Image: Dennis Pillion

Image: Katherine Bagley

Image: Black Belt Citizens Fighting for Health and Justice

An Investigation on Decentralized Wastewater Management Systems in Rural America

A Case Study on the Alabama Black Belt's Wastewater Infrastructure Crisis

Kennedy Brown
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About the Author

Kennedy Brown is entering her senior year at the University of Vermont (UVM) in Burlington, Vermont and will complete her B.S. in Civil Engineering in 2022 with minors in Mathematics and Community and International Development. She is also enrolled in an Accelerated Master's Program at the University of Vermont and will complete her graduate degree in Civil and Environmental Engineering in 2023. Kennedy is entering her third year working as a laboratory assistant in the Environmental Microbiome Engineering Research Group at UVM exploring alternate waste management systems on dairy farms in Vermont. She has presented her research at numerous conferences such as the New England Water Environment Association (NEWEA) annual conference and the Northeast Biosolids and Residuals Annual Conference. Kennedy is the Director of Academics for Pi Beta Phi Fraternity for women, an afterschool program coordinator for Linking Engineering to Life (LEL) with Million Girl's Moonshot, and a member of Tau Beta Pi and Engineers Without Borders. After completing her degrees, she intends to enter the workforce as a water resource engineer and eventually return to academia to obtain a graduate degree in Public Health Policy.

About the WISE Program

The Washington Internships for Students of Engineering program was established in 1980 with intentions to strengthen the intersection of engineering and public policy for future leaders of science and technology in the United States. Participating professional engineering societies nominate students to sponsor for the entirety of the summer program. Typical WISE programs consist of a nine-week journey for engineering students to spend the summer in Washington D.C. meeting with government officials to understand how engineers can contribute to the public policy process. This program emphasizes the need for educated and passionate individuals to contribute to the legislative and regulatory public policy decision-making process. For more information about the WISE program, visit www.wise-intern.org.

About ASTM International

ASTM International (ASTM), is a globally recognized leader in the development and delivery of international voluntary consensus standards. Today, nearly 12,000 ASTM standards are used around the world to improve product quality, enhance safety, facilitate market access and trade, and build consumer confidence.

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I would like to thank ASTM International for providing me this incredible opportunity through their sponsorship in the WISE Program. A major thanks to my mentors Matthew Pezzella and Travis Murdock for their continuous support and guidance throughout the program. Mark Ames who acted as the Faculty Member in Residence (FMR) for his mentorship and allyship navigating the world of public policy. Thank you to the staff at the Library of Congress for their advice and counseling in research. Major thanks to my mentor and professor Dr. Matthew Scarborough for his inspiration and continuous support in and out of the classroom. And lastly, thank you to my incredible fellow interns for their passion, authenticity, and friendship as we navigated Capitol Hill virtually from across the country.

Acronyms

ARRA- American Recovery and Reinvestment Act of 2009

ARWA- Alabama Rural Water Association

CBO- Congressional Budget Office

CWA- Clean Water Act

CWSFR- Clean Water State Revolving Fund

DWSRF- Drinking Water State Revolving Fund

DWWIA- Drinking Water and Wastewater Infrastructure Act

EPA- Environmental Protection Agency

IWTS- Integrated Wetland Treatment System

LCUWP- Lowndes County Unincorporated Wastewater Program

NCSS- National Cooperative Soil Survey Standards

NPDES- National Pollutant Discharge Elimination System

NRCS- Natural Resource Conservation Services

NRWA- National Rural Water Association

NSSS- Non-Sewered Sanitation Systems

OSDS- Onsite Sewage Disposal Systems

OSHA- Occupational Safety and Health Administration

OSS- Onsite Sewage Treatment and Disposal System

POTW- Publicly Owned Treatment Works

RCAP- Rural Community Assistance Partnership

RD- Rural Development

REAP- Rural Economic Area Partnership

RME- Responsible Management Entity

RUS- Rural Utility Services

SRF- State resolving funds

SDWA- Safe Drinking Water Act

TAT- Technical Assistance and Training

U.S.- United States

U.N. – United Nations

USACE- U.S. Army Corps of Civil Engineers

VPP- Voluntary Protection Program

WEF- Water Environment Federation

WRDA- Water Resource Development Act

WRRDA- Water Resource Reform and Development Act

WWD- Wastewater Disposal

Executive Summary

Wastewater treatment stability is a luxury taken for granted by many first world countries, yet hundreds of thousands of homeowners in America live without functioning sewage treatment systems. Wastewater infrastructure failure is the alarming reality for many rural communities in America who must rely on decentralized wastewater treatment systems to collect, treat, and disperse the liquid waste streams coming from their homes and businesses. Septic tanks are the most common form of decentralized treatment system in the U.S. Their popularity is due to their relatively inexpensive technology, but if not placed in perfect environmental conditions they are unable to function properly and tend to fail. Populations living in rural areas tend to be under considerable financial stress and the costs associated with the repair and replacement of failed septic tanks can be a daunting burden that is plaguing rural Americans.

The Alabama Black Belt is a region originally defined environmentally for having dark clayey soils once used for cotton production. Over time, the name has developed a social definition for its large African American population. This region contains a historically underserved rural population dependent on decentralized wastewater treatment systems to effectively and efficiently remove, treat, and dispose of their waste. The conventional septic systems implemented in this area are not compatible with the shrink-swell soil native to the Black Belt causing them to be extremely prone to failure. Homeowners with failed systems are forced to use alternative methods of removing their waste such as "straight piping." Uncontrolled wastewater treatment is a criminal offense in many states which leads to fining and violation notices for communities already struggling to financially support their systems.

The wastewater infrastructure crisis is not only an issue on the economic and social scale, but also poses a major threat to the stability of public health in rural communities. The failure of septic tanks can cause untreated waste to accumulate on the ground surface surrounding homes. Exposure to raw sewage is hazardous to human health due to presence of pathogens which are normally removed in the treatment process. Hookworm, a parasitic worm common in third world countries, was detected in the Black Belt in areas experiencing extreme cases of septic tank failure. Hookworm and other parasites, bacteria, and viruses attributed to raw sewage exposure can jeopardize the short-term and long-term health of individuals, especially those in rural communities lacking proper health care. If left unregulated, failing decentralized wastewater treatment systems will continue to plague public health, environmental justice, and the human right to sanitation and hygiene.

The lack of progress in this sector can be highly attributed to continued appropriations of funds to attempt to repair infrastructure with little understanding on the scope of the problem and how to sustain long-term system reliability. To improve the effectiveness, affordability, and durability of decentralized wastewater treatment systems, the federal government should look to meet the following recommended policy objectives in legislation:

1.) Decriminalization of Infrastructure Failure
2.) Quantification of Rural Infrastructure Conditions
3.) Expansion of Municipal Sewer Systems and Management Plans
4.) System Reliability Guarantee

These four policy objectives will assist in obtaining accurate data regarding the severity of the issue of private infrastructure failure on a national level. This understanding will help our nation determine the best path moving forward to provide all citizens working and satisfactory wastewater treatment systems. The recommended policy aims to resolve the current wastewater infrastructure crisis and prevent it from occurring again through the creation of programs and standards to provide long-term maintenance and reliability for system functionality. The recommended public policy places an emphasis on the human right to public health, sanitation, and hygiene for rural communities while working effortlessly to restore the integrity of the nation's wastewater infrastructure.

Introduction

In the United States (U.S.), 2.2 million individuals lack the human right of proper access to drinking water or basic plumbing, a right guaranteed by the International Covenant of Economic, Social, and Cultural Rights by the United Nations (U.N.) (*DIG DEEP- Our Work 2020*; *Alston, 2017*). The privilege of simple actions such as flushing a toilet, running a washer, and using a kitchen sink are often overlooked by urban populations connected to a centralized wastewater treatment system. It is estimated that 25-30% of all households in America are not connected to a public sewer and therefore must rely on decentralized systems (such as septic tanks), to effectively remove, treat, and dispose of their wastewater (*He, Student & Engin, 2006).* A 2019 survey by the U.S. Water Alliance modestly estimated that 12% of all Americans living in rural areas have inadequate decentralized sewage treatment systems (*McGaw & Fox, 2019*).

Decentralized systems often require private ownership on one's property, leaving the household entirely responsible for financing and maintaining the equipment. Majority of the population is untrained on wastewater management and private ownership can also be a financially pressing matter. This causes ownership of decentralized systems to be a substantial burden for rural families who often experience system malfunction and ultimately failure. Uncontrolled and untreated wastewater is not only an unsanitary and inhuman way of life, but it also poses an extreme threat to public health. Exposed raw sewage cultivates environments for pathogens such bacteria and helminths which can infect underserved populations and jeopardize their health. The EPA estimates that the total cost of drinking water and wastewater infrastructure needed to meet current regulations and guarantee human health and security exceeds 744 billion dollars over a 20-year period (*Humphreys & Ramseur, 2021*). A greater focus on legislation promoting tangible change is required to support rural communities, maintain public health, and rebuild the nation's wastewater infrastructure.

1.1 Defining Waste Management: Centralized vs. Decentralized

General wastewater treatment systems can be classified into two categories: centralized (distributed) and decentralized (on-site). Centralized wastewater systems are most commonly found in urban areas consisting of a larger population density with a sizeable tax-base able to maintain large-scale systems. These systems cover larger geographic ranges and direct wastewater streams through sewer systems to a centralized location (a treatment plant) (*WEF Distributed Systems Overview, 2019)*. The systems are usually funded through utilities from served populations and are often provided with additional funding from local, state, and federal levels. The continuous influx of adequate funding allows urban communities to maintain efficient and resilient centralized wastewater treatment plants with modern treatment technologies *(United States EPA, 2004).*

Approximately 25% of the American population does not qualify for centralized treatment systems due to either geographic, financial, or climate constraints (*Septage Management Administrative Code, 420-3-6*). Decentralized technologies can consist of singular dwelling systems (such as septic tanks) or cluster systems of few close-range homes. These systems are defined as treating individual waste streams without any physical linkage or central management (*WEF Distributed Systems Overview, 2019*). Decentralized treatment is appealing due to its varying size capacity and overall cost-effective nature. These systems are foundational in

American wastewater infrastructure as approximately one-third of new homes in the U.S. are being constructed using decentralized systems. Decentralized treatment has sizeable limitations, and its efficiency can be dramatically inhibited by conditions such as the environment, maintenance ability, and climate (*United States EPA, 2004*). In order to establish the reliability and resiliency of decentralized systems, adequate attention and continuous maintenance must be performed and funded by private owners. This responsibility can be a daunting burden that can jeopardize the public health and well-being of homeowners when faced with system malfunction or failure.

1.2 Rural Communities and Private Systems

Over 60 million people in the United States live in rural areas, defined by having a population of less than 2,500 people *(United States Census Bureau Rural America, 2010).* Currently 12% of the rural population does not have access to properly maintained sewage systems (*Infrastructure Report Card, 2021*). Population growth and current social changes are leading more individuals toward remote lifestyles emphasizing the need for advancements in rural infrastructure (*United States EPA, 2004*). Rural areas are noted for their lower population density and minimal technical and financial resources. Former United States Secretary of Agriculture Sonny Perdue states that these areas also face "diverse economic challenges… in accessing transportation, telecommunications, healthcare, housing, economic development resources, and job opportunities" *(Perdue, 2017).*

Lack of funding and low population densities are deterrents for centralized treatment implementation in rural communities. This results in the need for on-site systems for single dwelling units, most commonly in the form of septic tanks. Nearly 21 million homes in the U.S. rely on septic systems and they are most commonly found in the Deep South and New England (Figure 1) (*LaFond, 2015*). Decentralized treatment systems have major technical limitations and require nearly perfect environmental conditions and upkeep in order to function effectively and resiliently.

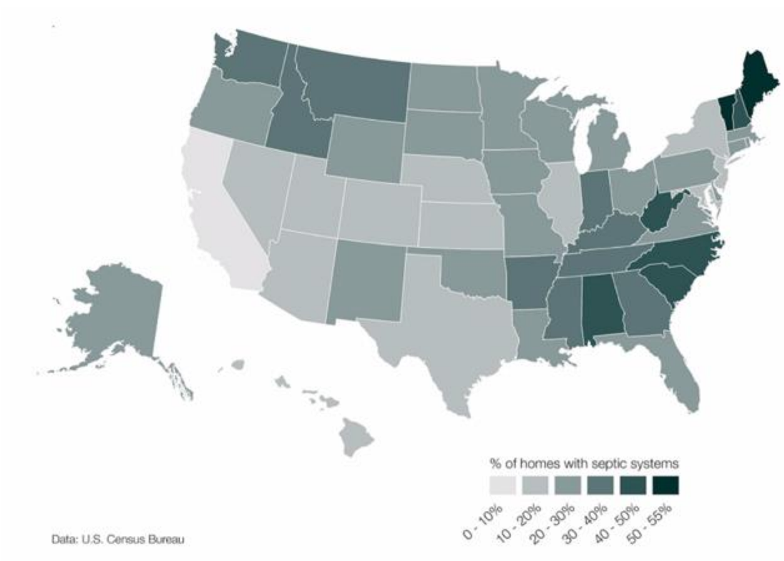


Figure 1. Map of the United States depicting concentration of septic tank usage. (Circle of Blue, Lafond 2015)

Decentralized technologies can fail in functionality due to a range of social and environmental conditions that vary across the U.S. These challenges include extreme fluctuation between drought and rainfall in California, unstable and treacherous soil foundations in Appalachia, and dense soil conditions in Alabama (*McGraw & Fox, 2019*). The distinctive obstacles faced in each area make a universal decentralized wastewater treatment technology such as septic systems unfeasible. The lack of community and individual funds in rural areas can make small centralized systems and decentralized systems nearly impossible to maintain in cases of emergency. This instability poses a major risk to public health and jeopardizes the foundation of American wastewater infrastructure. Technology implementation and management must be addressed on a case-by-case manner while ensuring support from a federal system to promote functionality and efficiency.

1.3 The Alabama Black Belt: A Microcosm for the National Wastewater Crisis

The United States Black Belt is a rural region spanning from Mississippi to Virginia as presented in Figure 2 (*Webster & Bowman, 2008*). Although this region crosses numerous state lines, it is primarily defined in nineteen counties across central Alabama (*S.1643, 2021*). The term "Black Belt" was originally coined because of the region's dark and clayey soils which historically provided optimal agricultural conditions for cotton production (*Falk & Rankin, 1992*). The region's name now has a stronger correlation to its large population of African American individuals. This area has a history rooted in slave trade and contains a demographic of marginalized individuals underserved economically and socially (*Webster & Bowman, 2008*).

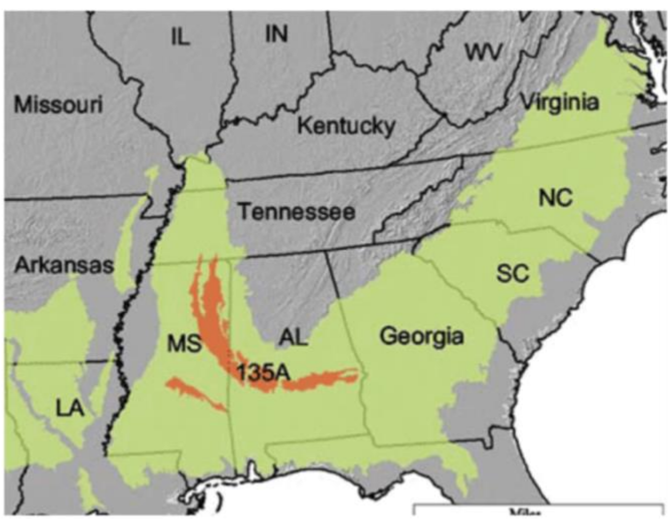


Figure 2. A map of the United States Black Belt and the Alabama Black Belt Region. *(Meza, 2018).*

The Alabama Black Belt is a microcosm for the failing wastewater infrastructure and regulations in rural regions across the country and has recently gained attention due its "third world living conditions" according to the U.N. Special Rapporteur in 2017 (*Alston, 2017*). The low population density and low average income deems the Black Belt region unsuitable for centralized wastewater systems. The dark clayey terrain that was once the South's most productive soils are highly incompatible with conventional septic systems. Black Belt populations also suffer from extreme poverty conditions with a mean household income of $24,000. The lack of proper infrastructure is a major inhibitor for business development in the area and deters economic growth (*McCoy & Cooley & White, 2004*).

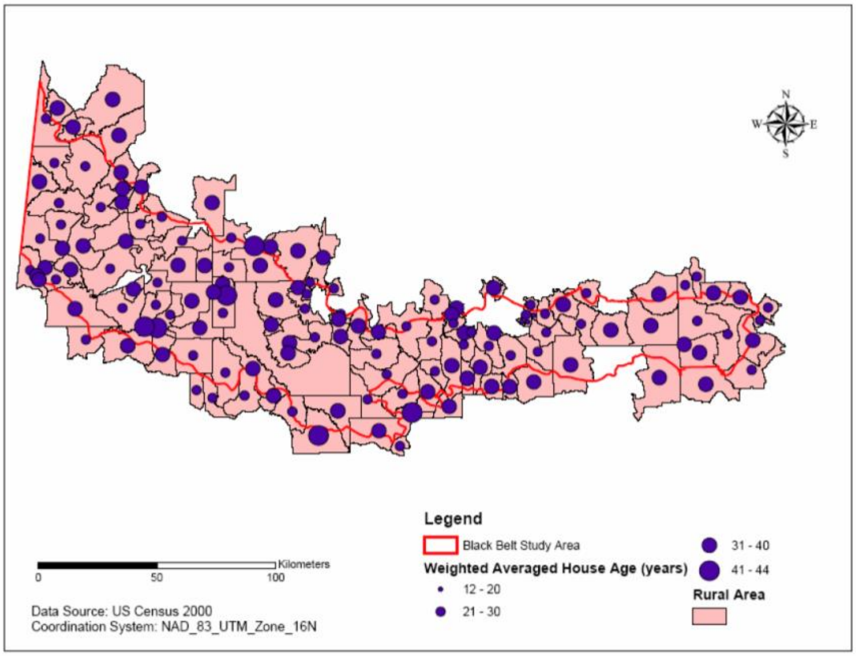


Figure 3. A map of the Alabama Black Belt depicting the weighted average septic tank age in the region (*Meza, 2018*).

Septic systems are a relatively inexpensive and low-tech solution to treating wastewater. Yet, their geographic incompatibility and lack of reliability impose a financial burden on residents in the Alabama Black Belt and have perpetuated a public health crisis. It is estimated that 40-90% of all septic systems in Alabama are inadequate or have failed due to negligence, environmental conditions, or age (*Septage Management Administrative Code, 420-3-6*). Majority of implemented systems are severely outdated (Figure 3) with some systems aging back to the 1950's. Outdated systems are unsatisfactory in meeting today's infrastructure demands and they are rarely replaced as repairs and installations can cost up to $30,000 (*Meza, 2018*).

Decentralized system failure partnered with the absence of economic stability, resources for repairs, and the proper soil conditions for the technology have forced first world citizens to live in third world conditions. Thousands of individuals in the area have resorted to utilizing PVC (Straight) Pipes to simply guide untreated sewage away from their homes. This method of disposal results in raw sewage ponds present in public spaces and in water environments posing a major risk to public and environmental health *(Meza, 2018*). Individuals exposed to the pathogens present in raw sewage have high chances of infection of parasitic worms such as hookworm and developing serious illness *(WHO Soil-Transmitted Helminth*

Infections, 2020). The Alabama Black Belt is a region facing an extreme public health crisis resulting from lack of prioritization of decentralized wastewater infrastructure. This region represents the potential future and terrifying reality for many rural communities across the country lacking wastewater treatment unless preventative action is taken.

"Proper Septic Maintenance is a commonly overlooked responsibility. Failing systems are a significant threat to our health and water quality" – Ben Grumbles, Former Assistant Administrator of the Office of Water

(*U.S. EPA, 2005)*

2. Background

2.1 Technologies in Decentralized Systems

Decentralized systems have the potential to effectively support water environments and public health when properly implemented and maintained. The flexible nature of these systems allows for expansion and development over time to provide demand-based treatment with greater efficiency and economic appeal. Advancements in decentralized system technology have been limited by lack of knowledge, experience, awareness, and funding. Over recent years, a greater attention has been placed on the ability of decentralized technologies to function in various social and environmental conditions. New research in this sector focuses on reducing associated costs, improving efficiency and resiliency, and reducing environmental and public health risks. Currently, the technology to provide advanced and capable systems suitable for varying environmental conditions comes with a large and unaffordable price tag. It is hoped that as these systems become more prominent and regulated that the market for advanced technologies will settle in order to assist the communities in greatest need (*Jaura, 2020*).

2.1.1 Types of Decentralized Systems

Overall, decentralized systems are characterized by the lack of central management through a municipal sewage treatment facility. Most decentralized systems require a permit for implementation which are regulated on the local and state levels (*Septage Management Administrative Code, 420-3-6*). Decentralized systems are classified as "private utilities" and require management from either a hired third-party or through homeowners of individually serviced dwellings.

Cluster systems (also known as small community systems) consist of multiple wastewater sources in a small geographic area and are usually managed under contract by a third-party responsible management entity (RME)(*Tooke*). The effluent from these systems can be discharged in a field or certified body of water. These systems find their obstacles in installation as the homes must be nearby and there is a major need for collaboration, communication, and financial trust among households (*Buchanan, 2021*). If implemented and maintained properly, they have the potential to decrease the overall financial obligations for individual entities through shared costs of equipment, installation, and maintenance (*United States EPA, 2004*).

Onsite systems (private systems) consist of individual treatment systems on a per-dwelling basis and can most often be found in the form of septic tanks. The equipment is connected directly to a single dwelling and uses mechanical technologies and the natural processes of the surrounding environment to collect, disinfect, and disperse wastewater (*United States EPA, 2004).* All costs and responsibilities associated with the onsite system are the sole responsibility of the served household including installation, permits, pumping and repairing (*Meza, 2018*). These systems tend to be neglected due to lack of technical expertise and financial resources by individual households which can jeopardize their wastewater treatment and health.

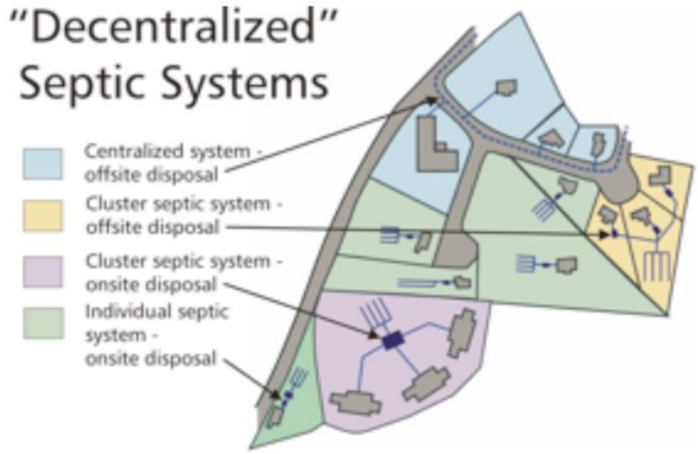


Figure 4. A descriptive image depicting the types of decentralized wastewater treatment systems and technologies (*Kamm & Murchison & Theriault*).

2.1.2 Current Technologies

Current technologies in the decentralized wastewater treatment field consist of varying degrees of treatment and dispersion efficiency. Recent research has given light to new innovative technologies such as media filters, evapotranspiration beds (ET), subsurface drip irrigation (SDI), and integrated wetland treatment systems (IWTS). These systems have the potential to function in varying climate conditions but currently are too expensive and unregulated for widespread implementations (*Behrends et al. 2007; Elliot & White, 2021; He et al. 2006*).

The most widely used technologies today include:

1) Septic Tanks- Septic tanks are systems in which wastewater flows from a dwelling into a large underground tank where heavy solids will sink to the bottom and lighter materials will float to the top. The liquid waste stream is then directed out of the system to be dispersed in a nearby area. Solids are retained and broken down in the tank by microbes and must be pumped out every 3-5 years *(Jaura, 2020).*
2) Drip Systems (Low Pressure Systems)- Drip systems are a form of dispersal maintenance in which small-diameter "drip tubes" are dispersed throughout a drain field. The dispersal rate is often controlled with an attached regulator to optimize

percolation using either timed control or low-pressure analyzation (*United States EPA, 2004*).

3) Mound Systems- Mound systems are used in areas with soil of low hydraulic conductivity or a high groundwater table. This system consists of a large, excavated soil heap constructed above ground level with dispersal pipes within. The mound provides a layer of pre-treatment and minimizes the amount of fluid entering the less-conductive soil. These systems are not financially optimal as they require significant amounts of land and soil *(United States EPA, 2004; White, 2021).*
4) Straight Pipes- Straight pipes are the simplest form of waste removal and require no actual technology. Straight pipe removal consists of PVC pipes directing waste streams from an individual's home to be discharged directly on ground surfaces or nearby ditches (*Meza, 2018*). These systems are illegal in numerous states and are often a last resort method for many homeowners as they do not treat wastewater only attempt to displace it from the home (*McKenna et al. 2017*)

2.1.3 Effluent Disposal Methods

Effluent disposal is a major concern among environmentalists and public health professionals as improper disposal can pose extreme risks for contamination and exposure. The two primary methods of treated effluent disposal are:

1) Drain Field (Absorption Field, Leach Field)

The most common method of disposal is through a drain-field or absorption field, in which treated sewage is dispersed through a series of buried pipes with expectations for it to permeate through the soil layer. Pipe dispersal efficiency is monitored and regulated through technical standards such as ASTM F481-97(2019) to ensure satisfactory performance and optimize soil absorption (*ASTM International F481, 2019).* The stream is further treated using naturally occurring soil microbes and it eventually reaches the groundwater table. The success of this method is highly dependent on the hydraulic conductivity of the soil in the field and the location of the groundwater table below the surface (*United States EPA, 2004)*

2) In-Stream

An alternate method is in-stream disposal in which effluent is placed in naturally occurring bodies of water or man-made ditches in the nearby community. This method of disposal is usually not preferred and requires an NPDES permit as to not disrupt the local ecosystems or potentially contaminate groundwater systems. *(White, 2021*).

2.1.4 Conventional Septic Systems

According to a 2015 study, 21 million homes in rural United States treat their waste using private conventional septic systems (*LaFond, 2015*). Conventional septic tanks are buried on the serviced property and have connector pipes to direct waste streams from home to tank and then onto a dispersal location (Figure 5). Septic tank construction and installation is generally mandated through various standards and regulations such as ASTM F449-20, ASTM C1227-20, and ASTM

C890-19 to ensure system functionality, performance efficiency, and public safety (*ASTM International F449, 2020; ASTM International C1227, 2020; ASTM International C890, 2019*). The underground tanks utilize an anaerobic treatment method to break down solid waste in the tank using microbial communities and then remove the remaining liquids (*United States EPA, 2004*). A consistent component of tank maintenance is the pumping of built-up solids every 3 to 5 years to avoid clogging and ensure proper liquid drainage (*Jaura, 2020*).

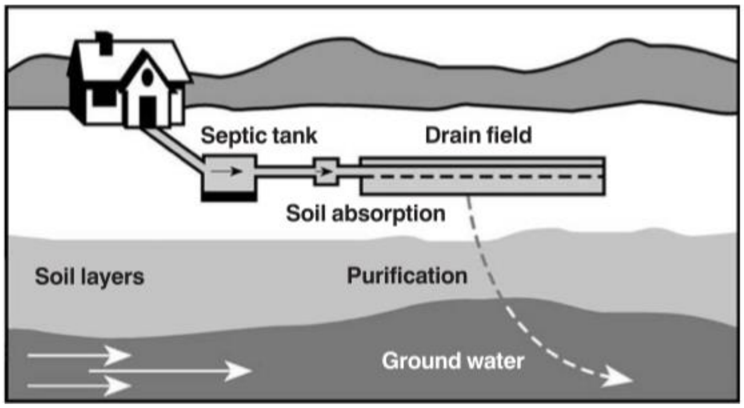


Figure 5. The layout and description of a conventional septic tank wastewater treatment system (*Frederick, Kreissl & Goo, 2021*).

Septic tanks were first reported in the late 1800's in the U.S. and eventually became a standard practice of decentralized waste treatment within the mid 20th century. Many of the septic systems in the ground today were constructed during this time period and have been designed and installed based on outdated codes and standards making them unfit for today's infrastructure demands (*U.S. EPA, 2005*).

Although septic tanks consist of fairly inexpensive technologies, they can be associated with high long-term costs such as permit fees (up to $500), installation and implementation fees (up to $20,000), pumping fees ($250-$500 every 3 to 5 years), and the repairing or replacement of failed systems (estimated between $4,000-$30,000 per system) (*Infrastructure Report Card, 2021; McCoy & Cooley & White, 2004).* The lifespan of a septic system is traditionally 20-30 years, but this value can be decreased dramatically if it is not properly maintained or compatible with the surrounding environment and climate (*Infrastructure Report Card, 2021; Meza, 2018).* Failed systems often result in contamination of the surrounding environment and raw sewage exposure either backing up through piping systems or cultivating on the ground surface. In a 1996 report by the EPA to Congress, septic systems were determined as the second greatest threat to ground water quality in the country *(U.S. EPA, 1996*). The lack of replacement of continuously aging septic systems continues to jeopardize ecosystems and human health and will not cease until properly replaced, repaired, and managed.

Alabama's Black Belt region is a prime example of the dramatic effects resulting from inadequate septic tank compatibility, implementation, and maintenance. Due to the geotechnical composition of the soil that comprises the Black Belt, conventional septic tanks often are incapable of properly functioning and inevitably become clogged and unusable. The high costs associated with septic tank failure forces unprepared individuals to either defer maintenance or implement a straight pipe to displace their sewage. According to a survey of Wilcox County, approximately 93.4% of households had unpermitted septic systems and 60% had visible straight pipes (*Jones C. & Jones R., 2016*). Another study of Bibb County showed that approximately 50% of surveyed homes displayed raw sewage ponds on the property grounds (*Elliot, 2021*). Although septic tanks have high rewards when properly maintained, there are also extreme risks and limitations of their functionality that can be detrimental to the well-being of rural communities. Septic tanks are a vital component of our nation's wastewater infrastructure, but their continuous neglect and lack of regulation has caused them to be a major inhibitor to proper waste treatment and public health.

2.2 Geotechnical Dependency

The functionality of a private wastewater treatment system is highly dependent on the geotechnical makeup and soil topography of the area. Soil composition dictates the efficiency of the treatment technology, the dispersal methods, and the likelihood of system failure. Soils with high permeability rates often are most appropriate for decentralized systems as treated streams can flow through the soil with lower chances of clogging soil pores (*Buchanan, 2021*). Low permeability soils are often counterproductive as a draining medium as they will absorb the liquid stream. This causes the soil layer to become extraordinarily dense and act as a barrier for further fluids to pass through leading to sewage build up on ground surface levels.

The soil in the Alabama Black Belt is mainly composed of vertosols, a shrink-swell clayey soil that is known to limit engineering uses due to its ability to change shape and properties with varying degrees of saturation (*National Resources Conservation Service-Soils, 2020*). The type of vertosol found in this area is known as "Blackland Prairie Soil" and as shown in Figure 6, it directly covers the entirety of the Black Belt region. When this soil is dry, it has a crumbly texture and often cracks at the surface, making it difficult to construct on or use for development. As the soil absorbs liquid and becomes saturated, it begins to take on clay-like characteristics by causing it to expand drastically and become an impermeable layer in the soil (Figure 7).

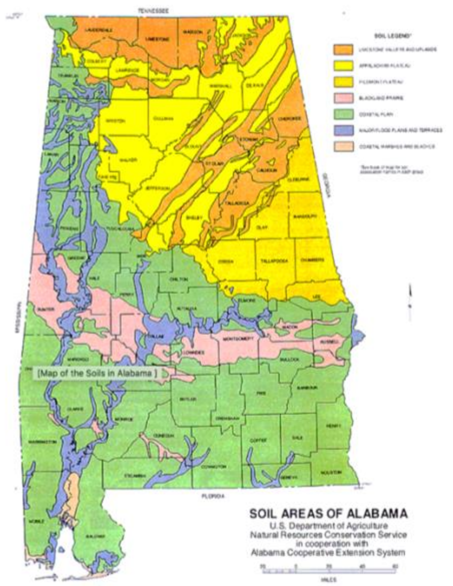


Figure 6. A map highlighting the types of soils in Alabama (*National Resources Conservation Service-Soils, 2020*)

Figure 7. Blackland Prairie soil, the most prominent soil in the Alabama Black Belt. (*National Resources Conservation Service-Soils, 2020*)

It is estimated that greater than 75% of the of the Blackland Prairie soil in the Alabama Black Belt is unsuitable for conventional septic tank usage (Figure 8) (*He et al., 2006*). This incompatibility is not only due to the clogging of septic field lines, but because of the instability of the soil which can lead to ruptures in the septic tank connections. As vertosol soils shrink and expand with varying degrees of saturation, septic tanks are subject to movement which can cause them to settle, crack, or disconnect. Although these systems are unsatisfactory in treating waste in this area, their inexpensive initial costs make them very attractive to low-income rural communities that need a simple method of treatment. This has led to the conditions of wastewater infrastructure in the Black Belt today: incompatible, inefficient, and failing septic tanks and little to no support and guidance for how to move forward.

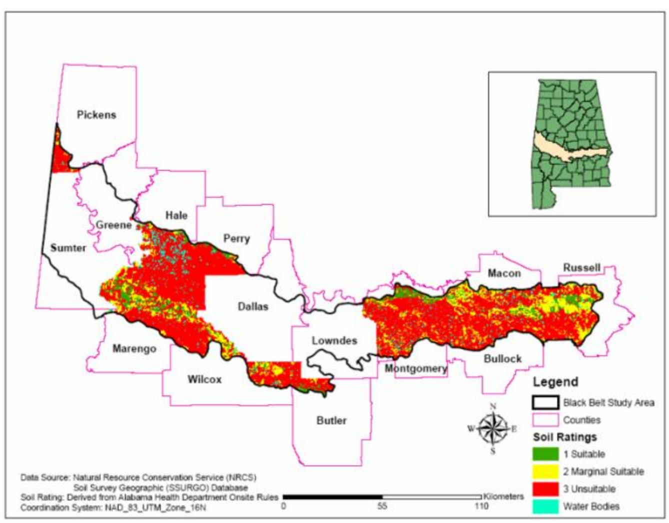


Figure 8. A map of the Alabama Black Belt showing the soil compatibility for on-site conventional septic systems (*He et al., 2006*).

2.3 A Public Health Crisis

Proper wastewater treatment is necessary not only to promote a humane and adequate lifestyle, but also to avoid a public health emergency. Exposure to raw sewage poses an extreme threat to the health and safety of community members due to the high levels of pathogen exposure in the form of viruses, bacteria, protozoa, and helminths (*Meza, 2018)*. Human illnesses such as aseptic meningitis, cholera dysentery, gastroenteritis, hepatitis, anemia, and typhoid fever have all have been attributed to raw sewage exposure (*Tooke*). Helminths are commonly known as soil-transmitted parasitic worms and affect 1.5 billion people worldwide, most commonly in subtropical regions facing extreme poverty, poor sanitation, and exposure of waste through open-defecation (*WHO Soil-transmitted helminth infections, 2015*). Hookworm is one of the most common forms of helminths effecting 406.3-480.2 million individuals worldwide and can be transmitted through skin exposure. Hookworm infection is associated with many severe symptoms such as abdominal pain, fatigue, anemia, and delayed physical and cognitive growth in children (*CDC-About Hookworm, 2020*).

Hookworm was eradicated in the United States in the early 1900's when modern developments in wastewater infrastructure greatly reduced the presence and danger of waterborne pathogens (*United States EPA, 2004*). Testing for third world pathogens such as hookworm was minimally conducted in the U.S. until 2017 when symptoms started appearing among community members in Lowndes County, Alabama. Testing data showed that more than one-third of adults tested in Lowndes County utilizing decentralized systems were infected with Hookworm (*McKenna et al., 2017*). The wastewater conditions in Alabama are not only unsanitary and inhumane—they are life threatening. Homeowners in the Black Belt fear infection from simply walking out of their doors as the parasites make home on the same front lawns where their children play. Short-term illness is rampant in these areas from constant exposure to an array of harmful pathogens, but the long-term effects on physical and cognitive growth in children is a perpetuation of the underserved nature of this area.

The actual number of those suffering from hookworm and other pathogenic infections in this area is highly underreported. Data is limited due to the lack of primary care physician access, testing equipment, and community compliance. Homeowners are also less likely to cooperate when forced to expose the condition of their wastewater infrastructure due to the criminalization laws regarding improper sewage treatment. The lack of quantification of the problem and ability to assess the associated health risks leaves public health officials in the dark of the prevalence of a third world infection in America.

This public health emergency may not be limited to the confines of the Black Belt, as rural communities across the nation suffer from inadequate wastewater systems and the absence of proper health care. It is known that bacterial and viral contamination of surface and groundwaters is often associated with areas of high septic tank presence. A 2001 study of a rural coastal community in Florida found that 81.8% of test stations scattered throughout the region had detectable levels of viral contamination from sewage on surface water and soils (*Lipp, Farrah & Rose, 2001*). A major struggle in the public health battle of decentralized systems is the lack of awareness of its level of severity across the nation. With more studies emerging and tests conducted, there is hope that there will be quantification of the threat wastewater infrastructure failure poses on American lives.

2.4 Environmental and Economic Justice

Historically, septic tanks were the cheapest alternative for decentralized treatment systems and were widely used across various terrains in America. Majority of the systems in rural areas were constructed greater than 50 years ago with initial permits passing less-restrictive regulations which do not comply with current regulatory requirements (*Humphreys & Ramseur, 2021*). Decentralized system owners often face financial hardships and can be burdened with the technical maintenance and costs associated with systems ultimately leading to lack of functionality and system failure. Over the past three years, media attention from local and national news sources such as the Montgomery Advertiser, the New Yorker, and the Washington Post have highlighted the current conditions in Alabama and shed light on "America's Dirty Secret" (*Kaplan, 2020; Gilpin, 2020; Okeowo, 2020*). The exposure of the severity of septic tank system failure rates and effects in Alabama exposed the need for decentralized treatment system regulation and support for this historically marginalized and underserved community.

Financing the permit application requirements and projects to install, repair, or replace wastewater infrastructure can impose extreme financial challenges for low-income rural community members (*Septage Management Administrative Code, 420-3-6*). Majority of the federally approved funding for state and local governments is allocated to publicly owned drinking water and wastewater systems *(Ramseur & Humphreys, 2020*). Rural communities lack economies of scale to develop or connect to centralized systems leading them to be solely responsible for all components of their wastewater treatment security (*WEF Distributed Systems Overview, 2019*). The financial stress placed on rural communities is only heightened as economic development is impeded by the absence of reliable water infrastructure. This means there is little opportunity for internal community development and economic growth, continuing the cycle of poverty in these areas.

Figure 9. A home in the Alabama Black Belt region with a raw sewage pools outside of their front door (Gilpin, 2018)

In many states, failure to comply with state codes for septic tank maintenance is a state offense which can results in the citations, fines, or even time in jail (*Meza, 2018*). In 2002, 37 families were brought to court in Lowndes County because they were using straight pipes to remove their waste after their septic tanks failed in a particularly heavy rain season earlier in the year. Fines were imposed on the families in order to "protect public health" and later that year a woman was arrested and spent three nights in a local jail for the same offense (*McCoy, Cooley & White, 2004*). Examples such as these occur across the country, in which individuals suffering from lack of infrastructure due to financial hardships are fined, placing greater financial stress and continuing the cycle of poverty. The wastewater infrastructure crisis transcends the need for finances and technical experts. It requires systematic change in the environmental justice of rural Americans to support decentralized communities in adequate infrastructure and financial needs without criminalizing them.

"Proper Infrastructure is essential to economic development in Lowndes County… for us this means that Alabama's "Third World" could finally come into the 21st Century"

- **Robert L. Woodson of NCN**

(McCoy, Cooley & White, 2004)

3. Current Legislation and Support

3.1 Historical Policy

Policy regarding American drinking water and wastewater infrastructure has its foundation in the Clean Water Act of 1972, a piece of legislation commonly referred to and amended for years proceeding (*Ramseur et al., 2020*). The growing population, rapidly changing climate, and failing outdated infrastructure has made the need for advancements in legislation of water, sanitation, and hygiene infrastructure a priority. It is notable that majority of introduced legislation prioritizes publicly owned systems with little reference to the regulation or funding provisions for privately owned systems. This is generally due to the miniscule perceived impact of small community or individually funded projects.

There are three pieces of passed and proposed legislation that set the foundation for current and future drinking water and wastewater infrastructure in America:

3.1.1 The Clean Water Act of 1972 (CWA)

The CWA (also known as the Federal Water Pollution Control Act) is the foundation of modern water infrastructure legislation in America. It opened the door for grant funding for drinking water and wastewater infrastructure and established minimum standards for public water treatment. The programs implemented by the CWA are monitored and regulated through the EPA (*United States EPA, 2004*).

Amendments to this act include the Safe Drinking Water Act (SDWA) and the Water Infrastructure Improvements for the Nation Act (WIIN). These amendments introduced programs such as the Clean Water State Rotating Fund (CWSRF), the Drinking Water State Rotating Fund (DWSRF), and the National Pollutant Discharge Elimination System (NPDES) (*United States EPA, 2004; Infrastructure Report Card, 2021*, *Ramseur et al., 2020*).

Many programs contain project requirements that make it difficult for funding to be applied to small scale communities. Project guidelines such as those outlined in the CWSRF and DWSRF force states to use granted funds on large-scale projects with tangible outcomes and short timelines to submit for the annual report (*Ramseur et al., 2020*). These project requirements and limitations for grant approval are public works centric and promote a defer-funds approach for small scale issues found in rural communities. Federal regulation of decentralized systems through the CWA could provide the attention and care that rural water infrastructure is lacking and could be a major driver in transforming the current conditions of decentralized wastewater treatment systems.

3.1.2 Water Resources Reform and Development Act of 2014 (WRRDA)

The WRRDA is a type of water resource development act (WRDA) which functions through authorizing civil works projects from the U.S. Army Corps of Engineers (USACE) (*Carter & Normand, 2020*). This program authorized the Water Infrastructure Finance and Innovation Act (WIFIA) program which is a pilot program to attempt to finance water infrastructure projects through USACE and the EPA. Similar to the programs listed in the CWA, construction projects must meet specified criteria including scale, progress, and environmental impact (*Carter et al., 2014*).

WIFIA is intended to prioritize nationally significant water infrastructure projects to benefit the overall public well-being. The credit assistance program provides low-cost loans for long-term projects to be used by areas in financially unstable situations (*Infrastructure Report Card, 2021*).

3.1.3 Drinking Water and Wastewater Infrastructure Act of 2021 (DWWIA)

The Drinking Water and Wastewater Infrastructure Act of 2021 (DWWIA) is a newly proposed authorization bill aiming to reauthorize and improve programs such as the DWSRF, WIFIA, WIIN, and CWSRF. A positive component of this bill is that it hopes to expand the eligibility and requirements from previous funding programs to include “small, rural, tribal, and disadvantaged communities” (*S.914- 117th Congress, 2021*).

This bill has the opportunity to promote flexible funding usage for projects and assist rural communities in repairing and maintaining their centralized systems. It also groundbreakingly includes Section 208 which prioritizes grants for low-income individual household decentralized wastewater systems (*S.914- 117th Congress, 2021*). The inclusion of this section is a major step in the right direction federally recognition of decentralized systems, but this section is a small portion of the entirety of the Act and may not be prioritized in its implementation.

3.2 Appropriations

A historic challenge faced in the journey for decentralized system improvement is the persistent underfunding of rural community infrastructure and the lack of local, state, or government funding for private system owners. Majority of the acts passed by congress have appropriated funds to assist publicly owned centralized systems such as in the CWA, CWSRF, SDWA, and WIFIA.

These appropriations make a small dent in the EPA's estimated 744 billion dollar need for wastewater and drinking water infrastructure to meet CWA and SDWA objectives (*U.S., EPA, 2021*). Unfortunately, with limited funding obtained by each state for each fiscal year and majority of populations concentrated in urban areas, funding is prioritized in areas that will see the greatest impact (or perceived impact).

Recent developments in awareness of decentralized system needs have created opportunities for appropriations for small and rural communities. Agencies such as the United States Department of Agriculture (USDA), USDA Rural Development (USDA RD), USDA Rural Utility Service (USDA RUS), and Environmental Protection Agency (EPA) have prioritized assistance funding specifically for infrastructure in low-income rural areas. In the fiscal year 2021, Congress appropriated 26.4 million dollars to small and disadvantaged community development (*U.S., EPA, 2021*). Funding assistance programs created under these agencies include the Special Evaluation Assistance for Rural Communities and Households (SEARCH), Rural Economic Area Partnership (REAP), Community Facilities Technical Assistance and Training (TAT) grant program, Sustainable Rural and Small Utility Management Initiative, and Community Development Block Grants (CDBG) (*U.S. USDA RD, 2016*).

Many appropriation programs aim to provide financial assistance for small and rural communities in infrastructure development, but often come with specific application qualifications that can be challenging for rural communities. According to a representative of USDA RD, the application process and requirements for program funding can be a timely obstacle for small communities. Programs tend to fund "good projects" with a foreseeable positive outcome and also tend to require a loan or grant "match" for a specific percentage of the funding to ensure there is "skin in the game" (*Bodey, 2021*). Obstacles such as these often ostracize populations in the greatest need of assistance and can inhibit the actual progress of our nation's wastewater infrastructure.

Funding is an effective method of enacting change to the overall state of the United States wastewater infrastructure and treatment systems. Although physical short-term change can be created through appropriations to repair and replace technology, meaningful long-term change is produced from systematic reformation in the resiliency and regulatory maintenance of systems. Funding attempts to solve the environmental and public health crisis after it has already gone too far, we need federal regulation and standards for local and state governments to follow to prevent the crisis from occurring again.

3.3 Advocacy, Media, and Nonprofits

In times of hardship and injustice, media attention and advocacy can be one of the greatest methods of pressuring systematic change. For the Alabama Black Belt, local media coverage turned to national news stories of the third world living conditions of rural homeowners. Activists such as Catherine Coleman Flowers created a platform and voice to advocate for marginalized rural communities suffering from neglected infrastructure.

"This is not just a southern problem. It's a rural problem, and it's an American problem"
-Catherine Coleman Flowers
(Coleman Flowers, 2020)

Coleman Flowers was born and raised in Lowndes County, Alabama in the heart of the Black Belt Region. Before the publication of her book "Waste: One Woman's Fight Against America's Dirty Secret," she founded the nonprofit Center for Rural Enterprise and Environmental Justice (CREEJ). Local nonprofits are often some of the greatest influencers in local and state level governments as they are usually comprised of constituents and community members who have a deep relationship with the community they are serving. They are able to assist small communities in funding applications and act as financial partners to match grants and loans from federal programs.

The EPA also provided a list of national organizations and institutions that can act as resources for rural wastewater treatment systems. This list includes programs such as the American Water Works Association (AWWA), National Rural Water Association (NRWA), the New England Water Environment Association (NEWEA), and the Water Environment Federation (WEF) (*Resources for Small and Rural Wastewater Systems*,). These organizations tend to work on larger scopes of advocacy and provide technical expertise on technologies and rural community development rather than addressing specific community issues.

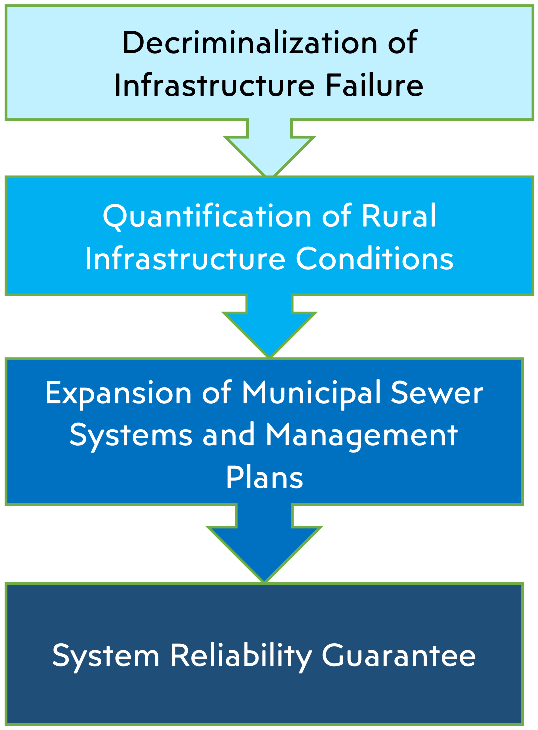
Nonprofit organizations overall, are vital to solving the national wastewater issue as they develop personal connections based on genuine intentions to solve the problem at hand. Nonprofit partnerships are great resources for underserved communities, but they should not be the only support mechanism for populations in need.

4. Policy Alternatives and Recommendations

This extensive and exhaustive issue of rehabilitating and maintaining the integrity of the United States decentralized wastewater infrastructure requires reform and collaboration across various disciplines. The most direct and effective way of achieving this is through a proposed appropriations act as an amendment to the Clean Water Act and as a companion bill to the Decentralized Wastewater Grant Act (*H.R. 3745, 117th Congress, 2021*). The sponsor of H.R. 3745 is Representative Terri Sewell (D-AL) whose district encompasses the Alabama Black Belt Region. Currently, the legislation maintains bipartisan support with cosponsor Representative Brian Babin (R-TX) and collaboration with U.S. Senator Corey Booker (D-NJ). The proposed route of this legislation within Congress is through the House Committee of Transportation and Infrastructure and the Senate Committee of the Environment and Public Works.

The current goal of the Decentralized Wastewater Grant Act is to increase the affordability of decentralized wastewater systems and expand smaller community systems. Through an observation of the characteristics of this bill and its support, it is noted that there is one cosponsor, no date to be taken up by committee, few public statements, no support from appropriations, and an overall lack of action at this point (*H.R. 3745, 117th Congress, 2021*)

In order for this national issue to be solved effectively and efficiently, there must be further action and prioritization taken on this topic. My proposed piece of legislation is a companion appropriations bill to H.R. 3745 in the Senate to provide further opportunity for funding and to show priority in the need for affirmative action. A potential cosponsor for this bill could be Senator Leahy (D-VT) who is on the Senate Appropriations Committee and has expressed his support of rural water and wastewater infrastructure projects (*Office of U.S. Senator Leahy of Vermont, 2021*). The recommended legislation in this report will provide funds to expand the responsibility of the Decentralized Wastewater Grant Act and will work to achieve four primary objectives:



Meeting these objectives will provide tangible solutions to see long-term improvements in rural communities in need. The recommended legislation intends to use funding from the EPA to fund on the ground assessments and visits to communities to provide a greater scope of the extent of the issue at hand. It also proposes the creation of a coalition task force of USDA RD, EPA, and technical experts to facilitate each step of the repair and maintenance of the decentralized wastewater treatment systems in the identified communities.

4.1 Decriminalization of Infrastructure Failure

A major inhibitor in the ability for advancement and reform in the nation's decentralized wastewater crisis is the criminalization of failed systems by State Departments of Public Health. A first step that needs to be taken in order to effectively solve the nation's wastewater issue is the decriminalization of the failure of private decentralized systems. The current legal enforcement methods for decentralized system operations are managed by state codes. The corrective action programs for uncontrolled sewage treatment can consist of violation notices, fines, and even civil and criminal offenses (*Frederick, Kreissl & Goo, 2002*).

According to the EPA's recommendations on corrective actions and enforcements for decentralized systems, "Emphasis should be placed on those tools that encourage compliance, rather than punishment" (*U.S. EPA, 2005*). In many states, monetary penalties are imposed on homeowners who do not meet their state's wastewater treatment standards. Punitive methods of corrective actions such as fining and criminal offensive measures are ineffective because (1) the funds used to pay the fine could be used to repair the flawed system, (2) fining impoverished communities perpetuates rural poverty, (3) the criminalization of failed systems is an inhibitor for communities or households to seek assistance or honestly answer surveys on their system conditions (*McCoy et al., 2004*).

In 2018, Alabama Representative Terri Sewell approached the Alabama Department of Public Health requesting the termination of citation writing for individuals in Alabama with failing sewage treatment systems (*Nuttall, 2021*). Representative Sewell's success in implementing a provisional moratorium was the first step in Alabama's trajectory to solve their state's sewage problem. Following this decriminalization, Representative Sewell's office noted that there was an increase in calls and reports of failing or inadequate decentralized systems across the region as individuals finally are able to reach out for help without the fear of punishment (*Nuttall, 2021*). Representative Sewell stated, "In order for us to solve the problem, we have to identify the scale of the problem" (*Brown, 2018*).

"It's not just Lowndes County. It's rural America. Even in Alabama, the problems are not just in the Black Belt. We can't fine people. We need to help them"

-Representative Terri Sewell (D-AL)

(*Brown, 2018*)

The success in the decriminalization of failed decentralized infrastructure in Alabama is a promising first step in the state's course for systematic remediation. The recommended legislation suggests the removal of the criminalization of failed or inadequate systems to the national level and to require states to remove the penalty process in corrective actions. The removal of counterproductive penalties is the first step necessary to actively quantify the scope of the nation's issue and prioritize solving it, not defer it to a later pay.

4.2 Quantification of Rural Infrastructure Conditions

The next step in understanding the scope of the nation's decentralized wastewater infrastructure crisis is to physically quantify the number of individuals living with unsatisfactory or failing systems. Due to the private ownership of decentralized systems, there is usually very little intervention by responsible governments on system types, conditions, and lifespans (*Elliot, 2021*). It is suspected that many government officials across the nation are unaware that there exist communities in their regions suffering from inadequate infrastructure, as the major inhibitors such as financing and criminalization have deterred communities from reporting (*Nuttall, 2021).*

In efforts to better understand the extent of the national crisis, on the ground data collection must be conducted in rural areas with home-to-home surveying and support. Some challenges faced by quantification efforts in the past consisted of absence of compliance, difficulty accessing homes, or private property restrictions. Specifically in the Black Belt, there are plots of land that contain multiple dwellings that utilize small and unofficial cluster systems that are unsuited for the flow-intake of multiple homes. These situations can pose challenges to quantification as there are very few guidelines or specifications on how to physically quantify decentralized treatment systems (*Nutall, 2021).*

The USDA RD Department uniquely contains local offices in each of the 50 states in which they make solid connections with state and local governments, local nonprofits, and community members (*Bodey, 2021*). The USDA RD has great potential to champion the quantification of rural infrastructure conditions and assess the sewage treatment systems in their state. The recommended legislation proposes the assembly of a task force within each USDA RD state office to travel and report the observed conditions of decentralized waste treatment systems. The USDA RD national program would develop standards and condition guidelines for assessment to actively quantify the scope of the issue on a national level. The administrative funds allocated through the appropriation of the new legislation would be used to fund the creation and implementation of these teams. Each task force would consist of technical experts, government officials, and local non-profit organization leaders to work with Local Water Boards to encourage compliance and trust among community members to report their current infrastructure conditions.

This component of the recommended legislation is vital to fix the issue of decentralized wastewater infrastructure on a national level. With the current lack of knowledge or awareness of the severity of the situations, funds are unable to be properly allocated. In order for the quantitation and understanding of the national crisis to be successful, it must follow the decriminalization of individuals suffering from infrastructure failure. The quantification is almost directly based on the public's cooperation in the physical assessment of their systems. In the absence of trust as noted in previously attempted studies, it could be extremely difficult to obtain numbers to understand the scope of the problem and create meaningful change in the system.

4.3 Expansion of Community Sewer System and Management Plans

Although decentralized wastewater treatment systems are a key part of our nation's infrastructure, the lack of affordable and reliable technology for rural communities makes decentralized systems a financial and public health risk. A key method to providing opportunities for adequate infrastructure is through the encouragement of community systems, either through the expansion of centralized sewer systems or the creation of cluster decentralized systems. The utilization of managed multiple dwelling sewer systems has the ability to provide financial relief to homeowners and create a larger income flow for system operators (*White, 2021*).

This recommended legislation proposes the requirement of wastewater utility expansion to all existing drinking water utilities and to dwellings in a specified range determined by technical professionals in the area. In Lowndes County 92% of homeowners are on centralized drinking water utility (not served by a private well), whereas only 21.8% of households are served by municipal wastewater systems (*Meza, 2018*). The development of centralized wastewater utility is much easier to create if a drinking water utility is already established (*Buchanan, 2021*). Following the quantification portion of the recommended legislation, USDA RD will be able to identify the communities in need and the potential for development in rural areas. Since the expansions will be public works projects funding can be generated through the grant and loan systems provided by the USDA RD and the State Revolving Funds provided by the DWSRF and CWSRF under the CWA.

An alternative method to develop treatment systems to serve multiple homeowners is the creation of voluntary consensus standards for cluster system technologies. Wastewater technologies would benefit from standards development on cluster treatment technology implementation regarding flow capacities, allowable home density utilizing the system, and environmental and climate conditions. A possible home for this standard could be in ASTM International committees D19 on Water or D34 on Waste Management. Cluster systems provide a centralized management impression while not needing to be near a municipal treatment plant. Cluster systems propose major benefits to participating homeowners as the shared technology costs decrease the overall financial obligation and the management of a RME allows for sustained maintenance (*White, 2021*). This development can be funded through the potential grant program established in the DWWIA as well as funding from the appropriations of the proposed legislation.

4.4 System Reliability Guarantees

The final component to generate lasting and meaningful systematic change in the nations wastewater infrastructure is mandating and regulating continuous maintenance and upkeep of systems from technical professionals. Funding and implementing projects to fix wastewater systems are only half of the battle faced by legislation. Systems need sustained maintenance and care to promote reliability and ensure that system failure is not a reoccurring cycle. The EPA promotes sustained management of systems, but majority of homeowners are uneducated on how to properly maintain their system to supplement its efficiency and soundness (*United States EPA, 2004*). The recommended legislation proposes a "guarantee requirement" that obligates engineering firms and RME's that administer decentralized systems to conduct routine maintenance and upkeep throughout the technology's expected lifespan.

A system reliability guarantee changes the face of the stakeholders in decentralized systems and an increase in stakeholder involvement generally stresses the need for performance compliance (*Frederick, Kreissl & Goo, 2002*). This component of the recommended legislation would create an incentive program for cooperating engineering firms implementing decentralized wastewater treatment systems utilizing further funding from the appropriations act. This program would create a special certification for cooperating firms under USDA RD (a certification that could be of benefit in the bidding for various government projects) and opportunity for financial subsidies. A model program that contains similar incentives for stakeholders is OSHA's Voluntary Protection Programs (VPP). The VPP creates cooperative relationships with industries that comply with OSHA's specified safety standards to recognize and reward through special certifications (*United States Department of Labor OSHA, 2020*). A similar program could be implemented between the EPA and engineering firms/technical experts for financial incentive and favorable treatment in exchange for agreement to conduct system lifespan guarantees.

The requirements for the technical experts (firms) would be to complete routine checkup and maintenance of system performability included in the initial installation pay (or paid for through government subsidies). This routine maintenance will guarantee that decentralized system infrastructure is not only repaired but is reliable. Previous times of homeowners performing informal work on systems without knowledge of technical components could be eliminated. Proper upkeep will will be an investment to certify that the costly public health and infrastructure crisis exceeding 744 billion dollars will not only be reconstructed but will be prevented from occurring again.

5. Final Notes: The Need for Immediate Action

Wastewater security is a human right denied to millions of Americans across the country who are facing third world living conditions due to the inadequate infrastructure, lack of advocacy, and neglect from federal legislation. In a situation that is so heavily intertwined in public health, environmental justice, and human rights, there is no better time to act than now. Decentralized wastewater treatment systems are foundational to the integrity of our nation's water infrastructure and need to be seen as a priority in current and future legislation. If immediate action is not taken on this national crisis, the number of Americans living without proper sanitation and hygiene in a first world country in the twenty-first century will only continue to grow. No person of any race, social class, or geographic location should be stepping over ponds of sewage outside of their own homes, fearful of pathogenic infection from simply being in their front yards.

The recommended legislation in this report prioritizes a human-centric approach to solving the nation's wastewater infrastructure crisis. The first two components of the legislation are focused on understanding the scope of the issue on a national level. First, the regulation of the decriminalization of uncontrolled sewage to encourage community compliance and show solidarity between public policy officials and communities in need. Second, an accurate and intensive quantification of the severity of the issue across the nation in order to assess the funding and resources necessary to construct tangible and effective change. Together, these objectives form the first stage of the legislation which acts to acknowledge the marginalized communities in need and determine the most practical methods to develop suitable infrastructure. The information gathered from these sections of legislation will also help to identify communities and projects that are eligible for existing funds from grant programs and loans.

The next phase for the recommended legislation provides the innovation necessary to physically repair failed systems and prevent this crisis from reoccurring. Current legislative approaches to solving this problem focus on the short-term solutions created through financial compensation. The only way to effectively solve this issue is through long-term preventative measures. This can be achieved through the third and fourth components of the recommended legislation: the expansion of centralized systems and the implementation of a system reliability guarantee. These methods promote the continuous maintenance of systems, whether that be through a municipal utility, a RME, or a private engineering firm. Sustained upkeep of systems is pivotal to the success of decentralized systems and overall wastewater infrastructure functionality. Until legislative solutions prioritize the long-term success of wastewater infrastructure, we will continue to face these obstacles time and time again expecting a different outcome.

Public policy has the potential to create impactful change to better the lives of marginalized and decentralized communities. This can be achieved through proper regulation, management, and advocacy for rural populations across the country suffering from insufficient wastewater infrastructure. Legislative action must be taken to support rural Americans and to rebuild and preserve the United States wastewater infrastructure together.

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