White Paper

The Case for a Next Generation of Decentralized Wastewater Treatment

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Executive Summary

According to many environmental authorities, traditional on-site wastewater treatment systems, better known as septic systems, are reaching a point of ineffectiveness in the United States. The technology used in most residential and commercial on-site facilities dates back to the 1950s and is costly to replace, leaving many systems in disrepair or failure today.

This paper explores the market needs and barriers faced by scientists seeking new solutions to wastewater treatment, and defines the opportunity presented by emerging technologies designed to address and reverse the groundwater pollution and environmental impact of traditional wastewater treatment solutions.

First, the market need is defined through three primary market drivers creating a tipping point of change in this area:

1. Unprecedented decline in ground water levels globally.

2. High cost of sewer line connections creates barriers to new housing development outside existing centralized treatment territories.

3. Groundwater pollution (caused by centralized treatment solutions and traditional septic systems) leads to drinking water pollution.

4. Industry and military expansion has resulted in a growing need for temporary solutions that do not leave a lasting footprint.

Second, an outline of barriers to progress in this area maps five traditional objections to new technology approval in this area. It is imperative that these barriers be reviewed and overcome in order to progress forward into a new generation of wastewater management solutions.

Third, we present the top three scenarios requiring development and implementation of new technologies for wastewater treatment:

1. At-risk areas with depleting or polluted aquifers;
2. Arid areas of the country where water shortages are already widespread;
3. Rural areas where municipal solutions are not available.

Finally, this paper outlines the benefits of NextGen Septic with Septigen technology, a new septic solution presented by NextGen Septic, LLC to address the market and environmental needs not currently being met by traditional septic technologies.

Understanding the Need - Macro Level

In 1997, the U.S. Environmental Protection Agency issued a report titled Response to Congress on the Use of Decentralized Wastewater Systems (EPA 1997), which stated that "adequately managed decentralized wastewater treatment systems can be a cost effective and long-term option for meeting public health and water quality goals, particularly for small, suburban and rural areas." This landmark report had the potential to alter the traditional view of septic systems as temporary, unreliable, and unmanaged solutions ideally replaced by central sewers.

In 2000, the Advanced On-Site Wastewater Treatment and Management Market Study (*Nelson, V.I., S. Dix, F. Shepherd. 2000. Advanced On-Site Wastewater Treatment and Management Study. Electric Power Research Institute. Palo Alto, CA.*) was issued by the Electric Power Research Institute and co-sponsored by the National Rural Electric Cooperative Association and the Water

Environment Research Foundation. The purpose of the Market Study, prepared by the Coalition for Alternative Wastewater Treatment (CAWT), was to assess the short-term opportunities and long-term potential for wastewater treatment systems that exceeded the performance of standard septic tank and soil dispersal approaches. These could be important both for upgrades of older systems on non-conforming lots and for enhanced removal of contaminants, particularly nitrogen and phosphorus. The study also examined the potential for a shift from homeowner maintenance to management services by professionals, with the intention of improving the performance of systems over time.

There are many emerging market drivers for new technologies in this area. The top three market drivers are outlined here:

1. Unprecedented decline in ground water levels

Many areas in the US are experiencing unprecedented decline in groundwater levels. Ground water is a valuable resource and its depletion is caused by sustained pumping coupled with drought conditions or slow percolation rates of water through the soil. Some of the negative effects of groundwater depletion are:

- drying up of wells
- reduction of water in streams and lakes
- deterioration of water quality
- increased pumping costs
- land subsidence

One water-quality threat to fresh groundwater supplies is contamination from saltwater intrusion. All of the water in the ground is not fresh water; much of the very deep groundwater and water below oceans is saline. In fact, an estimated 3.1 million cubic miles (12.9 cubic kilometers) of saline groundwater exists compared to about 2.6 million cubic miles (10.5 million cubic kilometers) of fresh groundwater (Gleick, P. H., 1996: Water resources. In Encyclopedia of Climate and Weather, ed. by S. H. Schneider, Oxford University Press, New York, vol. 2, pp. 817-823). Under natural conditions the boundary between the freshwater and saltwater tends to be relatively stable, but pumping can cause saltwater to migrate inland and upward, resulting in saltwater contamination of the water supply.

2. High cost of sewer line connections.

a. Beginning with the Clean Water Act in 1972, the federal and state governments provided grants for 75-90% of the cost of construction of central treatment plants and sewer lines (under the Construction Grants Program). Since these grants were phased out in the mid- to late 1980s and replaced by low interest subsidies on loans (the State Revolving Loan Fund or SRF), the cost of treating local water pollution problems in many rural areas has become prohibitive. Municipal officials and concerned citizens are seeking to determine if on-site approaches and management can provide a cheaper solution than sewers. Typically, sewer lines are 60-80% of the total cost of a central sewerage approach. Furthermore, municipal sewer districts in most US cities are cash strapped due to reduced funding from cities and states, and their ability to underwrite expensive sewer connections and receiving $400 - $1200 per year from each home, are no longer possible from their reduced budgetary support. The high cost of providing sewer line connections costs could be avoided with improved onsite treatment systems.

b. In the 1990's, the long-term population shift off of farms and into urban and suburban areas began to reverse. Soon, some of the fastest growing counties in the U.S. were rural areas, particularly in the South and West. However, many of these high-growth areas had poor and shallow soils not suitable for conventional septic system installation. These growth demands can only be met by construction of costly sewers or by more flexible permitting of advanced or alternative on-site systems.

3. **Groundwater pollution leads to drinking water pollution.**

a. Conventional septic systems were not designed to remove nitrogen, which can degrade drinking water supplies leading to public health concerns and degrade coastal waters resulting in eutrophication and loss of resources. Depending on its travel pathway, nitrogen can take years to pass through soils and groundwater to coastal estuaries. As septic system densities have increased over time, the cumulative impacts on groundwater, surface waters and sensitive ecosystems have become more noticeable. One way to remediate these problems, other than sewering, is to retrofit existing systems with new technology, to reduce nitrogen pollution, and/or to require that all new systems meet advanced effluent standards for nitrogen. Many states have already promulgated regulations that treated water from home sewage systems meet nitrogen and phosphorus limits, requiring new treatment solutions and standards be developed for decentralized systems.

b. As US metropolitan areas grow, and treatment plants reach capacity, many communities face the expense of major plant expansion and upgrades or building moratoria. And, throughout the country, older sewer lines are leaking and contaminating groundwater or streams. Replacement or repair of these sewers will also be expensive. Advanced on-site or cluster systems can provide a better alternative.

c. Hormones, drugs, and household chemicals from wastewater are increasingly recognized as threats to water quality and human health. These contaminants of emerging concern (CECs) are now commonly reported in U.S. rivers, streams, and drinking water supplies, and U.S. EPA is asking utilities to monitor for some CECs in drinking water, although regulations establishing allowable levels have not been set. Septic systems are likely the primary source of CECs into the groundwater aquifer on Cape Cod, where 85% of residents rely on septic systems. Previous studies by Silent Spring Institute have found CECs in public and private drinking water wells, groundwater, and freshwater ponds.

4. **Growing need for temporary solutions that do not leave a lasting footprint.**

a. Due to emergence of oil fields and natural gas wells using ground fracking techniques, and the growth of tar sands in Canada, there has been resurgence of temporary cities in remote regions, with no existing sewer lines and/or wastewater treatment plants. Currently, raw sewage from these temporary cities is being trucked to the nearest centralized wastewater treatment plant that has the capacity to accept added waste flow. In these applications, use of advanced septic systems has clear economic benefits. The treated water can be surface discharged or used for local irrigation.

b. The US Army is looking for an effective decentralized, sewage treatment system that can be easily deployed and moved from location to location without an extensive set-up time.

Barriers to Progress

In the past, local/county officials have discouraged the use of decentralized treatment systems, for the following reasons:

1. Decentralized systems were unreliable, incapable of being monitored remotely, thereby requiring high labor costs to track their failure, and were difficult to maintain by homeowners;

2. Centralized treatment systems had the capacity to accommodate additional houses, and even as urban sprawl occurred, metropolitan sewer districts were able to pay for installing extended sewer lines, since they received funding from cities and states and in some cases, even from federal sources;

3. Lack of knowledge that failed septic tanks were resulting in contamination of drinking water wells and, the recent finding that the presence of contaminants of concern (CECs) from septic fields were permeating to drinking water sources;

4. The fact that the world is running out of fresh water is not known to people yet, even though detailed write-ups on water shortages have appeared in newspapers, such as USA Today, etc; Water shortages in California became national news only during the last few years, and now counties across the US are realizing that they would suffer the same fate if something is not done about declining groundwater levels. Most county officials are unaware that according to the United Nations, water use has grown at more than twice the rate of population increase in the last century. By 2025, an estimated 1.8 billion people will live in areas plagued by water scarcity, with two-thirds of the World's population living in water-stressed regions as a result of use, growth, and climate change.

However, the face of our cities is changing. **State and county officials that fail to recognize these changes, as well as their fast pace, are like ostriches hiding their heads in the sand.** Cities provide the overwhelming majority of public water and wastewater infrastructure investment—accounting for more than 95% of total expenditures for these public services. In 2008 local government spent $93 billion on water and sewer services and infrastructure, while Congress provided only $2 billion in grants to states who then disbursed the money in the form of loans to local governments which have to be paid back with interest. U.S. Conference Mayors President Burnsville (MN) Mayor Elizabeth Kautz. "Right now the federal government is imposing many more mandates than the money needed to meet them." said Kautz. "Many of these mandates impose costs on cities to clean up the pollution caused by mining and agricultural activities. But it is our citizens, whose family budgets are already strained by the economy, who will have to pay the skyrocketing water and sewer rates." Current federal financial assistance programs are fragmented and not targeted to metro-urban areas that the nation depends on for employment, economic growth, and environmental stewardship. Currently the nation's preeminent federal water program--the State Revolving Fund (SRF) Loan Program—is inadequate in its current form and needs to be revitalized to meet 21st century needs. The SRF program has received flat funding while the federal government has dramatically increased mandates on local governments. In addition to the wave of unfunded mandates, increased costs are related to population growth, urbanization, and aging infrastructure. The combination of mandates and these other factors are forcing local government onto a spending treadmill where ever-growing annual investments may not be sufficient to guarantee safe, affordable and adequate supplies and services or meet state and federal requirements. Americans will likely face increased service disruptions, increased water main breaks, and greater impacts on local economies and threats to public health.

Furthermore, municipal wastewater agencies have spent billions of dollars on new sewer lines and improved wastewater-treatment plants to comply with standards that EPA drafts and imposes. EPA regulates most municipal pollution sources by requiring local government agencies to get federal discharge permits--the same as factories, power plants and other industrial facilities. Now, federal engineers and lawyers are pushing local governments hard to fix leaky or overloaded systems that spill raw sewage from time to time and violate federal water pollution standards.

Around the country, EPA is using its water-quality authority to force localities to raise billions more dollars to make sure that their treatment systems can handle surges of sewage in even the foulest weather. For example, after spending $1.7 billion to upgrade its system to meet federal standards, Cleveland's regional sewer district expects it will have to commit another $1 billion or so to prevent overflows from antiquated combined sewers that collect both sewage and storm water running into city streets. Threatened with $275 million in EPA fines, the Pittsburgh regional sewage system is working on a $3 billion project. EPA and the U.S. Department of Justice have also reached settlements that order Boston, New Orleans, San Diego, Honolulu, Miami, Cincinnati and Mobile, Alabama, to correct chronic sewage overflows.

Many municipal leaders contend that the EPA ignores what meeting all those requirements will cost the ratepayers whose monthly bills must pay off construction loans and cover operating expenses of upgraded sewage systems. In the 1970s, the federal government picked up 80 percent of the cost of the first round of sewage-treatment improvements through direct grants, but now only offers low-interest loans that sewage systems must pay back.

Some assessments estimate the national cost of repairing and replacing old pipes at more than **$US 1 trillion over the next two decades**. In addition, new treatment technologies are needed to meet Safe Drinking Water Act and Clean Water Act requirements, and cities often face these challenges alongside existing debts.

Beyond these infrastructure challenges, there are many health issues associated with Combined Sewer Overflows (CSO) and Sanitary Sewer Overflows (SSO). The EPA estimates about 3,500–5,500 gastrointestinal illnesses each year are caused by CSO and SSO pollution of swimming waters. Current estimates hold that microbial pathogens in U.S. public drinking water supplies sicken hundreds of thousands of people each year. Sensitive populations—the elderly, the very young, and those with existing health problems—are most vulnerable to waterborne enteric microorganisms. These populations make up about 20% of the U.S. public.

However, the use of decentralized treatment systems is also not without its problems. Failing onsite systems are recognized as sources of both groundwater and surface water contamination, posing a risk to public health (due to the presence of pathogens and nitrate) and the ecological health of lakes, rivers, and estuaries (due to nutrients that cause eutrophication). The regulation of onsite systems is currently undergoing important changes, and stricter and more uniform design and performance standards are expected in the future. Many existing systems will likely be required to upgrade.

Historically, the systems used for the onsite treatment and disposal of wastewater in the United States have required substantial land area. As a result, communities with a higher population density tend to have centralized collection systems that transport the wastewater to a centralized treatment plant. There is no specific total population, or population density, at which it is necessary to provide a sewer system, paving the way for new technologies to provide decentralized solutions that do not require vast amounts of land to properly treat wastewater in heavily populated areas.

Defining the Opportunity

There are **three** scenarios for expanded use of advanced, decentralized sewage treatments systems, and these scenarios are as follows:

1. The most likely future of the advanced system and management approach is in concentrated use in areas of the country where drinking water or natural resources are threatened, such as in sole source aquifer areas, around lakes, and near coastal estuaries, shellfish beds, etc. EPA and the states will be increasingly focused on nutrient impacts and microbial pathogen public health risks of conventional septic systems, and these concerns will intensify the search for cost-effective advanced on-site or cluster approaches. Most importantly, however, homeowners and municipal leaders will be particularly receptive to technology and management options in those parts of the country where water quality problems are highly visible and serious;

2. A second opportunity is in a coupling of advanced on-site and cluster technologies with water reuse in areas of the country, such as the arid Southwest, where water supplies are scarce and increasingly expensive. If small-scale technologies to disinfect and to remove nutrients are developed, which are reliable and meet high standards, wastewater can be recycled for landscape irrigation, toilet flushing, aquaculture, groundwater replenishment, habitat restoration, and other reuses. Furthermore, declining groundwater levels and the existence of a surprising number of droughts and water supply shortages in the Southeastern U.S. and even in relatively water-rich states such as Maryland. Some scientists predictions as many as 34 states will experience water supply concerns in coming years.

Water shortages, which used to be limited to the dry western states, are now a problem throughout the U.S. Even regions that once seemed to have limitless supplies of water are facing shortages and have begun imposing seasonal water restrictions on residents. In response to constantly increasing demand, groundwater is being pumped faster than it is being replenished. Underground aquifers, the source of about 60 percent of the U.S.'s fresh water, are being steadily depleted. Meanwhile, surface water in lakes and rivers is endangered by our increasing population demands. A lack of affordable fresh water has led some towns to halt development; however, local solutions are inadequate to the nation-wide problem.

3. A third promising opportunity for advanced systems and management is in booming rural areas, where conditions for conventional on-site wastewater disposal are poor. Significant new housing development is in the coastal zone, but also in states such as Georgia, Kentucky, Missouri, Arizona, New Mexico, and Tennessee. In new subdivisions, homebuyers and developers are much more willing to accept innovative infrastructure approaches, such as cluster systems and regular monthly maintenance fees, than are residents in older communities. In many of these states, advanced technologies are being permitted to facilitate growth. Particularly promising are opportunities to provide wastewater infrastructure for cluster “village” development, while preserving open space.

The Next Generation of Septic Solutions

In view of the above underlying issues, the main advantages of the NextGen Septic Solutions are as follows:

1. NextGen and its Septigen technology can treat the water at the local level, to an extent greater than the current centralized treatment plants, but without the cost of conveying the wastewater to the centralized plant, treating it and then losing the fresh water to the ocean;

2. NextGen systems can be retrofitted into existing septic tanks and thereby producing wastewater at the quality that is appropriate for the specific type of reuse, ranging from irrigation of low-value crops to toilet flushing; Given that the average person in the United States uses 170 liters/d (45 gal/d) of water outside the home, principally for irrigation, there is a large opportunity to replace the use of potable water with reclaimed wastewater for irrigation. Even if irrigation is not incorporated, it is worth recognizing that the common practice of disposing wastewater to the soil results in groundwater recharge; in some regions, such volumes may be an important part of the hydrological cycle.

3. In small communities, often located in agricultural regions, there is a large potential for reusing wastewater for agricultural irrigation. Ironically, much of the wastewater currently generated by small communities is currently disposed of on land (spray irrigation, infiltration basins, or overland flow), but no crop is harvested. As water becomes scarcer in many regions of the country, it is likely that land disposal will be converted to planned reuse.

4. In many cities, instead of spending millions to repair broken and leaking sewer lines, it is significantly easier and cheaper to install NextGen Systems to treat the water behind each house and only allow the treated water to be discharged through the existing, broken, leaky sewer pipe, which would allow the treated water to drain back to the water table. This can save aging municipal water and sewer districts millions while meeting the federal mandate of stopping raw sewage leakages into the ground. For example, a major midwestern city, handling 70 billion gallons of wastewater every year, has estimated the cost of mandated repairs to its aging sewer lines (average age 100 years) at $3.2 billion.

5. Also, NextGen systems installed in conjunction with municipal systems can lessen the load on the existing centralized treatment plants, thereby allowing them to handle storm water flows, instead of building underground storage facilities to handle increased wastewater loads during storms. Consider the following costs for handling Combined Sewer Overflows (CSO) and Sanitary Sewer Overflows (SSO) using the existing centralized treatment plants:

Combined Sewer Overflow

Recurring Annual Costs – 13 Cities

- Total – $19,377,660
- Average/City – $1,490,589
- Average Per Capita – $10.76

One-time, Non-recurring Costs – 7 Cities

· Total – $148,179,626

· Average/City – $21,168,518

· Average Per Capita – $90.33

Sanitary Sewer Overflow

Recurring Annual Costs – 24 Cities

· Total – $42,050,338

· Average/City – $1,752,097

· Average Per Capita – $32.08

One-time, Non-recurring Costs – 11 Cities

· Total – $101,651,302

· Average/City – $9,241,027

· Average Per Capita – $23.13

6. NextGen technology and system can be remotely monitored, which is essential for centralized monitoring of a large number of such decentralized systems, to maintain accountability and prevent continued operation of failed systems, which is the current situation; Furthermore, remote monitoring capability means that metropolitan sewer districts don't have to have large budgets for personnel required to inspect each NextGen septic system, to certify them each year.

7. Finally, the NextGen technology and system allows treated water to be locally returned back to the ground, and this can allow the groundwater table to be replenished instead of allowing the sewage to be treated centrally and then released into a larger water body, such as a creek, river or lake, from which the water does not return back to the ground; this has led to declining groundwater levels worldwide, and hence resulted in water shortages in areas suffering from drought, such as in California. While all decentralized treatment systems return water to the ground locally, NextGen technology does not require the soil to treat the water, meaning that the water returned the ground is non-polluting.

NextGen technology and system produces treated water that is clear, with no turbidity, or presence of bacteria, if the water is disinfected, using the solid-state UV light.

There are three options for water discharge after NextGen treatment:

1. Soil discharge in which case the water does not have to be disinfected using the solid-state UV light system; since the water is already treated, the size of the soil absorption field required will be smaller;

2. Direct discharge into a lake, river, pond or local stream; in this case, the water will have to be disinfected; and

3. Water can be piped back into the house's toilets for reuse; replumbing a house to allow treated water to be used in the toilets and for lawn sprinklers typically costs less than $1,000 for an average home. Additional extra water can be stored in a rain-water storage tank, or drip discharged into the soil.

Conclusion

As traditional septic tanks continue to fail and new housing developments continue to be built beyond municipal water boundaries, the need for an efficient, low-impact, next generation of wastewater treatment solutions is imperative. By treating wastewater in the system through expedited processes, de-centralized treatment solutions represent the opportunity to rebuild water tables, replenishing groundwater and diminishing the threat of groundwater pollution due to wastewater mismanagement.