

# ***SMALL SCALE WASTE MANAGEMENT PROJECT***

## ***Onsite Wastewater Facilities for Small Communities and Subdivisions***

by

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# ON-SITE WASTEWATER FACILITIES FOR SMALL COMMUNITIES AND SUBDIVISIONS

Richard J. Otis<sup>1</sup>

## INTRODUCTION

In 1970 approximately 19.5 million households or nearly 30 percent of all housing units in the United States disposed of their wastewaters by some form of private sewerage facilities (19). This number is growing at an increasing rate, due to an emerging trend of population movement to rural areas where community sewage treatment facilities are not usually available. Retired persons are moving back to rural areas, as well as young families who are following the growth of industries on the outlying fringes of metropolitan centers (2). Most of these rural households utilize septic tank systems to dispose of their wastewater. Because of poor design, construction or maintenance, however, a large number of these systems are failing to provide adequate treatment and disposal of their sewage.

Many households, while located in rural areas, are situated in small communities or subdivisions ranging in size from a few households to a hundred or more. In such instances, failing septic tank systems which allow raw or poorly treated sewage to reach the ground surface, surface body of water or even the groundwater, create a severe public health hazard and nuisance because of the close proximity of homes. Public wastewater facilities are often the only solution to abate the problem.

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### CONVENTIONAL PUBLIC FACILITIES

The traditional method of providing public wastewater facilities is to construct a system of gravity collection sewers which convey all the wastewaters to a single community treatment plant. This "central" system is preferred by governmental authorities, engineers and the public alike for several reasons. First, the gravity sewer system is tried and proven. There is much technical expertise in the theory, design and operation of central sewerage which has led to great confidence in the system. Second, central sewerage is usually more cost-effective because of economies of scale. It is less costly to serve many people with one system rather than each one individually. Third, central sewerage allows ready application of central (and usually public) management which is responsible for the proper functioning of the system. The availability of a single entity to manage the system is quite desirable from a regulatory authority's viewpoint because the authorities have an entity against whom they can bring administrative or judicial action to abate water pollution problems. Central management is also favored by the homeowner who no longer has to worry about his private system.

For smaller communities and subdivisions, however, such a conventional collection and treatment facility is impractical because of the financial burden it places on the residents or developer. This is largely due to the high cost of collecting wastewater from each home or business. Smith and Eilers (24) computed the 1968 national average of total annual costs of municipal wastewater collection and treatment facilities which showed that 65 percent of the total annual cost is for amortization and maintenance of the collection system. A more recent study by Sloggett and Badger (23) of 16 small communities in Oklahoma

showed a similar distribution. (See Table I) It is clear from this breakdown of the total annual costs that the collection system is the most expensive component of any system.

TABLE I. Distribution of Total Annual Costs for  
Municipal Wastewater Collection and  
Treatment Facilities

		Amortization Cost		Current Expenses			
				<u>Operation &amp; Maintenance</u>		Overhead	Total
		Collection	Treatment	Collection	Treatment		
Smith & Eilers (1968)	(24)	60.3%	15.3%	4.7%	8.4%	11.3%	100.0%
Sloggett & Badger	(23)	--	72.6%	--	14.2%	3.2% (lagoons)	10.0% 100.0%

In small communities homes are typically scattered, which cause the costs of sewerage to rise dramatically. In their study of 16 wastewater collection and treatment systems in Oklahoma, Sloggett and Badger (23) showed that the costs per customer rise as the number and density of customers declines. Construction costs per customer were compared to the density and number of customers served. (See Tables II and III) Both factors were shown to have a significant effect but the density of customers was shown to have the largest impact on per capita construction costs. In smaller communities where homes tend to be more scattered this cost can become excessive. Costs can reach \$8000 per household for the capital portion alone and may be even higher if treatment beyond secondary is required to meet water quality standards. It is not unusual for the cost of the complete system to approach the total equalized value of the community (15).

TABLE II. Cost of Construction per Customer Relative to Density of Customers for 16 Community Wastewater Facilities in Oklahoma (23)

	<u>Customers per Mile of Sewer</u>			
	Under 30	30-39	40-49	Over 50
Number of Systems	5	5	1	5
Average Cost/Customer (1972 dollars)	\$1,100	\$847	\$696	\$575
Average Number of Customers	96	119	310	256

TABLE III. Cost of Construction per Customer Relative to Number of Customers for 16 Community Wastewater Facilities in Oklahoma (23)

	<u>Number of Customers Served</u>			
	Under 100	100-199	200-299	300-400
Number of Systems	6	4	3	3
Average Cost/Customer (1972 dollars)	\$1,000	\$798	\$594	\$434
Customers/Mile of Sewer	28.3	37.8	49.4	55.2

To help communities meet the water quality goals of the Federal Water Pollution Control Act Amendments of 1972, the federal government was authorized by a provision in the Act to provide grants in aid of construction for 75% of the grant eligible portions of the wastewater facility. The availability of these grants would help offset the high per capita costs in small communities but, unfortunately, small communities have difficulty in obtaining them.

The federal funds are allocated to the individual states on the basis of need, but each state is given the power to determine how the funds are to be spent. Only minimum requirements are set out by the Act for states to follow in preparing a priority list of projects. For example, the Act requires that consideration be given to the severity of

the pollution problem, the population affected, the need for preservation of high quality waters and national priorities. The federal regulations seem to give the states some discretion by not requiring strict adherence to their rankings of pollution discharges. Thus, the priority lists usually work to the disadvantage of small communities, in that many of them are near the bottom, preceded by communities with larger populations and larger pollution discharges. This emphasis denies small communities any expectation of receiving badly needed funding for public facilities in the near future. It is obvious from this discussion that it is impractical to expect many small communities to construct conventional public wastewater facilities to eliminate failing private systems.

Central sewerage is also very costly for subdivisions. Because of the large front end cost of installing conventional gravity sewers with no immediate return developers prefer to utilize private septic tank systems to dispose of the wastewater. In older subdivisions, septic tank systems were often installed in unsuitable soils or constructed improperly, resulting in mass failures. The only solution has been to extend interceptor sewers to the subdivision from the nearby municipality.

This becomes a very costly proposition in several ways. The lack of an alternative forces the developer to subdivide land with relatively good soils. Not only does this often remove good agricultural land from production, but it also results in scattered development about a metropolitan center. The development will increase the tax base of the local government but the scattered development also increases the costs of providing other community services, such as roads, police and fire protection and other utilities. If septic tank system failure requires

eventual extension of municipal sewerage for the outlying subdivisions it becomes extremely costly, and also may be undesirable in some cases because of the strip growth that often occurs along the interceptor routes. The result may be a net economic and environmental loss to the community.

The need for a cost-effective yet viable alternative is certainly indicated. Regulatory officials and engineers are realizing that if the goals of the Federal Water Pollution Control Act are to be met more practical facilities must be developed for small communities and subdivisions.

#### NON-CENTRAL FACILITIES AS AN ALTERNATIVE

A "non-central" facility of several treatment and disposal systems serving isolated individual residences or clusters of residences may offer a less costly alternative to the conventional central facility in the non-urban setting. As Table I indicates approximately two-thirds of the total annual cost of a conventional facility is due to the collection system. In a community of scattered homes this proportionate cost could be even higher. If the central treatment plant could be eliminated, long sewer extensions collecting wastes from widely spaced homes would not be necessary. Instead, treatment and disposal could be provided where the wastes are generated. Individual or jointly used septic tank systems or other treatment and disposal methods could be used. Such a non-central facility of disperse systems could result in a substantial savings.

The implementation of a non-central facility would not exclude the use of central management, which is an extremely attractive factor of



conventional community facilities. Though a relatively untried concept, central management of a non-central facility could be employed. In fact, central management would be crucial to its proper functioning.

The non-central facility offers several advantages over the central sewerage approach:

1. Existing functional septic tank-soil absorption systems can be utilized rather than providing new service. Often, homeowners who are not having trouble or who have recently installed new septic tank systems do not wish to support community action that will cost them more money unnecessarily. Incorporating existing systems into the public system minimizes this opposition, as well as reducing the total cost of the public facility.

2. Isolated single homes and clusters of homes can be served individually instead of extending costly sewer lines out to them. This could be equally advantageous to existing communities, as well as newly platted subdivisions. Where future growth is not expected to be great enough to warrant sewer extensions, individual septic tank systems could be used. In cases where substantial growth is expected, such as in newly platted subdivisions, the first few homes built could be served by holding tanks which would be pumped and maintained by the management entity. When the number of homes increased to the point where a common disposal system is warranted, it could be built on land reserved for that purpose. This would delay construction until the time there are enough contributors available to pay for it.

3. Less costly treatment facilities can usually be constructed. In addition, subsurface disposal can often be employed which requires

minimal treatment and avoids the necessity of upgrading the treatment plant to meet changing standards for effluent discharges to surface waters. Where subsurface disposal is not possible the smaller flows may allow other simple treatment methods to be used. In addition, by limiting the area served the necessary excess capacity required for future growth is accurately known providing a more optimal design.

4. A more cost-effective facility may encourage smaller communities to proceed with construction rather than waiting for federal construction grants. This would speed abatement of water pollution problems. Where financial aids are necessary, a greater number of community facilities could receive construction grants because of the fewer dollars required for each project.

5. More rational planning of community growth is possible. Strip growth, which is encouraged by the construction of interceptor sewers used to collect wastes from outlying clusters of homes could be avoided. Growth could be encouraged in the more desirable areas by providing public service in those areas only.

6. Non-central facilities are more ecologically sound since the disperse systems dispose of the wastes over wider areas. Through this practice the environment is able to assimilate the waste discharge more readily, which reduces the need for mechanical treatment and the associated energy consumption.

Of course, there are disadvantages to non-central facilities which must be overcome if this alternative is to be successful:

1. Central management of a facility of small disperse systems is a fairly new and untried concept. Methods of public ownership of systems

on private land, necessary for proper operation and maintenance, must be tested. Operation and maintenance costs also may be higher than for conventional facilities because of its "non-central" nature. Due to the lack of experience, other problems will arise, which may not be anticipated.

2. There is little public confidence in wastewater facilities that do not convey the wastewater from areas of habitation; therefore, a non-central facility may be unacceptable. Failure of a conventional treatment plant is easy to accept, since it is usually a safe distance from any homes and does not disrupt the household routine. However, if failure of a treatment and disposal system within a non-central facility occurs, repairs must be made immediately.

3. Provision for the community's future growth is more difficult. A small reserve capacity can be built into each system which serves an area with some undeveloped lots, but if a landowner wishes to build where public service is not yet available, a decision must be made as to whether service should be provided. Since providing public service to single homes one at a time can be costly, a choice must be made between constructing individual systems, providing holding tank service until more homes are built in the area, or immediately constructing a larger joint system to handle anticipated growth.

4. By present guidelines many components of a non-central facility may not be eligible for grants in aid of construction, which are available through various federal and state financial aid programs. This would have the effect of increasing the cost to each customer served in comparison to central sewerage, even though the total costs may be less.

In general, the potential of non-central facilities seem to warrant further investigation. Many of the possible shortcomings of this alternate facility may vanish as some are constructed and experience gained.

#### COLLECTION AND TREATMENT ALTERNATIVES FOR NON-CENTRAL SYSTEMS

Proper facilities planning involves a systematic comparison of alternative methods of dealing with a wastewater treatment and disposal problem. The purpose of this comparison is to identify the most "cost-effective" solution which will minimize total costs to society over time. These costs include monetary and environmental, as well as other non-monetary costs.

The commitment by regulatory agencies and engineers to conventional gravity sewers with a common central treatment plant, however, has eliminated many worthy alternatives from consideration. If this bias can be changed, the utilization of the non-central concept has the potential of significantly reducing the environmental and monetary costs of wastewater facilities in many communities by either reducing the size or eliminating the collection system altogether and by simplifying the treatment facility.

The most extreme non-central system would be one where each home and other establishment were served by its own individual septic tank system. However, the most cost-effective community system will usually lie somewhere between the two extremes of central sewerage and individual systems. Either because of economies of scale or because site conditions are unfavorable for individual disposal systems, joint systems serving several homes may be constructed. The end result may be a mix of several individual and joint systems.

### Collection Alternatives

The single most expensive portion of central sewerage is the gravity collection system, yet alternatives to it are rarely evaluated. Three interesting alternatives might be employed.

Small Diameter Gravity Sewers: To take advantage of economies of scale or to avoid adverse sites, a nearby area might be available for construction of a joint system. In such cases, gravity sewers can be used to collect and convey the wastes to the disposal site. To reduce the costs of conventional gravity sewers, small diameter (4-inch) pipe offers an alternative if septic tank effluents rather than raw wastes are collected. The collection mains are joined by a typical gravity house connection coming from a septic tank or, in those instances where the elevation of a property would make it difficult to be served by a gravity system without a large cut, the building would be provided with a pump located in a chamber immediately following the septic tank to elevate the effluent in to the system.

The individual septic tanks would provide partial treatment of the wastewater by removing the larger solids to allow the use of smaller diameter pipe for collection. Since sand and other grit also would be removed in the septic tank, normal cleansing velocities in the mains need not be maintained. The 4-inch diameter mains are installed at a minimum gradient of 0.67 percent, based on a minimum velocity of 1.5 feet per second at half pipe capacity (25). Under these conditions a 4-inch diameter pipe can carry over 2000 gph sufficient to serve 670 persons, assuming a peak flow of 3 gph per person (22). Regular flushing to provide cleansing velocities (greater than 2.5 feet per second) can be

provided if necessary by collecting and pumping the effluent from several homes at the upstream end of each main for periodic surcharging. This type of collection system has been used extensively in South Australia since 1962 without surcharging with very good results (25).

Pressure Sewers: Where topography or soil conditions make gravity sewers costly, pressure sewers may be more economical. Pressure sewers have been tried in several places and have performed favorably (5, 7, 3). This system consists of a septic tank at each building or cluster of buildings to remove the large solids from the wastewater followed by a pump chamber with a small submersible pump to pump the settled effluent from the septic tank into a small diameter plastic main. (A grinder pump can be used to grind and pump the raw waste rather than using a septic tank.) Construction costs are reduced because the pipe need not be laid at a specific grade but can follow the contour of the land with the main being located just below the frost line. This permits the use of a simple trenching machine and eliminates deep cuts, often necessary for gravity sewers.

Flexibility for growth is good since the smallest pipe size used can accommodate up to 20 homes before a larger main is necessary. Further pipe size increases are necessary only by 30 dwelling increments (5). Such a system can easily be designed to handle nominal growth.

Vacuum Sewers: In temperate regions where soils are shallow, vacuum sewers offer another alternative. They provide many of the advantages of pressure sewers.

### Treatment and Disposal Alternatives

The degree and method of wastewater treatment depends upon the constraints of the receiving environment. In large municipal systems the volume of wastewater collected usually requires that a stream or river be used as the receiving environment. To protect the water quality, secondary or higher degrees of treatment are necessary. In addition, mechanically intensive treatment methods must be employed because large land areas are often unavailable. Thus, treatment and disposal alternatives for larger municipalities are limited and costly.

In small communities using non-central facilities, however, simpler and less costly treatment and disposal methods can be employed. Smaller volumes of wastewater permit a wider choice of disposal methods which may require only minimal treatment. Rather than discharging to a surface body of water, land disposal or evapotranspiration may be a more cost-effective alternative.

Land Disposal Alternatives: Land disposal becomes a particularly attractive alternative in rural areas where land is more likely to be available. The soil is an effective treatment and disposal media which should be utilized whenever possible. One type of system readily adaptable to non-central facilities is the septic tank-soil absorption field. This system can be designed to dispose of wastes from single homes or large clusters of homes. Unfortunately, these systems are usually considered only as an interim method of treatment and disposal until sewers are available (9). This is because septic tank systems have not been understood and therefore, have been improperly designed, installed and maintained. Thus, many failures have resulted which has created a lack of confidence in their reliability.

Recently, however, practical design criteria and installation procedures have been developed for soil absorption systems (4, 10). If followed, septic tank systems can be expected to last 20 years or more under many soil conditions. If used under the rubric of central management, these systems should be seriously considered as a realistic alternative.

Other systems, such as spray or ridge and furrow irrigation and infiltration-percolation ponds, also utilize the soil for treatment and disposal. These may be viable alternatives to consider depending on climate, yearly distribution of wastewater flow, etc.

Surface Water Discharge: Where soils are unsuitable or sufficient land is unavailable, it is necessary to use other methods of disposal. As an alternative, surface waters may be used as the receiving environment. This often requires that higher levels of treatment be provided prior to wastewater discharge. Intermittent sand filters, a method of treatment which was abandoned because of its requirement for large land areas, offer an alternative to package plants or lagoons. In non-central systems sand filtration becomes viable because of its simplicity and reliability. The smaller wastewater flows to be treated and higher loading rates reduce the required land area. High quality effluents low in biochemical oxygen demand and suspended solids can thus be produced with a minimum of maintenance (20, 21).

Evapotranspiration: In climates where evapotranspiration exceeds precipitation, evapotranspiration provides another disposal alternative. If land is available but is unsuitable for soil absorption, this alternative which has low treatment requirements may be more cost-effective than



discharging to surface bodies of water where high degrees of treatment are necessary.

Other: To reduce the size and cost of any treatment and disposal facility, chosen waste segregation and water conservation may be built into the system. Water conservation can reduce the total volume of waste to be disposed of while separate handling of toilet and grey water wastes may simplify treatment.

It may be that after consideration of these and other alternatives central sewerage is the best solution. Generally speaking, however, most small communities can make use of one or a combination of alternative systems that may be a mix of individual and joint systems all under public ownership to provide the most cost-effective facility. Public ownership would make many components of each system within the facility eligible for construction grants and provide proper and reliable maintenance needed for long life systems.

#### WESTBORO, WISCONSIN CASE STUDY

Few viable alternatives for small communities and subdivisions have ever been tried nor have there been incentives to do so. However, with the emphasis for cleaning up our nation's waterways moving from large municipalities to small communities, it is being realized that conventional solutions are too costly and may not be practical. This has caused the search for alternatives by several communities including Westboro, Wisconsin (16, 17), Glide, Oregon (11) and Fountain Run, Kentucky (18). The Glide Oregon and Fountain Run, Kentucky plans are discussed elsewhere at this conference (1, 6).

### Description of Westboro

Westboro, Wisconsin is typical of hundreds of small rural communities in the Midwest that are in need of improved wastewater treatment and disposal facilities but are unable to afford conventional sewerage. Westboro was established as a permanent northern Wisconsin community in the late 1850's as a result of the lumber industry (Figures 1 & 2). By 1900 the population had grown to about 900, but with the decline of the lumber industry the population also declined. The present population is approximately 200 persons. A small machine tool company and a sawmill employing a total of 5 to 10 people remain in town.

The community of Westboro has no municipal wastewater collection or treatment facility. There are 94 buildings located in the community, of which 69 are occupied, including a school, four churches and several commercial establishments. All are served by private wastewater disposal systems. A 1971 survey by the Wisconsin Department of Natural Resources (DNR) showed that 80% of the septic tank systems were discharging wastes above ground. Many of the systems were found to be interconnected by common drains discharging directly into Silver Creek which flows through town. This situation was declared a nuisance and a menace to health and comfort, as well as the public rights in the Upper Chippewa River Basin. Consequently, DNR issued an order to Westboro to stop all private homes from discharging wastes into Silver Creek, either by upgrading all failing septic tank systems or constructing public wastewater facilities.

### Proposed Central Sewerage

The soils and lot sizes prevent the replacement of most of the failing septic tank systems on an individual basis (Figure 3) so a public

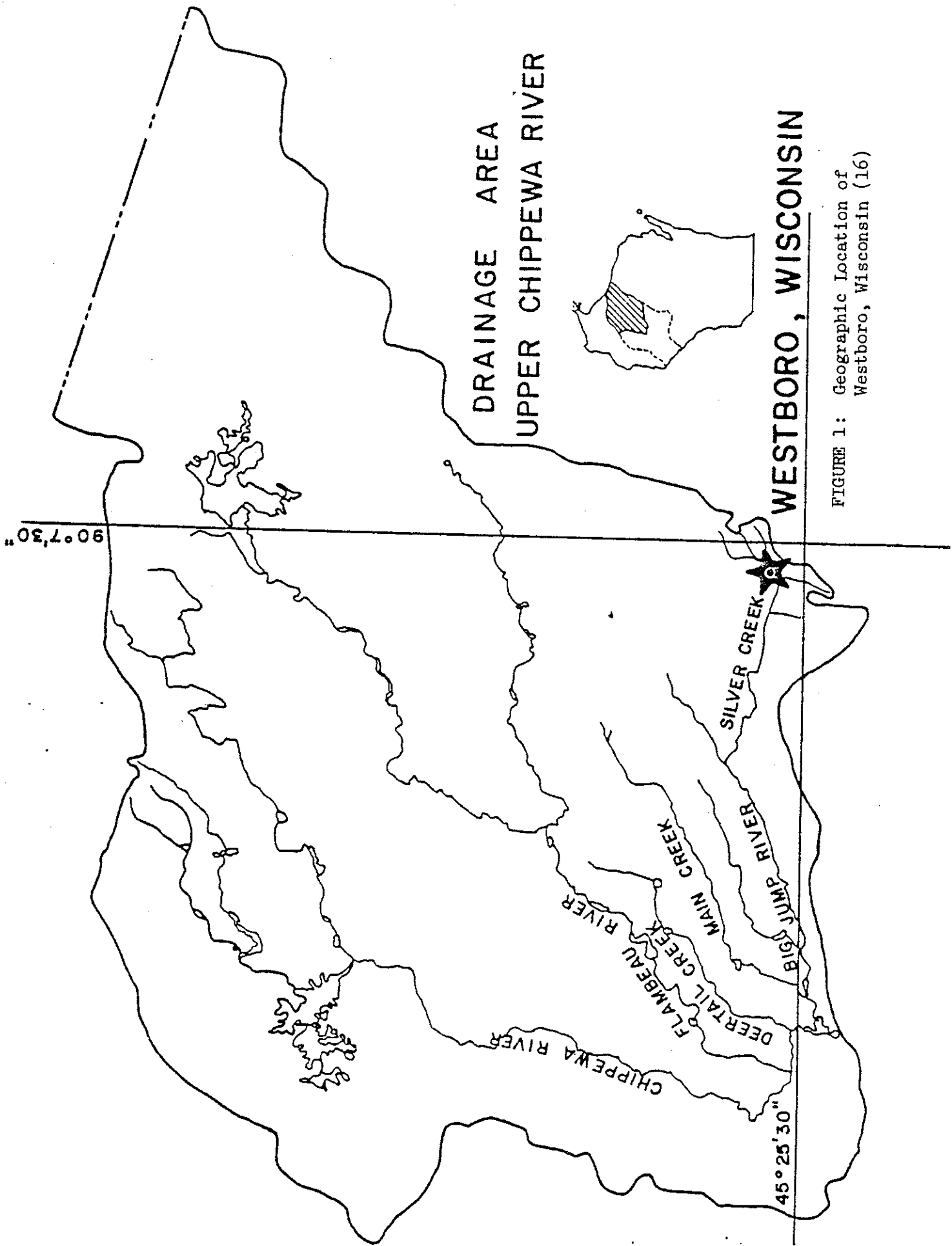
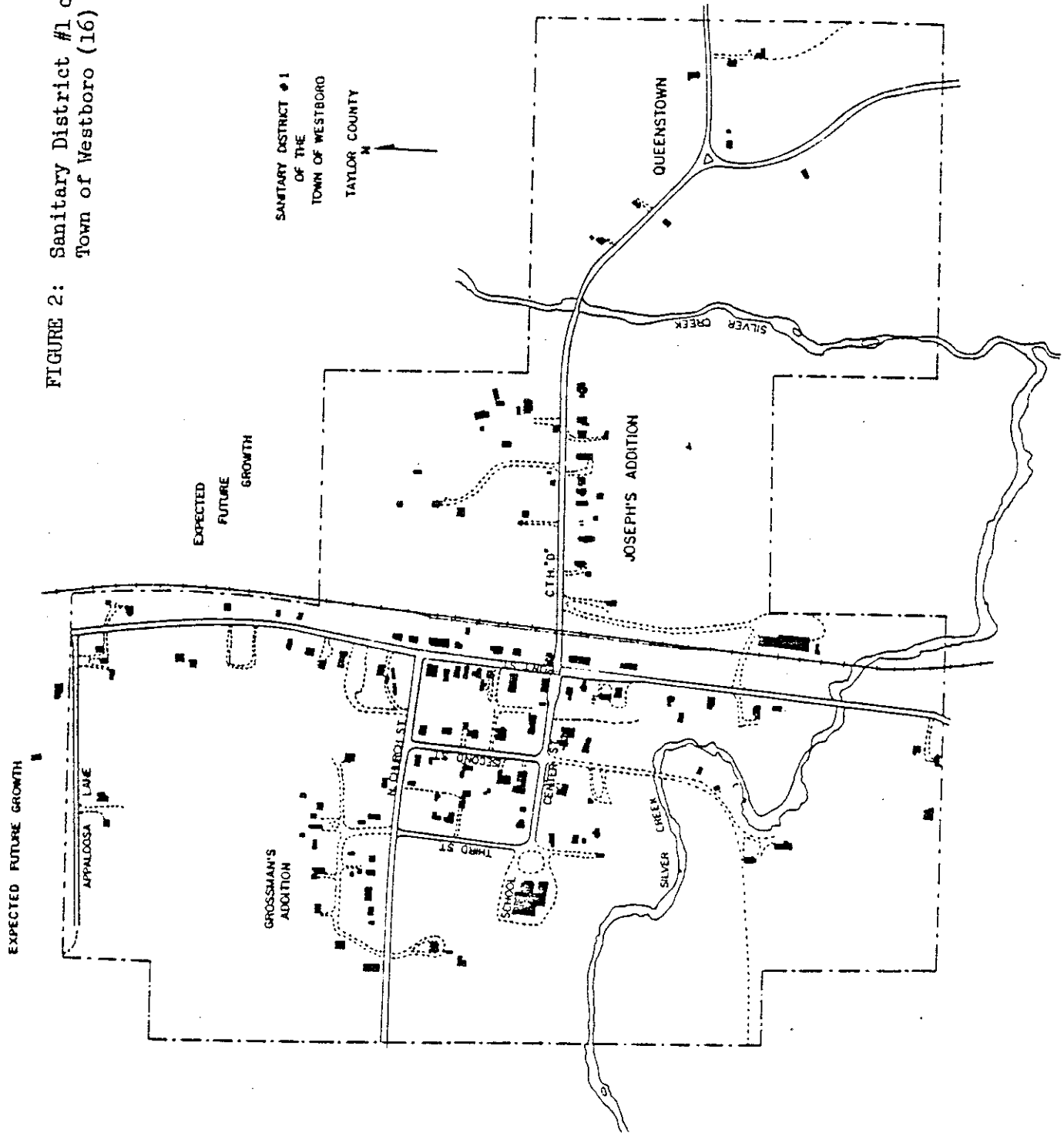


FIGURE 1: Geographic Location of Westboro, Wisconsin (16)

FIGURE 2: Sanitary District #1 of the Town of Westboro (16)



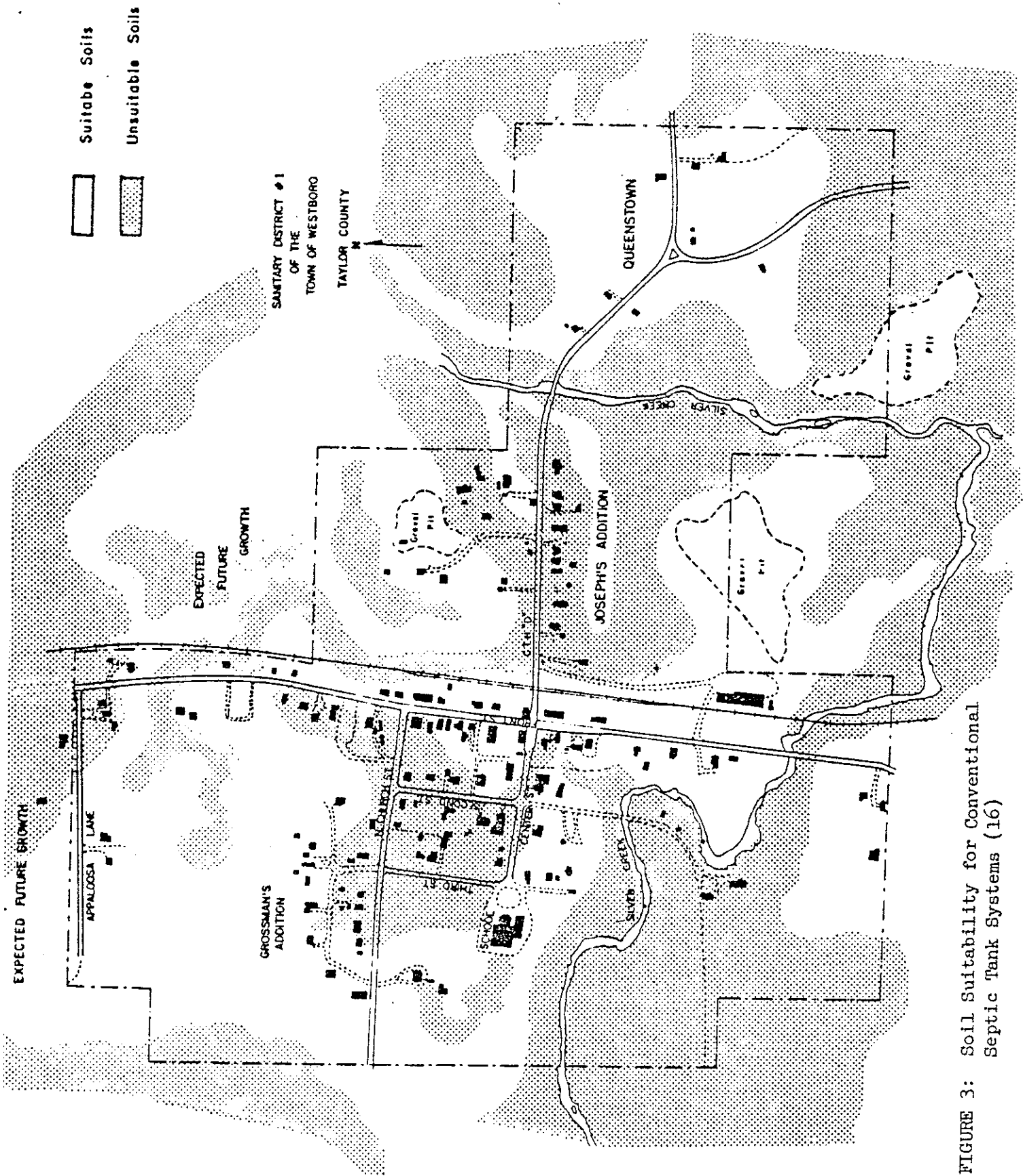


FIGURE 3: Soil Suitability for Conventional Septic Tank Systems (16)

facility was determined to be necessary. The community formed a sanitary district, "Sanitary District No. 1 of the Town of Westboro" (Figure 2) and in 1967 contracted with an engineering firm to complete a facilities plan to abate the water pollution problem. The firm investigated two alternatives, (1) gravity collection to an extended aeration package treatment plant and (2) gravity collection to a two cell lagoon. Both plans served only 60 of the 69 occupied buildings. Homes to the north of town near Appaloosa Lane and those east of Silver Creek in Queenstown were not included. (See Figures 4 & 5) Construction costs updated in 1976 were \$135,700 for the collection system required for both alternatives, \$115,650 for the package plant with a required 30-day effluent holding pond and \$175,925 for the stabilization lagoon (16). Total construction costs of these facilities, therefore, are estimated to be \$251,350 for Alternate 1 and \$311,625 for Alternate 2, including engineering and contingencies (16).

The Westboro Sanitary District applied for Federal EPA grants in aid of construction, but their priority for receiving funding is very low. As of February 1976, Westboro was 318 on the list of 420 to receive 75 percent of eligible costs of construction of the treatment plant and interceptors and 398 to receive similar funding for the sewers. This virtually rules out the possibility of obtaining a community facility for several years (13).

#### Alternative Non-Central Facilities Evaluated.

Having a sincere interest in abating their problem the residents of the Westboro Sanitary District agreed to cooperate with the Small Scale Waste Management Project at the University of Wisconsin to develop an

EXPECTED FUTURE GROWTH

FIGURE 4: Central System Alternate #1:  
Conventional Gravity Sewers -  
Extended Aeration Treatment (16)

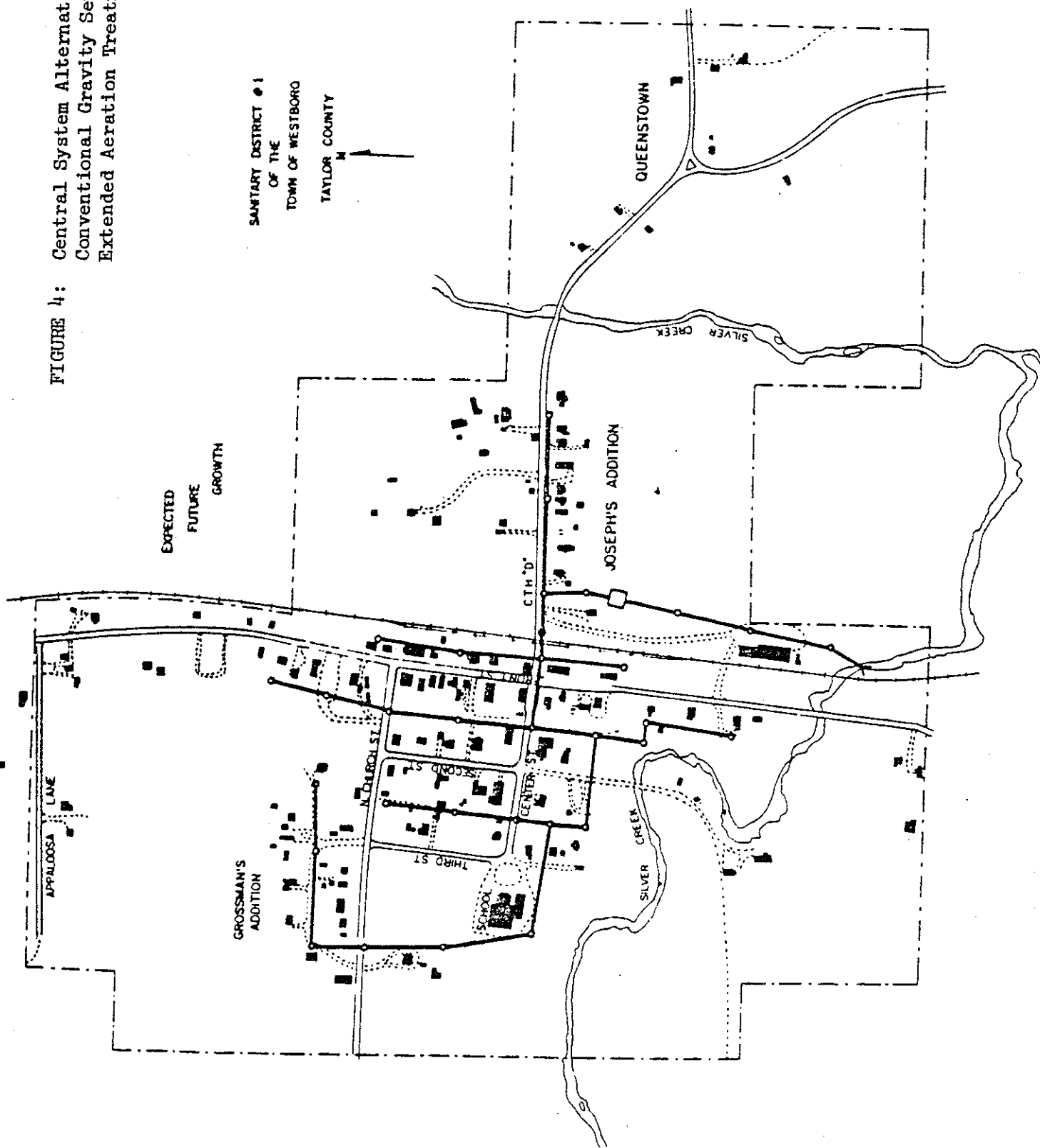
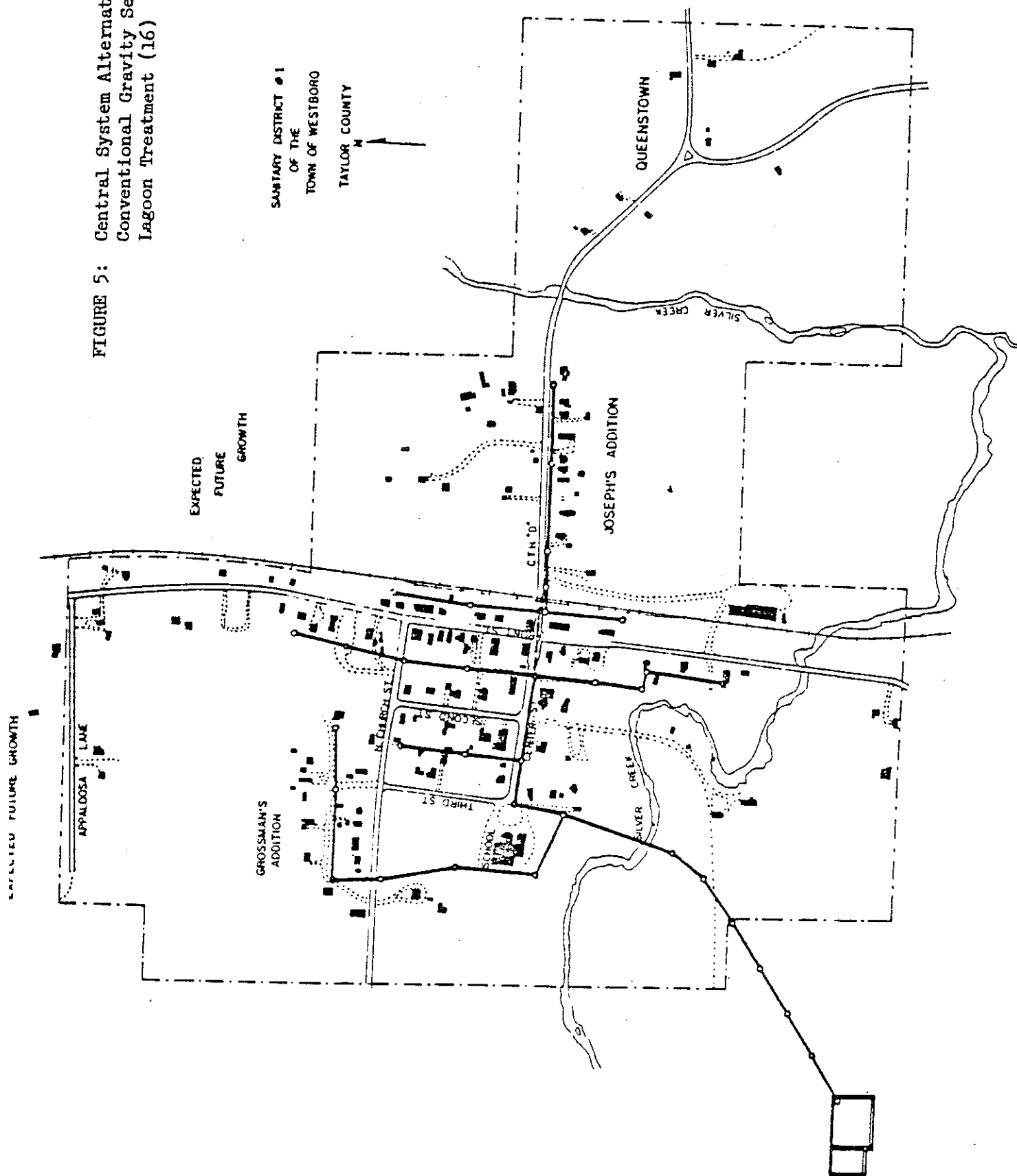


FIGURE 5: Central System Alternate #2:  
Conventional Gravity Sewers -  
Lagoon Treatment (16)



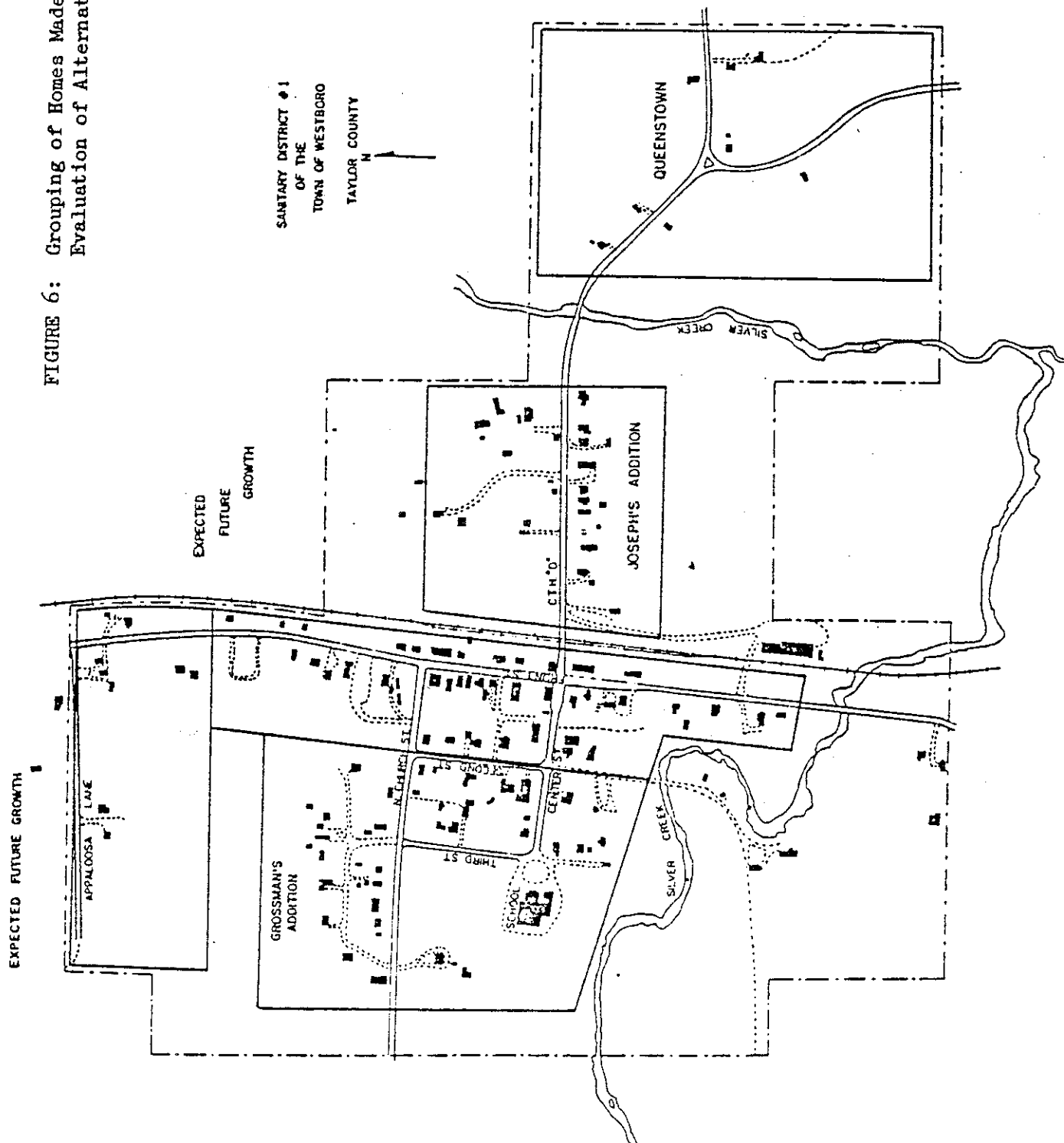


alternate plan which might be a more cost-effective facility. The objectives of the project were to evaluate the use of several small treatment and disposal systems placed in strategic locations within the community to serve individual homes or clusters of homes, but under central management, to compare total costs of alternate plans to the proposed conventional facility, and to determine the best method for management of such alternate facilities.

Since the collection sewers represented approximately half of the total construction costs in the conventional plans an effort was first made to reduce the size of the collection system. The community was divided into natural groupings of buildings for the consideration of various alternatives. Five groupings were made: (1) Front Street area, extending from Silver Creek north to the cemetery and from Second Street to the railroad tracks, (2) Grossman's Addition, including the area west of Second Street and the school, (3) Joseph's Addition, (4) Queenstown and (5) Appaloosa Lane, including the scattered houses north of the Front Street area (Figure 6). Each area was considered separately and in combination with adjacent areas to develop the most cost-effective system.

Collection systems were considered to be the best alternatives for the Front Street area which includes the business district. This area is primarily divided into small 150' x 50' lots. Most of the lots are developed leaving little area to construct new individual septic tank systems. Joseph's Addition is a low lying area with poorly drained soils. Individual mound systems could be installed but a common system would be more cost-effective. A similar condition occurs in Grossman's Addition area where individual systems could be installed but because of the density of homes, a common system offers the greatest advantage.

FIGURE 6: Grouping of Homes Made for  
Evaluation of Alternatives (16)



Several alternatives were considered for these areas. Because of the limited disposal sites available, it was appropriate to combine the Front Street and Joseph's Addition areas, with disposal to an extensive sand bench along Silver Creek east of town. Both pressure and small diameter gravity sewers collecting septic tank effluents were evaluated for these combined areas. In Grossman's Addition, four alternatives were evaluated. Because of topography, collection by small diameter gravity sewers to a point southwest of the school is well suited for this area. Disposal alternatives considered were soil absorption, sand filtration with chlorination before discharge to Silver Creek and pumping to the Front Street and Joseph's Addition gravity system. The fourth alternative was a pressure collection system, also combined with the Front Street and Joseph's Addition pressure system.

The remaining Appaloosa Lane and Queenstown areas are too sparsely developed to warrant collection systems. At present, individual systems seem to be the best alternative. Farm land with soils suitable for either a conventional or mound disposal system exist.

In summary, the non-central alternatives evaluated were (16):

Alternate 1

Part A: Grossman's Addition - Small diameter gravity sewers discharging to a soil absorption field west of the school (design load of 10,000 gpd).

Part B: Front Street and Joseph's Addition - Small diameter gravity sewers discharging to a soil absorption field northeast of Joseph's Addition (design load of 20,000 gpd).

Alternate 2

Part A: Grossman's Addition - Small diameter gravity sewers discharging to a soil absorption field west of school (design load of 10,000 gpd).

Part B: Front Street and Joseph's Addition - Pressure sewer discharging to a soil absorption field northeast of Joseph's Addition (design load of 20,000 gpd).

Alternate 3 (Figure 7)

Part A: Grossman's Addition - Small diameter gravity sewers discharging to intermittent sand filters west of the school with chlorine disinfection before disposal into Silver Creek downstream from the community (design load of 10,000 gpd).

Part B: Front Street and Joseph's Addition - Small diameter gravity sewers discharging to a soil absorption field northeast of Joseph's Addition (design load of 20,000 gpd).

Alternate 4 (Figure 8)

Part A: Grossman's Addition - Small diameter gravity sewers discharging onto intermittent sand filters west of the school with chlorine disinfection before disposal into Silver Creek downstream from the community (design load 10,000 gpd).

Part B: Front Street and Joseph's Addition - Pressure sewers discharging to a soil absorption field northeast of Joseph's Addition (design load of 20,000 gpd).

Alternate 5 (Figure 9)

Small diameter gravity sewers serving all areas to a soil absorption field northeast of Joseph's Addition (design load of 30,000 gpd).

Alternate 6 (Figure 10)

Pressure sewers serving all areas discharging to a soil absorption field northeast of Joseph's Addition (design load of 30,000 gpd).

Facility Selection

Final selection of one alternative over several others depended on three criteria: environmental impact, total cost and system reliability. The first two are obvious, since it is the goal of the engineer to design a facility which will protect the environment for the least cost. Judgments must be made as to whether additional environmental protection warrants added facility costs but much of this can be decided objectively. System reliability is less objective, however, and is influenced by the engineer's past experience. It is often more a confidence factor, which will eliminate some alternatives from consideration because they are not felt to be viable. This factor is what usually eliminates septic tank systems from consideration. Each of these must be weighed in the final selection.

The "Non-Central" Alternate #5 was selected as the best facility after weighing each criterium, though some assumptions made in the analysis must be proven through experience. This facility is a system of small diameter gravity sewers with final effluent disposal in a single soil absorption field (Figure 9). Pretreatment would be provided by individual septic tanks at each home. The effluent is conveyed to a conventional soil absorption field which is divided into 3 beds providing 1.5 times the estimated area necessary for absorption. Two beds would be in use at all times. The third would be alternated into use on a regular basis. This arrangement permits a bed to rejuvenate by "resting"

EXPECTED FUTURE GROWTH

FIGURE 7: Non-Central  
Alternate #3 (16)

EXPECTED  
FUTURE  
GROWTH

GROSSMAN'S  
ADDITION

SANITARY DISTRICT #1  
OF THE  
TOWN OF WESTBORO  
TAYLOR COUNTY

N. HILBACH ST.

THIRD ST.

SECOND ST.

CENTER ST.

CENT'D

JOSEPH'S ADDITION

QUEENSTOWN

SILVER CREEK

SILVER CREEK

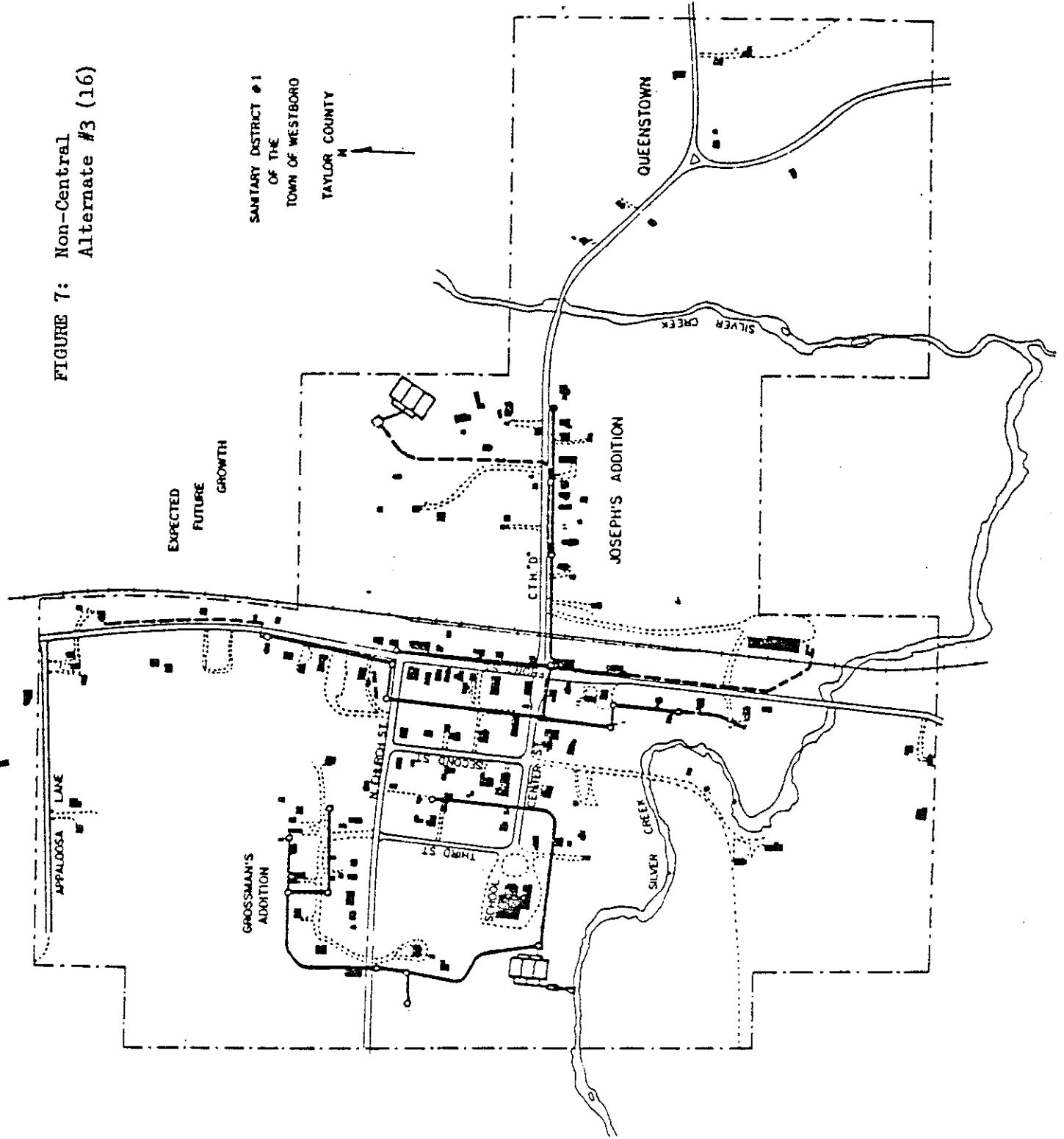


FIGURE 8: Non-Central  
Alternate #4 (16)

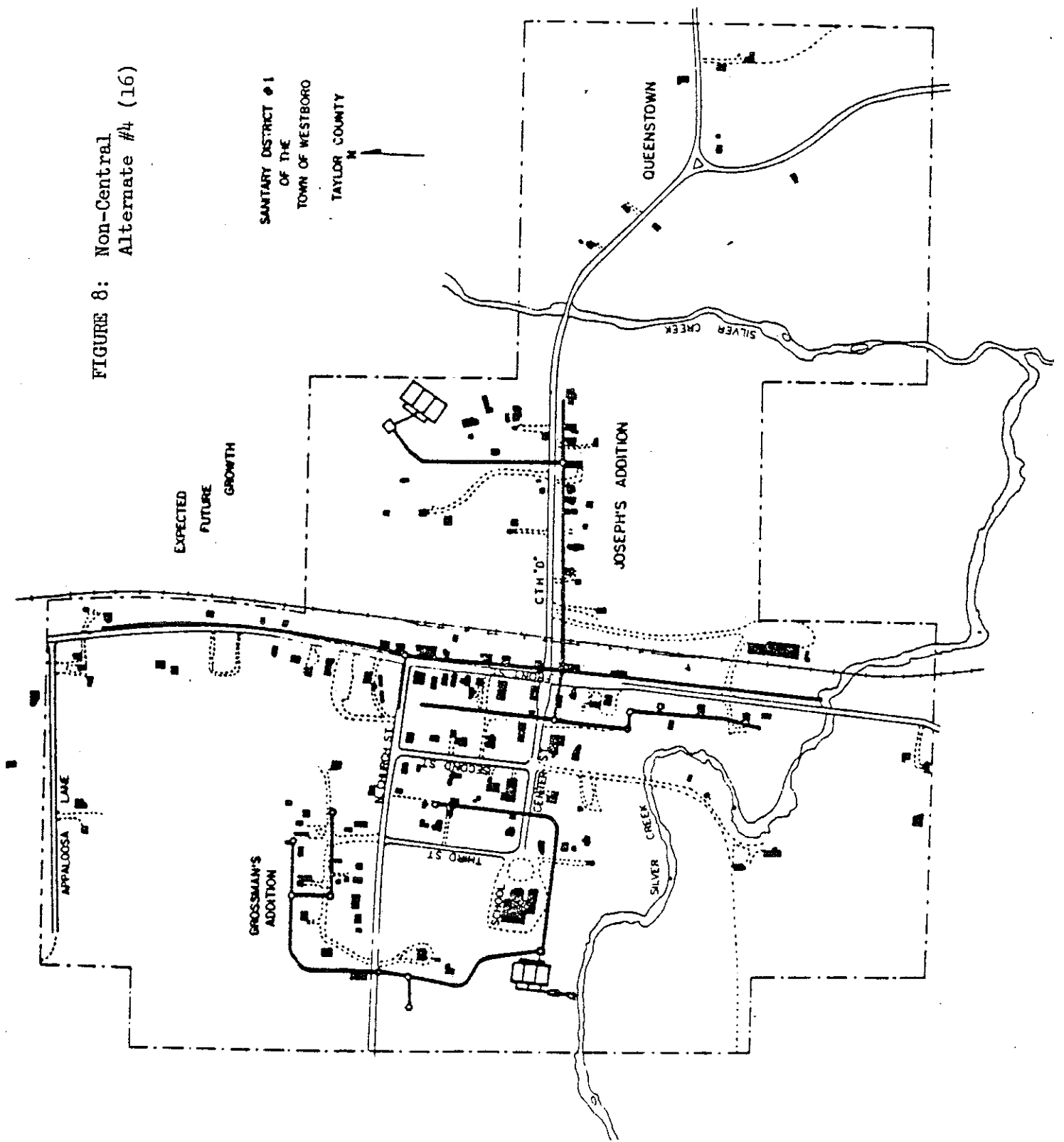
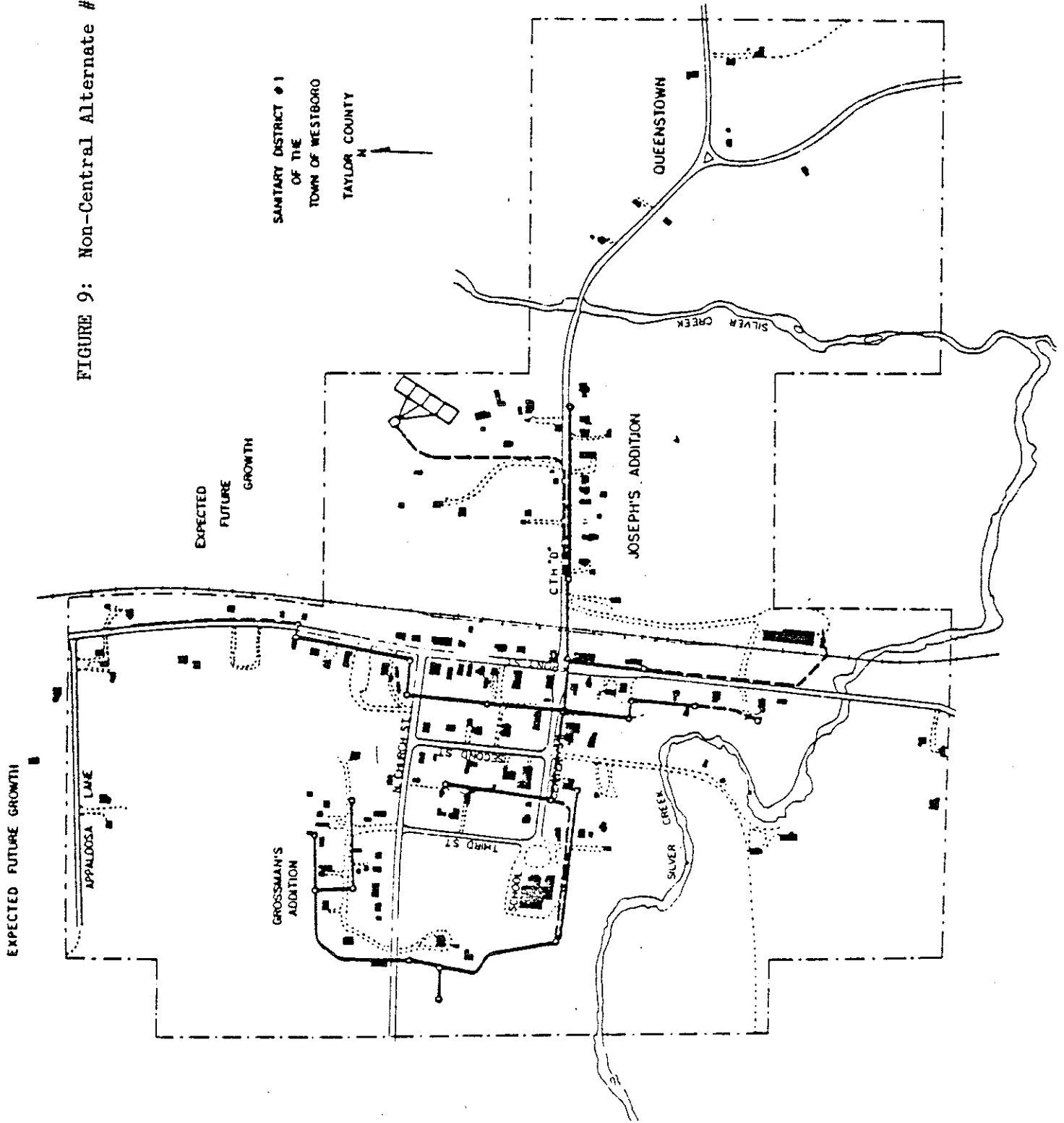


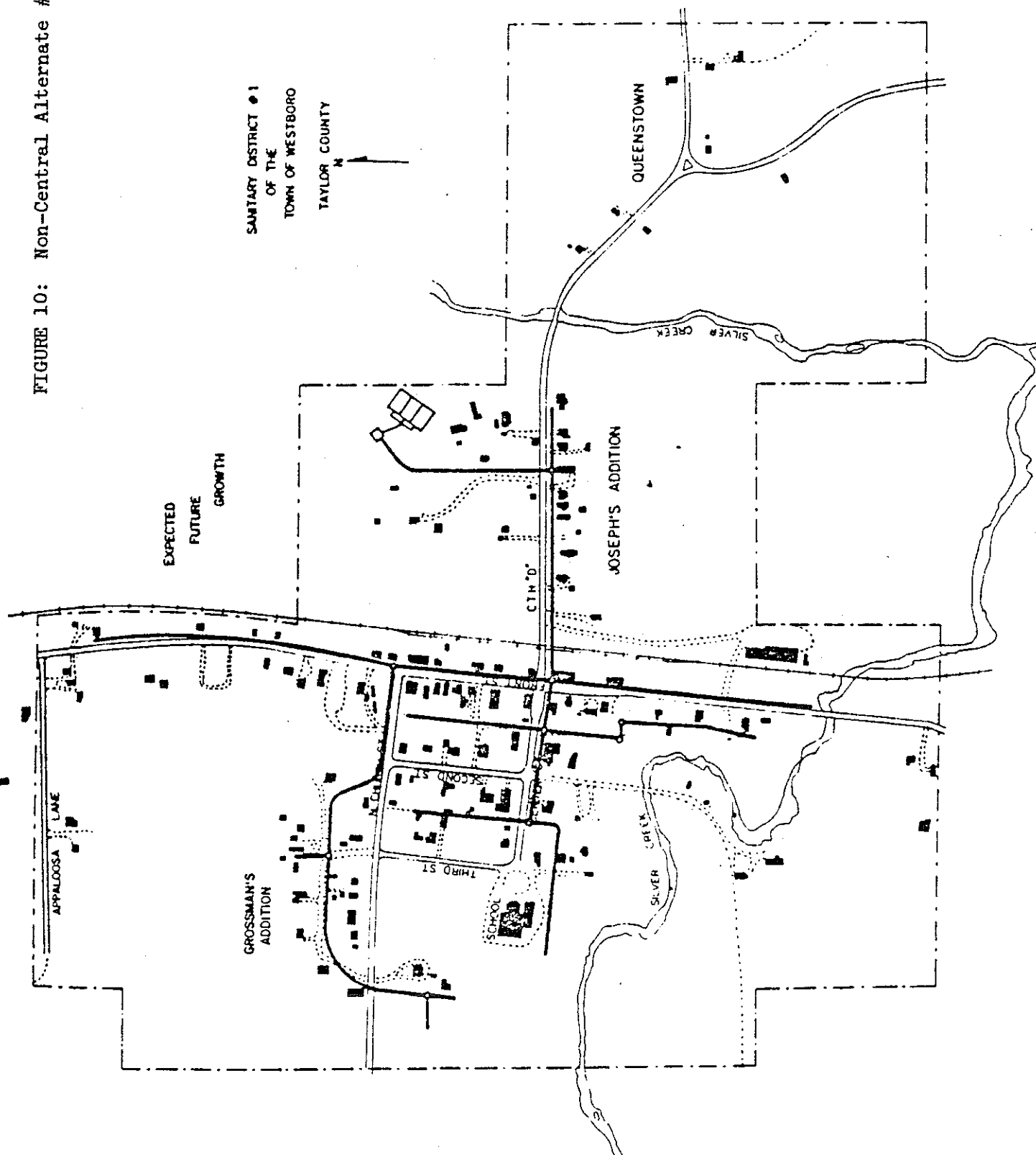
FIGURE 9: Non-Central Alternate #5 (16)





EXPECTED FUTURE GROWTH

FIGURE 10: Non-Central Alternate #6 (16)



and provides a stand-by unit. Homes outside the collection system would be served by individual septic tank systems.

This facility appears to be the least costly and more environmentally sound than the other alternatives evaluated. The reliability of this type of facility has not been established, however, but its selection is warranted because it is designed from extensive experience with smaller systems. In addition, its cost and environmental impact are a significant improvement over the conventional central facilities.

Cost comparisons between all alternates were made using present worth analysis. Present worth is equal to the initial cost plus the amount of money which must be invested at the present time to cover the costs of operation and maintenance over the life of the system. A life-time of 20 years with an annual interest rate of 7 percent was used in these computations. A summary of the estimated present worth of each alternate is presented in Table IV.

To make a fair comparison of costs, the conventional central facility alternates were redesigned to conform with present regulations and site conditions. Private individual system construction estimates were also included for those homes not served by the conventional alternates. While the cost of replacing these septic tank systems would not be borne by the District in the case of the conventional system their inclusion provides a fairer comparison between the "Central" and "Non-Central" alternates. Hookup costs are also included, for Alternates 1 and 2. They are estimated to be \$450 per service connection. Hookup costs for the "Non-Central" alternates are included in the construction costs.

"Non-Central" Alternate #5 is estimated to be the least costly of all the alternatives evaluated. The present worth of Alternate #5 is

TABLE IV. Summary of Present Worth Costs  
of Alternate Facilities (16)

"CENTRAL" SYSTEM ALTERNATE #1

Extended Aeration Treatment Plant

Collection	\$136,295.00	
Treatment	170,065.17	
Hookup	31,050.00	
Individual Systems	<u>11,976.23</u>	\$349,386.40

"CENTRAL" SYSTEM ALTERNATE #2

Raw Sewage Stabilization Pond

Collection	\$136,295.00	
Treatment	185,528.00	
Hookup	31,050.00	
Individual Systems	<u>11,976.23</u>	\$384,849.23

"NON-CENTRAL" SYSTEM ALTERNATE #1

Part A: Grossman's Add. - S.D. Gravity Sewers  
to Soil Absorption

Part B: Front St. & Joseph's Add. - S.D.  
Gravity Sewers to Soil Absorption

Part A	\$124,454.64	
Part B	145,229.00	
Individual Systems	<u>11,976.23</u>	\$281,659.87

"NON-CENTRAL" SYSTEM ALTERNATE #2

Part A: Grossman's Add. - S.D. Gravity Sewers  
to Soil Absorption

Part B: Front St. & Joseph's Add. - Press.  
Sewers to Soil Absorption

Part A	\$124,454.64	
Part B	185,308.00	
Individual Systems	<u>11,976.23</u>	\$321,738.87

"NON-CENTRAL" SYSTEM ALTERNATE #3

Part A: Grossman's Add. - S.D. Gravity Sewers  
to Sand Filters

Part B: Front St. & Joseph's Add. - S.D.  
Gravity Sewers to Soil Absorption

Part A	\$148,038.00	
Part B	145,229.00	
Individual Systems	<u>11,976.23</u>	\$305,243.23

"NON-CENTRAL" SYSTEM ALTERNATE #4

Part A: Grossman's Add. - S.D. Gravity Sewers  
to Sand Filters

Part B: Front St. & Joseph's Add. - Press.  
Sewers to Soil Absorption

Part A	\$148,038.00
Part B	185,308.00
Individual Systems	<u>11,976.23</u>

\$345,322.23

"NON-CENTRAL" SYSTEM ALTERNATE #5

Total Gravity Sewers to Soil Absorption

Joint System	\$254,440.00
Individual Systems	<u>11,976.23</u>

\$266,416.23

"NON-CENTRAL" SYSTEM ALTERNATE #6

Total Pressure Sewers to Soil Absorption

Joint System	\$294,154.00
Individual Systems	<u>11,976.23</u>

\$306,130.23

\$266,416 or approximately \$3861 per household, as compared to \$349,386 or \$5063 per household and \$384,849 or \$5578 per household for the "Central" Alternates #1 and #2 respectively. Thus, the non-central system results in a 25 to 30 percent savings per connection over the conventional facilities.

The environmental impact of "Non-Central" Alternate #5 should be minimal. Only nitrogen in the form of nitrate is expected to leach through the soil to the groundwater in amounts that may be significant. With the field's location near Silver Creek much of the nitrate will probably flow into Silver Creek increasing its nitrogen content. Phosphorus, however, will have been removed through adsorption and precipitation reactions in the soil (3). Pathogenic bacteria and viruses should also be removed (12, 14). This method of disposal is superior to direct discharge of treated effluent into Silver Creek because such effluents contain phosphorus and pathogenic organisms and viruses, as well as nitrogen.

#### Institutional Arrangements

To properly manage its non-central system, the Westboro Town Sanitary District must regulate all individual and jointly used on-site disposal systems operating within its boundaries. While no Town Sanitary District has attempted this in Wisconsin, it is within their power to do so (16, 17). Briefly, advantages would arise because the District would be able to better perform the following functions;

1. Design and construct sanitary facilities for existing and future structures.

2. Identify and obtain rights to land with suitable soils for disposal areas setting aside sufficient areas for future growth.
3. Operate and maintain all individual and joint systems within the District, including pumping of all septic tanks.
4. Monitor groundwater and surface water quality to detect failing systems.
5. Repair or reconstruct any failing systems.
6. Establish a fair assessment and rate structure for subscribers to pay for cost of services.
7. Apply for grants in aid of construction for portions of the sanitary facilities that the District will own.

Access to Private Property: Many of the facility components of the recommended non-central facility, such as septic tanks and effluent pumps will be located on private property. Since regular maintenance of these components is necessary for proper functioning of the facility, permanent legal access to the properties must be obtained for purposes of installation, operation and maintenance. These easements are required prior to construction. In most cases, however, the exact location of the existing septic tank is unknown. Therefore, a general easement tied to the location of the septic tank rather than the property line is proposed (16). Easements must also be obtained for any collection sewers of joint systems which cross private property.

It is hoped that the necessary easements can be acquired voluntarily from the property owners. Since all property owners within the district will be assessed for the cost of the facility, whether they use the facility or not, the owners might be encouraged to grant the required ease-

ments. Another factor which might serve to encourage the property owners to grant easements is the risk of prosecution by the county or state against the continuing use of their failing septic tank system. If the property owner fails to grant the easements voluntarily, however, the District could condemn such easements through eminent domain proceedings. This alternative, of course, is undesirable. The success of the non-central system depends on a strong "community effort."

Subscriber's Responsibilities: The District will be responsible for the operation and maintenance of all components of the facility located on private land commencing from the inlet of the septic tank. The property owner's only responsibility will be to provide and maintain the lateral drain from his home or establishment to the septic tank and any power costs associated with lifting his effluent into the collection sewer or absorption field, if necessary.

#### Financing of Proposed Plan

Since Westboro's priority for Federal EPA construction grants is very low, other sources of funding were sought for construction of the proposed facility. Tentative commitments were obtained from the Wisconsin Department of Natural Resources and the USDA Farmer's Home Administration (FmHA) for grants totaling approximately 50 percent of the construction costs. The remainder of the construction funds would be provided by a FmHA 4 percent, 40 year loan.

Special easements and monthly charges will have to be determined by the commissioners of the Sanitary District. However, to estimate their grant contribution, FmHA assumed a monthly charge of \$8 per residence, \$15 per commercial establishment and \$1240 for the school and a 0.004

sanitary levy which would be sufficient to retire the debt and cover costs for operation and maintenance. Special assessments of \$200 per residence, \$300 per commercial establishment and \$1500 to the school would be the remaining contribution made by the community.

Since those residents who recently constructed new septic tank systems would be reluctant to join the system, credit would be extended to them depending on the age and condition of their septic tank. In most cases the septic tank would be suitable for use by the community system, thereby saving the district the cost of a septic tank. This savings will be returned to the owner in an inverse proportion to the age of the tank.

New subscribers joining the system after construction of the facility should be expected to pay a larger assessment. A formula might be worked out whereby new residents would pay all costs of hooking to the collection sewer and their share of the absorption field. This is a decision which will have to be made by the district commissioners.

While the costs are within the financial capabilities of the community, the financial grants are not as large as hoped. Biases in funding guidelines prevent agencies from providing more despite the fact that Westboro made efforts to construct a more cost-effective facility. The DNR grant from funds provided by the State of Wisconsin is limited to 25 percent of construction costs of grant eligible items. Any portion of the system located on private property, whether or not permanent easements have been given, is not considered eligible. This is unfortunate, since it disallows the septic tanks which provide partial treatment necessary to permit the use of less costly sewers. The savings made by DNR due to the more cost-effective facility are not passed on to the



community. Land purchase is also excluded, though the soil becomes the final treatment facility in this plan.

The Farmers Home Administration does not distinguish between items for eligibility but rather bases their grant contribution on what they feel is the community's ability to pay. For the portion to be paid by the community, a 5 percent, 40 year loan is offered. The amount of the grant portion is determined by assuming a monthly charge and special assessment per residence and a sanitary tax levy according to the wealth of the community. This income is used to retire the debt and pay for operation and maintenance over the 40 year loan period. By back calculating, the amount of the grant is determined but it cannot exceed 50 percent of the total construction costs.

Both of these policies do not provide much incentive for communities to construct more cost-effective facilities. The guidelines for the DNR grant program should be reevaluated to see whether or not vital portions of the system located on private property cannot be grant eligible if permanent easements are obtained. If not, the community would be inclined to construct as much of the system on public right of way as possible. This could increase the cost to DNR and the taxpayer, but reduce the cost to the resident.

The FmHA policy provides little more incentive to construct less costly systems. By back calculating from a basic monthly charge and special assessment, the cost to the community residents changes little, regardless of the cost of the facility. This policy must be made more flexible to credit communities willing to make an effort to reduce costs.

### Monitoring Program

Performance reliability of the proposed facility remains to be proven. Public ownership and management of septic tanks located on each private lot served is rather new. The success of small diameter gravity sewers depends upon proper maintenance of the septic tanks. Further, the effects of a large soil absorption field on groundwater quality have not been established. These items will be monitored by SSWMP for the next three years, pending the availability of funding.

### SUMMARY

The demand for less costly wastewater facilities for small communities or fringe areas is increasing. Regulatory officials and engineers are realizing that if the goals of the Federal Water Pollution Control Act are to be met, more practical facilities must be developed for small communities and subdivisions. Recent studies have shown that up to 25 to 50 percent savings can be realized in public wastewater facilities in small communities by using alternatives to conventional sewerage (11,16, 18).

Though the results of these studies indicate that significant savings can be made by investigating other alternatives to conventional sewerage there are several deterrents to their widespread acceptance. Biases of engineers, regulatory agencies and funding agencies favor central gravity sewers and treatment plants. Probably one of the greatest deterrents to the use of such facilities is technical knowledge and experience with the performance of relatively untried techniques. Innovative designs take more time to prepare and have more risk associated with them. Since engineering fees are usually based upon a percentage of the construction

costs, there is little incentive to be innovative. The engineer gets paid less for doing more work and at a greater risk. Facilities like these need to be constructed and monitored to gain familiarity with non-central systems to increase their acceptance.

Regulatory agencies also favor conventional systems, due to confidence and familiarity in tried and proven methods. Innovative designs, therefore, take more time to review. Thus, the engineer is more likely to design a conventional facility that creates fewer stumbling blocks with the reviewing agency.

Another deterrent to acceptance of such facilities is the question of whether this type of plan would be eligible for federal and local construction grants. Certainly there is bias in favor of conventional sewerage, because of present component eligibility guidelines. Thus, while a conventional facility may be more costly because of its eligibility for construction grants, it becomes less costly to the subscribers. This bias is wasteful of tax dollars, as well as environmentally unsound, for it encourages communities to delay abatement efforts until funding is available.

Obviously, what is needed are additional planning studies of this nature, working with several communities or subdivisions each having different characteristics. Such studies would provide a data base to develop planning guidelines to determine the most cost-effective facility. Construction of several facilities would also increase experience with system performance to gain acceptance by engineers and the public. If it can be demonstrated that non-central facilities are effective, regulatory agencies also may see the need for a change in policy.

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