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SMALL SCALE WASTE MANAGEMENT PROJECT

An Alternative Wastewater Facility for Communities in Rural America

by

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July 1975

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AN ALTERNATE WASTEWATER FACILITY FOR COMMUNITIES IN RURAL AMERICA

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INTRODUCTION

A. Existing Situation

In the United States an estimated 15 to 17 million households, mostly in rural areas, are served by some form of private sewerage facilities (Annon, 1973). These facilities range from adequately functioning septic tanks with subsurface soil absorption fields to failing septic systems, cesspools or other inadequate variations such as direct discharge of untreated effluent into nearby surface waters. It can be assumed that a large number of people in the United States do not have satisfactory sewerage facilities. Of these 15 to 17 million households one source estimates that 5 to 10 million are relying on pit privies or direct discharge (Annon, 1973).

Many of these households, while located in rural areas, are situated in small generally disperse communities which are often unincorporated (legal non-entities which have no autonomy). Typically they range in population from a few homes to upwards of a thousand or more.

Assessment of the wastewater facility needs of these small rural communities has been difficult because of the lack of information. There has been no cataloguing of existing facilities on a state by state basis and the 15 to 17 million household figure cited above is only a rough estimate not set out on a community basis. However, the data in Table 1 taken from a 1968 study by the U.S. Department of Agriculture (USDA) give an indication of the situation in small rural communities.

Data on the State of Wisconsin (having approximately 2 percent of total U.S. population) was included to give perspective to the work in Wisconsin. The important point to note is that the lack of public sewerage facilities in both Wisconsin and the United States, as a whole, is most acute in the communities of 26 to

999 persons. Of a U.S. total in 1962 of 44,709 communities without facilities 42,837 of them fell within the 26 to 999 population range.

TABLE 1. Number of Communities With or Without Public Sewerage Facilities in 1962 (Annon, 1968)

Size of Community, Population	United States		Wisconsin	
	With	Without	With	Without
26-999	3803	42837	181	884
1000-2499	3879	1391	121	15
2500-5500	2027	349	56	3
Over 5500	2926	142	66	7
Total	11835	44709	424	909

Since 1962 there have been several governmental programs or actions, primarily at the federal and local level, which have attempted to supply adequate sewerage facilities to these communities. Consequently the data in Table 1 needs to be updated. In 1969 the Farmers Home Administration (FmHA) of the U.S.D.A. surveyed U.S. communities of less than 5500 population. Unfortunately the survey was biased by their definition of a community as being one which <u>should</u> be served by a central sewerage system. The number of communities listed in Table 2 are much lower than those in Table 1 because the definition excluded those communities which U.S.D.A. thought to be too dispersed to economically be served by a central system.

TABLE 2. Number of Communities Needing Central Sewerage Systems, 1969-1970 (Annon, n.d.)

Communities without central systems	23,356
Communities needing improvements to their central systems	6,823
Total Communities	30,179

These figures indicate that either too little attention has been given to wastewater problems in small rural communities or that the communities, because of their size, are unable to improve their facilities. Usually it is a financial problem which prevents action from being taken.

B. Typical Approach

In the past regulatory authorities at all 3 levels of American government (local, state and federal) have favored the "central" sewerage system for all communities, large and small. A central system is typically owned, operated and maintained by a central (usually public) entity and usually consists of a system of gravity collection sewers which discharge into a single community treatment plant. Preference for the "central" system is found in the engineering community as well. Hence, it is not surprising that preferences for the funding and approval of small communities systems has typically been for those of the "central" type.

In fact the regulatory authorities and the engineering community have considered private sewerage facilities (primarily septic tank systems) only as an interim method of disposal until sewers are available (Annon, 1958). The basis for the low status is perhaps due to past inappropriate applications and lack of engineering knowledge. Septic tank systems were poorly understood and therefore, improperly designed, installed and maintained. This led to many failures giving septic tanks an undeserved bad reputation, but conversely it cannot be denied that many such systems have operated very effectively and for long periods of time.

Thus, the estimate of 15 to 17 million households on private systems (mainly septic systems) should not be read to mean a corresponding number of homes which yet remain to be served by a central system. That is private sewerage facilities are not synonymous with bad sewer service just as "central" public facilities are not synonymous for good. The question of adequacy is one which requires a more in depth approach which at least involves an examination of all existing private systems to determine if they are operable.

The data in Tables 1 and 2 were based on this questionable premise that central sewerage facilities are the only type which can supply adequate sewer service to these small communities. This paper will attempt to show that one other viable alternative exists.

C. Reasons for this Preference

There are possibly several reasons for the governmental authorities to prefer this central system approach when regulating sewer funding or approving sewerage systems for small communities. First, the gravity sewer system is well established in larger communities as the most tried and proven cost effective means of providing vital sewer service in these more densely populated areas. Understandably the authorities might prefer to extend this approach to smaller communities because of their familiarity with this type of sewerage.

A second possible reason for preferring the central system is the belief that the central systems are more efficient due to economies of scale. The basis for this belief is questionable in more sparsely populated communities. Another reason for this preference might be the availability of technical expertise in the theory, design and operation of central systems.

However, despite the merits of all the above reasons it is felt that the single most important causative factor behind this preference has been the ready application of central (and usually public) management to the central system. The availability of an entity to manage the system is quite desirable from a regulatory authority's viewpoint. It is this management entity which is responsible for assuring that the sewerage system continues to function properly and in the event that it fails to do so the authorities have an entity against whom they can bring administrative or judicial action. It is this surety-potential defendant role that makes the central management entity so appealing to most governmental authorities.

In contrast, the typical private sewerage facility such as a septic tank system has no central management but is instead managed by the individual owner. The limited value of assurances given by individual owners and the distaste on the part of many regulatory officials to bring actions against individuals make central management all the more desirable. This desirability increases when one considers that for a given small community using individual systems there would be a multitude of entities (owners) to deal with compared with one central entity if a central system were used instead.

DISADVANTAGES OF CENTRAL SEWERAGE IN SMALL COMMUNITIES

A. High Per Capita Costs

As mentioned, the typical approach taken by regulatory and funding agencies has been to require even small rural communities to provide a central collection sewer system along with a common treatment facility. For these smaller communities, however, this approach is impractical due to the low density of homes and the resulting high per capita costs. Costs can reach $8000 per household for the capital portion of the system and may be higher if treatment beyond secondary is needed to meet water quality standards. It is not unusual for the system cost to approach the equalized value of the community (Annon, 1974).

The collection sewer is the most expensive component of a central system serving any sized community. But it is this capital cost of providing a means of collecting and conveying the wastewaters to the common treatment plant which makes this type of system economically prohibitive for smaller communities. Table 3 sets out capital cost data which show the prohibitive per capita costs of conventional sewers serving smaller communities.

TABLE 3. Per Capita Cost for Sewer Construction in 1968 (Exclusive of House Laterals, Interceptors and Outfalls) (Smith, 1970)

No. Communities	Average Population	Length of Sewer (Ft/Capita)	Cost (1968/Capita)
1791	387	36.93	499.51
2259	809	32.10	419.89
5375	2304	26.32	328.17
1516	6312	21.73	258.81
1200	12920	18.96	218.62
422	30089	16.15	179.14
203	66114	13.91	148.81
145	511212	9.43	91.91

Not only are the capital or construction costs for sewers the most expensive component of the central system, the same is true of the total annual costs. In 1968, the national average per capita cost for collection and treatment was \$19.80 per year. This was broken down to show that nearly 70% of the yearly cost to the subscriber is for collection (Smith, 1970).

Collection	\$13.34
Treatment	4.38
Overhead	2.08
	\$19.80 per capita per year

For small communities, of course, this cost is much higher.

B. Inability to Provide Service

Especially in smaller more disperse communities there may be outlying members of the community which are not able to be served by the central system due to prohibitive costs of extending sewers to those members. While it is realized that this problem also arises in most larger communities as well the situation is more prevalent in smaller communities. One source estimates that in over 30% of the communities with public facilities, at least 1/3 of the residences are not accommodated (Annon, 1968).

Also in the less populous communities there are fewer persons to ameliorate the higher cost associated with extending service to outlying members. This taken with the higher basic per capita costs of sewering smaller, disperse communities assures the frequent occurrence of this disadvantage associated with central systems.

C. Biases in Federal Funding Programs

Funding. The keystone of the United States water quality program is found in the Federal Water Pollution Control Act Amendments of 1972 (Act), PL 92-500, 33 USC 1251 et seq. One of the more important provisions of this act is the authorization of federal grants in aid of construction for 75 percent of the grant eligible portions of wastewater treatment works. This act is the principal source of federal funds of community facilities.

The funds are allocated to the individual states on the basis of need. However, the actual determination of the priority by which facilities will be funded is deferred to the individual state governments. Typically these priority lists are established by the state agency which has primary responsibility for water quality. For example, the Wisconsin Department of Natural Resources determines the priority list in Wisconsin.

Regulations adopted pursuant to the Act set out some minimum requirements for the states in preparing priority lists. Some of these require the state to consider the severity of pollution problems, 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.

Unfortunately the priority lists work to the disadvantage of small communities in that many of them are at the bottom of such lists preceded by larger communities with larger populations and pollution discharges. In Wisconsin this is the situation because the status determination of the priority list gives top priority to larger communities and the abatement of discharge into waters already polluted by such communities.

This emphasis denies to the smaller communities any expectation of receiving in the near future badly needed funding for central facilities.

NON-CENTRAL SYSTEMS AS AN ALTERNATIVE

In small communities a "non-central" system consisting of several on-site treatment and/or disposal systems serving individual residences or small clusters of residences offers an alternative to the central gravity sewer-single treatment facility preferred by regulatory and funding agencies. Under the rubric of "non-central" systems would be such examples as a community served by individual septic tanks with small diameter gravity sewers, or pump-pressurized sewers conveying the wastes to single or to jointly used soil absorption fields or to other treatment and disposal systems.

The use of a non-central system does not automatically exclude the possible use of central management. Though a relatively untried concept, central management of the dispersed facilities in a non-central system could be employed overcoming a major objection to the use of any system other than the conventional central one. Further, the non-central approach might be more cost effective in many applications due to deletion or reduction of costly conventional gravity sewers. Also, outlying community members often ignored because of the high cost of their inclusion could be served by such a system.

As previously discussed, many regulatory officials and the engineering community have viewed the septic tank-soil absorption system as an interim one at best. The Small Scale Waste Management Project (SSWMP) conducted at the University of Wisconsin-Madison, has shown that practical design criteria and installation procedures can be developed for soil absorption systems which, if followed, will result in soil absorption systems which can be expected to have a lifetime similar to the design lifetime of conventional treatment works. Where soil disposal is not possible, other low cost methods of treatment with surface disposal seem promising (Otis, 1975).

A. Advantages

The non-central system offers the following advantages over the central sewerage approach:

1. Existing functional septic tank-soil absorption systems can be utilized rather than providing new service.
2. Isolated outlying homes and clusters of homes can be handled individually instead of extending sewer lines out to them.
3. Only minimal treatment is required if subsurface disposal is practiced which avoids expensive secondary and tertiary treatment facilities.

4. The possible necessity of upgrading the treatment facilities to meet changing standards for effluent discharges to surface waters is avoided when soil absorption is used.

5. Operation and maintenance costs are low.

6. More rational planning of community growth is possible since strip growth encouraged by conventional sewers is avoided.

7. It is a more ecologically sound method of waste disposal since it returns the water and wastes to the land.

Those non-central systems which utilize subsurface disposal have an additional advantage. The advantage to small communities lies in the fact that this method of disposal should be grant eligible; whereas, the land used for other small community facilities such as lagoons or package plants is not. (40 CFR, Part 35, 940-2)

B. Disadvantages

Of course, there are disadvantages to non-central systems which must be overcome if this alternative is to be successful. Not all communities are fortunate enough to have suitable site conditions for the on-site disposal of septic tank effluent. The soils may be unsuitable or lot sizes too small for the construction of soil absorption fields. This not only makes it more difficult to dispose of the wastewater, but also more difficult to provide capacity for future growth of the community. In addition, care must be exercised in disposing wastes on land to prevent nitrate and other soluble ion contamination of the groundwater. Some industrial wastes would have to be handled separately. Finally, central management of dispersed facilities is a fairly new and untried concept. It has not been demonstrated that management of non-central systems can work effectively.

An additional disadvantage arises because of a question about the federal grant eligibility for some of the components of non-central systems. Under the Act components of such systems might be grant eligible if they are owned and operated by a public entity. (This public entity requirement is common to both types of systems and examples of some possible public management entities are listed in a subsequent section.) If the components meet this initial requirement there remains a question as to whether all types of components are grant eligible. For example, regulations adopted pursuant to the Act provide that grinder pumps would be eligible (40 CFR, PART 35.925-13). However, the regulations are not totally dispositive of all eligibility questions. Doubt remains as to whether a publically owned and operated septic tank would be eligible. Thus, this unresolved doubt acts as a disadvantage to the non-central system since no regulatory officials or engineering consultants are able to tell a small community what the total community costs will be because of this eligibility question.

OVERCOMING DISADVANTAGES ASSOCIATED WITH NON-CENTRAL SYSTEMS

A. Technical Solutions to Adverse Site Conditions

Many existing communities do not have site conditions favorable for individual on-site systems. Areas of a community are usually built up or platted into small lots which may not be sufficiently large to permit construction of soil absorption fields. In such cases, other methods of treatment and disposal must be investigated.

It may be possible to locate a remote site near the edge of the community with the proper site conditions at which wastewater from several homes can be collected and disposed of. Conventional or pressure-differential sewers can be used to collect the wastewater. Where the topography is rough, requiring deep cuts for gravity sewers, pressure differential sewers, either vacuum or pressure, can be much less costly. Pressure sewers seem to be the most attractive and experience with them has been good (Bowne, 1974; Carcich, et. al., 1974; Cliff, 1968). Small diameter pipes can be laid just below the frost line following the topography using a trenching machine. This does require that each house or cluster of homes have a pump, but the savings made in the installation of the collection sewer often outweighs their cost.

To reduce the cost of gravity sewers, small diameter pipes are another alternative if septic tank effluent rather than raw wastes were to be collected. In addition, curved sewers should be considered to eliminate manholes. Flushing of the sewers could be performed daily by surcharging. Wastewater could be collected from 2 or 3 homes at the upstream end of the sewer and pumped into the line once or twice a day.

If no suitable soils for construction of a conventional subsurface disposal field are located near the community, a mound system would be a possible substitute. This method of septic tank effluent disposal was developed for use in unsuitable soils by Witz and Russel in North Dakota and refined by SSWMP (Converse, et. al., 1975; Converse, et. al., 1973a,b; Witz, 1974). A medium sand fill material is placed over the original soil and the seepage bed constructed in the sand. These systems can be used in tight soils or where insufficient soil is available over groundwater or porous or creviced bedrock. They have been shown to be very effective (Bouma, et. al., 1973; Bouma, et. al., 1975). In southern climates or facilities serving seasonal operation spray irrigation or ridge and furrow irrigation are other methods to be investigated.

Additional treatment followed by surface discharge of the effluent is the only alternative other than a system of holding tanks if no suitable soil is available for disposal. Many low cost methods such as lagooning or oxidation ditches are available and used today, however, one of the cheapest methods and one so often overlooked is intermittent sand filtration of septic tank effluent. Intermittent sand filters have been shown to produce a high quality effluent while economical in operation and land requirements. The effluent qualities produced from sand filters loaded at rates of 16 to 32 gpd/ft^2 were able to meet a 20 mg/l BOD_5 and 20 mg/l SS federal and state effluent standards (Sauer, 1975). These are possible, however, only if regular maintenance is provided. If higher degrees of treatment are required, the application rate can be reduced. Filters loaded at rates of 1/4 gpd/ft^2 were able to achieve a BOD_5 of less than 10 mg/l and completely nitrified (Otis, Ziebell, 1973). Disinfection may be required by most state agencies following the filters if the waste is to be discharged to surface waters.

The use of collective systems at remote sites does pose some other problems, however. First, it makes it more difficult to provide capacity for future growth of the community. To overcome this, areas of probable growth must be identified and suitable land set aside for future disposal fields or additional capacity built into existing fields. This requires that the local unit of government adopt and strictly enforce zoning ordinances to insure a rational growth pattern.

Second, groundwater contamination, particularly by nitrates, becomes a concern when large quantities of wastewater are disposed of in a concentrated area. Nitrate at levels above 10 mg/l as nitrogen is felt to create a danger of methemoglobmenia in infants. Since nitrate is a very soluble ion able to move easily through the soil to the groundwater, the disposal area must be located where hydrogeologic conditions indicate that water supply wells will not be endangered. If suitable areas are not available, methods of nitrogen removal must be investigated or surface disposal used. Low cost nitrogen removal systems are presently being presently has a population of about 125 people. The only industry remaining in town is a small cheese factory and a machine tool company both employing a total of about 10 people.

There are 91 buildings located in the community, including a grade school, four churches and local commercial establishments. Of these, only 69 are occupied, the rest being vacant. A 1971 survey conducted by the Wisconsin Department of Natural Resources (DNR) showed that 80% of the occupied structures were discharging raw or poorly treated wastewater above ground via storm drains or open ditches. Much of the waste subsequently enters Silver Creek which flows to the south of town. Most of the septic tank systems have failed due to a combination of poor soils, poor installation and poor maintenance. Westboro, therefore, is currently under orders by the Wisconsin DNR to provide proper wastewater facilities.

B. Proposed Conventional Central Sewerage

In an effort to comply with the DNR order the residents of Westboro took the legal step of petitioning the township government to form a Town Sanitary District as provided for by Wisconsin State Statutes. These statutes provide enabling legislation for the formation of special purpose districts which clearly have all of the powers necessary for central management of either a central or a non-central system. The township authorized the formation of the Sanitary District #1 of the Town of Westboro having the boundaries as shown in figure 1. The district hired an engineering firm to develop a plan to solve their wastewater problem. The plan, completed in late 1967, recommended a gravity sewer collection system with treatment provided by a two cell stabilization pond (Ruble & Kaple, 1967). (See figure 2.) This is a typical plan proposed for most small communities in Wisconsin.

Because of the scattered housing not all of the residents within the district would be served by this plan. Homes to the north of town and to the east across Silver Creek would not be included because of the excessive costs involved. Thus, only 60 of the 69 occupied buildings would be provided with collection and treatment.

Even by restricting central sewerage to the more populated sections of Westboro the proposed system is very costly. Estimated construction costs in 1975 are $278,000 less hookups, contingencies, and engineering and legal fees. (See Table 2.) This is more than $4,600 per household served which the district cannot afford. Application has been made for United States Environmental Protection Agency (EPA) construction money, however, available to governmental or quasi-governmental management entities.

Various Possible Types of Central Management. The entities which could manage a non-central system, of course, vary from state to state due to different state constitutions, agency rules and regulations and basic policy. However, the following list sets out some entities that usually have the requisite powers to adequately manage a non-central system. The entities are as follows:

1. Incorporated Cities and Villages - local units of general government which have home rule powers;
2. Counties and Townships - again local units of general government;
3. Special Purpose Districts - quasi-governmental units;
4. Private Non-profit Corporations;
5. Rural Electric Cooperatives (the cooperatives which were established to work with the Federal government's Rural Electrification Administration to supply electric power to rural United States);
6. Private Profit-making Businesses; and
7. Other Governmental Agencies.

DEMONSTRATION OF A NON-CENTRAL SYSTEM WESTBORO, WISCONSIN

In September, 1974, the Upper Great Lakes Regional Commission (UGLRS) provided a demonstration grant to the Small Scale Waste Management Project at the University of Wisconsin, Madison, Wisconsin, to determine whether or not a more cost effective alternative to central sewerage for small communities can be developed utilizing on-site disposal techniques. The purpose of the project is to demonstrate if a non-central wastewater treatment and disposal facility is a technically feasible and a practical cost effective alternative subject to central management. The community selected for the demonstration was the unincorporated community of Westboro, Wisconsin.

A. Description of Westboro

Westboro is typical of many small communities in the Midwest. It is an older community which sprang up along the railroad as it moved north from Chicago, Illinois. Lumber was the community's principal industry but this has since declined and with it, the population. According to the 1970 federal census, the population of the township has declined 40% in the past ten years with the community of Westboro following this trend. The community

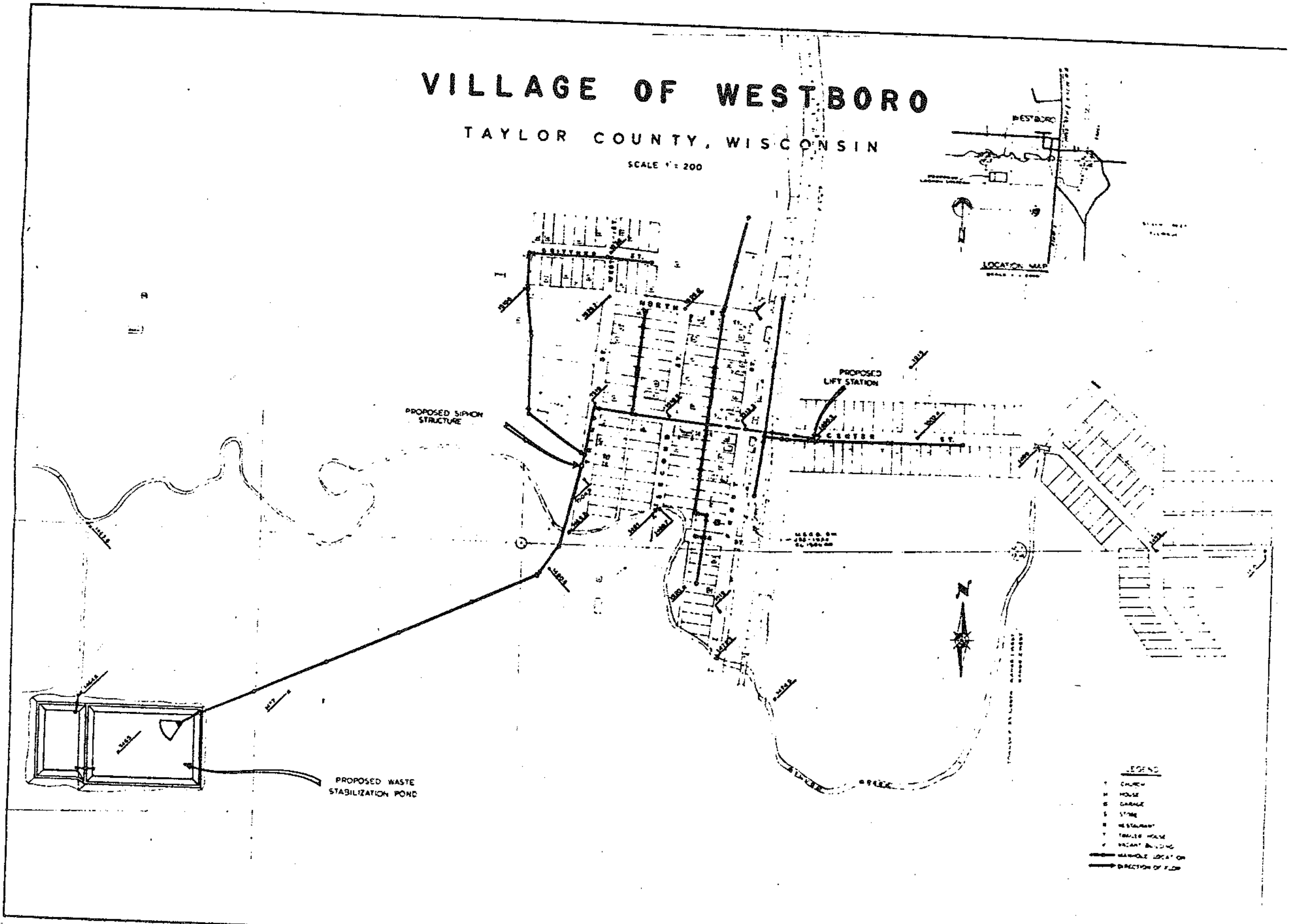

Figure 2. Recommended Conventional Central Sewerage

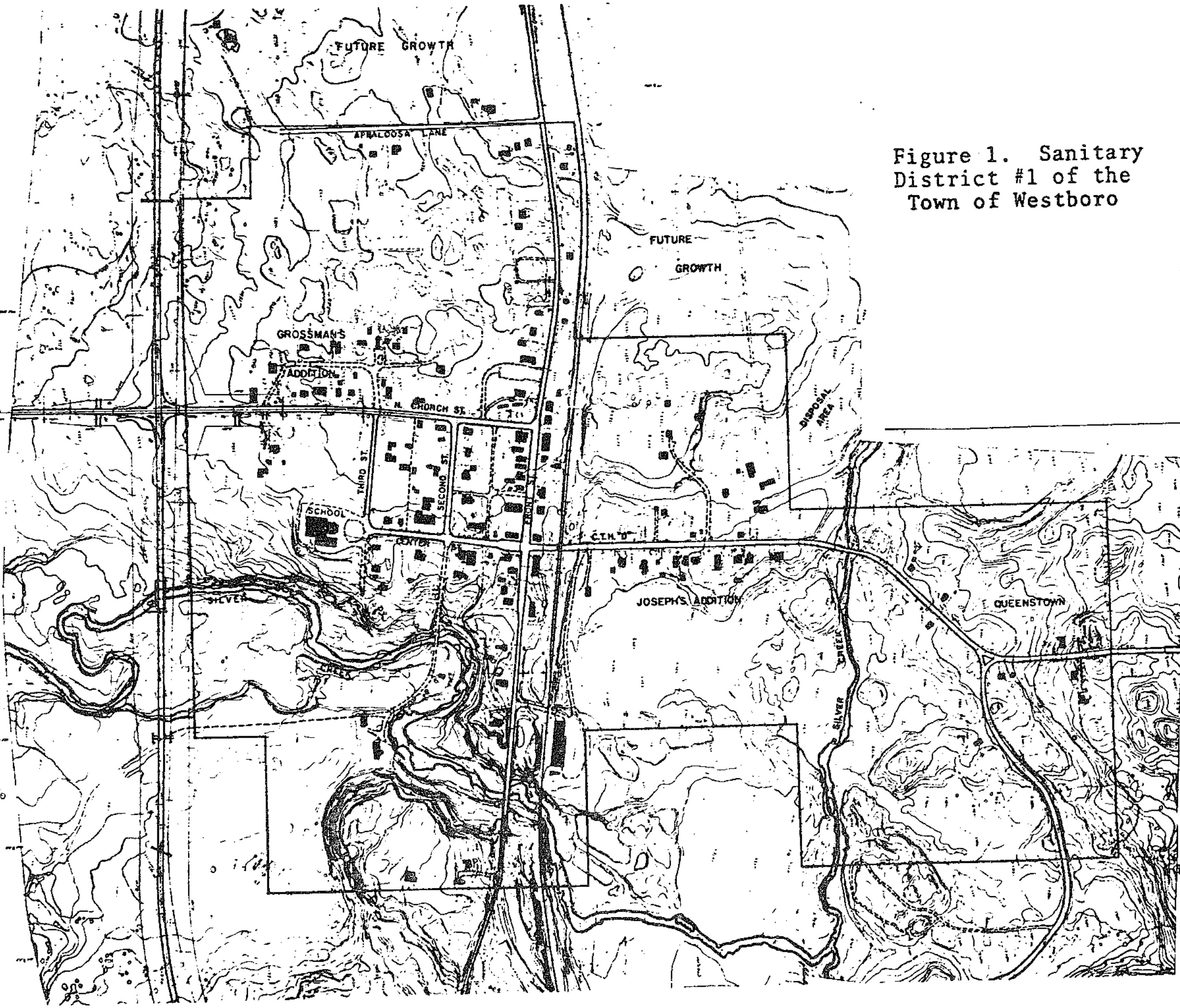

Figure 1. Sanitary District #1 of the Town of Westboro

investigated by SSWMP.

It may be that after consideration of all these alternatives, central sewerage is the best solution. Generally speaking, however, most small communities can make use of one or a combination of the above, to achieve a more cost-effective sewage handling facility.

B. Central Management of a Non-Central System

Of the disadvantages mentioned, management is probably the most critical. Though relatively untried, the use of individual or small jointly used on-site systems does not automatically exclude the use of central management. On the contrary, there are several methods of exerting public (and in some cases private) central management over such systems and these methods have been or are in the process of being successfully applied in various locations throughout the United States.

Powers Needed by a Central Management Entity. Any management entity which endeavors to administer on-site systems with the same effectiveness as one which manages the conventional central system should have the authority to perform vital functions. First, the central management entity should be empowered to own, purchase, lease and rent both real and personal property. Also it must have the authority to construct, plan, design, inspect, operate and maintain all types of sewerage system components located within its jurisdiction. This is true whether the component is a typical septic system serving a single family residence or a much more involved and complex one serving a group of residences. One should not imply that the entity is limited to providing services within its jurisdictional boundaries, but only that the entity at least have the above ownership and operation powers within its boundaries. Under state statutes, by interpretation by courts of law, or as terms of a contract, the entity may have extra-territorial jurisdiction to serve residences and to own and operate sewerage systems.

Secondly, while not a necessary condition of a management entity, it is highly desirable that the entity meet the eligibility requirements for both loans and grants in aid of construction of these systems from both the federal and state governments. For the primary source of federal funds the major requirement is public ownership and operation of the system. While it is obvious that a management entity can function without being eligible for these loans and grants, the viability of the "non-central" system is strengthened when grant money is used to offset some or most of the costs to the families served by the entity. This is especially true considering that low income rural families typically cannot afford to finance the entire cost of their sewerage system. One source cites that experience shows that these low-income families cannot pay wastewater bills in excess of $7.00 per month or a combined water-sewage bill of $14.00 per month and this rate is difficult to reach without benefit of public subsidy (Annon, 1973). The inequity should be especially obvious to non-rural residents, since they typically pay considerably less than this amount.

Third, the management entity should be able to enter into contracts, to undertake debt obligations either by borrowing and/or by issuing stock shares or bonds and to sue and be sued. These powers are more than mere legal niceties because without them the entity would not be able to acquire the property, equipment, supplies and services necessary to construct or operate any component of a non-central system.

Fourthly, the entity must be able to fix and collect charges for sewerage usage, determine the benefit of any property in its jurisdiction, set the value or cost of such benefit and collect or assess the cost from each property owner so benefitted. Further, as an optional power, the entity could have the power to levy taxes upon all owners within its jurisdiction for the purpose of raising funds to administer this non-central system. Obviously, this taxing power is limited to various governmental or quasi-governmental management entities. In lieu of taxing power, the non-government management entities must have the authority implied or directly granted to set and collect user fees sufficient to cover administrative costs as well as all others.

Fifth, and quite importantly, the entity must either have the power to plan and control how and at what time sewage service will be extended to those within its jurisdiction or to have general land use or zoning authority.

Lastly, as an optional power, the entity would be much more effective in protecting the public health and promoting good public sanitation if it were also empowered to make rules and regulations regarding the use of the system and to issue orders against violators of these rules or regulations. As a desirable additional power to promote good public sanitation, the entity should be empowered to require the abatement of malfunctioning systems and to require the replacement of all such systems, all according to the plans of the entity. This power may only be of town but it will be minimal.

It was immediately apparent that collection facilities would have to be provided for the buildings in the center of town. The soil is too slowly permeable to accommodate individual septic tank systems on the small lots. A remote site must be used for disposal. The sand bench east of town was selected.

As shown previously the most costly portion of conventional sewerage is the collection system. Therefore, less expensive methods were sought. It was determined that if septic tank effluent were collected rather than raw wastewater then pressure and small diameter curved gravity sewers would be less costly. Both types of collection are proposed for demonstration at Westboro. In each case, every home will be provided with its own septic tank. Though individual septic tanks are more costly than a single large central septic tank, there are advantages which outweigh their cost: (1) Small diameter (3" to 4") curved gravity sewers can be used since deposition of solids would not be a problem. Daily flushing provided by an upstream pumping station receiving wastes from 2 or 3 homes should be sufficient to keep the line clean. This allows the sewers to be installed with minimum slope and eliminates the need for manholes. (2) Pressure sewers are less costly since inexpensive submersible pumps can be used rather than costly and high maintenance grinder pumps. The problem of grease deposition on the crown of the pipe is also eliminated since it is removed in the septic tank along with grit and other solids.

Pressure sewers are proposed for Front Street, the blocks east of Second Street and Joseph's Addition. (See figure 3.) Joseph's Addition was included because of the very poorly drained soil conditions there. This system will serve 41 occupied structures with capacity for an additional 16 homes. Each home will have a 1,000 gal. (3785 l) septic tank followed by a pumping chamber with a small submersible centrifugal pump. In case of pump failure the pumping chamber will have a high water alarm and capacity for at least one day's flow above the alarm switch to allow time for repair.

The design of the pressure sewers follows the procedures developed by others (Environment/One Corp., 1974; Hydr-O-Matic Pump Division, 1974; Bowne, 1974). Small diameter plastic pipe 1-1/4 inches (3.2 cm) to 2 inches (.5 cm) in diameter will be used throughout. It will be laid just below the frost line following natural topography. The system will terminate in a siphon chamber at the disposal site east of town. The siphon will the district's priority for receipt of funds is 372 out of 395. As more communities apply, its assigned priority may drop further. Thus, Westboro is unable to comply with the DNR order. And with no alternative, DNR is powerless to do anything short of evicting the residents from their homes. The public health and environmental hazard continues.

C. Proposed Alternate Non-Central System

Before a facilities plan utilizing on-site treatment and disposal techniques could be developed surveys of Westboro were necessary to determine location and status of all septic tank systems, soil conditions, and areas of potential growth. District commissioners, local residents and county officials assisted in these surveys.

The septic tank survey revealed that only 17 of the 69 occupied structures had functional systems while 7 had no system at all. The condition of most of the septic tanks is unknown. It is assumed except for the 17 good systems nearly all of the tanks are no longer suitable.

The soil survey indicated that the soils in and around Westboro are primarily silt loams. In the center of town the soil is a somewhat poorly drained silt loam with estimated percolation rates of 30 to 90 minutes/inch (5 to 1.7 cm/hr). Surrounding the community is a well drained silt loam with estimated percolation rates of 20 to 45 minutes/inch (7.5 to 3.3 cm/hr). But the slopes there are greater than 10% limiting its use for soil absorption systems following the Wisconsin Department of Health Administrative Code H62.20. Along the bank of Silver Creek east of the business district a large sand bench compried of a clean medium sand was located. Estimated percolation rates are 10 minutes/inch (15 cm/hr). This area is relatively flat with the water table below 8 feet (2.4 m) making it a suitable site for a large scale soil absorption system.

In discussions with town board members and district commissioners, areas of potential growth were located in town. The areas bounded by Appaloosa Lane and Front Street just north of the district line and east of the railroad tracks just north of the disposal area are most likely to be developed. (See figure 1.) If a proposed dam is built across Silver Creek upstream from Westboro additional growth can be anticipated around the created lake. These are the only areas of large scale growth that must be contended with. Other home construction may occur within the center discharge twice daily to two subsurface disposal fields designed to handle 29,000 GPD (110,000 l/day). One standby disposal field will be provided to alternate between the other two on a periodic basis always allowing one bed to rest. The total cost of this system including hookups is estimated to be $104,000 or $2,500 per building initially served. (See Table 4.)

Small diameter gravity sewers are proposed for Grossman's Addition and the area west of Second Street. They will serve 18 homes and a 6 classroom elementary school initially with additional capacity of 4 homes provided. The system is designed to handle 20,000 GPD (76,000 l/day). The septic tanks at each home will drain directly into the 4 inch (10 cm) diameter plastic pipe. Provisions for surcharging will be made upstream by installing a pumping station which will accumulate a sufficient quantity of wastes from 3 homes to completely fill the sewer when the liquid is pumped out. This will flush out any deposited solids daily. No manholes will be installed but watertight cleanouts will be provided at changes in direction.

TABLE 4. Estimated Construction Costs of Non-Central Alternatives

	Front St. & Joseph's Add.	Grossman's Addition Alt #1 Sand Filters	Grossman's Addition Alt #2 Soil Fields	Individual Systems
Pretreatment	12,300	4,800	4,800	1,200
Collection	53,500	20,800	44,800	--
Treatment	--	40,720	--	--
Land Disposal	38,230	--	36,000	4,800
Total Construction Costs	104,030	66,320	85,600	6,000

The sewer will discharge to a low point just southwest of the school. Two alternatives are being investigated for the disposal of the collected wastes. The first is to further treat the septic tank effluent using intermittent sand filters before disinfection and discharge to Silver Creek. This type of system has been shown to be viable (Sauer, 1975). The filters will have removable insulated covers to allow maintenance to be performed. A standby unit will also be provided here for rotation of service. Disinfection will be by chlorine or ultra-violet light. The estimated construction cost of this system is $66,000 or $3,500 per structure served. (See Table 4.)

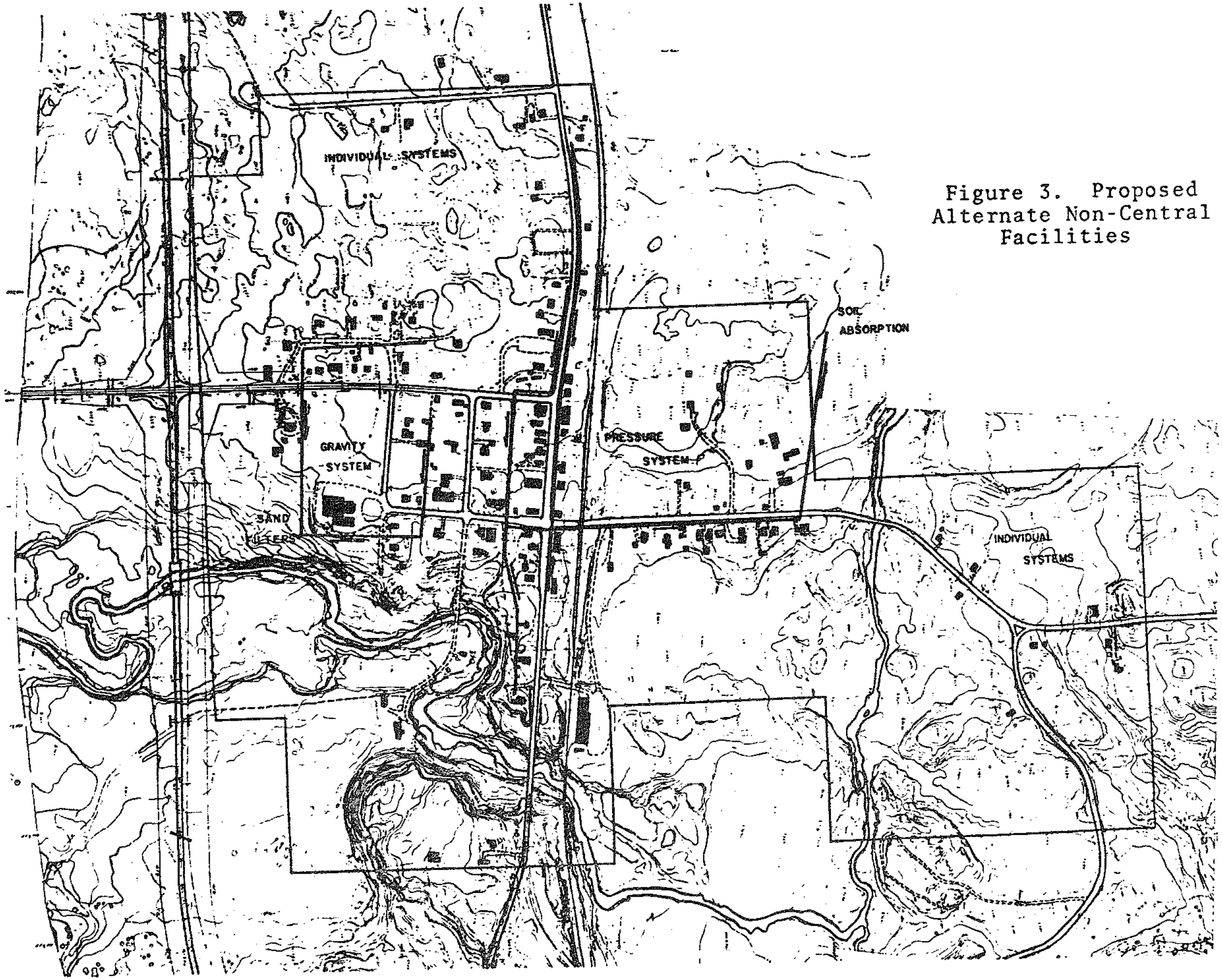

Figure 3. Proposed Alternate Non-Central Facilities

while that for the lagoon would not. Also, the septic tanks and pumps should be eligible. Thus, the cost differential per building served would make the non-central system even more attractive to residents of Westboro.

TABLE 5. Comparison of Total Annual Costs

	Conventional (Lagoon)	Alternate #1 (w/sand filters)	Alternate #2 (soil disposal only)
Pretreatment	--	18,900	18,900
Collection	104,120	74,300	98,300
Treatment	172,580	38,718	--
Land Disposal	--	43,030	79,030
Hookup	27,000	--	--
Total Construction	304,700	174,950	196,230
Amortized Cost (20 yr. 6%)	26,510	15,220	17,070
O & M	1,700	3,650	3,650
Total Annual Cost	28,210	18,870	20,720
Annual Cost/Building Served	470 (60)	273 (69)	300 (69)

If growth occurs in the anticipated areas, it would be easily accommodated by this system. It is recommended that the district purchase additional land on the sand bench which could be used as a disposal site for a large scale development in the area east of the railroad tracks. Growth in the area north of Appaloosa Lane is anticipated to be on large lots so individual systems would be the best alternative. A collection system with subsurface disposal could be installed if deemed necessary, however. A disposal site should be selected and reserved in that area, if much growth is truely anticipated.

Whatever type of facility is finally selected, it must maintain the quality of the surface and ground waters in the area. It is not expected that the groundwater used for private water supplies will be adversely affected by this system because of the location of the disposal sites. However, the nitrate concentration of the stream may increase below the sand bench used for soil absorption. To monitor any changes approximately one-third of the private wells in Westboro are presently being sampled regularly to obtain background water quality data. Monitoring will continue after installation of the disposal fields if funding is available

The other alternative is to pump the wastes over to the disposal area used for the pressure system. This would be a lower maintenance system. However, the necessary lift station increases the cost substantially. Construction costs of this alternative are $87,000 or $4,600 per building initially served.

All other homes and establishments in the district will have individual septic tank-soil absorption systems installed. These will be owned and operated by the district, however. This will include Queenstown and the homes along Appaloosa Lane. Approximately 4 homes will require new systems at an average cost of $1,500 each.

Maintenance will also be provided by the district for existing functional septic tank systems. If any failure occurs in the future the decision will be made either to repair the system or to hook up to one of the sewer systems.

Operation and maintenance costs of the complete system should not be great. All septic tanks will have to be pumped approximately once every 3 years at a cost of about $40 per tank. Bowne (1974) estimates the pumps will require rebuilding every 5 years at a cost of $50 each. Kreissl (1975) estimates pressure sewer maintenance to be from 8 to 9 cents/yr/ft (26-30 ¢/yr/m). One man would be needed to do routine maintenance on an average of 2 hours a day 5 days a week. On this basis total O & M costs are estimated to be $3,650/yr.

Estimated operation and maintenance costs for the proposed conventional central system are somewhat less. Sewer maintenance is estimated to be 7 to 8 cents/yr/ft (23 to 26 cents/yr/m) (Smith, Eilers, 1970). In addition, one man working an average of 1 hour a day 5 days a week would be needed to inspect and maintain the lift station and pond. Total O & M costs are estimated to be $1,700/yr.

For direct comparisons of the conventional and alternative facilities the total yearly costs can be computed. The capital costs are amortized over 20 years at 6 percent interest. Since systems include hookup this cost must be added to the cost of the conventional system. An average cost of $450 was assumed which includes pumping and filling the septic tank. Comparison of the computed yearly costs per building served shows the non-central facility can save from 33% to 39% over the conventional system (See Table 5).

Land costs are not reflected in these estimates. However, as pointed out previously, if federal funding under the Act is obtained the cost for the subsurface disposal field should be grant eligible such fees.

Land Use Controls. The district does not have general zoning authority; however, it can clearly control how and when hookups can be made to the proposed sewerage system. Some attempts have been made to anticipate growth and the system has additional capacity. The TSD can control how this capacity might be used. Further the Wisconsin Statutes provide that instead of providing a hookup to the collection sewer, the district may order any resident of the town to install an individual private sewerage system. In summary, the lack of zoning authority should not hamper the district.

Maintenance. The district has the authority to hire an employee to maintain the sewer systems and pump out the individual septic tanks. Or it may contract for either or both of these services.

DISCUSSION

Although exact data are not available, there are many small communities in the United States with populations of less than 1,000 which do not have adequate wastewater facilities. The approach preferred by regulatory authorities and the engineering community has been to require the construction of a central system consisting of gravity collection sewers and a single common treatment plant. For small communities, however, this approach is impractical due to the low density of homes and the resulting high per capita costs. With no alternative, many communities are unable to construct needed facilities often continuing a pollution problem and halting economic development.

In an effort to determine if a more cost effective alternative was available the Upper Great Lakes Regional Commission granted funds in September, 1974, to the University of Wisconsin, Small Scale Waste Management Project, for a demonstration project. The alternative chosen was a "non-central" sewerage system serving a small community using individual and jointly used septic tank-soil absorption systems. The purpose of the project is to demonstrate whether such a non-central facility is technically feasible and if it provides a practical cost effective alternative which is subject to central management as are conventional septic systems.

If such an alternative did prove to be most cost effective for these smaller communities the national policy demonstrated by the language and intent of the Federal Water Pollution Control Act to determine if significant and dangerous groundwater contamination is occurring. Additional well points will be put in around the selected disposal areas prior to installation to measure groundwater gradients and monitor water quality changes near the disposal area. Samples are also taken from Silver Creek above, in, and below Westboro to monitor water quality changes.

D. Sanitary District #1 of the Town of Westboro

While no Town Sanitary District (TSD) in Wisconsin has attempted ownership of individual systems, it is within their power to do so. The TSD in Westboro will attempt ownership of all the components of the non-central system described, and by so doing will seek federal funding under the 1972 Act.

Assessment. However, even if the TSD is successful in obtaining federal funding, it will probably be necessary for the residents of Westboro to pay some (probably 25 percent) share of the cost of this non-central system. The district has the requisite authority to raise the community's share. The probable approaches being considered for the TSD at this time involve arriving at a fair method of assessing the needed capital costs. One of three approaches will likely be choosen. The easiest to administer would involve splitting the community's share equally among the residents. While being the most straight forward it also has the danger of being most inequitable. There are no provisions for contributions from those who subsequently divide their land.

The second approach could involve a detailed attempt at estimating the actual costs of supplying services to each resident and specially assessing each accordingly. This is quite equitable but the district might find such an approach to be unworkable. Also it would be difficult to obtain an appropriate change in the event of subsequent land division by a resident.

The third approach would involve an assessment for value received. The assessment would be proportional to amount of frontage feet or the developable land area. Thus, the residents who currently own more than one lot in the subdivided portions of Westboro would be assessed for the value of sewer service to all of their lots. This third method of assessment would probably be the most equitable of the above three.

Users Fees. At this time the district anticipates that the rather low operation and maintenance costs will be borne equally among all users. However, the possibility of imposing a surcharge on the school and commercial establishments is being considered. Under state statutes the TSD is authorized to fix and collect

ACKNOWLEDGMENTS

We wish to acknowledge the assistance given us by A. Lietzke and E. Kilbly, Taylor County Extension Resource Agent and Zoning Administrator respectively in coordinating our activities in Westboro. Also, the help given us by the District Commissioners and other community residents cannot go unnoticed. A special acknowledgment must be given L. Forde for his development of much of the cost data used in this paper.

Amendments of 1972 would be furthered. That is, the cost savings resulting from a more cost effective system would permit the federal grant aids provided by the act to be extended to provide construction dollars to an increased number of communities.

It was this possibility of effecting a cost savings that encouraged the Commission to fund the demonstration project. The preliminary results of the project have shown that this "non-central" approach in the small community of Westboro, Wisconsin, can result in a cost savings of at least 33 or 39 percent over the least costly central system typically proposed for communities of this size. The two figures occur because of alternate methods of treating the effluent in one area of Westboro.

As a further conclusion legal analysis tends to indicate that the type of non-central alternative for Westboro is capable of central management. The management entity most suited to manage such a system in Wisconsin is the Town Sanitary District, a public entity formed by local township government.

of Civil and Environmental Engineering, University of Wisconsin, Madison.

Smith R. and Eilers R.G. (1970) Cost to the Consumer for Collection and Treatment of Wastewater, Water Pollution Control Research Series 17090-07/70. U.S. Environmental Protection Agency, Washington, D.C.

Witz R.L. (1974) "Twenty-five Years With the NODAK Waste Disposal System" Home Sewage Disposal, Proceedings of the National Home Sewage Disposal Symposium, ASAE Publication Proc-175.

REFERENCES

Annon (n.d.) Farmers Home Administration, U.S. Dept. of Ag., Washington, D.C., unpublished report.

Annon (1968) "Status of Water and Sewerage Facilities in Communities Without Public Systems" Agricultural Economics Report Number 143, Economic Research Service, U.S. Dept. of Agriculture.

Annon (1973) Water & Wastewater Problems in Rural America: Commission on Rural Water, Washington, D.C.

Anonymous (1968) "A Study of Sewage Collection and Disposal in Fringe Areas," Progress report of the Committee on Public Health Activities of the Sanitary Engineering Division, Journal of Sanitary Engineering Division, ASCE, 84, SA 2.

Bouma J., Converse J.C. and Magdoff F.R. (1973) "A Mound System for Disposal of Septic Tank Effluent in Shallow Soils Over Creviced Bedrock" Proceedings International Conference on Land for Waste Management, Ottawa, Canada (October 1-3).

Bouma J., Converse J.C., Otis R.J., Walker W.G. and Ziebell W.A. (1975) "A Mound System for On-Site Disposal of Septic Tank Effluent in Slowly Permeable Soils with Seasonally Perched Water Tables" Journal of Environmental Quality (in press).

Bowne W.C. (1974) "Pressure Sewer Systems" published by Douglas County Engineer's Office, Roseburg, Oregon.

Carcich I.G., Hetling L.J. and Farrell R.P. (1974) "Pressure Sewer Demonstration" Journal Environmental Engineering Division, ASCE, 100, EE1, pp. 25-40.

Cliff M.A. (1968) "Experience With Pressure Sewerage" Journal of Sanitary Engineering Division, ASCE, 94, SA5, Proc. Paper 6150, pp. 849-865.

Converse J.C., Otis R.J., Bouma J., Walker W.G., Anderson J.L. and Stewart D.E. (1975) "Design and Construction Procedures for Mounds in Slowly Permeable Soils With Seasonally High Water Tables" Small Scale Waste Management Project, University of Wisconsin-Madison.

Converse J.C., Otis R.J. and Bouma J. (1975a) "Design and Construction Procedures for Fill Systems in Permeable Soils With Shallow Creviced or Porous Bedrock" Small Scale Waste Management Project, University of Wisconsin-Madison.

Converse J.C., Otis R.J. and Bouma J. (1975b) "Design and Construction Procedures for Fill Systems in Permeable Soils With High Water Tables" Small Scale Waste Management Project, University of Wisconsin-Madison.

Environment/One Corporation (1973) "Design Handbook for Low Pressure Sewer System" 3rd Edition, Schenectady, New York.

Hydro-O-Matic Pump Division (1974) "Pressure Sewer System Manual and Engineering Guide" Ashland, Ohio.

Kreissl J.F. (1975) U.S. Environmental Protection Agency, Cincinnati, Ohio, Personal Communication.

Otis R.J. (1975) "On-Site Disposal of Small Waste Flows: University of Wisconsin's Small Scale Waste Management Project" University of Wisconsin, Madison, Wisconsin.

Otis R.J. and Ziebell W.A. (1973) "A Report of an Investigation of A Subsurface Sand Filter Loaded With Septic Tank Effluent at the Cleveland Heights Elementary School, New Berlin, Wisconsin" A report to the Wisconsin Department of Natural Resources and the Department of Health and Social Services, Small Scale Waste Management Project, University of Wisconsin-Madison.

Ruble and Kaple, Inc. (1967) "Preliminary Engineering Report on Waste Collection and Treatment: Community of Westboro, Wisconsin" Duluth, Minnesota.

Sauer D.K. (1975) "Intermittent Sand Filtration of Septic Tank and Aerobic Unit Effluents Under Field Conditions" M.S. Thesis, Dept.