, and the clarified effluent is discharged underground, where natural physical, chemical, and biological processes provide additional treatment in the soil. Conventional OSTDS are capable of 30% to 40% influent total nitrogen reduction (Florida Department of Environmental Protection [FDEP], 2015 and Hazen and Sawyer, 2015a). Various environmental processes transform nitrogen in the subsurface, such as denitrification, nitrification of ammonia, uptake by vegetation, and mineralization of organic nitrogen (FDEP, 2015).

OSTDS designed specifically to convert nitrogen in sewage to nitrogen gas, thereby reducing nitrogen loading, typically include multi-stage treatment processes, as compared to the simplicity of a conventional OSTDS. Nitrogen-reducing wastewater treatment systems convert incoming nitrogen to nitrogen gas in a three-step biological process.

1. Organic nitrogen is converted to ammonia-nitrogen (NH_4) by a mostly anaerobic (absence of oxygen in the wastewater) process called ammonification.
2. Ammonia-nitrogen (NH_4) is converted to nitrate-nitrogen (NO_3) by an aerobic (presence of dissolved oxygen in wastewater) biological process called nitrification.
3. Nitrate-nitrogen (NO_3) is converted to nitrogen gas (N_2) biologically in a low-oxygen (anoxic) environment. During denitrification, nitrogen gas bubbles harmlessly out of wastewater into the atmosphere.

This three-step process can be performed using both passive and active treatment technologies. In the process of reducing nitrogen, these systems simultaneously reduce organic matter dissolved and suspended in the wastewater, as measured using the water-quality parameters: biochemical oxygen demand and total suspended solids.

<u>Passive Treatment Technologies</u>

Passive nitrogen-reducing OSTDS are like conventional onsite systems in their operation and maintenance. A passive nitrogen removal system is an OSTDS that reduces effluent nitrogen using no mechanical aeration and only a single liquid pump for energy inputs, and uses reactive media for denitrification. A typical passive OSTDS consists of a layered soil and carbon-containing reactive media, where wastewater flows vertically through the horizontal layers, undergoing the three-step treatment process as it flows to a point of subsurface discharge. This class of OSTDS has been demonstrated to achieve total nitrogen removal rates exceeding 95% (Hazen and Sawyer, 2015a) at the pilot scale and on the order of 50% on an occupied single-family home (FDEP, 2017).

<u>Active Treatment Technologies</u>

Active nitrogen-reducing OSTDS typically include mechanical processing equipment installed in one or more subsurface tanks, where wastewater enters the system, is treated within the tank(s) during a defined residence time, and is discharged, meeting a specified standard. Typical unit processes include solids separation, aeration to increase the dissolved-oxygen concentration of the wastewater, mixing, and recirculation of wastewater within tank compartments. Some systems include the addition of a carbon source to promote microbiological denitrification. Active nitrogen-reducing OSTDS include electric pumps and air blowers that can be energized on standard residential electric service. This class of OSTDS has been demonstrated to reliably achieve total nitrogen removal rates in the 50 to 90% range.

Onsite Nitrogen-Reducing Capabilities

The degree to which an individual OSTDS can biologically remove nitrogen is subject to multiple factors, including the forms of nitrogen present in wastewater, presence of substrate and carbon sources to support microbial ammonification, nitrification, and denitrification, wastewater alkalinity, residence time in the system, and water temperature. These factors, combined with the specific technology used at an individual site, define the site-specific nitrogen-reduction level. Site-specific requirements for nitrogen reduction in Florida vary according to requirements imposed by Florida regulatory agencies, such as achieving a specified total maximum daily load as part of a Basin Management Action Plan or achieving performance-based treatment system requirements under the Florida Administrative Code (FAC). Effluent discharged from performance-based treatment systems must meet the following treatment standards for total nitrogen concentration:

- Advanced secondary: 20 milligrams per liter (mg/L);
- Advanced wastewater: 3 mg/L; and
- Florida Keys: 10 mg/L.

It must be noted that the aforementioned nitrogen treatment standards are applied at the discharge point of an active treatment system. Upon dispersal of the treated effluent to the native soil, additional nitrogen treatment occurs through plant uptake and soil attenuation. Plant uptake and soil attenuation can be up to 40% of the concentration when dispersed in the subsurface (FDEP, 2015).

In terms of active nitrogen-reducing OSTDS that typically include mechanical processing equipment, the FDOH lists 14 manufacturers of nutrient-reducing performance-based treatment systems on its web site (FDOH, 2017a). While most products are active systems that include mechanical equipment, the list also includes two reactive media- or filter-type technologies. The nitrogen-reducing capability of these systems ranges from 44 to 86%, measured based on the influent and effluent total nitrogen concentration (FDOH, 2017a).

In 2008, the Florida Legislature directed the FDOH to develop a tool box of cost-effective nitrogen-reduction strategies for OSTDS. The project had two main areas of focus: development of passive nitrogen reduction technologies; and evaluation and prediction of the fate and transport of nitrogen from OSTDS (FDOH, 2017b). The passive nitrogen reduction technology development effort began with bench-scale, layered soil and reactive media systems that demonstrated the ability to remove over 95% of influent nitrogen from wastewater. As reported by Hazen and Sawyer, an environmental engineering and consulting firm and the FDOH project contractor, these systems were subsequently transitioned to larger, pilot-scale units designed with various soil and reactive-media combinations (Edeback-Hirst, 2012). The pilot-scale systems achieved total nitrogen removal rates exceeding 95% (Hazen and Sawyer, 2015a). This program continued under an FDEP program where layered reactive media were installed beneath a conventional septic system drainfield (FDEP, 2016). A monitored installation from which nitrogen-reduction data are available has initially demonstrated the ability of the system to reduce total nitrogen concentrations by up to 50% using passive, non-electric technology that does not require more maintenance than a conventional septic system (FDEP, 2017).

Two wastewater treatment standards exist for assessing and certifying the treatment capability of OSTDS. Under 64E-6.026, FAC, a manufacturer applying for approval of a nitrogen-reducing OSTDS must submit compelling evidence that the system will function properly and reliably to meet performance-based treatment system requirements, which may include testing approved through the NSF Environmental Technology Verification Program. The NSF/ANSI 40 standard provides a means of assessing treatment system capabilities for effectively reducing the dissolved and suspended organic matter in wastewater, as measured by the biochemical oxygen demand and total suspended solids concentrations. The NSF/ANSI 245 standard provides a means of assessing the capability to reduce the total influent nitrogen concentration by at least 50% (NSF International, 2017). While Florida's performance-based treatment system regulations require treatment levels that exceed the NSF 245 criterion, most NSF 245-certified treatment technologies can consistently achieve considerably higher total nitrogen reductions than 50%. Any OSTDS certified under NSF 245 must also meet the requirements of NSF 40 for biochemical oxygen demand and total suspended solids reduction.

Reliability

The goal of any wastewater treatment system is to consistently achieve an assigned performance metric. While external factors can impact the performance of both decentralized and centralized wastewater treatment systems, both offer satisfactory long-term reliability.

Under 64E-6.029, FAC, all performance-based OSTDS must be monitored at least quarterly, which includes sampling and laboratory analysis, as well as manufacturer-specified maintenance. A component of the FDOH program for approving performance-based treatment systems is verification that the proposed product will produce satisfactory water quality on a consistent long-term basis. The maintenance program is intended to identify and remediate underperforming systems. Underperformance may occur because of wastewater flow exceeding the daily design flow, use of harmful chemicals by homeowners that impact the microflora in the system, or lack of adequate maintenance.

Centralized sewer systems are also subject to operational issues. These systems typically treat millions of gallons of wastewater per day, as compared to hundreds of gallons per day on a single-family home OSTDS, and are therefore subject to increased frequency of sampling, monitoring, and maintenance. When a centralized treatment system upset or a combined sewer overflow occurs, the impact can be significant, with the release of a large quantity of untreated or partially treated sewage to surface waters. A representative example occurred in the City of St. Petersburg when Hurricane Hermine passed through the area in 2016. Over the course of roughly 10 days, 136 million to 151 million gallons of sewage were released into Tampa Bay (New York Times, 2016). It was the third time in the prior 13 months that St. Petersburg had discharged significant amounts of sewage to a surface water body (New York Times, 2016). Releasing 143 million gallons (average of 136 million and 151 million) of sewage is equivalent to releasing the daily sewage flow produced by over 900,000 single-family homes (assuming 157 gallons of water use per household per day) (Water Environment Research Foundation, 2007). Unfortunately, events like this are common for centralized systems, whereas decentralized technologies are not subject to such large-scale environmental releases.

Onsite vs. Centralized System Costs

The capital and operational costs of OSTDS and centralized sewers are similar. Capital costs include the cost to design and install OSTDS on a lot or connect a home to a centralized sewer system. For OSTDS, operational costs include the annual cost to inspect and maintain a nitrogen-reducing OSTDS, in addition to the periodic cost to remove and dispose of solids from the septic tank. Operational costs to the homeowner for a centralized sewer system include the monthly base, usage, environmental, and administrative fees, as applicable, assessed by the sewer utility provider. A description and comparison of capital and operational costs for OSTDS and centralized sewer systems is provided below.

Capital Costs

The cost of installing a nitrogen-reducing OSTDS varies by site and product selected as part of the engineering design. Similarly, the per-home centralized sewer connection cost varies based on the number of homes being connected, distance to the centralized treatment facility, and complexity of the connection design. Notwithstanding, when evaluating these capital costs, constructing a nitrogen-reducing OSTDS is comparable to establishing a new centralized sewer residential connection.

While active nitrogen-reducing OSTDS all serve the same purpose in the treatment of wastewater, the components and construction can vary by technology and manufacturer. Some nitrogen-reducing OSTDS require a septic tank, while others do not. All require a soil absorption system for on-lot dispersal of the treated wastewater. Typical costs for a septic tank, nitrogen-reducing wastewater treatment system, and dispersal system range from $8,000 to $18,000 in Florida.

The capital cost of a passive nitrogen-reducing OSTDS is slightly higher than an active nitrogen-reducing OSTDS, but has a comparatively lower operation and maintenance cost with less maintenance and energy costs. The estimated capital cost of a passive, layered nitrogen-reducing OSTDS is $10,000 (Hazen and Sawyer, 2015b).

Engineering and construction costs for a centralized sewer system residential connection typically range from $7,000 to $30,000 per home (or more), depending on the complexity of the project (Citrus County Chronicle, 2017 and City of Jacksonville, 2017). Assessment fees could further increase connection costs. Owners may pay for the infrastructure cost up front in a lump sum or finance the costs over a period of up to 30 years at a low interest rate (City of Jacksonville, 2017).

Operation and Maintenance Costs

Passive nitrogen-reducing OSTDS have the lowest operational costs, represented by the fee for periodic septic tank pumping. A typical pumping frequency is 3 years, at an average cost of $300, for an annualized cost of $100.

For active nitrogen-reducing OSTDS, a typical operation and maintenance fee assessed by a maintenance provider licensed under 64E-6.019, FAC is $350 to $400 per year. For a septic tank pumped at a 3-year frequency at an average cost of $300 per event, the annualized cost is $100. Electricity to power the electrical components is approximately $100 per year. Between operating and maintaining the nitrogen-reducing system and pumping the septic tank, annual costs may range from $550 to $600.

Centralized sewer system usage typically includes monthly base, volume, and environmental fees. Annual fees for surveyed utilities range from $483 to $576. Costs for three centralized sewer systems are calculated below. Sewage volume is based on a home generating 157 gallons per day (Water Resource Environment Foundation, 2007) and 30 days per month, totaling 4,710 gallons per month (157 gallons per day x 30 days per month = 4,710 gallons per month).

- City of Jacksonville, Florida public utility (JEA, 2017)
    - Base fee for 5/8-inch water line into house - $14.10/month
    - Wastewater rate – $4.94/1,000 gallons x 4.710 thousand gallons = $23.27/month
    - Environmental rate - $0.37/1,000 gallons x 4.710 thousand gallons = $1.74/month
    - Subtotal = $39.11/month x 3% franchise fee = $40.28/month
    - Annual cost = $40.28/month x 12 months = $483.36

- Lee County, Florida (Lee County, Florida, 2017)
    - Base fee - $17.02/month
    - Administrative fee - $3.43/month
    - Wastewater rate – $5.85/1,000 gallons x 4.710 thousand gallons = $27.55/month
    - Subtotal = $48.00/month
    - Annual cost = $48.00/month x 12 months = $576.00
- Miami-Dade County, Florida (Miami-Dade County, Florida, 2017)
    - Base fee for 5/8-inch water line into house - $3.25/month
    - Wastewater rate – $6.34/748 gallons x 4,710 gallons = $39.92/month
    - Subtotal = $43.17
    - Annual cost = $43.17/month x 12 months = $518.04

Benefits of Onsite Technologies

Employing nitrogen-reducing wastewater treatment technologies on individual lots and cluster systems offers distinct benefits when constructed in lieu of a centralized sewer system expansion or constructing new centralized sewer systems.

- **Proven technologies** – The technologies and systems used for nitrogen reduction in OSTDS are proven to reduce total nitrogen concentrations and have been commercialized for decades. The FDOH has extensive experience regulating these systems.

- **Cost-effective** – The cost of constructing an onsite nitrogen-reducing wastewater treatment system is similar to that of a central sewer expansion.

- **Qualified OSTDS installers** – Any person involved in the installation, repair, or modification of an OSTDS in Florida must be licensed under 64E-6.019, FAC. This licensing process is intended to ensure that qualified individuals are installing nitrogen-reducing OSTDS and receiving regular training in the form of continuing education credits.

- **Qualified maintenance providers** – Under 64E-6.019, FAC, the FDOH regulates and licenses maintenance entities for all performance-based treatment systems to ensure systems are maintained and operated according to the manufacturer's specifications and designs. This includes the establishment of minimum qualifying criteria for maintenance entities, such as training, access to approved spare parts and components, access to manufacturer's maintenance and operation manuals, and service response time.

- **Groundwater recharge** – By default, the use of OSTDS includes the discharge of treated water to the subsurface environment, recharging Florida's groundwater supplies, rather than discharging to a surface water body that is typical of a centralized sewer system. This may be particularly helpful in limiting or preventing saltwater intrusion into freshwater aquifers in coastal areas.

- **Non-invasive** – Construction operations for OSTDS installation are typically confined to the parcel of land where the system is being installed, eliminating widespread impacts to the public and to roads that occur with the expansion of existing centralized sewer systems and construction of new centralized sewer facilities.
- **Transportation system protection** – While centralized sewer system construction requires the installation of extensive collection piping networks in roadways, onsite wastewater treatment technologies keep wastewater on the lot where the wastewater is generated, alleviating traffic disruptions and the overall disturbance associated with a centralized sewer system collection pipe network construction project.
- **Combined sewer overflow mitigation** – The use of OSTDS reduces flow volume to centralized sewer systems and the risk of combined sewer overflows where millions of gallons of raw sewage can be released to the environment as a result of rainfall events.

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The Florida Onsite Wastewater Association (FOWA) prepared this document to describe the capabilities and benefits of nitrogen-reducing onsite wastewater treatment technologies, which can be a key component of Florida's strategy to reduce nitrogen loading. Questions and requests for additional information should be directed to FOWA Executive Director, Roxanne Groover, at rgroover@fowaonsite.com or (321) 363-1590.