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Unsewered Communities: *Are alternative treatment technologies the solution?*

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As part of a recent study on behalf of the Iowa Policy Project, we had the opportunity to examine the prevalence of unsewered communities in the upper Midwest. 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, 2005c).

Unsewered Communities

Small, rural communities with declining populations essentially "fell through the cracks" 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 drain tile networks that discharge sewage directly to surface waters. Although direct discharge of untreated sewage is illegal, the practice continues in many 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 at the Town or County level. As a result, these communities often have no track record 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 (Table 1).

Table 1. Unsewered, unincorporated communities in Illinois, Iowa, and Minnesota.

State	Number of Unsewered Communities	Percentage that are Unincorporated
Indiana	677	76%
Iowa	739	81%
Minnesota	679	74%

Source: Minnesota Pollution Control Agency, 1999; Indiana State Department of Health and Rural Community Assistance Program, 2003, Iowa Department of Natural Resources, 2005c.

Environmental Impacts of Straight-Pipe Discharges

Straight-pipe discharge of untreated sewage poses a serious potential threat to human health and is leading to the contamination and degradation of rivers, lakes, and streams. Untreated sewage contains high levels of organic material, nutrients, bacteria, and pathogenic organisms. Discharge of untreated sewage results in overabundant of algae blooms, the spread of disease-causing organisms (pathogens), and impairment of our surface waters. The 2002 National Water Quality Inventory (U.S.EPA, 2002) reports that swimming is impaired in a high percentage of Midwestern waters that were assessed for this use, as shown in Table 2. One of the primary causes for impairment of these waters is bacterial contamination. While agricultural sources contribute to the overall problem, inadequately treated sewage plays a significant role, especially in streams with low or intermittent base flows.

Table 2. Swimming Use Impairment in Midwestern States.

State	Rivers and Streams		Lakes	
	Total Miles Assessed	**Percent Impaired**	**Total Miles Assessed**	**Percent Impaired**
Illinois	2,944	75%	152,628	86%
Indiana	17,541	38%	n/a	n/a
Iowa	836	52%	22,924	25%
Minnesota	6,584	74%	2,591,796	32%
Wisconsin	n/a	n/a	105,923	84%

Source: U.S. EPA, 2002 n/a = not assessed

Cost to Fix the Unsewered Problem

The cost of providing wastewater infrastructure to unsewered communities represents a significant financial challenge to Midwestern states. In Iowa, it is estimated there are over 100,000 polluting septic systems (Iowa Department of Natural Resources, 2005b). The estimated cost to address the needs of unsewered communities is between $214 and $322 million and the cost to fix and upgrade existing treatment facilities is expected to be upwards of $956 million (Iowa Department of Natural Resources, 2005a).

In Minnesota, there is an estimated 64,000 septic systems that pose an imminent threat to public health (Minnesota Pollution Control Agency, 2004). The Minnesota Pollution Control Agency estimates that it will cost Minnesota $1.2 billion to fix all of the septic problems in the state, and $3.4 billion to address all of its sewer and wastewater treatment plant needs (Minnesota Pollution Control Agency, 2004).

These financial requirements are much greater than the appropriations states are making for wastewater infrastructure. As a result, only a small percentage of the unsewered communities receive grant or loan funds in any given year. Decentralized wastewater management has been perceived as a means to provide more cost-effective wastewater service to small communities (U.S.EPA, 1997). Constructing cost-effective wastewater systems allows grant and loan funds to go further, with the net result of more treatment systems being built.

Infrastructure Options

The concept of decentralized wastewater management arises from the realization that large-scale treatment works cannot be cost-effectively scaled down for low-density or poor communities. There are four basic models of wastewater infrastructure, based on population density (Table 3).

Table 3. Wastewater Infrastructure Models.

Population Density	Wastewater Infrastructure Model	Technology Option	O&M Requirement
Lowest	Single-Home	Septic System	No central management.
↓	Cluster Model	Alternative System	Regular (e.g. monthly) O&M by a trained part-time operator.
↓	Pond Model	Stabilization Pond	Periodic (e.g. semiannual) O&M by a part-time operator.
Highest	Regionalization	Conventional Treatment Plant	Continuous (e.g. daily) O&M by a full-time operator.

A very important, but often overlooked, component of decentralized wastewater management is operations and maintenance (O&M). There are distinct O&M requirements associated with each wastewater infrastructure/technology option, as listed in Table 3. Effective wastewater management ultimately hinges on the community's ability to provide the appropriate level of O&M for their treatment system. The technology and O&M requirements in Table 3 are not interchangeable across infrastructure models.

The Single-Home model is generally not an option for small, unsewered communities due to lack of suitable soils and/or very small lot sizes. (If compliant onsite systems could readily be constructed, the straight-pipe problem wouldn't exist). In most cases, rural communities are not close enough in proximity to another community to make regionalization a cost-effective option. As a result, the two most common infrastructure models utilized by unsewered communities in the Midwest are the Cluster Model and the Pond Model.

Differences between the Pond and Cluster Models

Pond systems are very common in the upper Midwest. In Iowa, 73% of Iowa's 739 municipal treatment systems and 49% of Minnesota's 786 municipal treatment systems utilize ponds (Iowa Association of Municipal Utilities, 2002; Ballavance, 2006). The problem with the pond model is that it does not scale down well for small populations. Stabilization pond technology requires a large land area, the setback requirements are significant, and locating and purchasing suitable property is often a challenge. However, due to their simplicity, pond systems are popular in the consulting engineering community and considerable effort has been expended over the last 30 years to construct pond systems. In the Midwest, this means that if a pond could be cost-effectively constructed, that system likely has already been built. The result is a self-selection process, the unsewered communities that exist today are unsewered, in part, because a pond system could not be constructed cost-effectively.

Pond systems are low maintenance, and generally require O&M visits by a wastewater operator only twice a year. However, pond systems are not particularly effective at removing ammonia-nitrogen or phosphorus, and often have high concentrations of algae in their discharge effluent. They typically discharge effluent twice a year during periods of high stream flow, when there is adequate dilution capacity in the receiving stream. The presumption of high dilution capacity in the receiving stream means that ponds have less stringent treatment standards than continuous surface water discharges.

Communities are being guided to build wastewater systems under the Cluster Model because alternative technologies can offer considerable advantages over stabilization pond systems. Alternative technologies such as recirculating filters, attached-growth filters, and constructed wetlands typically require far less land area than the conventional (pond) technology, which results in significant upfront cost savings for the community (Wallace *et al*., 2005). In addition to this, many alternative technologies are capable of meeting stringent effluent discharge standards year-round, especially when combined with soil infiltration.

However, the alternative technologies used in the Cluster Model typically require more frequent O&M visits than pond systems. Whereas a pond system may only require O&M twice a year, most cluster systems will require O&M checks every two to four weeks. While the O&M associated with a cluster system may not be particularly onerous, cluster systems require a higher level of commitment to keep them running well.

The Cluster Model arose out of a need that could not be met by any of the pre-existing infrastructure models. While cost-effective technologies have been developed to fill the "technology gap" between the Single-Home and Pond models, the "O&M gap" hurdle has, in many cases, not been effectively addressed. Many communities that build treatment systems under the Cluster Model perceive that alternative technologies should have O&M requirements similar to pond systems (e.g. O&M visits twice a year) – anything else is deemed as "high maintenance". While most decentralized wastewater practitioners would accept one or two visits a month to a site as a reasonable amount of O&M, this acceptance does not necessarily extend to small unsewered communities. In Minnesota, misperceptions about the O&M requirements of alternative technologies are leading to a backlash against decentralized wastewater systems in the public sector.

Is the Problem Technology or O&M?

To shed some light on the issue, we compared the compliance rate of 74 alternative wastewater treatment facilities (cluster systems) in Minnesota to that of small National Pollutant Discharge Elimination System (NPDES) point-source facilities in the state. The alternative systems were designed by several engineering companies and operated by a number of different operators. The results indicate there is a correlation between system ownership (public or private) and system performance, as shown in Table 4.

Table 4. Performance of Wastewater Treatment Facilities in Minnesota during 2005.

System Type	Number of Systems Surveyed	Percentage of Facilities in Significant Compliance[1, 2]
Small NPDES point-source facilities	State-wide	90%
Alternative (privately owned)	64	95%
Alternative (publicly owned)	10	70%

[1]For a NPDES point-source wastewater facility, "significant compliance" is defined by the Minnesota Pollution Control Agency as not exceeding effluent pollutant limits more than twice in a 6-month period.

[2]For an alternative wastewater treatment facility, "significant compliance" was defined by the authors as not exceeding effluent pollutant limits more than twice in a 12-month period.

At 95%, the compliance rate for privately-owned alternative wastewater facilities is slightly better than small NPDES point-source facilities in Minnesota, which is 90% (Minnesota Pollution Control Agency, 2006). In contrast, publicly-owned alternative wastewater facilities report more effluent violations and O&M problems than their privately-owned counterparts, with only 70% of assessed systems achieving significant compliance during 2005. The difference in the number of private versus public systems surveyed is representative of the more prevalent use of alternative wastewater systems in the private sector.

If compliance was an inherent problem with alternative wastewater technologies, compliance rates should be about the same between public and privately owned systems. The fact that alternative systems are performing quite well in the private sector indicates that alternative wastewater systems do, in fact, work. The lower compliance rate with publicly-owned systems seems to be an indication that small communities are struggling with the O&M issue.

O&M of wastewater systems can be approached in a variety of formats. The U.S. Environmental Protection Agency has developed voluntary guidelines for the management of decentralized wastewater systems (U.S.EPA, 2003). These guidelines are summarized in Table 5:

Table 5. Voluntary National Guidelines for Management of Decentralized Wastewater Systems

Management Model	Description
Model 1 – Homeowner Awareness	Systems owned and operated by individual property owners
Model 2 – Maintenance Contracts	Property owners contract with service providers to perform O&M
Model 3 – Operating Permits	Permit issued by regulatory agency to property owners; regular monitoring and reporting completed by service provider
Model 4 – RME Operation and Maintenance	Permit issued to a Responsible Management entity (RME), who is responsible for O&M and permit compliance
Model 5 – RME Ownership	System is owned by RME, who is responsible for all aspects of system management.

Source: U.S. EPA, 2003

Existing regulatory programs at the County and State level for cluster wastewater systems generally operate at the Model 3 – Operating Permit level. The assumption behind existing wastewater permit programs is that by issuing a permit to the system owner, the owner will take the necessary steps to maintain the system and comply with the permit. This "build it and walk away" approach is an artifact of the 1972 Clean Water Act construction grants era. Back then, the cities that received funds for wastewater treatment had the institutional capacity to own and manage wastewater infrastructure, so a regulatory program based on operating permits was sufficient to ensure system performance.In many instances, the Model 3 – Operating Permit approach is not working for today's unsewered communities. Simply put, these communities do not have the institutional capacity to manage the wastewater infrastructure being provided to them.

The discrepancy in compliance rates between private and public alternative (cluster) systems depends on perception, accountability, and management capability. Private stakeholders such as residential developers, Homeowners Associations, businesses and resorts build treatment systems with money from private resources. These owners have a vested interest in the long-term management of their treatment system (after all, it's their money on the line!). Because they view their treatment system as an asset and want to protect it, private owners are much more likely to seek out contract services from an experienced O&M provider.

Publicly-owned systems, on the other hand, are financed through public grant and loan programs. These projects often do not receive support by local residents because the perceived monthly cost per home for sewer service is too high (after all, the straight pipe was free). In many states, public grant and loan dollars can be used for capital expenditures (e.g. construction of a new wastewater system), but not for system maintenance. The community is given a wastewater treatment system that they do not have the institutional capacity to maintain, and as a result, the system develops problems and ends up being classified as a "failure".

In order to ensure positive project outcomes, both the infrastructure and the need for institutional capacity must match the capability of the small community. In this regard, regulatory programs that incorporate RMEs (management Models 4 and 5 in Table 5) are probably a better approach for small unsewered communities. However, at the present time, most State and Federal grant and loan programs are focused on delivering infrastructure, not institutional capacity. Since RMEs are currently not available in many rural areas, what are the options for delivering infrastructure and O&M?

"Lowest Common Denominator" vs. "Educate & Organize"

There are two ways to ameliorate the disparity between the management capacity of small, unsewered communities and the O&M needs of the alternative wastewater facilities that will most cost-effectively serve them. The first option is the "Lowest Common Denominator" approach – provide communities with treatment systems they can operate, regardless of cost. The second option is the "Educate & Organize" approach – increase the institutional capacity of unsewered communities through education and responsible management entities so that they can build cost-effective treatment systems.

Under the Lowest Common Denominator approach, the goal is to select wastewater infrastructure based on the existing O&M capabilities and institutional capacity of the community. Cost-effectiveness is not the basis for system selection. Reviewing the infrastructure models presented in Table 3, this approach would limit technology selection to single-home septic systems or pond systems. Because many unsewered communities, by definition, cannot install compliant septic systems, ponds are the dominant technology that will be constructed under the Lowest Common Denominator approach.

Lowest Common Denominator technologies do not require O&M by an experienced service provider and can operate for long periods of time between maintenance visits. The upside to this approach is that these technologies are within the management capacity of an unsewered community. The downside, however, is that single-home septic systems and pond systems are likely not to be the most cost-effective technology choice. This will increase the capital cost of treatment systems. Since financial resources are finite, this will result in the construction of fewer treatment facilities in the long run. With the need for treatment facilities far exceeding available funding, unsewered communities will continue to pollute as they are put on long-term waiting lists for financial assistance. Thus, there is an externalized cost to public health and the environment.

The second option is the Educate & Organize approach. This approach focuses on increasing the management capacity of small communities through education and implementation of Responsible Management Entities (RMEs). There are many management entity options, including incorporated cities, rural water districts, public or private utilities, and environmental subordinate service districts. The advantage to the Educate & Organize approach is that it lays the foundation for effective, long-term wastewater system management. This approach utilizes the most cost-effective infrastructure option available and results in a positive outcome for both the community and the environment. The downside to this approach is that it requires a substantial investment in community outreach and education, as well as assistance in RME formation.

Implementing the Educate & Organize Approach

Given that financial resources are finite, there is a strong incentive to implement the Educate & Organize approach. This represents a distinct move away from the "build it and walk away" approach left over from the constructions grants era. Communities that have successfully implemented the Educate & Organize approach are extremely useful case studies and serve as examples to other unsewered communities. Three case studies using different RME approaches and alternative wastewater technologies are presented here.

Greenville, Iowa

The City of Greenville, Iowa is a community of 43 homes and two businesses. The city was being served by individual septic systems, the majority of which did not meet code requirements. As a result, untreated sewage was entering a local receiving stream.

Iowa has an extensive network of Rural Water Districts (RWDs), especially in the western part of the state (Iowa Rural Water, 2005). RWDs are ideal Responsible Management Entities because they have the capability to bond, and receive state and federal grant and loan dollars. They are knowledgeable about life-cycle asset management because they have experience in constructing and operating wastewater systems. Additionally, because RWDs operate as an independent utility (water and sewer) provider, they can provide services across municipal and county borders.

Funding for the system was provided by USDA Rural Development, the Iowa Department of Economic Development, and the City of Greenville. The funding recipient was Clay Regional Water, who constructed the system, owns the system, and is responsible for O&M. The system consists of small-diameter gravity sewer, a subsurface flow constructed wetland system, and a surface water discharge.

Credit River Township, Minnesota

Credit River Township is located in Scott County, a rapidly-developing area near the Twin Cities that does not have access to regional sewer. Scott County has required townships to meet growth patterns in accordance with the County's comprehensive plan, and density bonuses are given if developments use cluster treatment systems instead of individual septic systems.

In Scott County, cluster systems must be owned and managed by the Township through an Environmental Subordinate Service District (ESSD). ESSDs have become popular in Minnesota because they do not create another layer of government and services are paid for only by those who use them (Olson *et al*., 2002).

Credit River Township elected to develop using the cluster system model and currently has five ESSDs within the Township. Through the ESSD, Credit River Township is responsible for technical reviews, ensuring O&M is completed, system management, billing residents for use of the system, and ensuring that adequate funds are set aside for future replacement of treatment components. Some services, such as O&M, are contracted out to private-sector companies. The cluster systems constructed in Credit River Township utilize septic tank effluent pump (STEP) collection systems, recirculating sand and textile filter treatment components, and use mound systems for effluent disposal.

Lake Allie, Minnesota

The western shore of Lake Allie is an unincorporated area in Renville County, Minnesota. Due to very poor soil conditions and small lot sizes, many residents along the lake had non-compliant septic systems and no available backup land for replacing them. Homeowners along the lake approached Renville County, who agreed to create an ESSD (Olson *et al*., 2002). Formation of the ESSD allowed local residents to move forward with the project, which included a grinder pump pressure sewer system and a recirculating gravel filter. Treated effluent is disinfected and used by an adjacent golf course for irrigation. Currently, the ESSD contracts O&M to a wastewater treatment plant operator from a nearby municipality.

Moving Forward

The communities that received assistance during the construction grant era following the passage of the 1972 Clean Water Act were large enough for conventional technologies (e.g. mechanical treatment works, pond systems) to be implemented cost-effectively. This "first wave" of wastewater treatment in the United States during the construction grants era was very successful in providing wastewater treatment to large- and medium-sized populations. The systems built during this era provide wastewater treatment to roughly 80% of the population but represent only about *half* of the wastewater treatment plants needed in the Midwest. For instance, Minnesota currently has 786 municipal treatment systems, but still needs to meet the sewer needs of its 679 unsewered communities.

Unsewered communities will be served by a "second wave" of wastewater treatment construction. These treatment facilities can be built on either the Lowest Common Denominator approach or the Educate & Organize approach.

The Educate & Organize approach should be the preferred option because it is more cost-effective and results in long-term benefits (both for the community and the environment). However, this option requires considerable investment in training and creating responsible management entities, especially for unincorporated communities (which represent the majority of the need). Current methods of delivering financial assistance and technical services result in a "build it and walk away" approach, which is a paradigm left over from the construction grants era. This approach leaves communities struggling to operate and maintain their wastewater treatment systems. It is clear that much work remains ahead of us in the domains of policy-making, education, and technology before we are able to develop programs that will create sustainable wastewater solutions for unincorporated communities.

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