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(#14.10)

Richard J. Otis, Robert T. Fey

Small Scale Waste Management Project
University of Wisconsin

December 1981

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Wastewater facility planning in small unsewered areas can present unique problems to the engineer. The costs of constructing, operating and maintaining a conventional public wastewater facility are often beyond the financial capabilities of the people to be served. The high costs are usually the result of applying technologies that are well adapted to large urban areas to small communities where they are poorly suited. Until recently, most water pollution abatement efforts have been concentrated in large cities and metropolitan areas where a network of gravity collection sewers to convey the wastes to a common treatment plant is the most reasonable facility. This type of facility has come to be considered the ultimate design of any public wastewater facility. While this is the standard against which all alternative facilities should be judged, other lower cost alternatives need to be conceived if small unsewered communities are to be provided with adequate service at an affordable cost.

The Farmer's Home Administration estimates that user charges in excess of 3/4 to 1-1/4 percent of the community's medium annual family income will have a significant impact on family budgets.[1] In many small communities in the Upper Great Lakes area, the median annual family income is $10,000 or less. Therefore, annual user charges should not exceed $125.00, yet it is not uncommon for annual user charges for wastewater facilities in previously unsewered communities in Wisconsin to exceed $240.00 even with federal and state assistance.[2] Not only are these charges often beyond the users' abilities to pay, but they are frequently difficult to justify by the environmental benefits which result.

While the extent of sewers is sometimes an issue, the decision to sewer traditionally has been a foregone conclusion. Yet this is the single largest cost in conventional facilities. In an analysis of costs of all public wastewater facilities constructed in the U.S.[3], it was found that construction and maintenance costs of the collection system account for more than 65 percent of the average total annual costs of the facilities. In small communities, the proportionate costs of the collection system is usually much higher because development is more scattered, necessitating longer lengths of sewer between connections. Therefore, if the cost of the collection system could be reduced or eliminated, significant savings could be realized.

Probably the greatest savings to the community, however, can be made by reducing the operation and maintenance costs of the treatment plant. The costs of sewer construction are eligible for grant assistance from various funding agencies, but the day to day costs of operating and maintaining the wastewater facility must be borne solely by the community. Conventional treatment processes are often highly mechanized and require substantial operator attention. This is particularly true for small communities located on small streams or rivers where effluent standards beyond secondary are required. Simple, low maintenance treatment processes which can achieve the required effluent standards or which avoid direct discharge of effluent into surface waters need to be investigated if user charges are to be kept within realistic limits.

Because the problem with small unsewered communities is a common one around the Upper Great Lakes area, the Upper Great Lakes Regional Commission are frequently difficult to justify by the environmental benefits which result.

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Because the problem with small unsewered communities is a common one around the Upper Great Lakes area, the Upper Great Lakes Regional Commission

and the State of Wisconsin supported a study through the University of Wisconsin to demonstrate less costly facilities in a small community. Carl C. Crane, Inc., consulting engineers from Madison, Wisconsin, provided engineering services for the project. The small unsewered community of Westboro, located in north central Wisconsin, cooperated in the study. It is typical of hundreds of small rural communities in the Midwest which are in need of improved wastewater facilities but are unable to afford conventional sewerage. This paper describes the planning, implementation and performance of the selected alternative wastewater facility.

ALTERNATIVE FACILITY PLANNING

Westboro is located in Taylor County, Wisconsin, adjacent to a trout stream within the upper Chippewa River drainage basin. It was established as a permanent community in the late 1850's as a result of the lumbering industry. In 1873, the Wisconsin Central Railroad reached Westboro on its way north, bringing more people and jobs. The population reached about 900 in 1900, but with the decline of the lumber industry, the large sawmill in town closed and the population declined. By 1976, the population was approximately 205 people. Of 94 buildings located in the community, only 69 were occupied, including a school, four churches and several commercial establishments. A small machine tool company and a sawmill remained in town employing a total of about 10 to 15 people.

Until 1977, the community of Westboro had no public wastewater collection or treatment facility. All the buildings were served by private septic tank systems. A survey by the Wisconsin Department of Natural Resources showed that 80 percent of these systems were discharging wastes above ground. Many of the systems were found to be interconnected by drains which discharged directly into Silver Creek. 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, the Department of Natural Resources issued an order to the Town of Westboro to upgrade the existing septic tank systems or construct a public wastewater collection and treatment facility.

Because the soils and small lot sizes prevented the replacement of most of the failing septic tank systems, public sewerage was necessary. The Town Sanitary District #1 of the Town of Westboro was formed to incorporate all the buildings with failing systems which were endangering the water quality of the trout stream (Figure 1) and an engineering firm was hired to complete a facilities plan.

The firm investigated two treatment alternatives: an extended aeration package treatment plant and a two-cell lagoon. Conventional gravity sewers were proposed to collect the wastewater in both alternatives. Both plans would serve only 60 of the 69 occupied buildings. Homes to the north of Westboro near Appaloosa Lane and those east of Silver Creek in Queenstown would not be served because of the excessive costs of extending sewers to them. Though higher in initial cost, the engineering firm recommended the lagoon alternative because of the lower operation and maintenance costs (Figure 2). The estimated construction costs for this facility in 1967 were $124,900 for the collection system and $109,000 for the lagoon, or a total cost of $234,800, excluding engineering fees and contingencies. This amounted to approximately $3900 per unit plus an estimated $450 hookup charge. The district residents were unable to afford this cost so the plan was never implemented. When Federal construction grants became available through the Water Pollution Control Act of 1972, Westboro applied, but as of February, 1976 their priority to receive a 75 percent grant was 318 for the treatment plant menace to health and comfort, as well as the public rights in the Upper Chippewa River Basin. Consequently, the Department of Natural Resources issued an order to the Town of Westboro to upgrade the existing septic tank systems or construct a public wastewater collection and treatment facility.

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and 398 for the sewers out of 420 eligible communities. This virtually ruled out the possibility of constructing the facility for several years.

Alternative Facility Evaluation

Since the costs of sewer installation and treatment plant operation are the largest components of the total annual costs of public facilities, alternatives which would reduce these costs were sought. The University of Wisconsin[4] had been developing and demonstrating onsite treatment and disposal systems for individual homes and it was thought that the use of such systems under public management might offer significant cost savings.

The first step in the planning process was to evaluate the physical features of the community. Soil, topographic and plat maps of the area were obtained. A house to house survey in the district was also made by two district residents to determine the condition of existing onsite systems and location and construction of private wells. This information was used to make preliminary planning decisions.

The soils in and around Westboro are primarily loams and silt loams of the Amery, Freer, Santiago and Comstock series. These are deep, well to somewhat poorly drained soils lying over sandy glacial till. Along the western bank of the trout stream, north of County Trunk D, deposits of well-graded sands exist. Borings conducted for a proposed dam in the area showed these deposits to be over 20 ft (6 m) deep on top of glacial till. These comprise a bench rising approximately 25 ft (7.6 m) above the stream. South of County Trunk D the land is low with mucky peat soils predominating. Similar soils are also found in the southwest corner of the district.

While soils suitable for conventional septic tank systems exist in the district, most homes are located on poorly suited soils. The small lot sizes, particularly in the center of the district, preclude the use of alternative individual systems as well. Therefore, it appeared that the wastewater would have to be collected from most of the homes in the district for treatment and disposal in some other area. The results from the survey confirmed the need for off-lot disposal. Since discharge to the trout stream, would require a rather high level of treatment, methods of soil disposal were preferred.

A common disposal system was considered to be the best alternative for the Front Street area which includes the business district. This area is divided into small 50 ft (15.2 m) x 150 ft (45.7 m) lots. Most of these are developed, leaving little area to construct new individual septic tank systems. Joseph's Addition is a low lying area with poorly drained soil. Individual mound systems could be installed, but a common system would be more cost-effective. Individual systems also could be constructed in Grossman's Addition, but because of the density of homes, a common system appeared to be a better alternative. However, the soils in this area are silt loams which would require a rather large soil absorption field. Therefore, intermittent sand filters followed by disinfection with discharge to the trout stream was an additional alternative considered for this area.

The remaining homes to the north and in Queenstown were too scattered to warrant common disposal facilities. It was determined that these homes should remain on either publicly managed conventional septic tank systems or mound systems, if possible.

Because the collection systems required to collect the wastewater from the various clusters would be extensive, alternative methods of collection were investigated to keep the costs down. Small diameter gravity sewers and pressure sewers were compared to conventional gravity sewers. These alternative collection systems offer several advantages over conventional gravity alternative individual systems as well. Therefore, it appeared that the wastewater would have to be collected from most of the homes in the district for treatment and disposal in some other area. The results from the survey confirmed the need for off-lot disposal. Since discharge to the trout stream, would require a rather high level of treatment, methods of soil disposal were preferred.

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sewers. Both collect septic tank effluent rather than raw wastewater. Since all treatment and disposal methods under consideration require a settled waste, existing septic tanks could be used to eliminate the need for constructing sedimentation facilities at the disposal site. Also, less excavation is required for sewer installation. Because grit and settleable solids are removed in the septic tank, scouring velocities do not have to be maintained in the gravity sewers, allowing the pipe to be laid on a flatter grade. Pressure sewers, on the other hand, can follow the topography with the only requirement that the lines be placed below the frost line.

Several alternative systems for the various areas were considered. Because of the limited disposal sites available, it was appropriate to combine the Front Street and Joseph's Addition areas, disposing of the wastewater in a conventional soil absorption field to be located on the sand bench along the trout stream east of town. Both small diameter and pressure sewers were evaluated for these combined areas. In Grossman's Addition, the topography is well suited for gravity collection for conveyance of the wastewater to the area southwest of the school. Treatment and disposal alternatives considered were soil absorption, sand filtration with chlorination before discharge to the trout stream, and pumping to the Front Street/ Joseph's Addition gravity system for disposal in the soil absorption field. A pressure sewer combined with Front Street/Joseph's Addition pressure sewer with disposal in the sand bench was also evaluated.

Facility Selection

Each of the alternatives was evaluated and compared on the basis of reliability, environmental impact and present worth costs. After weighing each criterion, a system of small diameter gravity sewers collecting the wastes from each cluster and conveying them to a single area for soil absorption northeast of Joseph's Addition was recommended (Figure 3). Pretreatment would be provided by individual septic tanks already in place at each home. Homes to the north and in Queenstown would also be included in this system.

Cost comparisons between all alternatives were made using present worth analyses. These included operation and maintenance costs as well as capital costs. Hookup costs of $450 per service connection were included as a separate item in the conventional alternatives since the other alternatives include hookups as part of the construction costs. Individual onsite system construction estimates were also included for those homes within the district not served by the collection system. A system life of 20 years with an annual interest rate of 7 percent was used in the analysis.[5] This analysis indicated that the system of small diameter gravity sewers with a common soil absorption field would be the most cost-effective of all alternatives evaluated and more than 30 percent less costly than the conventional lagoon facility.

Assuming a 50 percent grant for construction of the facility from the Farmer's Home Administration (FmHA), and the State of Wisconsin, and a 5 percent, 40-year loan through the FmHA for the remainder, projected user charges would be $8 per month plus a $200 assessment for each connection. The district's commissioners felt this would be within the community's financial capability so they voted to continue with the project.

FACILITY DESIGN

Septic Tanks

The suitability of existing septic tanks was determined during the construction phase by removing the tank contents and inspecting the baffles and tank walls and covers. At homes where new septic tanks were necessary, from each cluster and conveying them to a single area for soil absorption northeast of Joseph's Addition was recommended (Figure 3). Pretreatment would be provided by individual septic tanks already in place at each home. Homes to the north and in Queenstown would also be included in this system.

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FACILITY DESIGN

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State-approved prefabricated 1000 gal (3785 l), single chambered tanks were specified regardless of the home size. The tank volume used for commercial establishments was determined from the sizing criteria given in the Wisconsin State Plumbing Code.[6]

Reinforced concrete, steel and fiberglass are approved materials for septic tank construction in Wisconsin but reinforced concrete was the preferred material because of its durability and structural strength. A bituminous compound coating was applied to the outer wall of the concrete tank in areas of high water tables to prevent infiltration.

Effluent Sewers

Experience with small diameter gravity sewers has been limited to Australia. Guidelines used for their design in Westboro were ones developed by the South Australia Department of Public Health.[7] These guidelines are summarized in Table 1.

Four-inch (10 cm) diameter mains were specified set at a minimum gradient of 0.67 percent. Assuming a peak flow of 3 gpd (11.4 lpd) per person[8] this size sewer can serve approximately 600 persons while flowing half full. This is a conservative design because peak flows are dramatically attenuated through the septic tank.[4,9] Peak flows of 1 gph (3.8 lph) per capita are more likely,[4] which increase the design capacity of each sewer line to 1800 persons.

Manholes were placed at the upstream end of each line and at spacings up to 600 ft (182.9 m). Greater than 400 ft (121.9 m) spacing was permitted because hydraulic jetting equipment is available which can reach more than 300 ft (91.4 m). Because settleable and floatable solids are excluded from the sewers, curvilinear alignments both in the horizontal and vertical planes were permissible. Manholes were only required at junctions and at locations necessary to maintain the maximum 600 ft (182.9 m) spacing.

Some homes had deep drains that were below the proposed sewer invert elevations. Small residential lift stations following the septic tanks were used at these homes to lift the wastewater into the gravity sewers.

Three community lift stations were necessary in the collection system. One is located southwest of the school where the wastes from Grossman's Addition are collected. These are pumped into the gravity main along Center Street. Another collects the wastes from the Queenstown area and pumps them across Silver Creek to the gravity main along CTH D. The third, located on CTH D, receives all the septic tank effluent collected and pumps it to the siphon chamber where it is dosed onto the soil absorption fields.

Due to the nature of the facility, some savings were made in the design of these lift stations. Because septic tank wastes are being collected, large solids-handling pumps are not necessary. Also, standby electricity generation equipment is not necessary because each home is on its own private well. In case of power outage, only water stored in the pressure tanks is discharged. Wastewater storage is provided in the lift stations, sewer mains and septic tanks (due to the three inch drop between the inlet and outlet of the tanks), which is sufficient to prevent backups. If not, a pumper is available to pump down the lift stations.

Soil Absorption Fields

Uncertainty arose as to what should be the design capacity of the absorption beds. In 1976, the population of Westboro was approximately 200 people and reasonably stable, but growth had been prevented because most of the soils in the area are unsuitable for individual septic tank systems. The provision of a public wastewater facility in Westboro would open up suitable building were permissible. Manholes were only required at junctions and at locations necessary to maintain the maximum 600 ft (182.9 m) spacing.

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sites. This could stimulate rapid growth but if too much excess capacity were to be included, the costs would become excessive. Therefore, it was decided that the field would be designed for maximum development within the present district boundaries only. Areas which potentially could be developed outside the district would not be included. If these areas were to be developed and annexed to the district, separate cluster systems serving only the new developments would be necessary.

Several methods for estimating the design flow were investigated. Good design criteria for large soil absorption beds is lacking because so few have been constructed and closely monitored. The usual method for sizing is to assume 150 gal/day (568 l/d) per bedroom served. The estimate provided by this criterion was 45,000 gal/day (170 m^3/d) which was not considered appropriate because it represents peak flow. With the large number of homes on the system, substantial flow equalization would be expected. This would allow designing for the average daily flow. If an average of 45 gal/day (170 l/d) per capita were assumed[8], a design flow of 13,000 gal/day (49 m^3/d) results. However, this estimate does not allow for any inflow or infiltration which may occur. As a compromise, 250 gal/day (0.95 m^3/d) or 30,000 gal/day (113.6 m^3/d) was assumed.

The application rate chosen for the absorption beds was dependent upon the soil type. The soil is primarily medium sand. Long term infiltration rates into such soils loaded with septic tank wastes have been determined to be approximately 1.2 gal/day/sq ft (0.049 $m^3/m^2 d$).[10] Therefore, a total area of 25,000 sq ft (2322.5 m^2) was necessary.

The necessary absorption area is provided in three 100 ft (30.5 m) by 130 ft (40 m) cells. Each cell has a design capacity of 15,600 gal/day (59 m^3/d) or approximately 50 percent of the design flow. At any one time, two of the cells are in service and the third acts as a standby. The standby bed is rotated into service annually so that each cell is loaded for 2 yr and "rests" for 1 yr. The resting phase is meant to restore the cell's absorption capacity through biochemical rejuvenation of the soil's infiltrative surface. Operating in this manner, the cells should last indefinitely if not overloaded. In case of failure, however, the standby bed would be rotated in immediately.

Pressure distribution networks were designed to distribute the wastewater uniformly over the infiltrative surface to prevent local overloading.[11, 12] Two 8-in (200 mm) PVC manifolds were used in each bed, feeding 4-in (100 mm) PVC laterals spaced every 5.25 ft (1.6 m). The laterals were perforated in the inverts with 15/32-in (11.9 mm) holes. Manifolds are fed by a 12-in (300 mm) PVC pipe leading from the siphon chamber.

Three 10-in (250 mm) siphons were installed, one for each bed. They are capable of discharging an average of 1000 gal/min (0.06 m^3/s) at the design head. The 12-in (300 mm) pipe into which they discharge is larger than the siphon to permit air in the pipe to vent back out the siphon chambers.

Two siphons are operating at any one time. They automatically alternate operation discharging approximately 8000 gal(30.3 m^3) per dose. At design capacity, each bed will receive 2 doses per day. The third siphon is taken out of service by closing a ball valve installed in the siphon's blow off vent.

OPERATION

The facility has been in operation since September, 1977. The sanitary district is responsible for the operation and maintenance of all components of the facility, including those located on private land commencing from the are in service and the third acts as a standby. The standby bed is rotated into service annually so that each cell is loaded for 2 yr and "rests" for 1 yr. The resting phase is meant to restore the cell's absorption capacity through biochemical rejuvenation of the soil's infiltrative surface. Operating in this manner, the cells should last indefinitely if not overloaded. In case of failure, however, the standby bed would be rotated in immediately.

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inlet of the septic tank. The individual septic tanks are owned by the district. Access to the tanks for maintenance is assured through permanent easements obtained from each property owner. These easements were general easements related to the septic tanks rather than metes and bounds descriptions. The property owner is responsible for providing and maintaining the lateral drain from his home or establishment to the septic tank and, if necessary, paying any power costs associated with lifting his effluent into the collection sewer.

The facility requires very little attention by the operator. All duties can be performed by an unskilled laborer. The tasks require no more than an average of 2 to 4 man hours per week. The maintenance schedule is summarized in Table 2.

Each year, one-third of the septic tanks are pumped to remove sludge accumulations. This work is performed by a local pumper under contract with the district. The pumper is given a pumping route to follow each year. Because the pumpings are regularly scheduled and not emergency runs, the costs of pumping can be much less than usual. By monitoring the sludge accumulations it may be determined that some tanks may require more frequent pumping than once every three years, while others will require less frequent pumping.

PROJECT COSTS AND FINANCING

Project Savings

The total project costs of the Westboro facility were $435,175 (1977 dollars). Of this amount, $351,500 was the cost of construction. The project costs are summarized in Table 3.

To determine the actual cost savings realized with this alternative facility, the cost of constructing the conventional stabilization pond alternative was estimated. To obtain a reliable estimate, unit costs were used from a neighboring community which had constructed a gravity collection stabilization pond facility serving 75 connections the same year. This community also constructed a water supply system at the same time, which reduced the wastewater construction costs somewhat. Table 4 presents a cost comparison of the two facilities.

This comparison indicates that a 12 percent savings per connection was made in the cost of construction over a conventional facility. This savings is not as great as hoped. However, the constructed facility serves every home in the district while the conventional alternative would not have served 13 of the homes because of the high cost of extending sewers to them. The alternative facility averaged 255 ft (77.7 m) of pipe laid per connection, while the conventional collection system would have averaged 195 ft (59.4 m) per connection. Thus, over 31 percent more pipe was laid for 12 percent less cost.

Construction Funding

Construction of the facility was financed through grants, loans and local assessments. Financial assistance was received from FmHA and Wisconsin's Department of Natural Resources. At the time of construction, FmHA was limited to a maximum grant participation of 50 percent (sum of all grants) of the total project cost, with the remainder provided through a 5 percent, 40-year loan. Wisconsin DNR provided a 21 percent construction grant. Eligible costs included 10 percent of the engineering fees and construction of facilities on public lands. Land costs were ineligible. The local share of construction costs was obtained through special assessments and hookup charges. Those homes which had good tanks were charged only a $100 hookup fee. If a new tank was installed, an additional $200 assessment was made. Some homes within the district had no indoor plumbing, but the owners indicated they intended to install plumbing in the used from a neighboring community which had constructed a gravity collection stabilization pond facility serving 75 connections the same year. This community also constructed a water supply system at the same time, which reduced the wastewater construction costs somewhat. Table 4 presents a cost comparison of the two facilities.

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near future. Tanks were installed on these properties and only the $200 was assessed the owners. A summary of the project's financing appears in Table 5.

User Charges

Four classes of users have been identified in Westboro based on estimated water use. Residential users represent the largest class. Until July, 1979, the residential users were billed $8/mo. of which $1.25 was for operating expenses and $6.75 was for debt retirement. Since that time, these charges have been increased to $10/mo to provide $2/mo for the district's depreciation account. The 1982 user charges for each class appear in Table 6. The operating budget for 1982 is shown in Table 7.

FACILITY EVALUATION

Because this type of wastewater facility is unique, few design criteria and performance data exist. Therefore, the operation of Westboro's facility is being followed to evaluate its performance. While the evaluation is still in progress, four years of operating data have indicated ways the design could be improved.

Design Flows

The total wastewater processed each day is metered at the main lift station where all the wastewater is pumped to the siphon chamber. Average daily flows have been less than 8000 gpd (30.3 m^3/d) or less than 100 gpd (0.4 m^3/d) per connection, including the school and commercial buildings. On a per capita basis, the flows are less than 40 gpd (151 l/d). These unit flows are more than 60 percent below the unit flows used to estimate the design flow. Future soil absorption field designs will be based on estimated per capita flows and projected populations.

Effluent Sewers

The intent behind using the small diameter gravity sewers was to reduce the costs of collecting the wastewater. However, significant savings in the costs of construction were not realized because uniform gradients sufficient to provide 1.5 ft/sec (0.4 m/s) at half full conditions were maintained. Also, manholes were provided at all junctions and at minimum intervals of 600 ft (1.83 m) to facilitate cleaning operations. If it could be shown that obstructions would not occur at reduced minimum velocities and if cleaning operations could be effective with fewer manholes, significant cost savings could result.

Observation of the sewers indicates that solids accumulations from the wastewater are limited to slime growths which easily slough from the side of the pipe. Grit and larger settleable solids have not entered the system except at manholes located along shoulders of roads. The manholes have been a constant source of grit and gravel. If it can be shown that hydraulic flushing is sufficient to remove the slime growths, then reduced pipe gradients or even variable gradients may be possible and the manholes replaced by simple cleanouts. Studies at Westboro are underway presently to demonstrate the feasibility of this concept. If successful, small diameter gravity sewer construction could be similar to water main construction where the hydraulic grade line elevation rather than the pipe invert elevation is the critical factor. This would reduce construction costs dramatically.

The sloughing of biological slime in the sewers has increased the suspended solids load onto the soil absorption field. This is a distinct shortcoming of the Westboro design. A terminal settling tank should be provided prior to the dosing tank to remove these solids. A tank with a

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detention time of 6 hrs would probably be sufficient.

Odors and corrosion of the lift stations have created minor problems. Agitation of the septic waste in the wet well by the incoming wastewater releases odorous and corrosive gases. The odor problem has been corrected by extending the inlet sewers vertically down below the low water level in the wet well. Corrosion, on the other hand, continues to be a problem. Non-ferrous metals are necessary for all lift station components.

Soil Absorption Field

The absorption capacity and treatment efficiency of the soil absorption cells have been monitored since their construction. The data collected indicates that the field is not operating like smaller fields on which the Westboro design was based. The present flows are only about 25 percent of the design flow. Yet, the two cells in operation remain ponded at all times, indicating that the infiltration rates are 0.5 to 0.7 gal/sq ft/day (2-3 cm/d) rather than the 1.2 gal/sq ft/day (5 cm/d) used in design. Apparently, the clogging mat which has formed at the infiltrative surfaces is more restrictive than those which typically form in smaller systems. The reasons for this have not been determined but are presently under investigation.

The groundwater quality is being monitored through a series of well nests surrounding the absorption field. A total of 28 wells are used. Monitoring of the groundwater elevation and quality in each of the wells began prior to wastewater application to the cells. Analyses include nitrogen, chlorides, total dissolved solids and fecal coliforms. This monitoring indicates that the groundwater quality is not being impacted seriously. Nitrate concentrations increased in some wells initially but remained below 10 mg/l as nitrogen. After the initial period, the nitrate was replaced by ammonia which continues to be found, indicating that the soil pore gas under the large beds is deficient of oxygen unlike that found below smaller beds. Fecal indicators have not been found, however. Except for the change in the form of nitrogen, the field appears to be treating the wastewater as expected.

SUMMARY

The alternate wastewater facility constructed in the community of Westboro has been a success. Though the residents were unable to afford conventional sewerage, the costs of constructing small diameter sewers and a common subsurface soil absorption field were within their financial capabilities. At least a 12 percent savings in construction costs realized. More significantly, this type of facility has reduced operating costs over conventional gravity sewers and a stabilization pond facility by 65 percent. The construction savings were not as great as hoped, but operational experience gained thus far indicates that changes can be made in the design which would increase the savings in future facilities of this type substantially.

While this project has been successful, there are deterrents to widespread implementation of similar plans for other small communities. Biases of engineers and regulatory agencies favor central gravity sewers and treatment plants. One of the greatest deterrents is the lack of knowledge and experience with the design and performance of alternative technologies. The facility built at Westboro demonstrates only one alternative which is not a suitable facility for many areas. Communities with undulating topography will find small diameter gravity sewers as costly as conventional sewers and communities with poor soil will not be able to utilize soil absorption. Other technologies have been developed for such situations but they have not been demonstrated in the small community setting.

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Also, regulatory codes are often too restrictive to permit construction of less costly facilities. The codes are based on design criteria, materials and construction techniques which were developed for urban areas where conventional sewerage is used. Therefore, these areas favor conventional sewerage. The result is that engineers are more likely to design a conventional facility which would create fewer objections by the reviewing agency.

Additional demonstrations of alternative facilities in small communities are needed. Such demonstrations would not only demonstrate the range of technologies available and their performance characteristics, but would also help to develop a planning methodology which could be used by engineers to generate the most appropriate wastewater facility in a given community. If the goals of the Clean Water Act are to be reached, then more practical facilities planning must be encouraged.

ACKNOWLEDGEMENTS

Credits

The assitance given by Allen H. Lietzke, Taylor County Extension Resource Agent and Earl M. Kilby, Taylor County Zoning Administrator, in coordinating activities between Westboro and the University of Wisconsin was essential to the success of this project. The active support given by the Westboro sanitary district commissioners, Earl Thums, chairman, and Paul Ochodnicky, secretary, resulted in the ultimate acceptance of the plan by the residents of Westboro.

Planning and monitoring phases of the project were supported by the

Upper Great Lakes Regional Commission and the State of Wisconsin.

Authors

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TABLE 1

South Australia Guidelines for Small Diameter Gravity Sewers[7]

Minimum Pipe Diameter	4-in (10 cm)
Minimum Velocity (1/2 full)	1.5 ft/sec (0.46 m/s)
Minimum Gradient	
4-in conduit	0.67%
6-in conduit	0.40%
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TABLE 2

Facility Maintenance Schedule

Daily

- Check lift station alarm lights.

Weekly

- Open lift stations for visual inspection of pump operation float control operation and debris accumulation.
- Record total weekly flow from pump, running time meters as per WPDES* permit requirement.

Monthly

- Check siphon operation.
- Inspect observation vents in each cell for depth of ponded water; switch cells if necessary.

Annually

- Each spring, alternate resting bed into service and drain manifold of bed taken out of service.
- Inspect the surface of the absorption field and fill any holes and depressions.
- Pump 1/3 of septic tanks each year according to schedule.
- Pump lift stations and siphon chamber to remove sludge.
- Flush sewer lines as necessary.

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* Wisconsin Pollution Discharge Elimination System

TABLE 3

Construction Cost Summary (1977 dollars)

COLLECTION (includes house lateral, septic tanks, collection mains and lift stations)		
Construction	$252,635	
Land and Rights	0	
Legal Services	4,500	
Engineering and Inspection	48,325	
Bond Council	1,000	
		$306,460
TREATMENT (includes siphon chamber and soil absorption field)		
Construction	$ 98,865	
Land and Rights	6,000	
Legal Services	2,500	
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	TOTAL	$435,175

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TABLE 4

Comparative Costs of Construction for
Conventional and Alternative Facilities (1977 dollars)

	Actual Costs of Westboro Facility	Estimated Costs[1] of Conventional Alternative
Collection	$252,635[2]	$181,315[3]
Treatment	98,865[4]	174,150[4]
Total	$351,500	$355,465
Cost/Connection	4,135 (85)[5]	4,677 (76)[5]
Number of Homes Unserved	0	13

[1] Unit costs obtained from Village of Curtis, Clark County. Gravity collection/ stabilization facility serving 75 connections. Constructed 1977.

[2] Includes septic tanks and house laterals.

[3] Includes customer hookup charges of $483.

[4] Excludes land costs.

[5] Number of connections.

TABLE 5

Summary of Construction Financing (1977 dollars)

Westboro Town Sanitary District		
Tank Assessments		
Residential (82 tanks x $200)	$16,400	
Commercial (3 tanks x $300)	900	
Hookup Charges (77 hookups x $100)	7,700	
		$25,000
Farmer's Home Administration (FmHA)		
Grant	$213,000	
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TABLE 6

1981 User Charges

Residential	81 @ $10.00/mo	$9720.00
Small businesses	1 @ 14.00/mo	168.00
Commercial	2 @ 17.00/mo	408.00
School	1 @ 112.00/mo	1344.00
	TOTAL ANNUAL REVENUES	$11,640.00

TABLE 7

1982 Operating Budget

Wages	$1,350
Office supplies & Misc.	100
Insurance and Bond	250
Utilities	400
Legal and Accounting	750
Repairs and Maintenance	750
Loan	1,000
FmHA Loan Interest	5,200
Depreciation	8,000
TOTAL	$17,800
1982 REVENUES	$11,640
DEFICIT	$ 6,160[1]

[1] To be taken from depreciation account.

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