PERFORMANCE AND RELIABILITY OF DECENTRALIZED WASTEWATER INFRASTRUCTURE

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ABSTRACT

Review of available information in Minnesota, Iowa, and Indiana indicates that these states (and by extension, the rest of the Midwestern region of the U.S.) have approximately 700 unsewered communities per state. These communities tend to be small, poor, and have limited experience in governance (most are unincorporated). Decentralized wastewater technologies are often perceived as the most cost-effective means to deal with the environmental problems arising from straight-pipe discharges. However, the track record of decentralized systems in the state of Minnesota indicates that operation & maintenance is a critical component of effective system performance. At the present time, compliance rates for decentralized systems are significantly lower for public systems vs. privately-owned systems. A number of factors appear to influence compliance rates; the most significant of which is the decision to hire qualified contract operators. Lessons learned from the U.S. model can be beneficially applied to small community wastewater needs throughout Spain and Portugal

Key Words:
Unsewered community; straight-pipe; decentralized wastewater; O&M; constructed wetlands

INTRODUCTION

Even in relatively developed countries like the United States, there is a strong need for decentralized wastewater infrastructure. While the conventional "Big Pipe" infrastructure model is essentially built out, significant infrastructure gaps remain. As an example the state of Minnesota has 786 municipal treatment systems serving approximately 80% of the population; however 679 unsewered communities remain.

Although decentralized systems are the most effective solution for the small and scattered communities that lack wastewater treatment, the perceived lack of reliability and treatment effectiveness of decentralized systems is a major impediment to adoption of decentralized infrastructure. Conventional "big pipe" infrastructure has redundancy requirements that are codified in the "Ten State Standards" and similar U.S. design documents, and the municipalities that own these

systems have the institutional capacity to operate the systems in perpetuity, creating a culture that favours reliability and operations over initial capital cost.

In the decentralized field, reliability standards are typically set by the equipment manufacturer, and there is a strong emphasis on vendor designs. Systems are then provided to communities that have no track record in owning or operating infrastructure. The result is a tendency to produce high-risk, low redundancy systems that have the lowest initial capital cost.

Redundancy, reliability, and treatment performance are closely related. Designs that provide greater redundancy allow for more reliable and stable treatment performance, with more room for operator error. For instance, the reliability of constructed wetlands increases from 50% to 90% when the size of the wetland increases by a factor of 2.3.

Due to their small size, flows and loads are not attenuated in decentralized systems. As a result, designers must take into account redundancy at both the organic loading and hydraulic levels. High organic loads from illegal discharges will quickly lead to overloading and failure of small treatment systems. Facilities such as waste stabilization ponds gain reliability due to their long (180-day) retention times. If used properly, soil dispersal systems represent a redundant treatment reactor for most pollutants other than nitrate.

RESULTS AND DISCUSSION

As part of a recent study on behalf of the Iowa Policy Project (Wallace *et al.*, 2005), we had the opportunity to examine the prevalence of unsewered communities in the northern Midwest region of the United States. Analysis of available information indicates that there are a variety of common threads among the situation in these states. The prevalence of unsewered communities is surprisingly consistent, with 677 unsewered communities in Indiana, 679 in Minnesota, and 739 in Iowa (Minnesota Pollution Control Agency, 1999; Indiana State Department of Health and Rural Community Assistance Program, 2003; Iowa Department of Natural Resources, 2005).

In the United States, the wastewater infrastructure needs of small rural communities was not addressed during the construction grant era following passage of the Clean Water Act in 1972, mainly because they were too small for conventional approaches (e.g. mechanical treatment works or pond systems) to be implemented cost-effectively. As a result, small rural communities rely on aging individual septic systems or drainage networks that discharge sewage directly to surface waters. Although direct discharge of untreated sewage is illegal, the practice continues throughout the United States. Factors common to unsewered communities in the Midwest include size, financial situation, and lack of governance.

- **Community size.** Unsewered communities are small. Indiana estimates that 88% of their unsewered communities have 200 homes or fewer, 78% have 100 homes or fewer, and 51%

have fewer than 50 homes (Indiana State Department of Health and Rural Community Assistance Program, 2003). This closely resembles the situation in Iowa, where incorporated communities without sewer average 64 homes (with 90% of these homes lacking wastewater treatment) and unincorporated communities average just 30 homes (of which 80% lack basic treatment). Some regulators use the term "micro community" to more clearly express the very small size of these communities.

- **Financial situation.** Unsewered communities are poor. For instance, in Indiana, 90% of residents in unsewered communities earn a low-to-moderate income, and over 48% of those residents qualify as "low-income" (Indiana State Department of Health and Rural Community Assistance Program, 2003). Wastewater infrastructure can be expensive relative to the financial means of the community. In order to finance wastewater infrastructure, communities need to be able to make effective use of available grant and loan programs.
- **Lack of governance.** Small communities generally have limited or no experience with self-governance. Typically, issues such as funding, taxes, and road repairs are dealt with by larger units of government at the Town or County level. As a result, these communities often have no history of financing, owning, and managing infrastructure, which makes it difficult for them to organize and effectively implement projects. This is especially true for unincorporated communities, which comprise a significant majority of unsewered communities in the Midwest.

Developing sustainable decentralized infrastructure requires clear adoption of a policy strategy. Either the "lowest common denominator" or "educate and organize" strategy can be employed. The lowest common denominator makes operation and maintenance the primary driver of infrastructure selection, not cost effectiveness. Simply put, infrastructure is matched to the institutional capacity of the community, regardless of cost. The "educate and organize" strategy seeks to adopt the most cost-effective infrastructure, and then increase the institutional capacity of the community through education and training to effectively operate the system.

At the present time, neither of the policies were formally adopted by regulatory, funding, and educational agencies. The current status quo is an artefact of the construction grants era, and can best be characterized as the "build it and walk away" approach. This approach was adequate for developing "big pipe" infrastructure, but is not appropriate for small unincorporated communities that make up the majority of the wastewater need in the United States.

CONCLUSION

Creating sustainable wastewater infrastructure at the decentralized scale will require improvements in how systems are designed, operated, owned, and managed. This in turn will require

institutional changes in system regulation, education and training programs, and the allocation of financial assistance. Lessons learned from the US model can be beneficially applied to small community wastewater needs throughout Spain and Portugal where a higher proportion of communities have unsewered domestic sewage disposal.

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Author Biographies

Scott Wallace is President of Naturally Wallace Consulting, a leading design firm for decentralized infrastructure. Mr. Wallace has designed over 200 wastewater systems, and is a registered professional engineer in 19 states. He has authored numerous technical publications, including Treatment Wetlands, Second Edition, and Small-Scale Constructed Wetland Treatment Systems.

David Cooper is Director of ARMIberica Medioambiental and Chairman of ARM Ltd, the leading firm involved in the design and construction of wetland treatment systems in the United Kingdom. David is currently engaged in the upgrade and refurbishment of the wetland treatment system at Heathrow Airport, and consults on a wide variety of small-scale wastewater treatment systems in the UK.