Chapter 3

POTENTIAL COSTS AND SAVINGS

Cost is a key factor that affects the selection of wastewater management options for a community. The cost of these options varies depending on specific community characteristics, including population size and density, topography, distance to an existing treatment facility, and local performance requirements. These variables make it difficult to present a valid national comparison of costs for decentralized and centralized systems. To illustrate the differences in the cost-effectiveness of various technology options, cost estimates were developed for two hypothetical communities. Several components of the cost estimates presented may vary considerably from community to community, and may impact the cost-effectiveness of one technology option over another option. For example, land costs vary regionally and may be prohibitive in some communities for construction of large treatment facilities.

Descriptions of the two hypothetical communities on which cost estimates were based are presented below, followed by a summary of the technology options considered for different areas in the communities with different population and site characteristics; and a comparative summary of costs for different types of wastewater management options.

Costs are based on a variety of sources, including cost equations for centralized collection developed by Dames and Moore (based on Smith, 1978); centralized treatment costs presented in the WAWTTAR computer model developed at Humboldt State University (Gearheart et al., 1994); costs for small diameter gravity sewers presented in EPA documents (EPA, 1991; EPA Region IV, n.d.) and in Abney, 1976; cluster treatment costs presented in Abney, 1976 and Otis, 1996; onsite system treatment and operation and maintenance costs used in the COSMO computer model, developed at North Carolina State University (Renkow and Hoover, 1996); average land purchase costs, based on data for North Carolina; and equipment and labor costs based on data from Wisconsin. A detailed description of the cost estimation methodologies used for each type of wastewater collection and treatment technology is presented in Appendix D.

COMMUNITY PROFILES

Costs are presented for (1) a hypothetical small, rural community, and (2) a hypothetical community located on the fringes of a metropolitan center (referred to as the "fringe" community). The profiles of both types of communities are described below.

Rural Community - The rural community has a population of 450 people living in 135 homes. These homes are located on 1-acre lots or larger lots and are serviced by conventional onsite wastewater systems consisting of septic tanks and leach fields; wastewater is transported from the tanks to the leach fields through gravity distribution. About 50 percent of the onsite

systems (67 systems) are currently failing due to inadequate sizing, inappropriate site conditions, or lack of maintenance. As shown in Figure 1a, these 67 failing systems are located in the northeastern section of the community near a river where there is a high water table and a prevalence of soils with low permeability.

Fringe Community - The fringe community, located 10 miles from the nearest city, has a current population of 770 people in 220 homes, but is expected to grow to a total population of 1,550 people in 443 homes located on 1/2-acre lots. The existing homes are serviced by conventional onsite wastewater systems consisting of septic tanks and leach fields; wastewater is transported from the tanks to the leach fields through gravity distribution. As shown in Figure 1b, about 50 percent of the existing onsite systems (110 systems) are currently failing due to inappropriate site conditions, including a high water table and soils with low permeability, and lack of maintenance. The metropolitan area is serviced by a centralized collection and treatment facility with unused capacity (10 miles away).

For comparative purposes, costs for centralized, cluster, and decentralized onsite systems are provided for both the rural and fringe communities, as described below.

TECHNOLOGY OPTIONS AND PERFORMANCE GOALS

The technology options considered for the rural and fringe communities are summarized below. All of the options considered are assumed to be capable of achieving the secondary treatment standard of 30 mg/L for BOD and TSS, as well as disinfection goals for significant bacteria reduction; disinfection of cluster and onsite system effluent is provided by physical and biological processes as the effluent moves through the soil.

Appendix D ("Cost Estimation Methodology") provides a detailed description of each technology, the methodologies and assumptions used in developing the cost estimates, and the capital costs and annual operating and maintenance (O&M) costs for each technology. Appendix D also includes a discussion of how costs were indexed to 1995 dollars.

Rural Community - Wastewater options considered for the rural community include:

- *Centralized system* - New conventional gravity collection servicing the entire rural community and construction of a new centralized treatment facility, with treatment consisting of a facultative oxidation pond and disinfection. This has been the most frequently used option to address the small community problems described in this report.

- *Cluster systems* - New alternative collection (small diameter gravity sewers [SDGS]) and construction of new small cluster treatment systems, each consisting of a sand filter and a central leach field (cluster systems would be installed only

where onsite systems are currently failing; properly functioning onsite systems would continue in use).

- *Onsite systems* - Replacement of failing conventional onsite systems (septic tanks and leach fields) with new onsite systems consisting of septic tanks, intermittent sand filters where necessary, and leach fields; low pressure pipe (LPP) distribution would be used to transport the wastewater from the septic tanks up to, and through the leach fields. The sand filters and LPP distribution address the issues of a high ground-water table and low-permeability soils.

Fringe Community - Wastewater options considered for the fringe community include:

- *Centralized system* (two options considered) - A new conventional gravity collection system connected to an existing centralized treatment facility that currently serves the main municipality. In option 1, the facility has sufficient collection and treatment capacity, and in option 2, the facility has sufficient capacity to handle the added load to the sewers, but requires additional treatment capacity. Treatment for both centralized options is provided by a sequencing batch reactor (SBR) with grit removal, screening, disinfection, and sludge disposal.

- *Cluster systems* - New alternative collection (small diameter gravity sewers [SDGS]) and construction of new small cluster treatment systems, each consisting of a central sand filter and a central leach field; for new homes, the installation of new onsite septic tanks which connect to the SDGS.

- *Onsite systems* - For existing homes, replacement of failing onsite systems with new onsite systems consisting of septic tanks, intermittent sand filters where necessary, and leach fields, with wastewater transported up to, and through the leach fields with low pressure pipe (LPP) distribution; for new homes, installation of new onsite systems consisting of septic tanks and leach fields, with wastewater transported to the leach fields with low pressure pipe distribution (LPP).

SUMMARY OF COSTS

Cost summaries and comparisons for each technology option considered are presented below. Costs include the capital costs necessary to install the system(s) and the annual costs to operate and maintain the system(s). Capital costs were annualized over 30 years (the life of the system) for each technology option using a discount rate of 7 percent (OMB, 1996). All costs are presented in 1995 dollars. Table 1 presents a summary of the estimated costs for the rural community. Similarly, Table 2 presents the costs for the fringe community.

Table 1. Summary of Rural Community Technology Costs

Technology Option[1]	Total Capital Cost (1995 $)	Annual O&M Cost[2] (1995 $)	Total Annual Cost (Annualized Capital Plus O&M - 1995 $)
Centralized systems[3]	$2,321,840 - $3,750,530	$29,740 - $40,260	$216,850 - $342,500
Alternative SDGS collection and small cluster systems[4]	$598,100	$7,290[6]	$55,500
Onsite systems[5]	$510,000	$13,400[6]	$54,500

Note: The rural community consists of 450 people in 135 homes

[1]All technology options presented are assumed to have a 30-year life span.

[2]O&M costs include: centralized system - treatment chemicals such as chlorine and sulfur dioxide, energy to run equipment such as mixers, pumps, and aerators, and labor; cluster system - yearly inspections of onsite components including sand filter, quarterly inspections of the central leach field, 10-year pumpouts of individual septic tanks, replacement of distribution pump every 10 years; onsite systems - quarterly inspections of systems, including septic tanks, leach fields, and sand filters, pumpouts of septic tanks and replacement of distribution pumps every 10 years; the establishment of an organization to provide wastewater management assumes that maintenance of all existing and future onsite systems will be performed; therefore, the annual O&M cost estimates include costs for new systems as well as existing onsite systems that are still functioning effectively.

[3]Represents conventional gravity collection and construction of a new centralized treatment plant within the rural area, consisting of a facultative oxidation pond and disinfection; the conventional gravity collection system costed for the rural community was evaluated for two population densities (1 home per acre and 1 home per 5 acres), and therefore a range of costs are presented for this technology option.

[4]Includes intermittent sand filters and gravity distribution to leach fields where onsite systems are failing.

[5]Includes replacement of failing onsite systems with (1) onsite systems consisting of septic tanks with LPP distribution to leach fields where soils have poor drainage and (2) onsite systems consisting of septic tanks and sand filters with LPP distribution to leach fields where water table is high.

[6]O&M costs for cluster systems are lower than O&M costs for onsite systems because of the lower labor requirements for operating and maintaining a single centralized sand filter and leach field in a cluster system than for operting and maintaining up to 135 individual onsite sand filters and leach fields.

Table 2. Summary of Fringe Community Technology Costs			
Technology Option[1]	**Total Capital Cost (1995 $)**	**Annual O&M Cost[2] (1995 $)**	**Total Annual Cost (Annualized Capital Plus O&M - 1995 $)**
Centralized systems[3] -			
System type #1:			
at 1 mile from existing sewer	$3,322,900	$83,800	$351,600
at 5 miles from existing sewer	$5,377,800	$95,900	$529,300
System type #2:			
at 1 mile from existing sewer	$3,786,900	$83,800	$389,000
at 5 miles from existing sewer	$5,841,800	$95,900	$566,700
Alternative SDGS collection and small cluster systems[4]	$3,783,700	$18,000[6]	$322,900
Onsite systems[5]	$2,117,100	$59,240[6]	$229,900
Note: The fringe community consists of 1,550 people in 443 homes (includes future growth)			

[1]All technology options presented are assumed to have a 30-year life span.

[2]O&M costs include: centralized system - treatment chemicals such as chlorine and sulfur dioxide, energy to run equipment such as mixers, pumps, and aerators, and labor; cluster system - yearly inspections of onsite components including sand filter, quarterly inspections of the central leach field, 10-year pumpouts of individual septic tanks, replacement of distribution pump every 10 years; onsite systems - quarterly inspections of systems, including septic tanks, leach fields, and sand filters, pumpouts of septic tanks and replacement of distribution pumps every 10 years; the establishment of an organization to provide wastewater management assumes that maintenance of all existing and future onsite systems will be performed; therefore, the annual O&M cost estimates include costs for new systems as well as existing onsite systems that are still functioning effectively.

[3]System type #1 represents conventional gravity collection connected to an existing sewer and treatment system that already has adequate capacity to handle the additional load; System type #2 represents conventional gravity collection connected to an existing sewer system that already has adequate sewer capacity but requires expanded treatment capcity to handle the additional load. For both systems, treatment consists of an SBR and disinfection.

[4]Includes central intermittent sand filters and gravity distribution to central leach fields.

[5]Represents onsite systems consisting of septic tanks with LPP distribution to leach fields for new homes; replacement of failing onsite systems with (1) onsite systems consisting of septic tanks with LPP distribution to leach fields where soils have poor drainage and (2) onsite systems consisting of septic tanks and sand filters with LPP distribution to leach fields where water table is high.

[6]O&M costs for cluster systems are lower than O&M costs for onsite systems because of the lower labor requirements for operating and maintaining a single centralized sand filter and leach field in a cluster system than for operting and maintaining up to 443 individual onsite sand filters and leach fields.

Rural Community Costs - As shown in Table 1, for the rural community, the most cost-effective option for meeting performance goals is using new onsite systems to replace the old onsite systems that are failing. The newer onsite systems will include low pressure pipe distribution (LPP) to achieve effective operation in areas with poor soil drainage, and sand filter and LPP in areas with a high water table to provide additional treatment before the effluent reaches the water table. The use of cluster systems with alternative collection for the failing onsite systems is not significantly more expensive; if soils were unsuitable for onsite systems, the cluster alternative would be the best choice. As the distance between homes in the rural area increases, however, cluster system collection costs would increase. Compared to the onsite or cluster system options, centralized collection and treatment is not cost-effective.

Fringe Community Costs - A summary of the estimated costs for the fringe community is presented in Table 2, including total capital costs, annual O&M costs, and the total annual cost (i.e., annualized capital plus annual O&M) for each option.

Table 2 shows that for the fringe community, in this instance, installing new onsite systems to replace the old onsite systems that are failing and new onsite systems for new homes would be the most cost-effective option. However, construction of cluster systems with alternative collection might be the preferred option in this type of growing community where space may be limited for individual onsite systems. In cases where a fringe community is relatively close to a sewer interceptor (e.g., 1 mile), and the existing centralized collection and treatment facility can accept the additional wastewater loadings, it might be cost-effective. If a fringe community is located relatively far from a sewer interceptor (e.g., 5 miles), centralized collection and treatment may not be cost-effective, especially if treatment and collection facilities require upgrading to handle additional flows. These results are typical of fringe communities, which are often "gray" areas regarding costs; that is, depending on their proximity to existing centralized facilities and their population densities, the most cost-effective option for fringe communities often varies depending on site-specific conditions. Long term growth also may be a factor in determining the most appropriate solution. Additionally, the assimilative capacity of the receiving environment may limit the utility of centralized systems that discharge to surface waters.

CONCLUSIONS

Results of the cost analysis indicate decentralized systems, whether onsite or cluster systems, are generally cost effective means of managing wastewater in rural communities due to the distance between homes and land availability. In small communities and fringe areas of metropolitan cities, the most cost effective solution depends on population density, distance to the sewer interceptor, and availability of land. The centralized alternative can be competitive with decentralized options in fringe areas, where the distance to the intercepting sewer is less than 5 miles and the receiving water body can accommodate the additional waste load. Although excluded from this analysis, the relative costs of failure for centralized systems can be far greater, given that all wastewater is concentrated at a central location (point source).