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# SMALL SCALE WASTE MANAGEMENT PROJECT

## *Guide to Wastewater Facilities Planning in Ancyroid Areas. Volume II: Engineer's Guide*

by

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# CHAPTER 1

# INTRODUCTION

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 in 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 only 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 of 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 (FmHA, 1978). In many small communities, the medium annual income is no more than $10,000. Therefore, monthly user charges should not exceed $10.50, yet average monthly user charges for wastewater facilities in previously unsewered communities range from $12 to $22 even with federal and state assistance. 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 has traditionally 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., 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 (Smith and Eilers, 1970). 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 high 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.

It is the task of the engineer to develop a plan that will meet the water quality and public health goals over the planning period for all members of the planning area at an affordable cost. This requires that the engineer investigate unconventional technologies, various management institutions and all available funding programs to develop the least costly design. Obviously, the number of alternative facility plans which could be developed from the available technologies and the various ways in which they could be employed is enormous. A systematic comparison of each combination and permutation would result in the most cost-effective facility for the community but the savings made over a conventional facility might not offset the engineering costs of the planning. While the proportionate costs of planning unconventional facilities will be higher than for conventional plans, the costs must be held to a minimum to realize the greatest savings.

It is the purpose of this handbook to introduce to the consulting engineer an approach to facility planning in small unsewered areas that may help solve many of the frequently encountered problems. Chapter 2 briefly describes alternative technologies for conveyance, treatment and disposal of wastewater. A separate sheet summarizing typical applications, design criteria, performance characteristics, operation and maintenance requirements, and environmental impacts for each technology appears in Appendix A. References to sources that provide more detailed design information are also included. The engineer must select from the various alternative technologies those needed to plan the most appropriate facility for the area. To reduce the size of this task, Chapter 3 presents a planning procedure developed for small unsewered areas. It directs the planning efforts toward the most appropriate alternatives by providing assessment criteria that can be used to eliminate alternatives of little promise early in the planning process. The final two chapters describe management institutions and methods of financing necessary to implement and operate the proposed facility. Chapter 4 describes the various institutions permitted to manage wastewater facilities. A discussion of which management institution would be most appropriate for the selected facility is included. To aid in developing an acceptable financial plan to implement a project, Chapter 5 describes various sources of revenue. Financial aid programs are described and how the unconventional technologies and facility plans are handled by each. Methods of raising revenue locally also are discussed.

This handbook is only intended to be a guide. It should not be considered as a design manual or as presenting ranges of design criteria that will be acceptable to a regulatory agency. Many of the technologies and concepts described are relatively new and while proven in small applications, are largely untried in a community setting. The objective of this handbook is to inspire the engineer to be creative and to try new ways of solving old problems. For technologies or applications where existing design codes are not appropriate, the design must be based on the engineer's best judgement supported by sound justification. The engineer should not feel he must confine himself to the technologies or applications described in this guide. Instead he should rely on his good judgement to decide if an alternative method will truly meet the needs of the community, remembering the community has final responsibility for the facility's performance. This is not always easy, but it is the challenge of engineering.

References

Farmer's Home Administration, U.W. Department of Agriculture, Washington, D.C., 1978.

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

# CHAPTER 2

## ALTERNATIVE METHODS FOR THE COLLECTION, TREATMENT AND DISPOSAL OF SMALL WASTEWATER FLOWS

Treatment and disposal of wastewater in a manner that will prevent public health hazards, nuisances or environmental degradation is the ultimate objective of all wastewater facilities. The wastewater must be held and treated sufficiently before discharge into the environment to achieve this goal. The degree of treatment required depends upon the assimulative capacity or capability of the environment to transform and recycle pollutants remaining in the treated wastewater such that the pollutants do not accumulate to harmful levels. This will vary from site to site. Where the assimulative capacity of the environment is high, the degree of treatment the wastewater must receive prior to discharge is not as great. This reduces the complexity and cost of the treatment works. Thus, the environment into which the wastewater is discharged can become a valuable part of a wastewater facility.

Conventional public facilities usually collect and treat the wastewater at a central plant where the effluent can be ultimately discharged to a surface water course. Since water quality must be maintained along the entire water course, effluent standards that the treated waste must consistently meet are specified by the local water quality agency. At a minimum, secondary treatment is required of all discharges but higher levels of treatment may be required if the size of discharge is determined to be a threat to the fish and aquatic life habitat. Thus, not only are the costs of collecting the wastewater high from low density populations typically found in small communities, but also the costs of consistently treating the wastewater to a specific level. If effluent discharges were made into other elements of the environment with higher assimulative capacities, significant savings might be realized.

Wastewater may also be disposed of onto the land or into atmosphere by a variety of methods. If used properly, these environments can provide higher levels of treatment than mechanical treatment works with much less operator attention and maintenance, but they do have their price. Since natural ecosystems are relied upon, larger land areas are needed than for mechanical treatment works. This price is too much to pay in urban areas where land is a highly sought commodity, but in small communities, land often can be obtained at a reasonable cost.

With the availability of ample land for treatment sites, the number of treatment and disposal options increase dramatically. Several treatment and disposal sites could be located within the community to keep costs of collection to a minimum by decentralizing the facility and treating and disposing of the wastes near where they are generated. This also could reduce treatment costs because the wastes would not be concentrated in one spot but dispersed over larger areas so that the receiving environments could be used more effectively.

The most extreme decentralized wastewater facility is one where each building is served by an individual onsite disposal system. Unfortunately, it is the failure of these systems to function properly which forces most communities into constructing conventional wastewater facilities in the first place. The cause of the failures can usually be traced to poor siting, design, construction and maintenance. Because these systems are located on private property, it has been the individual owners who have been solely responsible for them. The owner seldom has the training or inclination to maintain his system in good order, nor does he often have the incentive to seek someone who does. However, many of these failures can be corrected for a moderate cost and if properly maintained could eliminate the need for a central facility. Since regular and timely maintenance is a key element to the success this approach, public management of the systems paid for through user charges would be necessary. Some communities could completely solve their problem by forming a public onsite system management district to rehabilitate and maintain all the individual systems within their jurisdiction at a very reasonable cost.

In many cases, though, the site and soil conditions on each lot preclude the upgrading of the existing onsite systems. Alternatives to the conventional septic tank system could be installed, but they are usually more complex and costly. In such cases, it may be more cost effective to serve a group of homes on a common or "cluster" system. Cluster systems have the advantage of economy of scale as well as the possibility of locating the system on a nearby site with site conditions suitable for a less costly treatment system. Again, public management would be necessary as an integral part of the system.

A mix of individual and cluster systems is probably the more cost effective facility in most unsewered communities. It may be that one larger cluster system is necessary to serve most of the residents while individual systems are used only to serve outlying homes and establishments. Like conventional facilities, however, large cluster systems can require rather extensive collection systems. Since these systems can be a major cost factor, alternatives to conventional sewers should be considered.

Thus, the engineer has many options from which to select to reduce the total costs to the users of wastewater facilities. These options are summarized in Figure 2-1. The remainder of this chapter briefly describes and compares some of these alternative technologies which may be employed. More detailed information regarding each technology option discussed can be found in Appendix A.

## WASTEWATER REDUCTION

Reducing the wastewater volume of strength at the source if becoming recognized as a viable method of improving the performance of existing wastewater facilities or reducing the size or complexity of new facilities. Wastewater reduction can be achieved through the use of various marketed devices. The most reliable, however, are those that reduce or eliminate flows from the toilet because they are least affected by user habits.

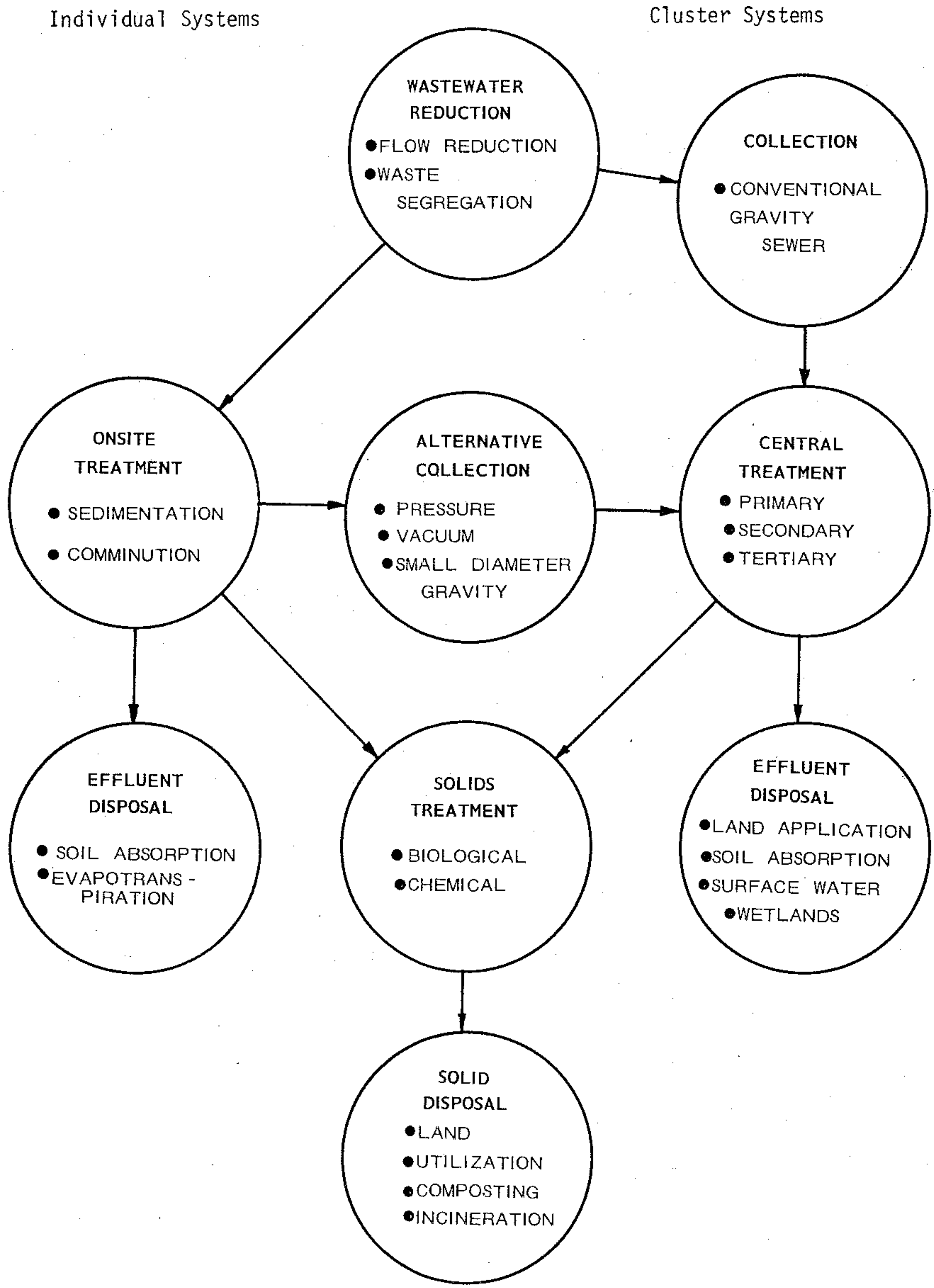


Figure 2-1. Wastewater Facility Planning Options

Toilets account for 30 to 35 percent of the total daily flow from a typical household and 25 percent of the $BOD_5$, 80 percent of the nitrogen and 30 percent of the phosphorus (Siegrist et al., 1978). The reduction of part or all of the wastewater generated by toilets can extend the life of hydraulically overloaded wastewater facilities through the use of low flow devices or recycle units. (However, if the wastewater is collected in gravity sewers, the reduced flow may result in more frequent clogging of upstream ends of the sewers.) Removal of the pollutants and flow by utilizing non-water carriage toilets can extend the life of organically overloaded treatment plants or eliminate the need for nutrient removal processes if otherwise required. Disposal of the residuals from the toilets are by other means. The various types of proprietary devices and units are described in the following tables (U.S. EPA, 1980).

COLLECTION SYSTEMS

Collection systems are necessary where the wastewaters from two or more buildings are conveyed to a common site for treatment and disposal. Several alternative methods are currently employed. They are:

- Conventional gravity sewers
- Small diameter gravity sewers
- Pressure sewers
- Vacuum sewers
- Hauling

Figure 2-2 schematically depicts each alternative showing those components that are commonly located on private property and those located in the public right away. Their characteristics are compared in Table 2-4. More detailed discussion of each can be found in Appendix A.

In selecting the most appropriate collection system for a given application, several factors should be considered. These include (1) capacity, (2) cost of excavation, and (3) quantities of infiltration/inflow. A discussion of each of these factors follows.

<u>Capacity</u>

Sufficient capacity must be provided in the collection system to carry the peak flows expected during the design life of the system. In conventional gravity sewer design, the carrying capacity is typically estimated by assuming an average daily per capita contribution of 100 gallons or greater. The peak flow is estimated by taking 250 to 400 percent of the per capita contributions at the end of the planning period. These estimates are meant to be inclusive of contributions from small commercial establishments and normal infiltration/inflow rates. Individual flows are usually estimated or measured separately.

This rule of thumb works well for the design of conventional gravity sewers but is inappropriate for the design of alternative collection systems.

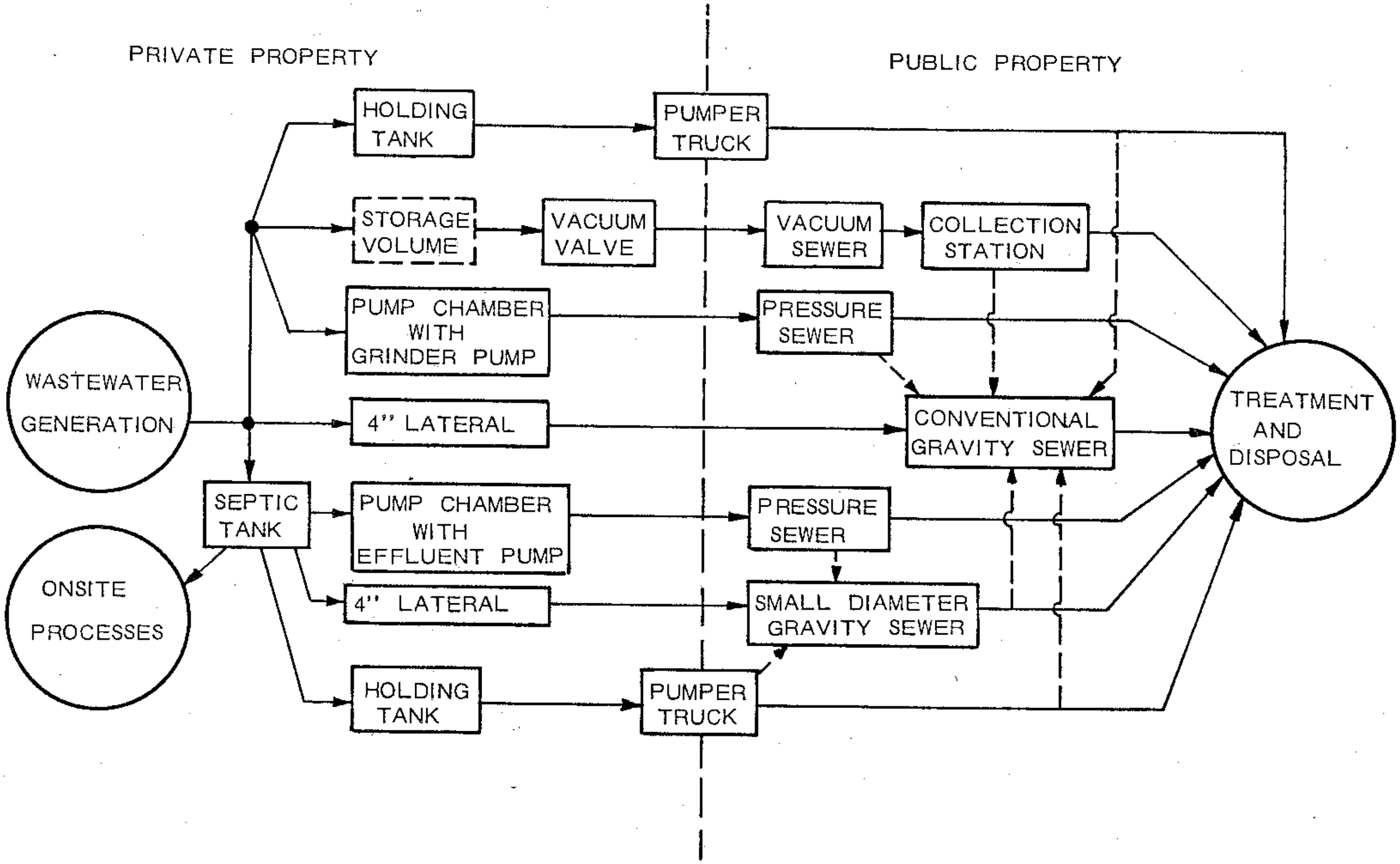


Figure 2-2. Collection Alternatives

Table 2-1. Wastewater Flow Reduction - Water Carriage Toilets and Systems

| Generic Type | Description | Development Stage[a] | Application Considerations | Operation and Maintenance | Water Use Per Event gal | Total Flow Reduction[b] gpcd | Total Flow Reduction[b] % |
|---|---|---|---|---|---|---|---|
| Toilet with Tank Inserts | Displacement devices placed into storage tank of conventional toilets to reduce volume but not height of stored water.<br><br>Varieties: Plastic bottles, flexible panels, drums or plastic bags. | 4-5 | Device must be compatible with existing toilet and not interfere with flush mechanism.<br><br>Installation by owner. | Post-installation and periodic inspections to insure proper positioning. | 3.3-3.8 | 1.8-3.5 | 4-8 |
| Dual Flush Toilets | Devices made for use with conventional flush toilets; enable user to select from two or more flush volumes based on solid or liquid waste materials.<br><br>Varieties: Many | 3 | Device must be compatible with existing toilet and not interfere with flush mechanism.<br><br>Installation by owner. | Post-installation and periodic inspections to insure proper positioning and functioning. | 2.5-4.3 | 3.0-7.0 | 6-15 |
| Water-Saving Toilets | Variation of conventional flush toilet fixture; similar in appearance and operation. Redesigned flushing rim and priming jet to initiate siphon flush in smaller trapway with less water.<br><br>Varieties: Many manufacturers but units similar. | 5 | Interchangeable with conventional fixture.<br><br>Requires pressurized water supply. | Essentially the same as for a conventional unit. | 3.0-3.5 | 2.8-4.6 | 6-10 |

Table 2-1 (continued)

| Generic Type | Description | Development Stage[a] | Application Considerations | Operation and Maintenance | Water Use Per Event gal | Total Flow Reduction[b] gpcd | Total Flow Reduction[b] % |
|---|---|---|---|---|---|---|---|
| Washdown Flush Toilets | Flushing uses only water, but substantially less due to washdown flush.<br><br>Varieties: Few. | 3-4 | Rough-in for unit may be nonstandard.<br><br>Drain line slope and lateral run restrictions.<br><br>Requires pressurized water supply. | Similar to conventional toilet, but more frequent cleaning possible. | 0.8-1.6 | 9.4-12.2 | 21-27 |
| Pressurized Tank | Specially designed toilet tank to pressurize air contained in toilet tank. Upon flushing, the compressed air propels water into bowl at increased velocity.<br><br>Varieties: Few. | 3 | Compatible with most any conventional toilet unit.<br><br>Increased noise level.<br><br>Water supply pressure of 35 to 120 psi. | Similar to conventional toilet fixture. | 2.0-2.5 | 6.3-8.0 | 14-18 |
| Compressed Air-Assisted Flush Toilets | Similar in appearance and user operation to conventional toilet; specially designed to utilize compressed air to aid in flushing.<br><br>Varieties: Few | 3-4 | Interchangeable with rough-in for conventional fixture.<br><br>Requires source of compressed air; bottled or air compressor.<br><br>If air compressor, need power source. | Periodic maintenance of compressed air source.<br><br>Power use - 0.002 KwH per use. | 0.5 | 13.3 | 30 |

Table 2-1 (continued)

| Generic Type | Description | Development Stage[a] | Application Considerations | Operation and Maintenance | Water Use Per Event gal | Total Flow Reduction[b] gpcd | Total Flow Reduction[b] % |
|---|---|---|---|---|---|---|---|
| Vacuum-Assisted Flush Toilets | Similar in appearance and user operation to conventional toilet; specially designed fixture is connected to vacuum system which assists a small volume of water in flushing.<br><br>Varieties: Several. | 3 | Application largely for multi-unit toilet installations<br><br>Above floor, rear discharge.<br><br>Drain pipe may be horizontal or inclined.<br><br>Requires vacuum pump.<br><br>Requires power source. | Periodic maintenance of vacuum pump.<br><br>Power use = 0.002 KwH per use. | 0.3 | 14 | 31 |

a 1 = Prototype developed and under evaluation.
2 = Development complete, commercial production initiated, not locally available.
3 = Fully developed, limited use, not locally available, mail order purchase likely.
4 = Fully developed, limited use, locally available from plumbing supply houses or hardware stores.
5 = Fully developed, widespread use, locally available from plumbing supply houses or hardware stores.

b Compared to conventional toilet usage (4.3 gal/flush, 3.5 uses/cap/day, and a total daily flow of 45 gpcd)

Table 2-2?. Wastewater Flow Reduction - Non-Water Carriage Toilets

| Generic Type[a] | Description | Development Stage[b] | Application Considerations | Operation and Maintenance |
|---|---|---|---|---|
| Pit Privy | Hand-dug hole in the ground covered with a squatting plate or stool/seat with an enclosing house.<br><br>May be sealed vault rather than dug hole. | 4 | Requires same site conditions as for wastewater disposal (see Chapter 8), unless sealed vault.<br><br>Handles only toilet wastes<br><br>Outdoor installation.<br><br>May be constructed by user. | When full, cover with 2 ft of soil and construct new pit. |
| Composting Privy | Similar to pit privy except organic matter is added after each use. When pit is full it is allowed to compost for a period of about 12 months prior to removal and use as soil amendment. | 4 | Can be constructed independent of site conditions if sealed vault.<br><br>Handles only toilet waste and garbage.<br><br>May be constructed by user.<br><br>Outdoor installation.<br><br>Residuals disposal. | Addition of organic matter after each use.<br><br>Removal and disposal/reuse of composted material. |
| Composting-Small | Small self-contained units accept toilet wastes only and utilize the addition of heat in combination with aerobic biological activity to stabilize human excreta.<br><br>Varieties: Several. | 3-4 | Installation requires 4-in. diameter roof vent.<br><br>Handles only toilet waste.<br><br>Set usage capacity.<br><br>Power required.<br><br>Residuals disposal. | Removal and disposal of composted material quarterly.<br><br>Power use = 2.5 KwH/day.<br><br>Heat loss through vent. |
| Composting-Large | Larger units with a separated decomposition chamber. Accept toilet wastes and other organic matter, and over a long time period stabilize excreta through biological activity.<br><br>Varieties: Several | 3-4 | Installation requires 6- to 12-in. diameter roof vent and space beneath floor for decomposition chamber.<br><br>Handles toilet waste and some kitchen waste.<br><br>Set usage capacity.<br><br>May be difficult to retrofit.<br><br>Residuals disposal. | Periodic addition of organic matter.<br><br>Removal of composted material at 6 to 24 month intervals.<br><br>Power use = 0.3 to 1.2 KwH/day.<br><br>Heat loss through vent. |

Table 2-2 (continued)

| Generic Type[a] | Description | Development Stage[b] | Application Considerations | Operation and Maintenance |
|---|---|---|---|---|
| Incinerator | Small self-contained units which volatilize the organic components of human waste and evaporate the liquids.<br><br>Varieties: Several. | 3 | Installation requires 4-in. diameter roof vent.<br><br>Handles only toilet waste.<br><br>Power or fuel required.<br><br>Increased noise level.<br><br>Residuals disposal. | Weekly removal of ash.<br><br>Semiannual cleaning and adjustment of burning assembly and/or heating elements.<br><br>Power use = 1.2 KwH or 0.3 lb LP gas per use. |
| Oil Recycle | Systems use a mineral oil to transport human excreta from a fixture (similar in appearance and use to conventional) to a storage tank. Oil is purified and reused for flushing.<br><br>Varieties: few. | 2 | Requires separate plumbing for toilet fixture.<br><br>May be difficult to retrofit.<br><br>Handles only toilet wastes<br><br>Residuals disposal. | Yearly removal and disposal of excreta in storage tank.<br><br>Yearly maintenance of oil purification system by skilled technician.<br><br>Power use = 0.01 KwH/use. |

[a] None of these devices uses any water; therefore, the amount of flow reduction is equal to the amount of conventional toilet use: 16.2 gpcd or 36% of normal daily flow (45 gpcd). Significant quantities of pollutants (including N, $BOD_5$, SS, P and pathogens) are therefore removed from wastewater stream.

[b] 1 = Prototype developed and under evaluation.
2 = Development complete; commercial production initiated, but distribution may be restricted; mail order purchase.
3 = Fully developed; limited use, not locally available; mail order purchase likely.
4 = Fully developed; limited use, available form local plumbing supply houses or hardware stores.
5 = Fully developed; widespread use, available from local plumbing supply houses or hardware stores.

Table 2-3. Wastewater Flow Reduction - Wastewater Recycle and Reuse Systems

| Flow Sheet Description | Development Stage[a] | Application Considerations | Operation and Maintenance | Total Flow Reduction[b] gpcd | Total Flow Reduction[b] % | Wastewater Quality Impacts |
|---|---|---|---|---|---|---|
| Recycle bath and laundry for toilet flushing | 2 | Requires separate toilet supply and drain line.<br>May be difficult to retrofit to multi-story building.<br>Requries wastewater disposal system for toilet and kitchen sink wastes. | Periodic replenishment of chemicals, cleaning of filters and storage tanks.<br>Residuals disposal.<br>Power use. | 16 | 36 | Sizable removals of pollutants, primarily P. |
| Recycle portion of total wastewater stream for toilet flushing. | 3 | Requires separate toilet supply line.<br>May be difficult to retrofit to multi-story building.<br>Requires disposal system for unused recycle water. | Cleaning/replacement of filters and other treatment and storage components.<br>Residuals disposal.<br>Periodic replenishment of chemicals. | 16 | 36 | Significant removals of pollutants. |

Table 2-3 (continued)

| Flow Sheet Description | Development Stage[a] | Application Considerations | Operation and Maintenance | Total Flow Reduction[b] gpcd | Total Flow Reduction[b] % | Wastewater Quality Impacts |
|---|---|---|---|---|---|---|
| Recycle toilet wastewaters for flushing water carriage toilets | 4 | Requires separate toilet plumbing network.<br>Utilizes low-flush toilets.<br>Requires system for nontoilet wastewaters.<br>May be difficult to retrofit.<br>Application restricted to high use on multi-unit installations. | Cleaning/replacement of filters and other treatment components.<br>Residuals disposal.<br>Power use. | 16 | 36 | Significant removals of pollutants. |
| Recycle total wastewater stream for all water uses | 1-2 | Requires major variance from State/local health codes for potable reuse.<br>Difficult to retrofit. | All maintenance by skilled personnel.<br>Routine service check.<br>Periodic pump out and residuals disposal.<br>Power use.<br>Comprehensive monitoring program required. | 45 | 100 | No wastewater generated for onsite disposal. |

[a] 1 = Prototype developed and under evaluation.
2 = Development complete; commercial production initiated, but distribution may be restricted.
3 = Fully developed; limited use, not locally available, mail order purchase likely.
4 = Fully developed; limited use, locally available from plumbing supply houses and hardware stores.
5 = Fully developed; widespread use, locally available from plumbing supply houses and hardware stores.

[b] Based on the normal waste flow information presented in Table 4-2.

Table 2-4. Summary of Collection System Characteristics

| ITEM | CONVENTIONAL GRAVITY SEWERS | SMALL DIAMETER GRAVITY SEWERS | PRESSURE SEWERS | VACUUM SEWERS | HAULING |
|---|---|---|---|---|---|
| Capabilities and Limitations | Lift stations or deep excavation required in undulating terrain<br>No limit on length | Lift stations or deep excavation required in undulating terrain<br>No limit on length | Installation may follow topography<br>Maximum lifts and sewer length limited by pump's hydraulic capacity | Installation may follow topography<br>Maximum lift is approximately 15' & maximum sewer lengths approximately 4000' (Between vacuum pump stations) | Special situations<br>·Outlying user<br>·Seasonal user |
| Excavation Requirements | Pipe must be laid at specified grade with straight alignment<br>Trenches wide enough to allow in-trench assembly<br>Burial below frost-line | Pipe must be laid at specified grade, but curvilinear alignments may be possible<br>Trenches wide enough for in-trench assembly<br>Burial below frost-line | Pipe laid without regard to alignment or grade<br>Narrow trenches (Assemble outside trench)<br>Burial below frost-line | Downhill grades between trap and life assemblies<br>Narrow trench (Assembly outside trench)<br>Burial below frost-line | Holding tank |
| Required Onsite Items | 4" Lateral | 4" Lateral<br>Septic tank | Septic tank-effluent pump or grinder pump<br>Controls | Sump and vacuum valve | Holding tank |
| Pipe | 8" Minimum | 4" Minimum | 2" Minimum | 3" Minimum | - |
| Pipeline Appurtenances | Manholes at specified locations | Cleanouts or manholes | Air relief valves at high points<br>Cleanouts | Lift and trap assemblies | - |
| Operation and Maintenance | Clean sewers<br>Lift station maintenance<br>Energy for pumps | Clean sewers<br>Lift station maintenance<br>Energy for pumps<br>Septage removal and disposal | Individual lift stations inspection (yearly)<br>Overhaul (Once/10 years)<br>Clean sewers<br>Septage removal (in STEP systems) | Vacuum valve inspection (yearly)<br>Overhaul (as required)<br>Collection station daily inspection<br>Pump overhaul<br>Energy for pumps | Holding tank<br>Pumping |
| State of Technology | Proven and well demonstrated | Developing more information on operation and maintenance, design criteria (Scouring velocities, minimum slopes) | Design and concept well demonstrated<br>Improve hardware & information on operation, maintenance needed | Design procedures need improvement<br>Improved hardware & information on operation and maintenance needed | Proven |
| Wastewater Character | Untreated | Settled and septic | STEP - Settled<br>GP - Comminuted | Untreated | Untreated |
| Relative Costs | | | | | |
| Construction | High | Mod/High | Mod | Mod | Low |
| Operation | Low | Low/Mod | Mod | Mod/High | Very high |

Because of differences in design and operation, infiltration rates and peak flows are significantly different. Infiltration rates may be reduced by using smaller diameter pipe or eliminated altogether by the use of pressure sewers. Therefore, estimates of infiltration rates should be made separately from per capita contributions. Actual per capita water usage is 45 to 50 gpd (Siegrist et al., 1976).

Peak flows are attenuated in alternative collection systems because each provides on-lot storage of wastewater. Septic tanks used with small diameter sewers reduce peak flows from 3 gph/capita to 1 gph/capita (University of Wisconsin, 1978; Baumann et al., 1978). Peak flows in pressure and vacuum sewers are a function of the pumping units or vacuum valves selected. Usually, peak flows can be assumed to be much less than those experienced in conventional gravity systems.

Excavation

Excavation costs are the major cost item for gravity collection systems. Careful consideration should be given to the need for draining basements and the use of alternative collection systems to reduce these costs. Costs of excavation can be reduced significantly by maintaining shallow sewers. It is not always necessary to provide drainage for basement drains. Many homes in unsewered communities have no basement drains and if they do, sump pumps could be provided to lift wastes into shallow sewers. This could be particularly cost effective where shallow bedrock or water tables exist.

Alternative collection systems also can reduce costs of excavation. Small diameter gravity sewers are designed to carry septic tank effluent only and therefore may be installed at flatter gradients since grit and other solids are eliminated. Pressure and vacuum sewers can follow the topography since uniform gradients do not need to be maintained, thus requiring only simple trenching equipment.

Infiltration/Inflow

Extraneous flows in collection systems can result in hydraulically overloaded conditions in treatment facilities and therefore must be controlled. Inflow must be rigorously controlled at the source by prohibiting roof and foundation drains into the sanitary sewer. Infiltration is difficult to prevent entirely in areas of high groundwater tables. Shallow sewer placement may reduce the magnitude of infiltration or eliminate it altogether. Small diameter gravity sewers can have fewer, smaller and tighter joints also reducing the magnitude of infiltration while pressure sewers can eliminate all infiltration. On the other hand, vacuum sewers may be more susceptible to infiltration. Where shallow water tables exist, careful consideration should be given as to which alternative is most appropriate.

## TREATMENT

A wide variety of options exist for treatment of small wastewater flows. Figure 2-3 illustrates the major alternatives and how they fit into the process train. Some of the alternatives are suitable for small installations serving individual residences or small clusters of residences while others are more suited for larger groupings. The major treatment options discussed in this manual are listed below. A summary of the various features, advantages, disadvantages and the expected performance of a variety of alternate treatment process trains is provided in Tables 2-5 through 2-7. A more detailed discussion of each alternative can be found in Appendix A.

- Septic tank
- Suspended growth aerobic treatment
- Fixed film aerobic treatment
- Stabilization ponds
- Overland flow
- Intermittent sand filtration
- Disinfection processes
- Nutrient removal processes

Selection of the most appropriate alternative is based upon several considerations. The more important of these are (1) the method of effluent disposal selected, (2) the complexity of the system, and (3) the operating costs.

### Disposal Method

The method chosen for effluent disposal will dictate the treated quality of the wastewater and hence the treatment processes needed to achieve this quality. Evaporation and land disposal usually have lower quality requirements than surface water discharge.

### Complexity

Increasing the complexity of the treatment works usually increases maintenance costs and the needed skills of the operator. In small systems, economies of scale that help to keep user charges to a minimum are often lacking. Also, it can be difficult to find someone within the community with sufficient skills who is willing to operate the plant. Therefore treatment works that are not energy intensive or do not require skilled labor should be sought.

### Operating Costs

Costs of operating the wastewater facility becomes a very significant share of the total user charge. Comparing alternatives strictly in terms of present worth is not sufficient. Two alternatives may be equal in terms of present worth but because of financial aid programs which can pay up to 85 percent of the construction costs, the subsequent user charges can be quite different.

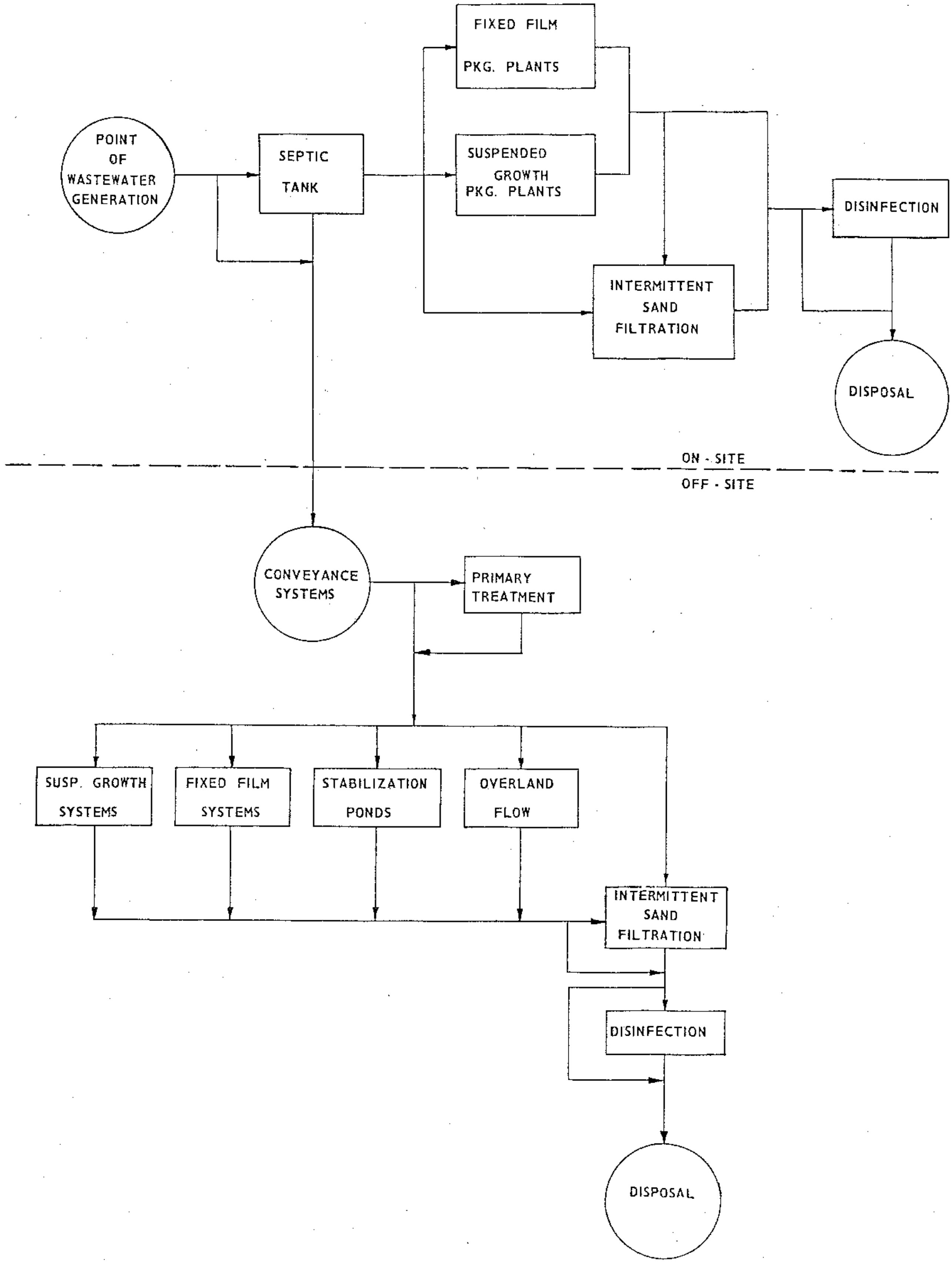


Figure 2-3. Effluent Treatment Alternatives

Table 2-5. Summary of Treatment Options

| PROCESS | APPLICABILITY | PRETREATMENT | CONSTRAINTS: SITE | CONSTRAINTS: CLIMATIC | RESIDUALS | STATUS OF* TECHNOLOGY |
|---|---|---|---|---|---|---|
| | **SEPTIC TANK** | | | | | |
| Septic tank | Treatment equivalent to primary. Removes grit, settalable and floatable solids. | None | None | None | Septage | 1 |
| | **SUSPENDED GROWTH AEROBIC TREATMENT** | | | | | |
| Extended Aeration | Removal of colloidal, suspended and dissolved organics, Nitrification | Screening, Degritting | None | Sensitive to low temperatures | Sludge | 1 |
| Oxidation Ditch | Removal of colloidal and dissolved organics; Nitrification | Primary | Relatively level, moderate land area required | Sensitive to low temperatures | Sludge | 1 |
| Contact Stabilization | Removal of colloidal and dissolved organics | Primary | None | Sensitive to low temperatures | Sludge | 3 |
| Complete Mix | Removal of colloidal and dissolved organics | Primary | None | Sensitive to low temperatures | Sludge | 3 |
| | **FIXED FILM AEROBIC TREATMENT** | | | | | |
| Trickling Filters | Removal of colloidal and dissolved organics. Nitrification at low loadings | Primary | Moderate land area | Sensitive to low temperatures | Sludge | 1 |
| Rotating Biological Contactors | Removal of colloidal and dissolved organics. Nitrification in multiple stage units | Primary | None | Sensitive to low temperatures | Sludge | 3 |
| | **STABILIZATION PONDS** | | | | | |
| Aerated, Aerobic | Removal of colloidal and dissolved organics | Primary | Level site, Moderate area | Sensitive to low temperatures | Sludge | 1 |
| Aerobic | Removal of dissolved organics | Primary and sec. tmt. | Large, level area required | Sensitive to low temperatures | Algal Cells | 1 |
| Aerated Facultative | Removal of colloidal and dissolved organics | None | Large, level area required | Sensitive to low temperatures | Sludge Removals (1/10 yrs) | 1 |
| Aerobic Facultative | Removal of colloidal, suspended and dissolved organics | None | Large Level area required | Sensitive to low temperatures, Anaerobic conditions in winter or colder climates | Sludge Removals (1/10 yrs) | 1 |
| | **INTERMITTENT SAND FILTRATION** | | | | | |
| Buried | Removal of suspended solids and organics Generally used Onsite; Nitrification | Primary | Moderate land area required | Little effect | None | 1 |
| Open | Removal of suspended solids and organics; Nitrification | Primary | Moderate land area required | Sensitive to low temperature | Sand | 1 |
| Recirculating | Removal of suspended solids and organics; Nitrification | Primary | Moderate land area required | Sensitive to low temperatures | Sand | 2 |
| | **LAND APPLICATION** | | | | | |
| Overland Flow | Removal of organics and nutrients | Screening, Degritting | Large sloping site with relatively impermeable soils | Operates best during growing season | Crops | 4 |
| | **DISINFECTION** | | | | | |
| Chlorination | Pathogen reduction | Low levels of SS and $NH_3$ | None | Sensitive to low temperatures | Possible toxics | 1 |
| Iodination | Pathogen reduction | Low levels of SS | None | Sensitive to low temperatures | None | 1 |
| Ultraviolet Irradiation | Pathogen reduction | Low levels of SS; Turbidity $\leq$ 10 | None | None | None | 4 |

* 1 - Proven.
2 - Proven for individual installations; Use on community wide basis needs demonstration.
3 - Proven for large installations; Effectiveness for plants under 75,000 gpd needs demonstration.
4 - Proven in pilot studies; full scale operation needs demonstration.

Table 2-6. Operational Considerations for Treatment Options

| PROCESS | LABOR REQUIREMENTS | CHEMICALS | ENERGY[a] | DEGREE OF COMPLEXITY[b] |
|---|---|---|---|---|
| Septic Tank | Inspect and Pump as Necessary | None | 2 | A |
| Suspended Growth Aerobic Treatment | | | | |
| ·Extended Aeration | Maintain aerators and pumps; Sludge removal and disposal | None | 4; (Oxygen supply and mixing) | C |
| ·Oxidation Ditch | Maintain aeration rotors and pumps; Sludge removal and disposal | None | 3; (Oxygen supply and mixing) | B |
| ·Contact Stabilization | Maintain aerators and pumps; Sludge removal and disposal | None | 4; (Oxygen supply and mixing) | C |
| ·Complete Mix | Maintain aerators and pumps; Sludge removal and disposal | None | 4; (Oxygen supply and mixing) | C |
| Fixed Film Aerobic Treatment | | | | |
| ·Trickling Filters | Maintain distribution system; Sludge removal and disposal | None | 3; (Filter head-losses) | B |
| ·Rotating Biological Contactor | Maintain drive mechanism of contactor; Sludge removal and disposal | None | 2; (Turn discs) | B |
| Stabilization Ponds | | | | |
| ·Aerated Aerobic | Maintain aerators; Sludge disposal | None | 3; (Oxygen supply and mixing) | B |
| ·Aerobic | Minimal | None | 1 | A |
| ·Aerated Facultative | Minimal | None | 2; (Oxygen supply) | A |
| ·Aerobic Facultative | Minimal | None | 1 | A |
| Overland Flow | Slope and cover maintenance | None | 2; (Distribution) | B |
| Disinfection | | | | |
| ·Chlorination | Replenish chemicals; Monitor residual $Cl_2$ | $CCl^-$;$Cl_2$ | 1 | A |
| ·Iodination | Replenish chemicals | $I_2$ | 1 | A |
| ·Ultraviolet Irradiation | Clean lamps | None | 3; (Lamps) | B |
| ·Ozonation | Maintain $O_3$ generation equipment; Monitor residual $O_3$ | $O_3$ | 4; (Ozone generation) | D |

(a) 1 - None
2 - Low
3 - Moderate
4 - High

(b) A - Simple (no skilled labor required)
B - Moderate (limited amounts of skilled labor required for equipment maintenance)
C - High (Skilled labor required for operation and maintenance, reduces as size decreases)
D - High

Table 2-7. Typical Performance of Treatment Processes

| Process | EFFLUENT CONCENTRATIONS (mg/L) | | | |
|---|---|---|---|---|
| | Biochemical Oxygen Demand (5 day) | Suspended Solids | Nitrogen | Phosphorus |
| <u>Septic Tank</u> | 150 | 60 | 55 (70% $NH_3$, 30% Organic) | 15 (80% Inorganic) |
| <u>Suspended Growth Systems</u> | | | | |
| Extended Aeration | 15-25 | 20-30 | 30-40 (Primarily $NO_3^-$) | 7-15 |
| Oxidation Ditches | 15-25 | 20-30 | 30-40 (Primarily $NO_3^-$) | 7-15 |
| Contact Stabilization | 15-25 | 20-30 | 25 (80% $NH_3$) | 7-15 |
| Complete Mix | 15-25 | 20-30 | 25 (80% $NH_3$) | 7-15 |
| <u>Fixed Film Systems</u> | | | | |
| Rotating Biological Contactors | 15-25 | 20-30 | 25 (Primarily $NO_3^-$) | 7-15 |
| Trickling Filters | | | | |
| Low Rate | 15-25 | 25-35 | 25 (Primarily $NO_3^-$) | 7-15 |
| High Rate | 20-30 | 30-40 | 30 (80% $NH_3$) | 7-15 |
| <u>Stabilization Ponds</u> | | | | |
| Aerated Aerobic | 15-25 | 20-30 | 30-40 (Primarily $NO_3^-$) | 7-15 |
| Aerobic | 50-70 | 100-170 | 30-40 (Cells) | 10-20 |
| Aerated Facultative | 25-35 | 60-80 | 20-25 ($NO_3^-$ and Cells) | 4-10 |
| Aerobic Facultative | 40-50 | 60-100 | 20-25 ($NO_3^-$ and Cells) | 4-10 |
| <u>Overland Flow</u> | 5-10 | 5-10 | 10-15 (40% $NH_3$, 60% $NO_3^-$) | 4-10 |
| <u>Intermittent Sand Filtration</u> | | | | |
| Buried | 25-30 | 25-30 | 30-40 ($NO_3^-$) | 7-15 |
| Open | 5-10 | 5-10 | 30-40 ($NO_3^-$) | 7-15 |
| Recirculating | 5-10 | 5-10 | 30-40 ($NO_3^-$) | 7-15 |

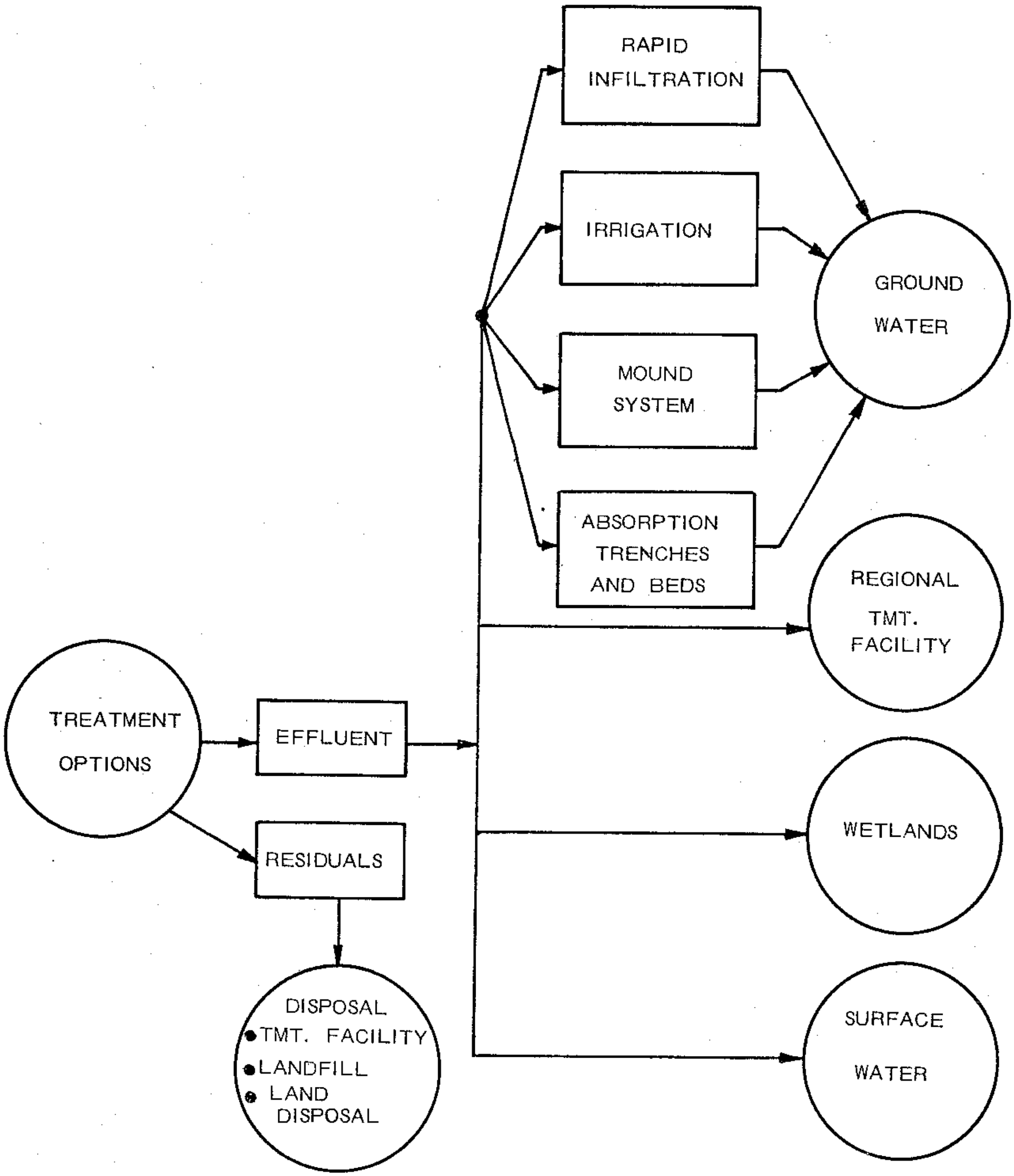


Figure 2-4. Treatment Alternatives
(Nutrient removal and residuals treatment not shown)

## EFFLUENT DISPOSAL

Under the proper conditions, treated wastewater may be safely disposed of onto the land, into surface waters or wetlands, or evaporated into the atmosphere by a variety of methods. The commonly used methods are listed below and depicted in Figure 2-4.

- Soil absorption
- Surface water discharge
- Wetland disposal
- Regional treatment facility
- Evaporation (not discussed here because of its limited potential due to climatic conditions)

Selection of the disposal method is the most important aspect of the facility design since the selection and layout of the collection and treatment systems are dependent upon the location of the disposal site and the method used. Selection is based upon (1) site characteristics, (2) monitoring requirements, and (3) costs.

### Site Characteristics

Since disposal by surface water discharge usually has strict effluent quality restrictions, land disposal or evaporation is more attractive because of the reduced pretreatment necessary. However, sites are more restricted for these methods of disposal due to soil, geologic or climatic characteristics. More suitable sites may be found remote from the waste source but costs in transmission may reduce the cost advantages. These factors must be carefully weighed.

### Monitoring Requirements

Monitoring the effluent as may be required by the regulatory agency can be a very significant operating cost that is often overlooked in cost effective analyses. Requirements for monitoring are meant to insure that the effluent meets the discharge permit requirements. This item should be carefully considered since it can greatly increase the user charges and operator skill required.

### Costs

As discussed previously, selection of the most appropriate facility should not be based upon present worth alone. A breakdown between capital and operating costs should be made. In this manner the impact of financial aid programs on user charges can be made.

Unique aspects of land disposal should also be noted. Land values can appreciate in time and should be used in present worth calculations. Also revenues may be generated from crop production.

Disposal Alternatives

Soil Absorption: Methods which use soil absorption as a final disposal point rely on the soil matrix to purify the wastewater before the liquid percolates to the groundwater. Physical, chemical and biological processes which occur in the soil effectively remove most major pollutants within 3 to 5 feet of unsaturated soil. Reliance on the renovating capability of the soil results in site specific design constraints. Site suitability for the processes described in this section are dependent upon the soils, geology and topography of the planning area.

Current methods which use soil absorption as a final disposal method may be grouped into four major types.

- Rapid infiltration systems
- Irrigation systems
- Subsurface absorption trenches and beds
- Mound systems

Tables 2-8 and 2-9 summarize the various soil absorption disposal methods available. More detailed descriptions can be found in Appendix A.

Surface Water Discharge: State water quality agencies specify effluent limitations for all treatment plants discharging to surface waters. The limitations are based upon the assimulative capacity of the receiving body of water and its potential use. Typically, limits are specified for $BOD_5$, suspended solids and pH but nutrient limitations may also be included. The water quality agency must be contacted to determine the effluent quality required.

Wetland Discharge: Wetlands can be effective renovators of wastewater effluents. Typically, they are capable of removing 80 percent of the $BOD_5$, 30 percent of the suspended solids and 40 percent of the nitrogen. Since their use is relatively new, the exact capabilities of wetlands for wastewater disposal and/or renovation is relatively unknown. Therefore, the water quality agency in the area should be consulted to determine the acceptable effluent limitations. For more information see Duffer and Moyer (1978), Spangler et al. (1976), and Small (1978).

Conveyance to a Regional Treatment Facility: Some small unsewered communities are located near municipalities which have existing treatment facilities. Regional facilities can yield significant cost reductions because of economies of scale. The feasibility of constructing an interceptor sewer to transport the wastewater from the unsewered community to the regional treatment facility depends on many factors including the:

1) Distance to the facility,
2) Desirability of growth along the interceptor corridor,
3) Willingness of the municipality to accept the wastewater,
4) Availability of acceptable discharge locations closer to the unsewered community, and

Table 2-8. Design Considerations for Disposal by Soil Absorption

| | RAPID INFILTRATION | IRRIGATION | ABSORPTION TRENCHES & BEDS | MOUND SYSTEMS |
|---|---|---|---|---|
| Application Technique | Surface | Surface or sprinkler | Subsurface | Subsurface (pressure distribution) |
| Minimum Pretreatment | Primary sedimentation (Use of septic tank effluents may cause odors) | Primary sedimentation (Function of crop & area of application) (Use of septic tank effluents may cause odors) | Primary sedimentation (usually by septic tanks) | Primary sedimentation (usually by septic tanks) |
| Vegetation | Not essential | Required | N/A | N/A |
| Disposition of Wastewater | Percolation to groundwater | Evapotranspiration and percolation to groundwater | Percolation to groundwater | Percolation to groundwater |
| Site Characteristics | | | | |
| · Soils | Sands, Loamy sands | Soils with percolation rates faster than 240 min/in. | Soils with percolation rates faster than 60 min/in. | Soils with percolation rates faster than 120 min/in. |
| · Depth to Groundwater | 10 ft (Less if underdrains are provided) | 3 - 5 ft | > 5 ft | > 2 ft |
| · Depth to Bedrock | > 10 ft | 3 - 5 ft | > 5 ft | > 5 ft (Except for permeable soils over shallow porous bedrock: > 2 ft) |
| · Topography | Level terrain preferred but not required | Surface application: < 5%; Spray irrigation (Crops): <15%; Spray irrigation (Forests): <30% | Function of percolation rate | Function of percolation rate |
| · Climate | Little effect | Storage required for cold periods | Little effect | Little effect |
| Environmental Aspects | Odors, Increase in $NO_3^-$ & $Cl^-$ concentrations in groundwater | Odors, Health Concerns for spray irrigation | Increase in $NO_3^-$ & $Cl^-$ in groundwater | Increase in $NO_3^-$ & $Cl^-$ in groundwater |

Table 2-9. Treatment Capabilities of Soil Absorption Disposal Methods

| | RAPID INFILTRATION | IRRIGATION | ABSORPTION TRENCHES & BEDS | MOUND SYSTEMS |
|---|---|---|---|---|
| $BOD_5$ | Nearly complete removal | Nearly complete removal | Nearly complete removal | Nearly complete removal |
| Suspended Solids | Nearly complete removal | Nearly complete removal | Nearly complete removal | Nearly complete removal |
| Nitrogen | Complete nitrification; Little removal | Complete nitrification; Some removal (Function of crop) | Complete nitrification; Little removal | Complete nitrification; Little removal |
| Phosphorus | Significant removals, (Function of soil) | Nearly complete removal | Nearly complete removal (Except in coarse, clean sands) | Negligible removal through fill; Nearly complete removal in underlying soil |
| Pathogenic Bacteria | Nearly complete removal | Nearly complete removal | Nearly complete removal | Nearly complete removal |
| Virus | Complete removal | Complete removal | Complete removal | Complete removal |

5) Estimated user charges assessed the residents in the unsewered community for use of the regional facility.

Regionalization may provide cost reductions, but it also may foster growth in a manner unacceptable to the local residents. Land use impacts should be carefully scrutinized prior to any serious consideration of using interceptor sewers.

## SOLIDS DISPOSAL

Solids generated in the treatment processes discussed above must be disposed of in a safe and sanitary manner. Summaries of both the quantities and characteristics of the solids generated during treatment of the liquid fraction of wastewater are presented in the references cited at the end of this section. Figure 2-5 depicts the disposal options normally available for the small unsewered community. Discussion in this section will center around the three major disposal options shown in Figure 2-5. In addition, a brief discussion of conditioning and dewatering will be provided.

### Conditioning/Dewatering

Some small communities may not be required to provide some form of treatment for their solids prior to disposal since the small amount of solids normally produced generally precludes such a requirement. However, conditioning of solids either through digestion (aerobic or anaerobic) or chemical addition may be necessary to prevent odors or reduce pathogens. Addition of sludge treatment processes can greatly increase the cost of treatment facilities and consequently disposal options which require a minimum amount of treatment of the solids prior to disposal are highly desirable.

### Disposal to a Regional Treatment Facility

Some small communities are located relatively close to a larger treatment facility. These larger facilities may be able to accept the solids from the smaller community for treatment and disposal. The feasibility of such an approach depends upon the following factors.

1) The distance from the small community to the regional treatment facility.
2) The existing (or proposed) sludge disposal capabilities of the larger facility.
3) The ability to obtain long-term agreements for the disposal of solids at the larger facility.

Septage can be added at a wide variety of locations within a treatment facility but care should be taken to avoid shock loadings. Sludges generally are added only to the solids handling portion of a plant. This alternative can be extremely attractive to a small community since they need not add costly sludge handling facilities. Private haulers, in many instances, may also be retained to provide the transport of the solids to the regional facility.

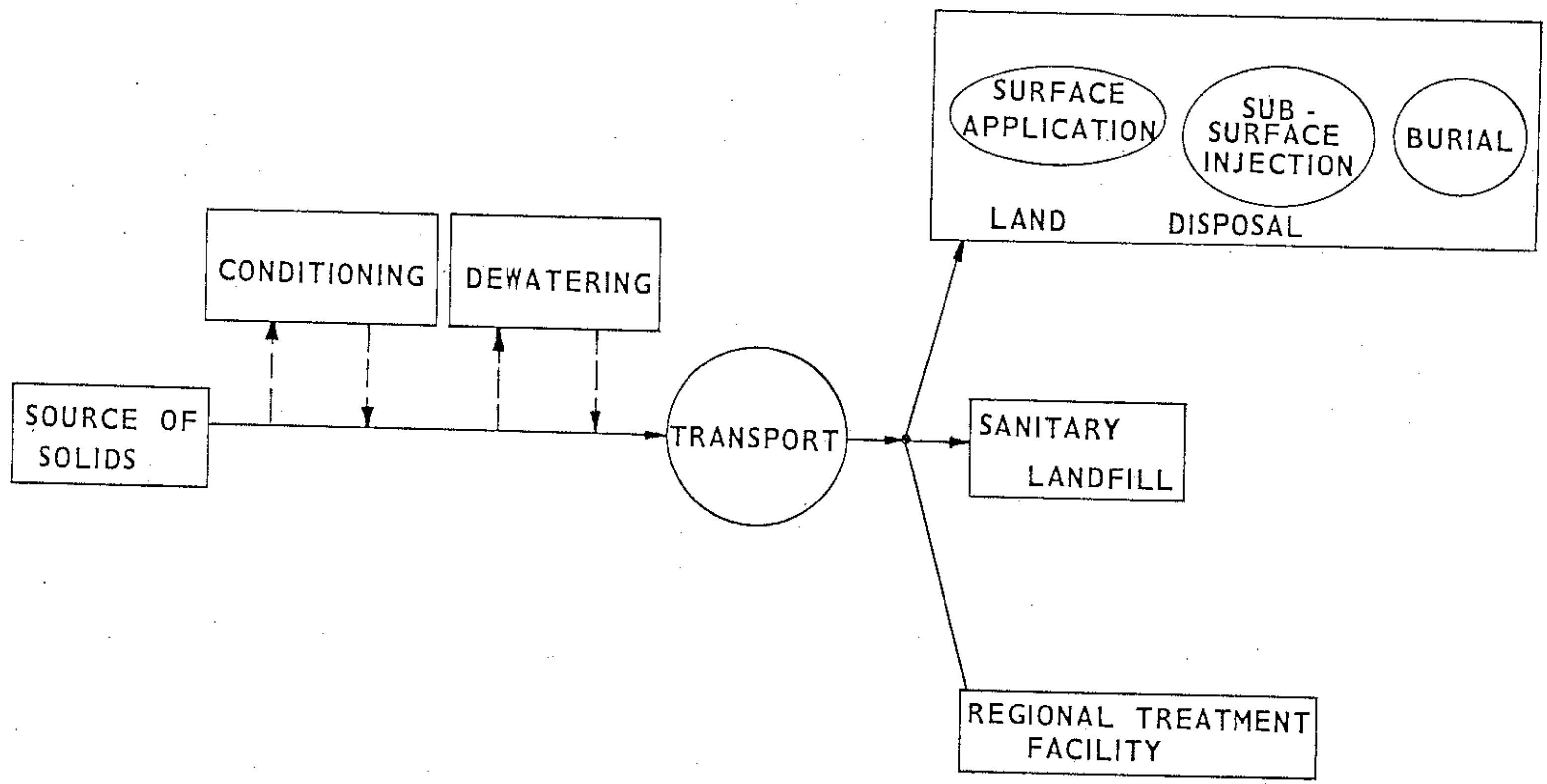


Figure 2-5. Solids Disposal Alternatives

## Sanitary Landfill

Disposal of solids in a sanitary landfill has been a standard practice for larger communities. It often requires that the sludge be conditioned and dewatered. Use of this disposal option for small communities therefore depends on the amount of conditioning and dewatering which the solids must undergo prior to their placement in the fill.

## Land Disposal

Availability of suitable land and the small quantities of solids generated in facilities serving small communities often make land disposal the most viable alternative for disposal of solids. Deposition of the solids on land allows recovery of some of the fertilizer value of the solids as well as providing material to build up the humus layer of the soil.

Major concerns when using the land as a disposal location for solids include the fate of the pathogens, heavy metals and nitrogen in the applied solids and the generation of odors. Effects of pathogens can be minimized by maintaining low loadings on sites and not allowing use of the particular plot for food crops for a given period after application of the solids (typically, a period of one year is sufficient). Heavy metals generally are of minor importance because small communities do not have the industries which contribute heavy metals to the treatment facilities. Nitrogen should not be applied in amounts in excess of crop requirements. Proper management, particularly rapid incorporation of the solids into the soil reduces odors to a minimum.

Some of the treatment options may require storage of the excess solids during periods when applications cannot be made. Typically, digestors (either aerobic or anaerobic) provide sufficient storage capabilities if effective management practices are employed. Processes which generally require external storage are fixed film systems and conventional activated sludge systems.

The management entity may utilize private pumpers licensed by the state to transport and dispose of solids. Long term contracts between the pumper and the community should be obtained to insure that services are provided as required.

For more information concerning sludge handling see EPA (1979) and WPCF (1977). Additional information about septage can be found in Cooper and Rezek (1976, 1977), Kolega and Dewey (1974), and Condren (1978).

## References

Baumann, E.R. et al., "Septic Tanks" in Home Sewage Treatment, Amer. Soc. Agric. Engr. Pub. 5-77, St. Joseph, Michigan (1978).

Condren, Arthur J., Pilot Scale Evaluations of Septage Treatment Alternatives, EPA 600/2-78-164, 1978.

Cooper, I.A. and Rezek, J.W., "Septage Disposal in Wastewater Treatment Plants", Proceedings of the Third National Conference on Individual On-Site Wastewater Systems, 1976.

References (continued)

Cooper, I.A. and Rezek, J.W., "Septage Treatment and Disposal", Alternatives for Small Wastewater Treatment Systems", Vol. 1, Part II, U.S. EPA October, 1977.

Duffer, W.R. and J.E. Moyer, Municipal Wastewater Agriculture, EPA 600/2-78-110, June, 1978.

Environmental Protection Agency, Process Design Manual for Sludge Treatment and Disposal, EPA 625/1-79-011, Sept. 1979.

Kolega, J.J. and Dewey, A.W. "Septage Disposal Practice", Proceedings of the National Home Sewage Disposal Symposium, American Society of Agricultural Engineers, 1974, pp. 122-129.

Siegrist, R.L. et al., "Characteristics of Rural Household Wastewater", Journal Envir. Engr. Div. ASCE, 102, EE3 (June, 1976), pp. 533-548.

Siegrist, R.L. et al., "Water Conservation and Wastewater Disposal" in Home Sewage Treatment, Amer. Soc. Agric. Engr. Pub. 5-77, St. Joseph, Michigan (1978).

Small, Maxwell, "Wetlands Wastewater Treatment Systems", International Sympsoium of the State of Knowledge in Land Treatment of Wastewater, Vol. 2, pp. 141-148, 1978.

Spangler, F.L. et al., Wastewater Treatment by Natural and Artificial Marshes, EPA 600/2-76-207, 1976.

University of Wisconsin, "Management of Small Wastewater Flows", U.S. EPA 600/2-78-173, Cincinnati, Ohio (1978).

U.S. EPA, Manual for Onsite Wastewater Treatment and Disposal Systems, 1980.

Water Pollution Control Federation, Wastewater Treatment Plant Design, Manual of Practice No. 8, 1977 (Chapters 25, 26 and 27).

# CHAPTER 3

# PLANNING APPROPRIATE WASTEWATER FACILITIES

Planning wastewater facilities that will meet water quality and public health goals at a cost small communities can afford requires a proportionately greater effort than is customary for larger communities. Each community can be quite different. No single solution will work for all. In larger communities it is a forgone conclusion that gravity collection sewers will be used with a central treatment plant. Alternative analysis is limited primarily to the site of the treatment plant and the unit processes to be used. However, in small communities, individual onsite systems, clusters and alternative collection systems must be investigated to keep costs down. Maximum use must be made of the existing facilities and the natural resources of the community. This increases the need for detailed field work and public involvement. But it is not practical to evaluate every possible alternative. A systematic procedure should be followed which eliminates alternatives of little potential early in the planning so that field work concentrates only on the most viable. The five step procedure outlined in Figure 3-1 and discussed in this chapter is offered as a guide.

## PRELIMINARY ASSESSMENT

The objective during this phase is to define the scope of the problem, identify potential sources of needed information and provide a cost estimate for the planning. If grant funds are involved it would also include the application for a facilities planning grant. Since the work done during the preliminary assessment phase is prior to any grant application, it is entirely at the community's or engineer's expense. Therefore, the level of effort should be limited only to that necessary to provide an accurate estimate of the planning costs.

### Needs Analysis

The first step the engineer must take is to arrange a meeting with the community officials to discuss the needs and goals of the community and the directions the planning might take. If the community is small with much public interest, it might be valuable to make the meeting public. The engineer should use this meeting as an opportunity to learn the politics of the community and to establish a good working relationship with the client. This is important because if alternative facilities planning is to be effective much more public participation than occurs in conventional planning is needed. If the engineer can gain the confidence of the residents early in the project, the planning will go much more smoothly.

One issue which should be discussed in this meeting is why the facility is needed. The planning may be initiated in response to orders from the water quality agency because failing onsite disposal systems are impairing the water quality of the area. On the other hand, the residents may recognize a water quality or public health problem which needs correcting or they may wish to encourage development. If community improvement is the reason

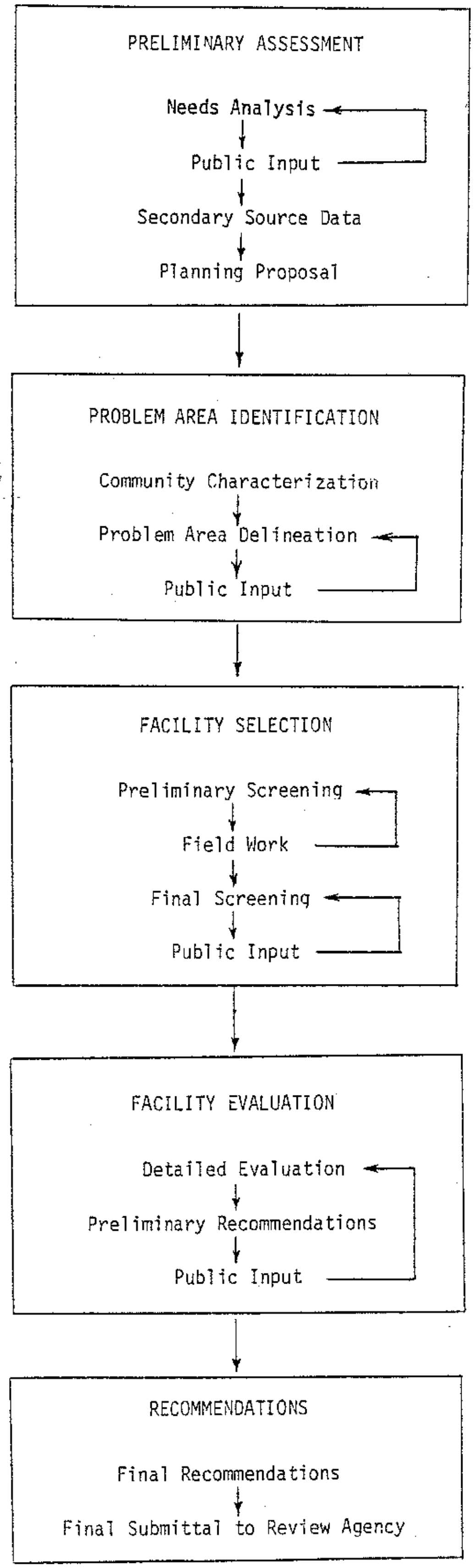


Figure 3-1. Wastewater Facilities Planning Procedure for Small Unsewered Communities

behind the desire for a facility, the community should be made aware that federal or state grant funds will not be available to them unless they can document that there is a water quality or public health problem which could be corrected by the construction of a wastewater facility. A sampling program may be necessary to provide documentation, but often the county zoning administrator or sanitarian is familiar with the problem and can supply the necessary verification without sampling. If sampling is necessary the community should realize it will be at their expense.

The process of wastewater facility planning and the direction it might take should also be discussed. In most cases, the residents assume that they have no choice but to construct a conventional facility of gravity sewers with a central treatment plant. Other options should be described to them such as individual systems under public management and scattered cluster systems. These types of facilities may reduce the costs substantially because they can be used to correct only the existing problems. Some residents may prefer a conventional facility because they feel it is the most reliable and only permanent solution. If they are growth minded, they also see conventional sewers as a means of encouraging development within the community. While this may be true for some, others may oppose a conventional facility because of the cost or because they prefer to discourage growth. They may feel they should not share in the cost of developing new areas for someone else's profit. These attitudes must come to the attention of the engineer so that the best facility can be planned for the community.

## Secondary Source Data Collection

To develop a good alternative plan, it is necessary for the engineer to gain a good understanding of the soils, geology, topography and the existing wastewater disposal systems in the community. It can be costly for the engineer to collect this data. Fortunately, however, much of the needed information may be available from other sources. Therefore, before a cost estimate is made for the planning work, a check should be made of the availability of data which would reduce the field work.

The following sources of information should be checked:

- Census Data

  Regional planning agency
  National census

- Area-wide Water Resources Planning

  State water quality agency
  Regional planning agency

- Water quality and effluent standards

  State water quality agency

- Soils description

  Local farmers

State Geologic Survey

Detailed soil surveys may be published for the county including soil maps at a scale of 1:15,840

Soil and Water Conservation District Office/Soil Conservation Service

If a soil survey is not yet published for a county, check with SCS to learn if the mapping is in progress. Field work sheets may be available.

- Groundwater Elevations

  U.S. Geologic Survey; State Geologic Survey

  USGS Quadrangle maps can be used to establish the regional water table elevation

- Geology

  U.S. Geologic Survey; State Geologic Survey

- Topography

  Department of Transportation

  Aerial stereo photographs may be available for the area if a state or federal highway passes near the community

  U.S. Geologic Survey

  USGS Quadrangle maps

- Land Use

  County Zoning Administrator

  Plat maps

  County Register of Deeds

  Plat maps

- Existing Onsite Disposal Systems

  County Sanitarian
  County Zoning Administrator

Cost Estimation for Planning Proposal

The engineer and community must realize that alternative facilities planning takes considerably more effort than planning for conventional facilities because of the need for detailed information about the community. Field work and public participation beyond that which is customary is usually needed. However, if successful, the additional costs are insignificant in comparison to the savings made in construction of the facilities and their operation and maintenance.

Based on the limited information the engineer is able to collect during this preliminary assessment, it is difficult to estimate accurately the amount of effort which will be required to develop a good facilities plan. Sufficient information should have been gathered, though, to make a judgement as to what information is needed and how much is available in adequate detail from the secondary sources. What is not presently available will have to be collected by the engineer. The collection of data through field work and meetings may become a substantial portion of the total planning costs. It must be included in the estimate if an adequate job of planning is to be done.

## PROBLEM AREA IDENTIFICATION

The objective of this phase of the planning is to identify those areas within the community where new or improved wastewater facilities are needed. It is in these areas where the planning efforts are concentrated. Areas where the existing onsite systems can be expected to perform adequately over the planning period with proper maintenance are not considered at this point. This determination requires that the potential of the existing onsite systems be evaluated.

### Community Characterization

Since evaluation of existing septic tank systems is a difficult and time consuming task, it is desirable to eliminate from consideration those systems which are incompatible with the desired growth and development plan or have little hope of functioning adequately over the planning period. This requires that the engineer have a clear understanding of how the community wishes to develop and a good knowledge of the soil and site conditions which effect septic tank system performance.

#### Growth and Development

Information concerning the growth and development of the community is gathered from local planning agencies and the community officials. Questions which must be answered are:

- What is the current and projected population?
- What are the significant growth determinants and how are they expected to change? Will construction of a public wastewater facility result in an increased rate of growth? What is the employment outlook in the surrounding area?
- What is the pattern of development in terms of location, density and character? Is this pattern determined by soil and site suitability for septic tank systems? What changes would the community like to see in this pattern?
- What land remains undeveloped? Does it remain undeveloped because of the lack of wastewater facilities?

Once the information is gathered, it is useful to display it on a plat map. Existing and expected future development is shown.

## Soil and Site Suitability for Soil Absorption Systems

Information regarding the soil types and their suitability for soil absorption systems for all areas in and around the community must be obtained. A detailed soil survey may have been completed for the area which can be obtained from the state geologic survey. If it is not published, field sheets or other useful information may be available from the district soil and water conservation office, the county zoning administrator or county sanitarian. Also, the county zoning administrator or sanitarian may be a source of information concerning soil tests made in the area. Some cursory soil sampling by the engineer may be desirable. Whatever information is obtained is plotted on the same map used to show present and future development of the community. Topography and any significant geologic features which may restrict the use of soil absorption systems also should be noted.

## Evaluation of Existing Onsite Systems

Before beginning a survey of existing septic tank systems, areas within the community where individual septic tank systems definitely are not a suitable alternative must be delineated. Areas may be unsuitable because of lot size, density, planned development, etc. Collection of the wastewater is required in these areas so evaluation of the existing systems is not necessary. Care should be used not to eliminate areas on the basis of the soil maps alone, however, unless other information such as soil borings or local knowledge is obtained to confirm the map's accuracy.

The developed lots are studied first. Are the soil and site conditions suitable for soil absorption of wastewater on each lot with the current development pattern? Would onsite systems still be suitable under the desired development pattern? In cases where insufficient information is available to make this determination, suitable conditions are assumed to exist at this point.

Next, a similar determination must be made for the undeveloped lots. Other considerations enter into this determination, however. Does the community wish to promote development on these lots? If not, no further consideration is necessary. If development is desired but the soil and site conditions are unsuitable for subsurface soil absorption, can the lots be replatted or rezoned such that each lot becomes suitable? If this cannot be done, is the community willing to invest in future development by providing a collection system to serve the unsuitable lots? If the community wishes to make this investment then onsite systems can be eliminated from further consideration in favor of cluster systems. However, it would be wise for the engineer to evaluate both alternatives because there may be a significant cost savings of which the community residents are unaware.

An evaluation of the existing systems is performed only in those areas where individual septic tank systems seem to be feasible. Incorporating these systems into the proposed public facility may reduce the costs of the facility substantially. Therefore, it is necessary to determine if the existing systems are sound and can be expected to perform adequately with regular maintenance over the planning period. If systems are found to be functioning poorly, the cause of the problem must be determined to ascertain whether rehabilitation or reconstruction is possible.

The first step in the evaluation is a quick survey to locate any areas where the majority of the systems seems to be failing. Residents and the county zoning administrator or sanitarian are helpful in this step. More than likely, it is less costly to provide a common system in such areas rather than rejuvenating or rebuilding the individual systems because of economies of scale. If so, these areas can also be excluded from detailed evaluation.

The septic tank systems in the remaining areas should be investigated in detail. The county zoning administrator or sanitarian should be consulted for any sanitary permit applications that may be on file for systems recently reconstructed in the area. The applications should provide soil test data and a sketch of the system installed. In addition, a door to door survey is performed to gain as much information as is possible. The survey should include an interview with the homeowner and a visual inspection of the system. The questionnaire in Appendix B can be used as a guide. It is recommended that this survey be performed by residents of the community rather than outsiders who may not be trusted. If residents are hired to perform this survey, however, they must be trained as to how a septic tank system functions and the causes of failure. The information collected should be sufficient to determine how the system can be rehabilitated if necessary (see Appendix C).

### Designation of Problem Areas

With the information gathered at this point, those areas where new or improved facilities are needed are delineated on the plat map. A distinction should be made between those areas where off lot disposal is the only alternative and those areas where individual onsite systems may be feasible if the existing systems can be rehabilitated. It is beneficial to hold a public meeting at this point to invite comments on the delineated areas to confirm the designations and to make appropriate changes. These then become the areas in which the engineer will concentrate efforts in developing the facility plan.

## FACILITY SELECTION

Once the areas in the community which are in need to improved or new wastewater facilities are identified, the next step is to select viable facility designs for detailed evaluation. Because of the large number of alternative technologies which are available, selection of the most appropriate facility can be a time consuming process unless a systematic procedure is followed. To be effective, this procedure must be able to eliminate the alternatives with the least potential based on the limited information gathered in the previous two steps. This reduces the additional field work to that necessary to select between only the most promising options.

A recommended procedure is presented in Figure 3-2. Each node in the diagram represents a point where a specific decision must be made to choose the best path to the next node (see Table 3-1). To develop this procedure, some simplifying assumptions were made.

- Where no restrictions exist, subsurface soil absorption of septic tank effluent is the least expensive alternative.
- Maximizing the use of existing septic tank systems minimizes the total costs.

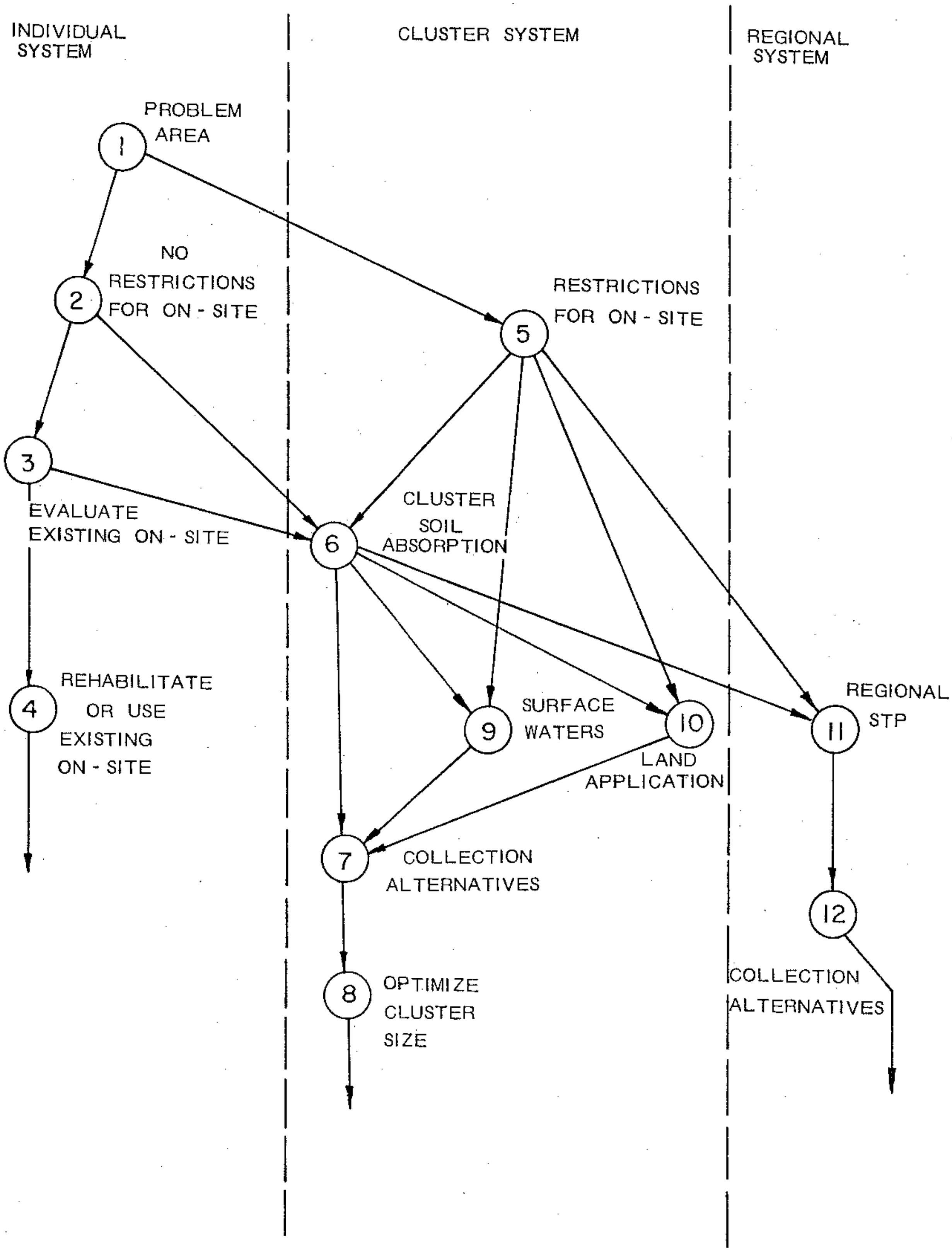


Figure 3-2. Facility Selection Procedure

| NODE | DECISION | ACTION |
| --- | --- | --- |
| 1 | Do the developed lots have soil and site characteristics suitable for onsite subsurface soil absorption? | Yes - Proceed to Node 2<br><br>No - Proceed to Node 5 |
| 2 | Do the undeveloped lots have soil and site characteristics suitable for onsite subsurface disposal? (If not, can the area be replatted to make each lot suitable?) | Yes - Proceed to Node 3<br><br>No - Proceed to Node 6 |
| 3 | Are the existing onsite systems functioning properly? (If not, can they be rehabilitated easily?) | Yes - Proceed to Node 4<br><br>No - Proceed to Node 6 |
| 4 | | Determine costs of rehabilitation |
| 5 | Is a suitable area available for a cluster soil absorption system within a reasonable distance? | Yes - Proceed to Node 6<br><br>No - Proceed to Nodes 9, 10, 11 |
| 6 | Does it appear collection costs will not be excessive? | Yes - Proceed to Node 7<br><br>No - Proceed to Nodes 9, 10 11 |
| 7 | | Layout collection options and proceed to Node 8 |
| 8 | | Compare costs of various cluster sizes |
| 9 | | Design low maintenance treatment works to meet water quality standards |
| 10 | | Design low maintenance land application system to meet local design requirements |
| 11 | | Investigate feasibility and local cost share of conveying wastes to a regional treatment plant |
| 12 | | Layout collection options |

Table 3-1. Facility Selection Decisions Corresponding to Figure 3-2

- Cluster soil absorption fields are less costly than individual fields where new construction or reconstruction is necessary for a number of lots unless collection costs are excessive because of economies of scale.

This procedure is used to select the most cost-effective facility for each designated problem area. This is done in an attempt to keep the costs of constructing collection sewers to a minimum. Once this is completed, problem areas can be grouped together on a larger common system in an attempt to reduce the total community costs. In this analysis, economies of scale are investigated to determine if the cost reductions in the treatment and disposal facility will offset the increased costs of collecting the wastes from more than one problem area. Costs of operation, maintenance and monitoring must be included in this analysis.

Preliminary Screening

In this step all disposal options within the community should be identified. Areas which appear to have soils suitable for subsurface or surface application should be noted and standards that a treated wastewater effluent must meet to discharge into the local streams or marshes are established. The former are obtained from soil maps or information from the residents of the area, while the latter must be obtained from the State water quality agency.

At this point, the field work necessary to select an appropriate facility for each problem area can be planned. This should include the following:

- Building locations and foundation elevations
- Street elevations
- Septic tank locations
- Evaluation of selected areas for cluster soil absorption systems

This information is necessary to lay out the least costly collection system. It should be collected even if it appears the existing onsite systems can be utilized. It may be that if the systems require substantial rehabilitation, it will be less costly to construct a common disposal field.

Once the information is displayed on maps of the community, selection of wastewater facilities for each problem area begins. The areas that are considered first are those where rehabilitation of the existing systems may be possible. Rehabilitation techniques are outlined in Appendix B. If substantial rehabilitation is required for a number of buildings and a suitable area for a cluster soil absorption system exists within the area, then rehabilitation should be abandoned in favor of the cluster system. Where a suitable cluster area exists some distance away but it is not obvious that clustering would be more cost effective, both alternatives should be evaluated.

After this decision has been made for the areas where rehabilitation is considered, disposal options are considered for the other problem areas. Soil absorption is the first choice because of the low operation and maintenance costs. Other disposal methods are investigated when no suitable site for a cluster soil absorption field is found. These methods include surface water discharge, land application and transport to a regional treatment plant. In selecting these facilities, the emphasis is put on processes with low operation and maintenance costs.

Once the treatment and disposal facilities are selected for each problem area, collection alternatives are investigated. Though it may be less costly to combine one or more problem areas together on a common treatment and disposal facility, at this point the collection system for each cluster should be laid out separately. The end result should be the most cost effective facility for each problem area.

### Final Selection

In this step, further savings are sought by combining clusters together for common treatment and disposal. If the cost of providing collection facilities between two clusters is less than either of the two treatment facilities, then combining the two clusters should be seriously considered. However, the consequences of constructing extended collection lines must be evaluated in terms of any additional connections that may affect the size of the treatment and disposal facilities. If the extensions pass through areas which the residents do not wish development, the engineer should present them with both alternatives.

When the initial facilities selection is complete, a public meeting is held to present the various courses of action which the community may take. All options considered, the impacts of each and their relative costs are fully explained by the engineer. The comments made at this meeting are used by the engineer to select the most desirable alternative facilities for detailed evaluation.

## FACILITY EVALUATION

In this phase of the planning, the engineer concentrates on estimating detailed costs for the various alternatives the community finds acceptable. These estimates include costs for construction, operation, maintenance and monitoring used to develop the total present worth of each alternative. In this form, the alternatives can be compared to determine the most cost effective plan. However, the most cost effective alternative may not be the least costly for the community residents. Federal and State funding programs only provide grants and loans for the construction of the facilities. Operation, maintenance and monitoring costs which are reoccurring and ever-increasing must be borne by the residents. Therefore, the costs for each alternative must be broken down to show the probable local share based on the various funding programs available and how this local share might be generated through assessment and user charges.

At this point, the final public meeting is held to present the engineer's recommendation. Since the costs to each resident is the primary concern, the engineer must know the probability of the community receiving various grants so the residents can make an informed decision whether to proceed. It may be that the engineer will be asked to re-evaluate some options.

RECOMMENDATIONS

Based on the comments receiving at the last public hearing, the final facilities plan is prepared for submittal to the reviewing agency. At this point the community should be fully aware of their options and the probable costs of the selected facility. There should be general agreement within the community to back the plan.

# CHAPTER 4

# MANAGEMENT OF SMALL WASTEWATER FACILITIES

Sound management of wastewater treatment and disposal facilities is an essential component of an effective water pollution control program. If a wastewater facility plan is to be properly implemented, administered, operated, and maintained, a public or private management institution must be established. Several types of institutions can be organized with the necessary powers to provide sewerage services to the public. The choice of one type over another is largely dependent upon the legal status of the area to be organized.

## POWERS NEEDED BY A MANAGEMENT INSTITUTION

Management entities that are to provide sewerage services must have the authority and power to perform vital functions. The entity should be able to do the following as discussed by Otis and Stewart (1976).

- Plan, design, construct, inspect, operate, maintain and own all wastewater systems within its jurisdiction and, as applicable, systems outside its legal boundaries.
- Enter into contracts, sue and be sued, and undertake debt obligations either by borrowing or issuing bonds for purposes of acquiring necessary property, equipment and supplies.
- Raise revenue by fixing and collecting users charges and levying special assessments and taxes (taxation is possible only for governmental entities).
- Plan and control how and at what time wastewater facilities will be extended to those within its jurisdiction.

In addition to these necessary powers it is also desirable for a management entity to have the ability to:

- Make rules and regulations regarding the use of the system or systems under its jurisdiction and to provide for the enforcement of those rules through express statutory authorization.
- Meet the eligibility requirements for both loans and grants-in-aid of construction from both federal and state agencies.

## ACCEPTABLE MANAGEMENT INSTITUTIONS

This discussion concentrates on those institutions acceptable for wastewater facility management in the State of Wisconsin. It is not possible to discuss all the various entities that have the necessary powers to manage wastewater facilities throughout the United States. There are many similarities between states but each state's statutes and case law must be examined to determine which entities are acceptable. This discussion may help those users outside the State of Wisconsin, however, by suggesting possible entities to examine.

There are several acceptable management entities for wastewater facilities in Wisconsin. These include:

- Towns
  - a. Town Boards
  - b. Utility Districts
  - c. Unincorporated Villages
  - d. Town Sanitary Districts
- Villages
- Cities
- Counties
  - a. County Boards
  - b. Public Inland Lake Protection and Rehabilitation Districts
- Non-governmental Entities
  - a. Cooperatives
  - b. Non-stock Corporations
  - c. Stock Corporations (profit or non-profit making)

Table 4-1 summarizes the powers that each of these institutions has and the specific Wisconsin statuatory authorization for these powers.

## ESTABLISHMENT OF A MANAGEMENT ENTITY

In most instances a management entity has been established prior to initiation of wastewater facility planning. In other cases an entity must be established. The following brief discussion highlights the powers and establishing procedures of the various entities.

### Towns

In Wisconsin, towns have broad powers to construct, maintain, operate, and finance sewerage projects or they may purchase the services if they wish. In other words, no special restrictions on the town's power with regard to sewerage are found. Towns in counties of more than 150,000 may, upon petition, build sewers and assess the cost to the property fronting on the street. Towns which have adopted village powers of course have those.

Towns have several legal options open to them if they decide to provide sewerage services. They include:

- Provide the service itself.
  This is a power of the town board given without restriction. No citizens' petition is needed to undertake service. A town board exercising village powers also has village powers, including provision of sewerage services.
- Create a Utility District
  A combined water-sewer utility may be established by a town. It may collect, treat, and dispose of sewage and have lateral, main, and intercepting sewers and plant and equipment necessary for

its functions. A utility district is apparently seen primarily as a financial device through which a town can exercise its powers to provide sewerage services within a geographic area smaller than the whole town. The utility district may be used to absorb a Town Sanitary District. To establish a utility district, a public hearing and majority vote of the town board is required.

- Establish an unincorporated village.
  A town board which has been authorized by the annual town meeting to exercise village powers may determine to provide sewers in an unincorporated village, the boundaries of which it has legally established. The town board has the power to provide "any convenience or public improvement" within such a village. The unincorporated village can be a sort of special district established to provide services within a limited area in which population has clustered.

- Establish a Town Sanitary District (TSD).
  A town sanitary district can be established to plan, construct, operate and maintain public wastewater facilities. Alternatively the TSD may wish to take on a limited role and simply function as an auxiliary to a metro sewerage district or even arrange for sewerage service to be furnished by a metro, joint system, or a municipality. It can also be established to provide public water and garbage collection to people living in unincorporated areas as well as treat aquatic nuisances, maintain storm water and drainage facilities and regulate public health.

A TSD is ordinarily established by the town board after an initiating petition by property owners. However, if the DNR sees the need for a district but the town fails to act, the DNR may establish a district by order.

The territorial boundaries may encompass part or all of the town depending on the specific service needs. Once formed, each property owner within the district must contribute to the cost of the services received. A TSD may also sell services to users outside its limits.

## Villages

Villages have powers to construct, acquire, lease, extend, improve, repair, operate and maintain wastewater facilities. They are given the same broad powers as cities to provide this function. They may establish a combined water-sewage disposal system. They may also establish a utility district by extraordinary majority of the board or arrange for sewerage service to be furnished by a metro or a joint sewerage system.

## Cities

Cities can take any necessary legal actions in order to provide sewerage services to all or part of the city. The city council or a board of public works may exercise the power. Third and fourth class cities may establish a utility district by extraordinary majority vote of the council.

# Table 4-1. Acceptable Management Entities in Wisconsin[(a)]

| | | | Necessary Powers | | | | | Desired Powers | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Management Entity | Applicable Location | Method of Formation | Own, Operate & Maintain | Contract | Sue/ Be Sued | Finance[(b)] Indebtedness | Raise[(c)] Revenue | Make Rules & Regulations | Accept[(d)] Grants & Loans | Service Extensions or Alterations |
| Towns | 59.07<br>County Bd.<br>Pop. >150 | 59.07 | 66.076<br>General Provision | 60.01 | 60.01 | TB 60.18<br>GOB 67.04<br>B 67.12<br>MB 66.066<br>SAB 66.54<br>RB 66.059 | T 60.18<br>UC 66.076<br>SA 66.60 | 66.076 | EPA 66.33<br>WEF 66.33<br>144.24<br>FmHA<br>EDA<br>HUD | 66.076 |
| Utility District | 66.072<br>Town<br>Inc.-Village<br>City(2nd-4th Class) | 66.072<br>51% of Town Bd.<br>75% City Council<br>Village Bd. | 66.072(1) | 66.072 | 66.072 | MB 66.066<br>MoB 66.066<br>SIB 66.54 | T 66.072(2)<br>SA 66.08 | | | |
| Unincorporated Village | Populous Area of a Town | 60.29(6)<br>Town Board | | | | | | | | |
| Town Sanitary District | 60.301 | 60.301-60.304<br>Petition of 51% of Landowners<br>60.315 - DNR | 60.306 | 60.305 | 60.30 | DB 60.307<br>MB 60.305<br>B 60.307<br>SIB 60.309<br>RB 66.059 | T 60.306<br>UC 60.306<br>SA 60.309 | 60.306 | EPA 66.33<br>WEF 66.33<br>FmHA<br>EDA | 60.306<br>60.315 |
| Villages | Population >150 | 61.01-61.08<br>Petition followed by Court Action | 61.34<br>61.36<br>61.45 | 61.10<br>61.54-56 | Inherent | GOB 67.04<br>SIB 66.54<br>B 67.12<br>MB 66.066<br>RB 66.059 | T 61.34<br>61.46<br>UC 66.076<br>SA 61.42<br>66.60 | 61.50 | EPA 66.33<br>WEF 66.33<br>FmHA<br>EDA<br>HUD | |
| Cities | Population >1000 | 62.06 Petition followed by Court Action | 62.18 | 62.15 | Inherent | GOB 67.04<br>B 67.12<br>MB 66.066<br>RB 66.066<br>SAB 666.54 | T 62.18<br>UC 66.076<br>SA 66.06 | 62.11<br>62.14 | EPA 66.33<br>WEF 66.33<br>FmHA<br>(Pop. <10,000)<br>HUD<br>EDA | 62.07<br>62.18 |
| Counties | | | 59.07<br>County Services or On-Site Systems | 59.01 | 59.01 | RB 66.059<br>MB 66.066 | T 59.07 | | WEF 144.24<br>FmHA | |
| Public Inland Lake Protection & Rehab. District | 33.21 | 33.24-33.26<br>Petition of 51% of Landowners | 33.22<br>Annual Meeting Approval | 33.22(1) | 33.22(1) | DB 33.22<br>B 33.31<br>SAB 33.31 | T 33.30(2)<br>SA 33.32<br>UC 33.22 | 33.22 | EPA 66.33<br>WEF 66.33<br>PILPAR 33.16<br>FmHA | 33.33<br>33.36 |
| Cooperatives | Unlimited | 185.04<br>(5 or more Adults) | 185.02 | 185.03(4)<br>185.41<br>(5 yr limit) | 185.03(2) | 185.03(4)<br>B 185.03(5) | 185.03(6) | 185.03<br>(6),(8),(12);<br>185.51 | FmHA Loan<br>(if Qualified) | 185.11<br>185.71,72 |
| Non-Stock Corporation | Unlimited | 181.30<br>(1 or more Adults) | 181.03<br>181.04(5) | 181.04(7) | 181.04(2) | B 181.04(7)<br>I 181.04(8) | 181.04(9) | 181.04(15) | FmHA Loan<br>(if Qualified) | 181.11<br>181.50<br>181.56 |
| Stock Corp. (Profit or Non-Profit) | Unlimited | 180.44<br>(1 or more Adults) | 180.03 | 180.04(7) | 181.04(7) | B 180.04(7)<br>I 180.04(8) | 180.04(9) | 180.04(16)<br>185.50 | FmHA Loan<br>(if Qualified) | 180.753<br>180.769 |

(a) Numbers refer to the appropriate chapters and sections in the Wisconsin State Statutes.

(b) DB - District Bonds, B = Borrowing, SIB - Special Improvement Bond, RB - Revenue Bond, MB - Municipal Bond, MoB - Mortgage Bond, SAB - Special-Assessment Bond, TB - Town Bond, GOB - General Obligation Bond, I - Investment.

(c) T - Taxation, UC - User Charge, SA - Special Assessment.

(d) EPA - U.S. Environmental Protection Agency, WEF - Wisconsin Environmental Fund, FmHA - Farmer's Home Administration, EDA - Economic Development Agency, PILPAR - Public Inland Lake Protection and Rehabilitation, HUD - Department of Housing and Urban Development.

## Counties

Counties apparently have some of the powers necessary for an effective management entity but ownership of such systems may be limited to facilities at county institutions. Generally, counties tend to encompass too large an area to provide efficient service for the handling of wastewater in the individual communities which are located in the county. However, they appear to have sufficient powers to operate effectively as a management entity for individual systems in those sections of a county without an existing management entity. Provision of general maintenance services, septic tank pumping and septage disposal for onsite systems may be within the county's jurisdiction provided that the costs for such services are recovered from user's fees. Through specific statutory authorization, counties are now eligible for monies under the Wisconsin Fund program which can be used for the rehabilitation of existing onsite systems under private ownership.

## Public Inland Lake Protection and Rehabilitation Districts (PILPRD).

A Public Inland Lake Protection and Rehabilitation District may be established by the town or county board after an initiating petition by landowners to undertake a program of lake protection and rehabilitation of all or part of a lake within the District. The services provided could include sewerage.

Public Inland Lake Protection and Rehabilitation Districts may have an advantage over the TSD in areas involving significant lake frontage. The major benefit which accrues from the formation of a PILPRD is the eligibility for funding (up to 90% of eligible costs) under the Public Inland Lake Protection and Rehabilitation Law (Chapter 33 of the Wisconsin Statutes). Eligibility for funding under this law depends on a project's rating in a priority system established by the Department of Natural Resources. These districts may be granted many of the powers of the Town Sanitary Districts but permission for the use of these powers requires voter approval at an annual meeting. Some degree of local control is lost since two of the five available seats on the board of commissioners are not necessarily occupied by members residing in the district. Instead, the county board and town board governing the area included in the district each retain control over one of the positions on the district's board of commissioners.

## Nongovernmental Entities

Nongovernmental entities like corporations and cooperatives may, in certain situations, provide an adequate means for serving rural residents. Situations where they are useful include areas where the number of users is insufficient to warrant establishment of a governmental entity (generally less than 20 users) or in new subdivisions which, in general, are ineligible for most funding programs. For larger applications and older communities, there are significant cost reductions available to the users, if they form a governmental agency with the ability to accept grants-in-aid. Nongovernmental entities have more inherent flexibility in their operation since the rules specifying their procedures are not limited by statute but rather in the entities' bylaws. Cooperatives allow for more member control than do corporations, although service contracts for the cooperatives are limited to five years. Nongovernmental agencies may also be satisfactory short-term alternatives for an area until there is sufficient interest or population to form a governmental entity. At a later date when there is a sufficient population, the nongovernmental entity may be dissolved in favor of a governmental entity.

References

Otis, R.J. and D.E. Stewart, "Alternative Wastewater Facilities for Small Unsewered Communities in Rural America", Small Scale Waste Management Project, University of Wisconsin, Madison (July, 1976).

Additional References

Felstehausen, H. and E. Abbott, "Institutional Factors in the Creation of Local Sanitary Districts in Wisconsin", Water Resources Center Tech. Report WIS WRC 74-01, University of Wisconsin, Madison (1974) 81 p.

Klessig, L.L. and D.A. Yanggen, "Town Sanitary Districts in Wisconsin: Their Legal Powers, Characteristics and Activities", Inland Lake Renewal and Shoreland Management Demonstration Project, University of Wisconsin-Extension, Madison (1973) 42 p.

Roy F. Weston, Inc., "Management of Onsite and Alternative Wastewater Systems", U.S. Environmental Protection Agency, Cincinnati, Ohio (in press).

Schten, E.V. "Organizing, Operating, and Financing Sewerage Systems - A Layman's Summary of Relevant Wisconsin Statutes", Report for the Wisconsin Department of Natural Resources and West Central Wisconsin Regional Planning Commission (1973) 35 p.

# CHAPTER 5

## FINANCING OF WASTEWATER FACILITIES

Revenues needed to construct and operate a publicly owned wastewater facility should be collected from the users in proportion to the benefits that each receives. However, few communities can afford to pay for new facilities entirely on their own. This is particularly true of small rural communities where household incomes are generally lower than in larger metropolitan areas. Thus, the implementation of a facility plan and often the planning itself cannot proceed because of economic hardships.

To encourage water pollution abatement, several federal and state financial aid programs have been established to reduce the costs to the users. These programs provide either grants and/or long term, low interest loans for a substantial portion of the costs of wastewater facility planning and construction. The remainder of these costs plus the costs of operating and maintaining the plant must be borne by the community. Special assessments, property taxes and user charges are used to recover these costs. Since the implementation of the plan usually hinges on the development of a sound financial plan that holds the local share to an affordable level, it is important to be familiar with available financial assistance programs and methods of raising revenue locally.

### FINANCIAL ASSISTANCE PROGRAMS

Financial assistance for the planning, design and construction of public wastewater facilities in small communities is available from a variety of sources. Current funding sources include:

- U.S. Environmental Protection Agency (EPA)
- Farmer's Home Administration (FmHA)
- Department of Housing and Urban Development (HUD)
- Economic Development Administration (EDA)
- State of Wisconsin
  - Wisconsin Fund (WF)
  - Public Inland Lake Protection and Rehabilitation Program

Each varies in applicant eligibility requirements, items eligible for assistance, and maximum allowable amount of assistance. These are discussed below. It is important to note that the availability of monies from these programs vary and are limited, therefore the time of application can be critical. Inquiries regarding availability of financial assistance should be made early in the planning process.

#### Environmental Protection Agency

The U.S. Environmental Protection Agency is authorized through the Water Pollution Control Act of 1972 (P.L. 92-500) as amended in the Clean Water Act of 1977 (P.L. 95-217) (Federal Register, Sept. 27, 1978) to provide grants to qualified applicants for the planning and construction of wastewater facilities. Eligible applicants include any public body of government which the state has given the authority to construct, own, operate and maintain wastewater treatment facilities. Allocation of the monies follows a priority rating system based upon the severity of the pollution problems and need.

(In Wisconsin, the priority rating system is described in Chapter NR 160 of the Wisconsin Administrative Code. The Wisconsin Department of Natural Resources administers this program.)

Application for grants are made for each of three phases or steps of the project. Step 1 is the facility planning effort in which available alternatives are compared and the most cost-effective, environmentally sound alternative is selected. The second phase, or Step 2, involves the preparation of the detailed plans and specifications for the alternative selected in Step 1. In Step 3, actual construction of the selected alternative occurs.

Wisconsin has elected to exercise the option of funding Step 1 and 2 work regardless of the priority standing for eligible projects. Consequently, nearly all communities, regardless of their position on the priority list, may obtain 75 percent grants for the costs of planning and plan preparation providing a documented health or water quality problem exists in the applicant's jurisdiction.

Step 3 grants provide 75 percent of the eligible costs for treatment plant and/or collection system construction. These grants traditionally have been difficult to obtain for small communities because they usually are located very low on the state's priority list. Since this has been a common problem throughout the United States, the Clean Water Act of 1977 requires that "rural" states, of which Wisconsin is one, must set aside 4 percent of their annual allotments to fund innovative and alternative facilities in communities with populations less than 3500 or in sparsely populated areas of larger communities.[1] Therefore, if a small community wishes to implement a plan that is unconventional, the community can qualify for a construction grant from this set aside.

Innovative and alternative facilities, according to the Act, are facilities using technologies that reclaim or reuse water, conserve or recover energy, reduce costs or improve toxics management. The "alternative" technologies have been proven or used in practice, while the "innovative" technologies are not fully proven under the circumstances of their contemplated use. Six criteria are used by the EPA Regional Administrator for defining innovative and alternative facilities as shown in Figure 5-1.[2]

Individual onsite treatment and disposal systems are considered as alternative facilities under this program if public management is provided.[3] The systems may be publicly or privately owned as long as the public management body certifies that the systems are properly installed, operated, and maintained, establishes a user charge/industrial cost recovery system, monitors water quality in the area, and assures unlimited access to each system. The system must serve a principal residence (occupied greater than 51 percent of the time) or a small commercial establishment (dry weather flow less than 25,000 gpd) constructed prior to December 27, 1977. Included as eligible items for funding are non-water carriage toilets which leave a

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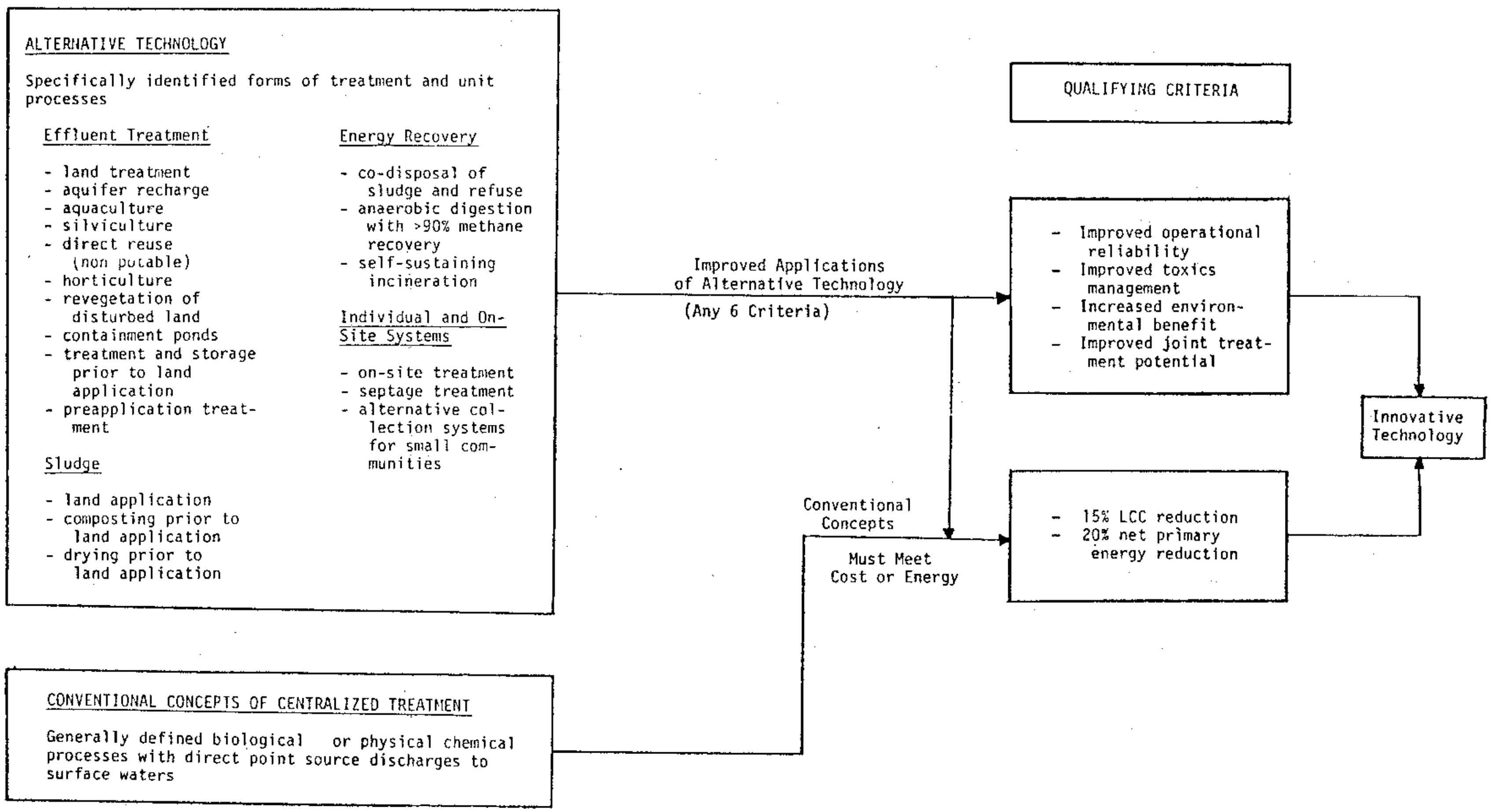
[1] 40CFR35.915-1 (Federal Register, Wednesday, September 27, 1978).

[2] 40CRF35, Appendix E; Innovative and Alternative Technology Guidelines.

[3] 40CFR35 Sections 918, 917-1(b), 917-2(a), 905-23.

FIGURE 5-1.

GENERALIZED CLASSIFICATION OF INNOVATIVE AND ALTERNATIVE TECHNOLOGY



residue that must be removed periodically. In addition, collection equipment and treatment and disposal facilities for residuals from treatment units or toilets located on private property are eligible.

Although specifically exempted as innovative or alternative technology when used in large communities, alternative collection systems do qualify as alternative technology in small communities or sparsely populated areas of larger communities.[4] These include pressure, vacuum and small diameter gravity sewers. These collection systems are also exempt from the collection policy.[5]

Additional monies are available to increase the grant amount from 75 percent to 85 percent for projects deemed to be alternative or innovative by the EPA. Reserves of 2 percent for fiscal years 1979 and 1980, and 3 percent for fiscal year 1981 were included in Public Law 95-217. Of this reserve, one-half of one percent of the state's allotment must go to innovative processes. Thus, if a community chooses to implement a plan using innovative or alternative treatment and/or collection technology, 75 percent of the eligible construction costs of the entire project are available from the 4 percent set aside. The innovative and alternative portions are also eligible for an additional 10 percent grant. Therefore, small communities can receive up to 85 percent construction grants through this program.

One final provision of the innovative and alternative funding package is that a 100 percent grant to modify any facility funded at the 85 percent level may be awarded if the regional administrator determines that:

- Facilities have not met design performance specifications,
- Failure has increased capital and O/M costs, and
- Failure occurs within 2 years of the completion of construction.

This provision is meant to reduce the risk to the community that chooses to construct an unconventional facility.

## Farmers Home Administration

The Farmers Home Administration (FmHA) oversees a wide variety of programs designed to aid farmers and rural residents. Four of their programs may be used to finance the planning, design and construction of wastewater treatment facilities. Of the four programs two provide aid directly to low-to-moderate income individuals. The community-wide programs are:

- Development grants for community domestic water and waste disposal systems.[6]
- Loans for community facilities.[7]

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[4] 40CFR35 Section 908 (b).

[5] U.S. Environmental Protection Agency Program Requirements Memo (PRU) 79-8.

[6] 7CFR 1823.471 - 1823.477.

[7] 7CFR 1933.17 & 1933.18.

Available programs to aid individuals in obtaining safe and sanitary dwellings include:

- Loans to low-moderate income indiciduals [8]
- Loan/grants to low income individuals [9]

Discussions below are divided into community and individual programs. For detailed information about the availability of funds, application forms and procedures, the community should contact the state FmHA office in Stevens Point.

*Community-wide Programs*:

The FmHA grant and loan programs for water supply and waste disposal are part of its Community Facilities Program. The basic intent of this program is to provide adequate water supply and wastewater disposal facilities in those areas of the country which are rural or rural in nature. Aid is available to eligible applicants in areas which are rural or in locations adjacent to urban centers with a population of less than 10,000 which are rural in character. Priority is given to water and sewer projects in those communities with a population less than 5500 which have inadequate water supply or waste disposal facilities.

Eligible applicants include cities (with populations less than 10,000), villages, town, counties, utility districts, public inland lake protection and rehabilitation districts, associations, cooperatives and non-profit corporations. Preference is given to public bodies serving communities with inadequate water supply or waste disposal facilities. Areas receiving any grants or loans from FmHA must have a stable or growing population. Projects must allow for the foreseeable future growth in the area and be necessary for the orderly growth of the community.

Projects which are fundable include water supply facilities, sanitary sewers, wastewater treatment plants, storm sewers and solid waste disposal facilities. Funds may be used to:

- Pay engineering fees
- Construct necessary structures
- Acquire land or easements
- Finance projects funded with other funds

Funds may not be used to pay for combined sewers, operation and maintenance costs, purchase of existing systems or refinancing existing indebtedness.

Grant amounts are determined for each project by the regional administrator depending on the circumstances of each applicant. Certain maximum limits have been set for grants. The absolute maximum grant amount is 75 percent of the eligible development cost. This includes monies from other funding sources.

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[8] 7CFR 1822.1 - 1822.9.

[9] 7CFR 1904.301 - 1904.313.

Two rules are used to further determine allowable grants for each individual community. The two rules are the "reasonable" rule and the "income" rule. The reasonable rule allows an administrator to offer grants sufficient to reduce the total user charge for a community to a level similar to other communities having similar economic conditions. Using the "income" rule, the administrator considers the percentage of median income used to finance the debt service portion of the project. If the debt service portion of the annual user charge exceeds the limits summarized in Table 5-1, the administrator may offer grant assistance sufficient to reduce the debt service portion to those limits.

Table 5-1. "Income" Rule Limits

| Median Income | Maximum Percentage of Income for Debt Service Portion of User Charge |
|---|---|
| $\leq$ 6000 | $\leq$ 0.75 |
| 6000 - 10,000 | $\leq$ 1.0 |
| $>$ 10,000 | $\leq$ 1.25 |

Median income levels are determined by the U.S. Department of Commerce (Bureau of Census Publications) or the state administrator if the census data is believed to be inaccurate.

Grants from the FmHA may be used in conjunction with other monies (either loans or grants). Interagency communications between various funding agencies will determine what percentage, if any, of the funds will come from the FmHA. Funding from the grant program depends on congressional authorizations each fiscal year and is competitive in nature. If a particular project appears to be eligible, the state administrator of the FmHA should be contacted to determine both the availability of funds and the likelihood of obtaining those funds for a particular project.

Loans also are available from FmHA. These may be obtained with or without grant support to finance water supply and waste disposal projects should the community be unable to finance projects through their own resources or obtain commercial credit at reasonable rates and terms. Eligible applicants and priorities are similar to the FmHA grant program. Eligible uses of the monies are also similar except that existing facilities may be purchased with loan funds. Loan conditions are a 5 percent interest rate repaid over 40 years (or the project life, if shorter).

*Individual Programs:*

The individual loan and grant programs administered by the FmHA are designed to provide low-to-moderate income individuals safe and sanitary dwellings. Funds may be used to provide adequate water supply and sewage disposal facilities. This includes wells, public water supply connections, toilet facilities, onsite disposal systems, sewer laterals, etc. Eligible applicants include persons not owning adequate dwellings or farm owners without decent housing. Applicants must be U.S. citizens without sufficient resources to provide adequate housing, have sufficient income to meet loan obligations, have low or moderate income as determined by the State Director. Funds may be used to provide adequate water supply and sewage disposal facilities. Rates for the loan are determined using guidelines administered by the state FmHA office (current rates are 8 1/2%). Repayment of the loan must occur within 33 years (10 years or less, if not secured by a mortgage).

Certain low-income individuals may also qualify for low-interest loans or grants. To be eligible for low-interest loans, they must meet the requirements of the individual loan program but without sufficient resources to secure the loans in the program described above. Loans obtained may be used to provide sanitary water supply and waste disposal systems for homes in satisfactory condition. Maximum grant amounts are $5000 with the rate being 1 percent. Maximum repayment periods depend on the loan amount (within 10 years for loans less than $1500; within 15 years for loans between $1500 and $2500; within 20 years for loans between $2500 and $5000).

Grants may also be available for individuals over age 62 with incomes so low that they would be unable to repay any of the costs associated with the provision of adequate sanitary facilities. Grant recipients may not sell their residence without repayment of the grant for a period of 3 years after the grant award. Combination loan/grants are available for individuals over age 62 with some financial resources. Eligibility for these grants or loans are determined on an individual basis by the State Office.

Loans and grants to individuals may be used <u>only</u> for construction purposes in the provision of safe and sanitary dwellings. If a community appears to have applicants who are eligible for these programs, they should contact the state FmHA office and assist, in whatever way possible, the low-income individuals applying for these programs.

<u>Department of Housing and Urban Development</u>

The Department of Housing and Urban Development (HUD) has funds available for small communities through its Block Grant Program. Eligible activities for block grant funds include sewers, water supply, solid waste disposal facilities, street improvements, and flood and drainage facilities. Treatment plants and intercepter sewers are <u>not</u> eligible for block grant funds.

A project must be consistent with one or more of the following purposes to be considered:

- Support the deconcentration of low-income housing
- Support realistic and attainable strategies for expanding low- and moderate-income housing
- Promote more rational land use
- Promote increased opportunities for low- and moderate-income persons
- Correct deficiencies in public facilities which affect the public health and safety, especially for low- and moderate-income persons

Single purpose projects must address serious problems with housing, economic conditions, or public facilities which affect public health and safety. Grant money should principally affect low- and moderate-income individuals (individuals whose incomes are less than 80% of the regional areas median income). A special reserve has been set-up with this program to correct serious deficiencies in public health programs which affect the health of the citizens in the applicant's jurisdiction.

Application for block grant funds is divided into a pre-application (or screening) and actual application. Eligible applicants for this program include cities, counties, villages, towns and states. Special purpose districts are not directly eligible for grants although a unit of general local government (e.g., a county) may apply on behalf of the area served by the special purpose district. Grants are awarded to those eligible applicants evidencing the greatest need (as shown by poverty or substandard housing). Communities most likely to obtain funds are those which have serious economic problems, substandard housing or unsanitary living conditions. Allocation of block grants is done on a yearly basis.[10] The program is competitive in nature with the demand for the grants greatly exceeding the available supply. However, twenty percent of the total block grant program has been allocated to non-metropolitan areas. Exact information concerning available funds, application procedures and application forms may be obtained by contacting the regional HUD office. Deadlines for filing application forms are published in the Federal Register and generally occur in March or April.

Economic Development Administration

The Economic Development Administration (EDA) of the U.S. Department of Commerce administers several programs designed to aid areas of the country which have economic problems. The EDA administers the Public Works Program which is designed to provide the public facilities to improve a community's economic condition. The program is flexible and can provide funds for the construction of wastewater disposal facilities (especially sewers) and water supply facilities when the construction of these facilities promotes the economic well-being of the community.

Grants of up to 50 percent of the projects eligible costs are available if a project directly or indirectly satisfies any of the following objectives:

- Tends to improve opportunities in the project area for the successful establishment or expansion of commercial or industrial facilities (e.g., the construction of utilities)
- Assists in the creation of additional long-term employment opportunities in the area
- Benefits the long-term unemployed and members of low-income families
- Fulfills a pressing need of the designated area

Supplementary grants of up to 100 percent of a project's eligible costs are available for areas which have severe economic problems such as limited borrowing and taxing abilities, natural disasters or high unemployment (greater than 8 percent) on low median income (less than $4400).

Eligible uses of the grant money include preliminary expenses (grant application), land acquisition, construction, machinery and equipment purchase, engineering services and legal fees.

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[10] 24 CFR 570.424 (Comprehensive or multi-purpose grants) & 24 CFR 570.428 (single purpose grants).

Eligible applicants include states, counties, cities, villages, towns and special purpose districts (e.g., sanitary districts). All applicants must be located in either a designated redevelopment area or a designated economic development center. Determinations of an area's eligibility are made by the EDA following criteria prescribed in the Code of Federal Regulations. (Designated areas in Wisconsin include most of the northern counties with only the counties of Waushara, Outagamie, Clark, St. Croix, Pierce, Columbia, Green Lake, Dodge, Ozaukee, Washington, Waukesha, Jefferson, Dane, Green, Grant and Milwaukee County outside of the City of Milwaukee being non-designated areas.)

As in all governmental funding programs, the amount of funding changes from year-to-year as the agencies budget changes. Usually, the funding is at such a level so as to preclude grants to all qualified applicants. Communities interested in, or who feel they are qualified for EDA grants should contact the regional EDA office. This office will provide information on the availability of funds, the likelihood a grant will be offered and the application procedures.

State of Wisconsin

Like many states, Wisconsin has established financial aid programs of its own. Two programs presently exist; the Wisconsin Fund and the Public Inland Lake Protection and Rehabilitation Program.

*Wisconsin Fund*

The Wisconsin Fund is a new state grant program for the planning, design, and construction of public wastewater facilities.[11] It became effective July 1, 1978 and is to terminate July 1, 1988. It is designed to provide financial assistance to those communities unable to obtain EPA Step 3 grants because of their priority ranking. In addition, a small portion of these funds is set aside for counties to rehabilitate failing private septic tank systems. These two portions of the program are discussed separately.

Community Wastewater Facilities: Cities, towns, villages, counties, county utility districts, town sanitary districts, public inland lake protection and rehabilitation districts, metropolitan sewerage districts or any federally recognized tribal governing body may apply for grant assistance from this program to plan, design, and construct publicly owned facilities or privately owned onsite systems that are publicly maintained. To qualify, the public body making the application cannot be on the EPA fundable portion of the priority list over the next 12 months. If no EPA funds are available for Step 1 or Step 2 activities the Wisconsin Fund may provide up to 75 percent of the eligible costs. (This is usually not necessary because all eligible applicants presently can receive EPA grants for these steps.) Up to 60 percent of the eligible costs can be obtained for construction of the facilities. This share can be combined with federal grant assistance from sources other than EPA as long as the combined total does not exceed 75 percent.

[11] Wisconsin Administrative Code Chapter NR 128 "Point Source Pollution Abatement Grant Program".

An important difference between the EPA and Wisconsin Fund programs is the fundable capacity of the collection and treatment works. While EPA has a 20 year planning period for collection and treatment works and up to 40 years for collection intercepters, the fundable capacity under the Wisconsin Fund is that capacity necessary to collect and treat the projected flows 10 years from the date of construction. This capacity cannot include flows from industrial users discharging more than 25,000 gpd. The fundable capacity for intercepter sewers is that capacity necessary to transport the projected flows on June 30, 1985. Like the EPA program, however, individual onsite systems are eligible provided a public management entity is established and they are cost-effective.

Funds under this program are allocated following the priority ranking given the applicant as described in NR 160. Each applicant wishing assistance under this program must notify DNR between October 1 and December 31 if they intend to construct the following year. Those applying are placed on a funding list in order of their relative priorities. The Department of Natural Resources awards grants to as many of the projects as the available funds permit. If an applicant has not submitted complete plans and specifications by June 30 of that year, the applicant may be passed over to allow funding for communities further down the list. Communities applying late between January 1 and April 1 will be put on a supplemental funding list and funded if funds are still available from the primary list.

Rehabilitation of Individual Onsite Systems: Three percent of the Wisconsin Fund is reserved for the replacement or rehabilitation of failing septic tank systems. Under this program grants of up to 60 percent (or $3000 per residence, whichever is less) of the project's eligible costs are provided.[12]

Only counties may apply for this money on behalf of one or more property owners. To qualify, the county must pass an ordinance enforcing the Department of Industry, Labor and Human Relations onsite disposal system code[13] (all counties must have this done by July 1, 1980) and establish a maintenance inspection program. The maintenance inspection program must insure that all new or rehabilitated onsite systems are operated and maintained properly. For septic tank systems, this means inspection of the septic tank every three years and pumping if necessary. The county may either provide this service or require the property owner have it done.

Once a sound maintenance program is established, the county may apply for rehabilitation grants. The grant money can only be used to reimburse property owners. The failing system must serve a principal residence (a residence occupied more than 51% of the year) or a small commercial establishment (flow less than 2100 gpd) that was inhabited prior to July 1, 1978.

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12 Wisconsin Administrative Code NR 128.30 "State grants for the replacement or rehabilitation of private sewage systems".

13 Wisconsin Administrative Code H63 "Private domestic sewage treatment and disposal systems".

The system also must have written enforcement orders issued against it from the county or the state as provided in the state statutes before any work is done. Cluster systems serving more than one principal residence or small commercial establishment may also receive grants under this program.

Applications must be received by DNR before January 1st to be considered for a grant in that fiscal year. The county may submit more than one application for rehabilitating different groups of failing systems at different times. Allocation is by an established priority ranking system if requests exceed available funds. Property owners should contact their county zoning administrator or sanitarian for more detailed information.

Public Inland Lake Protection and Rehabilitation Program

The Wisconsin Department of Natural Resources administers the Public Inland Lake Protection and Rehabilitation Program (PILPAR). Grant monies are available only to Public Inland Lake Protection and Rehabilitation Districts which are undertaking planning or implementation of programs designed to improve lakes within the district's jurisdiction.

Financial assistance for project implementation is based upon the availability of federal financial assistance and other pertinent factors. Generally, a maximum limit of 80 percent of the eligible project costs will be maintained.

Planning studies are eligible for grants of up to 60 percent of the eligible project costs. Should the applications for financial assistance exceed the available funds, projects will be ranked so that the highest priority is assigned to the project which contributes most to furthering the following objectives:

- Protection and enhancement of environmental values by preventing the degradation of aquatic life, surface and groundwater quality, natural beauty and scientific values, land values and improvement of a lake's water quality through improvement measures in the lake and direct drainage basin
- Preservation of public rights in navigable waters
- Cost-benefit comparison with other projects
- Assurance of local involvement and a commitment to lake protection and rehabilitation
- Consideration of the urgency of the need for lake protection and rehabilitation

Applications for planning must occur prior to March 15. Information on the current funding levels for the PILPAR program and application forms and procedures may be obtained from the Office of Inland Lake Renewal, Department of Natural Resources.

Summary

Funding sources are summarized in Table 5-2. Each of the programs detailed below is subject to legislative change both in the statutory authorization of the appropriation of monies to fund the programs. Consultation with the appropriate agency is recommended prior to any detailed planning to insure that funds are indeed available under any particular program.

Currently in Wisconsin, small communities are likely to receive monies for both Steps 1 and 2 projects through the EPA program provided they have a documented public health or water quality problem. Funds for construction of facilities in small communities are more difficult to obtain since these communities must compete against larger communities with higher priorities on most funding programs. The best sources for construction funds at the present time are the EPA (through its 4% reserve for alternatives to conventional treatment in small communities), the FmHA or the WF point source or septic tank replacement and rehabilitation grant program.

## LOCAL FINANCING

Local financing is necessary to pay the local share of the construction and the operation, maintenance and administration of the facility. The necessary funds may be obtained either by borrowing or by raising revenue through the sale of services, assessments or taxation. Borrowing and special assessments are commonly used methods to finance capital expenditures while a system of user charges and taxation are used to recover operation, and other recurring expenses. The following discussion relates primarily to the State of Wisconsin.

### Methods of Borrowing

Most of the local share of construction costs is usually obtained through the sale of bonds if FmHA loans are not available. Bonds may be sold so that they are payable at one time or are due each year over a period of several years. The latter is preferable because it is easier to meet the debt service requirements. The term of the bonds sold should be about equal to the expected life of the facility being financed. Very short-term bonds place too much burden on the initial users while very long-term bonds are unfair to future users because they will be paying for a replacement facility while still paying for the original facility.

The types of bonds commonly used include general obligation bonds, special assessment bonds, and revenue bonds. These are discussed below. Their issuance is regulated by state law and varies according to the legal structure of the issuer. Table 4-1 should be consulted for specific limitations.

#### *General Obligation Bonds*

General obligation bonds including municipal bonds, promissory notes and delinquent tax bonds are backed by the full taxing power of the issuer. That is, the issuer can use ad valorem (general property) taxes to repay the bonds. These types of bonds have several advantages:

## Table 5-2. Financial Assistance Programs

| | Environmental Protection Agency | Wisconsin Fund: Point Source Program | Wisconsin Fund: Onsite System Rehabilitation | Farmers Home Administration: Community Programs | Farmers Home Administration: Individual Programs | Housing and Urban Development | Economic Development Admin. | Public Inland Lake and Rehabilitation Program |
|---|---|---|---|---|---|---|---|---|
| Eligible Applicants | Cities<br>Counties<br>Towns<br>Sanitary Districts<br>Utility Districts<br>Metropolitan Sewerage Districts | Cities<br>Counties<br>Towns<br>Sanitary Districts<br>Utility Districts<br>Metropolitan Sewerage Districts | | Cities<br>Counties<br>Towns<br>Villages<br>Sanitary Districts<br>Utility Districts<br>Cooperatives<br>Non-Profit Corporations | Individuals Qualifying Under Section 502 or 504 (Low-Moderate Income Individuals) | States<br>Cities<br>Villages<br>Counties<br>Towns | States<br>Cities<br>Villages<br>Towns<br>Sanitary Districts<br>Utility Districts (in designated areas) | Public Inland Lake Protection and Rehabilitation Districts |
| Eligible Activities | Treatment Facilities<br>Intercepter Sewers<br>Collection Systems<br>Sewer Rehabilitation<br>Individual Onsite Systems | Treatment Facilities<br>Intercepter Sewers<br>Collection Systems<br>Sewer Rehabilitation<br>Individual Onsite Systems | Repair and Rehabilitation on Existing Septic Systems | Water Supply<br>Sewers<br>Treatment Plants | Upgrade Dwellings with Unsatisfactory Sanitary Facilities | Water Supply<br>Sewers | Water Supply<br>Sewers (Projects Intended to Improve Areas Economic Condition) | Projects Designed to Protect or Improve a Lake's Quality |
| Use of Funds | Engineering Fees<br>Eligible Construction Costs<br>Land Acquisition if part of Treatment Process | Engineering Fees<br>Eligible Construction Costs<br>Land Acquisition if part of Treatment Process | Eligible Construction Costs | Engineering Fees<br>Eligible Construction Costs<br>Land Acquisition | Construction or Repair | Local Discretion | Engineering Fees<br>Construction<br>Machinery and Equipment<br>Land Acquisition | Engineering Fees<br>Construction Costs |
| Grant Amounts | Conventional<br>75% Steps 1,2 & 3<br>Innovative and Alternative<br>75% Step 1<br>85% Steps 2 & 3 | 60% Maximum | 60% Max. (Up to $$3000 per Residence) | 75% Maximum Based on "Reasonable" or Income Rules | Available if over 62 and Low Income Individual | Max. Determined by Area Administrator | 50% Max. (Supplementary Grants Available, if Eligible) | 80% Maximum |
| Priority | NR 160 Wisconsin Administrative Code | NR 160 Wisconsin Administrative Code | NR 128.30 Wisc. Administrative Code | Determined by State Administrator | | Deter. by 24CFR 570.428 | Determined by Regional Administrator | NR 60 Wisconsin Admin. Code |
| Loans | Not Available | Not Available | Not Available | 5% for Project Life (or 40 yrs) | 8.5% for 33 Years if Qualified; 1% for Varying Terms Depending on Am'ts if Qualified Under Section 504 | Not Available | Not Available | Not Available |
| Administrating Agency | Wisconsin Department of Natural Resources<br>Madison, Wisconsin 53704 | | | Farmers Home Administration<br>U.S. Dept. of Agriculture<br>Stevens Point, WI 54481 | | Housing & Urban Development<br>744 N. 4th<br>Milwaukee, WI 53202 | Economic Development Administration, Federal Building<br>510 Barstow<br>Eau Claire, WI 54701 | Wisconsin Department of Natural Resources<br>Madison, WI 53704 |

- Interest rates are lower because the bonds are backed by the full credit of the community
- The security feature usually enables public sale at attractive terms
- Overhead costs for financing are usually less because they do not require the detailed documentation needed for revenue bonds
- Repayment can also be made through service charges to the users

If the local bonding limit is approached, other means of long term borrowing must be used such as revenue or special assessment bonds.

*Revenue Bonds*

Revenue bonds including mortgage bonds, public improvement bonds, and bond anticipation notes are backed by the earning power of the issuer. User charges are used to repay the bonds. The amount issued is usually limited by the amount of risk the investors are willing to take.

Advantages that revenue bonds have are:

- They are not included in the legal debt limitation
- They do not usually require voter approval
- They can be used to finance projects beyond the legal boundaries of the issuing body.

However there are difficulties in issuing these bonds. Selling bonds for entirely new systems may be difficult because there is no established record of earnings. Another is the fact that the net revenues must be somewhat higher than are actually necessary to repay the bonds. This margin over the debt requirements is called "coverage" intended to protect against unplanned costs or lack of planned revenues. It varies with the risk of the issue from 20 to 50 percent.

*Special Assessment Bonds*

Special assessment bonds can be issued only when certain properties are served as in the case with sewers, where the benefits to individual properties are obvious. These include contractors' certificates, general obligation-local improvement bonds, as well as special assessment bonds. Repayment is through benefit assessments rather than general taxes. Therefore, they are considered a greater risk by the investor and carry a higher interest rate. Because of the higher rates, many local governments borrow construction capital general obligation bonds that are repaid through special assessments.

<u>Methods of Raising Revenue</u>

Revenue must be raised by the unit of government operating the facility to pay the debt obligations, operating expenses and future capital extensions or improvements. This can be done through taxation, service charges and standby charges.

*Taxation*

Property taxes and special assessments are commonly used taxing methods although local income, sales, liquor, cigarette and hotel/motel occupancy taxes can also be used. Property taxation is the ad valorum tax levied by the jurisdiction on all taxable property within its boundaries. Care must be used in using this method, however to insure that the costs of the facility are distributed proportionately among all classes of users.

Special assessment taxes are levied against a specific property or area of a jurisdiction for a special action, such as the laying of sewer pipes to connect the house to the sewers. It is used where some or all of the benefits of the action are seen to accrue to a specific property or specific area in the jurisdiction.

*Service Charge*

A service or user charge is a charge for service rendered. Most user charges include charges for debt retirement and for operating, maintenance and replacement costs. Each is proportioned to the users according to waste volume, waste strength or other specific characteristics that may impact the cost of treatment and disposal.

*Standby Charge*

Although a specific property may not utilize the wastewater facility initially, a charge can be levied to cover the cost of making the service available. The charge helps the jurisdiction carry the costs of the wastewater facility before it is fully utilized.

Summary

The methods of local financing of wastewater facilities vary somewhat among the various jurisdictions empowered to provide sewerage services. Table 4-1 provides a brief summary of the methods available to each type of jurisdiction. The references are to the Wisconsin Statutes.

## FINANCIAL PLANNING FOR WASTEWATER FACILITIES

The need for sound financial planning for wastewater facilities cannot be overstressed. Implementation of the proposed facility plan ultimately rests on the community's ability to pay for the project. Therefore, it is important to assess the financial capabilities of the community early in the planning process to insure the proposed project is not overly ambitious. A screening procedure and worksheet is provided in Appendix C to make this determination.

References

U.S. EPA, Innovative and Alternative Technology Assessment Manual, MCD 53, EPA 430/9-78-009 (1978).

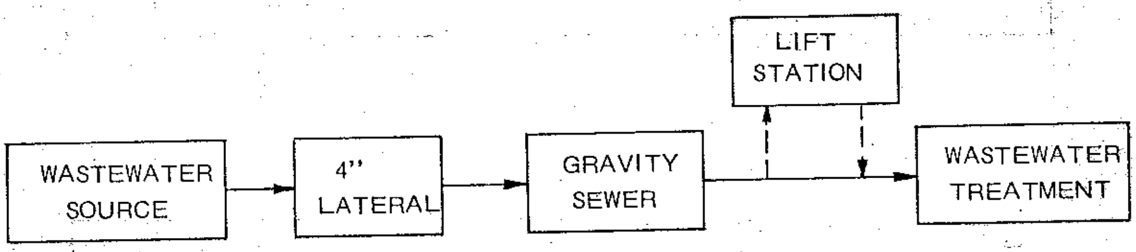
# APPENDIX A

# WASTEWATER COLLECTION, TREATMENT AND DISPOSAL ALTERNATIVES

# COLLECTION ALTERNATIVES

CONVENTIONAL GRAVITY SEWERS

Description: Conventional gravity sewers employ conduits of a minimum specified diameter laid at a minimum specified grade with a straight alignment between manholes. Manholes are placed at any changes of grade, direction, pipe size or at specified minimum intervals. Minimum conduit sizes are specified for ease in cleaning and to provide adequate space to handle the anticipated flows. Grades are specified to insure that velocities sufficient to prevent any long-term solids deposition in the sewer occur on a frequent, recurring basis. Typically, conduits in conventional gravity sewers have been sized to maintain a velocity of 2 feet per second. Lift stations are required in areas of unfavorable topographic relief (e.g. undulating or flat terrain) to avoid excessive excavations.




Applications: Used for transporting raw wastewater.

Limitations: Construction costs are high in areas with low population density, areas of high bedrock that necessitates costly rock excavation, areas of flat or undulating terrain necessitating cuts deeper than 15 feet and areas of high groundwater. Limited flexibility in location.

Design Criteria:

| | |
|---|---|
| Minimum Conduit Diameter: | 8" |
| Minimum Slope | 8" - 0.40%<br>10" - 0.28% |
| Minimum Velocity: | 2 fps when full |
| Hydraulic Capacity: (Peak Flow) | Submain sewers - 400 gpcd plus any commercial and industrial contributors.<br>Main sewers - 250 gpcd plus any commercial and industrial contributors. |
| Depth: | Sufficient to prevent freezing. |

Status of Technology: Well proven; standard of engineering practice.

Residuals: None.

Reliability: Very reliable, no moving parts except for lift stations.

Operation and Maintenance:

Labor: Clean lines as needed
Energy: Required for lift stations
Chemicals: None

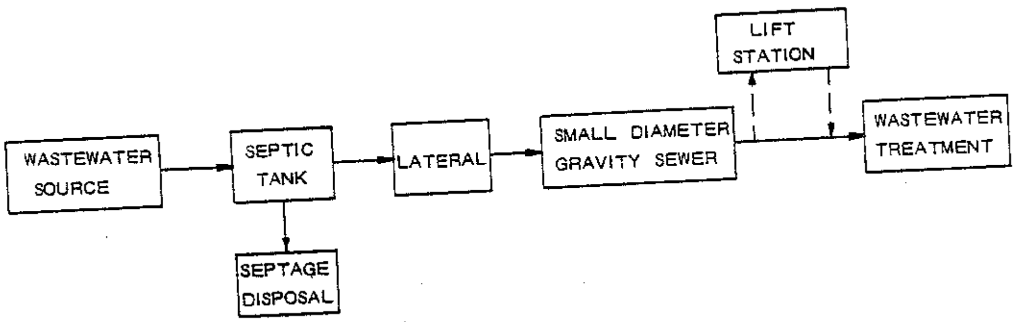
Environmental Impacts: Significant disruption of local area during construction including erosion and loss of trees in forested areas. Excess capacity in sewers can foster future growth.

References:

Water Pollution Control Federation, Design and Construction of Sanitary and Storm Sewers, Manual of Practice No. 9, 1969.

## SMALL DIAMETER GRAVITY SEWERS

Description: Small diameter gravity sewers are, in concept, similar to conventional gravity sewers except for the inclusion of a septic tank at each point of entry into the system. Inclusion of a septic tank greatly reduces the concentrations of grit, suspended solids and grease. (Typically, 60-80% of the influent suspended solids and nearly all of the settleable or floatable suspended solids are removed.) Provision of the septic tank allows for smaller minimum conduit sizes; reduces the required minimum velocity; eliminates solids handling requirements for pumps in any of the system's lift stations; allows for curvilinear alignments both in the horizontal and vertical planes. Regular septic tank pumping is required.




Applications: Well-suited to areas with failing septic systems since the sewer may be hooked to the existing septic tank, particularly if final treatment and disposal is to be by subsurface soil absorption.

Limitations: Not suited for densely populated areas due to septage handling requirements; minimum conduit sizes will serve approximately 2000 persons at a peak flow of 1 gph/capita.

Design Criteria: Based on Australian guidelines.

| | |
|---|---|
| Minimum Pipe Diameter: | 4 inches |
| Minimum Velocity (@ 1/2 capacity): | 1.5 feet/second |
| Minimum Gradient: | |
| 4" | 0.67% |
| 6" | 0.40% |
| 8" | 0.33% |
| Cleanouts: | Required to minimize inflow |

These criteria may be overly restrictive since 4 inch conduits used in subsoil absorption fields receiving septic tank effluent that are laid at grades between 2-4 inches per 100 ft (0.17% - 0.33% slope) show little or no solids deposition.

Status of Technology: New in the United States although systems of this type have been satisfactorily operated in Australia since 1962.

Demonstration installation:

Westboro, Wisconsin
5 miles of sewer; 85 connections

Residuals: Septage from septic tanks.

Reliability: Relatively unknown although preliminary information on the Westboro system suggests that the systems are as reliable as conventional gravity sewers provided an adequate septic tank pumping schedule is maintained.

Operation and Maintenance:

Labor: Periodic flushing of sewers, septage disposal
Energy: Required for lift stations
Chemicals: None

Environmental Impacts: Possible odors at lift stations or major junctions, disruption of local area during construction, septage disposal.

References:

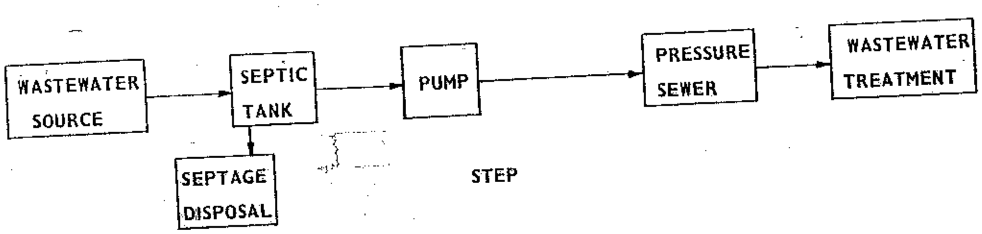
1) South Australia Department of Public Health, "Septic Tank Effluent Drainage Schemes", Public Health Inspection Guide, No. 6, Norwood, South Australia (September 27, 1968).

2) Otis, R.J., "An Alternative Public Wastewater Facility for a Small Rural Community", Small Scale Waste Management Project, University of Wisconsin, 1978.

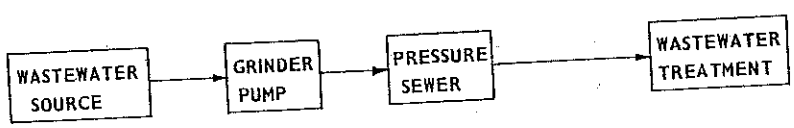
## PRESSURE SEWERS

Description: Pressure sewer systems use small diameter conduits which are laid following the terrain of the area being served at a depth sufficient to prevent frost damage. Wastewater is transported in the system utilizing the energy imparted by small submersible pumps. Each user (or group of users) served by a pressure sewer system must have its own pressurization unit. The major types of units available may be classified as either septic tank effluent pump (STEP) systems or grinder pump (GP) systems. Their differences are summarized below.

| Item | STEP | GP |
|---|---|---|
| 1). Required on-site units | Septic tank, submersible pump | Grinder Pump |
| 2). Residuals | Septage | None |
| 3). Use of existing units | Septic Tanks | - |
| 4). Wastewater character | Settled wastewater, medium strength domestic waste, no dissolved oxygen | Comminuted wastewater, strong domestic waste. |
| 5). Mechanical complexity (Maintenance requirements) | Relatively simple | Inclusion of grinder blades requires more moving parts and increases complexity. |
| 6). Relative cost | Less costly than GP units if existing septic tanks are utilized. | Similar to STEP if existing septic tanks are not utilized. |




STEP




GP

Applications: Pressure sewer systems become an attractive alternative in areas where the placement of gravity systems are excessively high. Typically, pressure sewers are less costly in areas of undulating or flat terrain, shallow bedrock and high groundwater since pressure sewers may be laid following the general topography of the planning area which greatly reduces excavation costs. Areas which are sparsely populated may also be served economically by pressure sewers particularly if future growth in the area is expected to occur slowly.

Limitations: Design of these systems may be done for widely varying situations. The ultimate determinant in the viability of pressure sewers is their cost relative to a gravity-based system. Actual physical limitations are imposed by the hydraulic capabilities of the selected pumps, conduit diameter and the terrain.

Design Criteria:

Configuration: Dendriform layout (no loops)
Pump Specifications: Depends on site conditions and type of pressure sewer.
Conduit Design:

Minimum Diameter: 2 inches (actual sizes used are a function of the number of users, length of line and topography)

Minimum Velocity (@ capacity): STEP - 1.5-2 ft/sec
GP - 2.5-3 ft/sec

Appurtenances:

| | |
|---|---|
| Clean-outs: | End of each line |
| Valves: | Isolate system branches |
| Air-Release Valves: | High points in system |
| Pressure Sustaining Valves: | Prevent gravity drainage |

On-Site Items:

STEP: Septic tank, pump vault, pump
GP: Pump vault, pump

Status of Technology: Developing technology with a large number of systems recently installed or under design. Equipment improving very rapidly as more systems are installed.

Residuals:

STEP: Septage
GP: None

Reliability: Good, improving as equipment (pumps, etc.) improves

Operation and Maintenance:

| | |
|---|---|
| Labor: | Pump maintenance and repair, septage disposal for STEP systems |
| Energy: | Required for pumps (800 kwhr/household/day) |
| Chemicals: | None |

Environmental Impacts: Possible odors, especially at junctions with gravity sewers, septage disposal for STEP systems. Exfiltration can occur at leaky joints.

References:

1) Kreissl, J.F. Alternatives for Small Wastewater Treatment Systems, Vol. 2, Part 1 (Pressure Sewers), U.S. Environmental Protection Agency, October, 1977.

2) Bowne, W.C. "Pressure Sewers", U.S. EPA Training Session, Wastewater Alternatives for Small Communities, 1978.

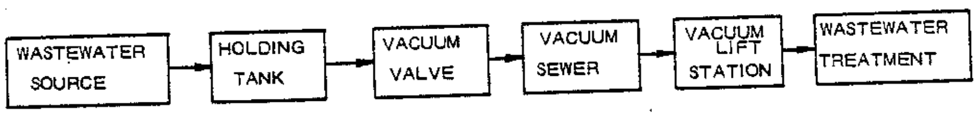
3) Langford, R.E. "Effluent Pressure Sewer Systems", Water Pollution Control Federation Annual Convention, October 2-7, 1977.

4) E/One Corporation. Design Handbook for Low Pressure Sewer System, 1973.

5) Hydromatic Corporation, Design Manual.

VACUUM SEWERS

Description: Vacuum sewers transport wastewater utilizing the driving force provided by a difference between the ambient atmospheric pressure and an approximately 1/2 atmosphere vacuum maintained in the sewer. Systems of this type are laid out with a series of transport pockets between which conduits of 3, 4 or 6" in diameter are laid following specified grades. Each user (or group of users) being serviced by the system must be provided with a valve which acts as an interface between the atmosphere and the sewer. Numerous valve types are available, some of which handle all the wastewater flow from a household, and some which allow for water conservation by using a vacuum toilet with a separate grey water holding tank. The vacuum is maintained in the sewer system by a vacuum pump (either sliding vane or liquid ring types) located at a central collection station.




Applications: Vacuum sewers are most viable in areas of flat terrain, shallow bedrock, high groundwater and relatively low population densities.

Limitations: Systems of this type have limited lift capabilities and are more suitable to areas of level terrain. Maximum lift is approximately 15 feet with existing systems. Maximum line lengths on flat terrain between collection stations are approximately 4000 ft. Performance of vacuum sewers is adversely affected if a low initial to design population ratio occurs since inefficient operation results.

Design Criteria:

| | |
|---|---|
| Trap Spacing: | 200-400 ft. |
| Conduit Design: | |
| Minimum Diameter: | 3 inches |
| Minimum Velocity: | 2 ft/sec @ 0.7 full |
| Head Losses: | |
| Traps: | 1.5 ft. |
| Vacuum Valve: | 5 ft. |
| Vacuum Pressure: | 15-25 mm Hg |
| Maximum Lift: | 15 ft. |
| Appurtenances: | Lift and trap assemblies<br>Cleanouts |
| On-Site Items: | Vacuum valve and other appurtenances as required. |

Status of Technology: Developing technology, design procedures need improvement; improved hardware and information on operation and maintenance needed.

Demonstration: Bend, Oregon (see reference 3)

Residuals: None

Reliability: Not well documented, operation of system in small communities is likely to require significant training for effective performance.

Operation and Maintenance:

Labor: Inspect valves yearly, inspect and repair every 4-8 yrs, clean sewers as required, maintain vacuum collection station.

Energy: Power for vacuum pumps (.0024-0.44 kwh/gal of transported sewage)

Chemicals: None

Environmental Impacts: Limited impact during construction, no exfiltration to pollute groundwater, possible odors at the collection station.

References:

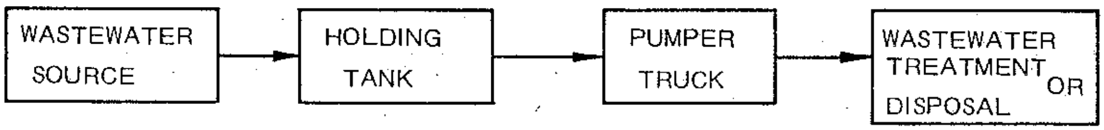
1) Cooper, I.A. and Rezek, J.W., "Vacuum Sewers", Vol. 2, Part 2, Alternatives for Small Wastewater Treatment Systems, United States Environmental Protection Agency Technology Transfer Seminar Publication, October, 1977.

2) AIRVAC, Vacuum Sewage Transport and Collection Design Criteria Manual, 1976.

3) Eblen, J.E. and Clark, Lloyd K., Pressure and Vacuum Sewer Demonstration Project, EPA Report No. 600/2-78-166, September, 1978.

HOLDING TANK - HAULING SYSTEMS

Description: In holding tank-hauling systems a user's wastewater flows by gravity to a holding tank. Wastes are stored in the holding tank until it is full, at which time a pumper truck removes the stored wastewater and transports if to a disposal location.




Application: Generally, only practicable in servicing remote users in a small unsewered community or seasonal homes. Operating costs for such systems are excessive for year-round use. If such a system is proposed, wastewater conservation segregation should be utilized in the household being served to minimize the volume of wastewater which must be transported.

Limitations: High operating expenses for year-round operation.

Design Criteria:

| | |
|---|---|
| Holding Tank: | Check local codes |
| Disposal: | Check local codes |

Residuals: Septic wastewater

Operation and Maintenance:

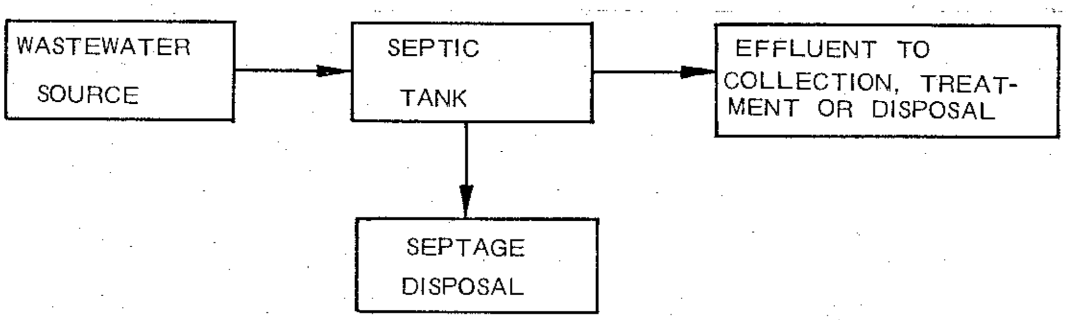
| | |
|---|---|
| Labor: | Removal of Holding tank contents |
| Energy: | Pumping tank contents |
| Chemicals: | None |

# TREATMENT ALTERNATIVES

SEPTIC TANKS

Description: Septic tanks are enclosed, baffled sedimentation basins in which settleable solids and floatable materials are removed from the waste stream. Primary functions performed by a septic tank include:

1. Solids - liquid separation
2. Storage of solids and floatable materials
3. Anaerobic digestion of accumulated materials (maximum reduction approximately 40%)




Applications: Used for on-site systems, integral component of small diameter gravity sewers and STEP pressure sewers, pretreatment for soil absorption systems and intermittent sand filters.

Limitations: Odors may be a problem in some applications. Accumulated solids require removal at regular intervals. Disposal locations and carriers for the septage must be available.

Design Criteria:

Volume: Approximately 1 day detention time @ average flow when 2/3 of tank is being utilized for storage.

Depth: Shallow tanks preferred over deep tanks of the same volume.

Compartmentalization: Tanks handling more than 2000 gpd should be compartmentalized into a minimum of 2 compartments and a maximum of 4. The first chamber should be at least 1/2 of the volume.

Performance: Turbid, malodorous effluent.

| | |
|---|---|
| $BOD_5$: | 150 mg/L |
| SS: | 60 mg/L |
| Nitrogen: | 55 mg/L total (70% $NH_3$-$NH_4^+$, 30% organic) |
| Phosphorus: | 15 mg/L (80% organic) |

Status of Technology: Proven in small installations. Performance of larger tanks has been satisfactory although the number of installations is limited.

Residuals: Septage (remove every 1-3 years in individual tanks, more frequently in larger tanks).

Reliability: Excellent, if proper pumping schedules are maintained.

Operation and Maintenance:

| | |
|---|---|
| Labor: | Sludge removal from tanks (once every 3 years) |
| Energy: | None |
| Chemicals: | None |

Environmental Impacts: Possible odors during cleaning, septage disposal.

References:


1) U.S. Public Health Service, Manual of Septic Tank Practice, Publication No. 526, Department of Health, Education and Welfare, Washington, D.C. (1967).

2) Baumann, E.R., et al., "Septic Tanks" in Home Sewage Treatment Amer. Soc. Agr. Engr. Pub. 5-77, St. Joseph, Michigan (1978).

3) U.S. EPA, Manual for Onsite Wastewater Treatment and Disposal Systems, U.S. EPA Technology Transfer (1980).

Design Criteria:

| Item | Extended Aeration | Oxidation Ditch | Contact Stabilization | High-Rate Complete Mix |
|---|---|---|---|---|
| Food to Microorganism Ratio (lbs $BOD_5$/lbs MLVSS) | 0.05-0.15 | 0.03-0.10 | 0.2-0.6 | 0.2-0.4 |
| Sludge Residence Time (days) | 20-30 | 20-30 | 5-12 | 6-12 |
| Mixed Liquor Suspended Solids (mg/l) | 3,000-6,000 | 3,000-5,000 | 1,000-3,000 (reactor); 4,000-10,000 (contact basin) | 2,000-5,000 |
| Volumetric Loading (lbs $BOD_5$/1000 $ft^3$) | | | | |
| Typical Ranges | 10-25 | 10-20 | 30-40 | 40-60 |
| Wis. Adm. Code | 12.5 | - | 30 | 40 |
| Hydraulic Detention Time (hrs) | 18-36 | 12-96 | 0.3-0.7 (reactor; 3-6 (contact basin) | 2-6 |
| Wis. Adm. Code | 24 | - | 3 (contact) | 6.0 |
| Recycle Ratio (% of forward flow) | .75-1.5 | .25-0.75 | .25-1.0 | .25-1.0 |
| Lbs $O_2$/lbs $BOD_5$ Removed | 1.5-1.8 | 1.5-1.8 | 0.7-1.0 | 0.7-1.0 |

Performance:

| Modification | % $BOD_5$ Removal |
|---|---|
| Extended Aeration | 80-95 |
| Oxidation Ditch | 80-90 |
| Contact Stabilization | 85-95 |
| High Rate, Complete Mix | 80-90 |

Status of Technology: Well proven, standard secondary treatment technology. All modifications presented above have had significant operational time in the United States.

Residuals:

| Modification | Waste Sludge (lbs. Solids/lb. $BOD_5$ Removed) |
|---|---|
| Extended Aeration | 0.15-0.3 |
| Oxidation Ditch | 0.15-0.3 |
| Contact Stabilization | 0.4 -0.6 |
| High Rate, Complete Mix | 0.5 -0.7 |

Reliability: Reliable if sufficient time is allowed for required operational duties.

Operation and Maintenance:

Labor: Process monitoring, equipment maintenance, sludge disposal.
Energy: Significant energy requirements for air supply.
Chemicals: None

Environmental Impacts: Odors if improperly operated, noise from oxygen supply systems, sludge disposal.

References:

1) Water Pollution Control Federation. Wastewater Treatment Plant Design, Manual of Practice No. 8, Washington, D.C. (1977).

2) Environmental Protection Agency, Process Design Manual for Wastewater Treatment Facilities for Sewered Small Communities. (Report No. EPA-625/1-79-009).

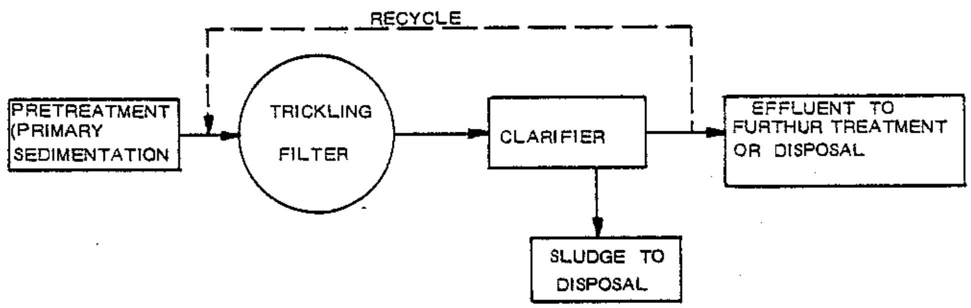
3) Metcalf and Eddy, Wastewater Engineering, 2nd Edition, McGraw-Hill, New York, (19 ).

FIXED FILM AEROBIC REACTORS

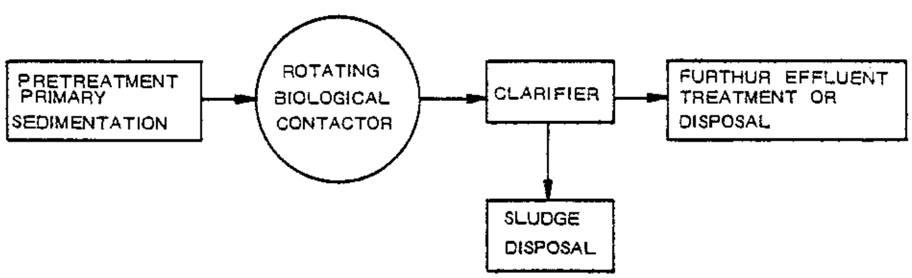
Description; Fixed film aerobic systems are biological treatment processes employing a large surface area of fixed media (rock, wood, synthetic) upon which microorganisms attach and grow. The wastewater is distributed over the media in the presence of air so that the biomass may contact and aerobically metabolize the waste materials. These processes are usually followed by a solid-liquid separation step. Recycle of the treated wastewater back to the fixed media may also be practiced. Aeration may be provided by natural ventilation, mechanical aeration or forced air ventilation.

The two most frequently used fixed film reactors are the trickling filter or packed tower and the rotating contactor.

Trickling Filter: Trickling filters are packed beds of rock, wood or synthetic media placed within a tank with underdrains. The wastewater is applied to the upper surface through a distribution system. The waste trickles over the media surface and is collected by the underdrains for solid-liquid separation before recycle or discharge. Aeration is provided by natural ventilation or forced air blowers.




Rotating Contactor: Rotating biological contactors (RBC) employ a series of plastic circular discs mounted on a horizontal shaft within a tank. The discs are partially submerged and slowly rotated as the wastewater passes through the tank. The biomass attached to the discs is alternately in contact with the waste and the atmosphere. Aeration occurs during exposure to the atmosphere. The treated waste is usually settled or filtered prior to disposal.



Application: Widely used for secondary treatment. Effectively removes both soluable and suspended oxygen demanding substances. May also be used as roughing units for high strength wastes.

Limitations: The processes are vulnerable to temperature reductions. Enclosures are required for effective winter operation in cold climates.

Design Criteria:

Trickling Filters:

| | Plastic Media | Rock Media High Rate | Rock Media Low Rate |
|---|---|---|---|
| Hydraulic Loading (gal/day/$ft^2$) | 700-1400 | 230-900 | 25-90 |
| Organic Loading (No. $BOD_5$/day/1000 $ft^3$) | 10-50 | 20-60 | 5-20 |
| Recirculation Ratio | 0.5:1-5:1 | 0.5:1-4:1 | None |
| Bed Depth (ft) | 20-30 | 3-6 | 5-10 |
| Void Space of Media | 95% | 50% | 50% |

Rotating Contactor:

| | With Nitrification | Without Nitrification |
|---|---|---|
| Organic Loading (lbs $BOD_5$/1000 $ft^3$/day) | 15-20 | 30-60 |
| Hydraulic Loading (Gal/Day/$ft^2$ media) | 0.3-0.6 | .75-1.5 |
| Stages | minimum of 4 | minimum of 4 |
| Rotational Velocity (ft/min) | 60 | 60 |
| Tank Volume (Gal/$ft^2$ media) | .12 | .12 |
| Secondary Clarifier Overflow Rate (Gal/day/$ft^2$) | | |

| Effluent SS | |
|---|---|
| 20-30: | 800 |
| 10-15: | 400-600 |

Performance:

Trickling Filter: Based on design criteria above and temperatures greater than 13°C.

| | Percent Removal | | | |
|---|---|---|---|---|
| | Plastic Media | Rock Media High Rate | Rock Media Low Rate | |
| $BOD_5$ | 80-90 | 60-80 | 75-90 | |
| $NH_4$-N | 20-30 | 20-30 | 20-40 | Above based on design criteria and temperature >13°C |
| P | 10-30 | 10-30 | 10-30 | |
| SS | 80-90 | 60-80 | 75-90 | |

Rotating Biological Contactor: For four stage system with primary and secondary clarification.

| Constituent | % Removal |
|---|---|
| $BOD_5$ | 80-90 |
| SS | 80-90 |
| P | 10-30 |
| $NH_4$-N | Up to 95 |

Status of Technology: Trickling filters are well proven although the performance of small filters at times has been insufficient to achieve secondary treatment standards. Rotating biological contactors are a new process in the United States but there has been relatively extensive, satisfactory use of the technology at larger installations in Europe.

Residuals: Solids from the secondary chamber (Approximately 400-700 lbs of dry solids per million gallons treated).

Reliability: Generally good, although high loadings in the initial modules of the rotating biological contactors may impose excessive loads on the drive shaft. Temperature control is required to insure adequate year-round performance in cold climates.

Operation and Maintenance:

Labor: Maintenance of mechanical components, sludge disposal.
Energy: Minimal for rotating biological contactors; amounts for trickling filters are a function of the pumping required. Power requirements are less than suspended growth systems.
Chemicals: None

Environmental Impacts: Possible odors from poorly maintained plants. Residuals disposal.

References:

1) Water Pollution Control Federation, Wastewater Treatment Plant Design, Manual of Practice No. 8, Washington, D.C. 1977 (Chapter 15 - Biological Filters).

2) U.S. Environmental Protection Agency, Process Design Manual for Wastewater Facilities for Small Sewered Communities, 1977 (Chapters 8 and 9).

## POND SYSTEMS

Description: Wastes are degraded in ponds through a variety of processes which are similar to the biological processes occurring in streams, lakes and reservoirs. Five major types (listed below) are commonly used to treat the wastewater. Oxygen for aerobic oxidation is provided either by mechanical (diffused aerators and mechanical aerators) or natural (wind, photosynthesis) processes. Lagoons may operate on a continuous or intermittent flow basis.

Common Types: Aerated aerobic, aerated facultative, aerobic facultative, aerobic and anaerobic (heavily loaded system which will not be discussed in this section).

Applications: Widely used as a secondary treatment process for small communities.

Limitations: Cold weather severely restricts effectiveness of pond systems. Problems with solids carryover may also require supplementary polishing units (e.g. sand or rock filtration).

Design Criteria:

| ITEM | PROCESS | | | |
|---|---|---|---|---|
| | Aerated Aerobic | Aerated Facultative | Aerobic Facultative | Aerobic |
| Description | Completely mixed system. $O_2$ is supplied either through diffusers or mechanical systems. Sedimentation facilities required. | Aerators only at surface. Solids sedimentation at lower depths with some anaerobic decomposition. | $O_2$ supply in system by algal and surface mixing by wind. | Shallow pond where algae provides sufficient $O_2$ to maintain aerobic conditions throughout pond. |
| Application | Treatment of raw domestic wastewaters. | Treatment of raw domestic wastewaters. Especially useful in northern climates. | Treatment of raw domestic wastewaters. Limited use in cold climates. | Nutrient removal, treatment of soluble organics. Secondary effluents. |
| Advantages | Relatively small volume, odor free, high degree of treatment. | Relatively small volume, relatively odor free, high degree of treatment. | Low O & M costs, high degree of treatment. | Low O & M costs. |
| Disadvantages | Highest O & M costs of any pond system. | Substantial O & M costs. | Large volume and area required, possible odors. | Large volume and area required, possible odors. |
| Flow Regime | Completely mixed. | Complete mixed surface layer. | Arbitrary | Arbitrary |
| Retention Time (days) | 3-20 | 7-20 | 7-30 | 10-40 |
| Depth (ft) | 6-20 | 3-8 | 3-6 | 3-4 |
| $BOD_5$ Loading (lbs/acre/day) | 20-400 | 30-100 | 15-50 | 60-120 |

Performance:

| | | | | |
|---|---|---|---|---|
| Removals | 80-95% | 80-95% | 80-95% | 80-95% |
| Effluent Conc. | | | | |
| BOD mg/L | 15-25 with | 20-30 | 30-40 | 40-60 |
| SS mg/L | 20-30 settling | 50-80 | 60-120 | 80-150 |
| Comments | Supplementary sedimentation; facilities required. | Useful facility in northern areas where the surface freezes. Reduces odors in spring. | Possible odors in spring due to inability of algae to generate sufficient $O_2$ early in year. | Useful as polishing ponds. Ineffective for water operation in Wisconsin. |

Status: Proven

Residuals: Sludge must be occasionally removed from bottom of the ponds (once every 10-20 years).

Reliability: Generally good, although susceptible to periods of solids carryover.

Operation and Maintenance:

| | |
|---|---|
| Labor: | Process monitoring (minimal) sludge disposal |
| Energy: | Limited |
| Chemicals: | None |

Environmental Impacts: Possible odors, especially in the spring; Sludge disposal. Possible leakage to the groundwater table.

References:


1) Water Pollution Control Federation, Design of Wastewater Treatment Plants, Manual of Practice No. 8, Washington, D.C. 1977 (Chapter 22).

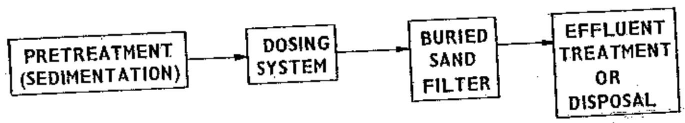
2) Tchobanoglous, G. "Wastewater Treatment for Small Communities", Part I, Public Works, July, 1974, p. 61.

3) Caldwell, D. H., Uhte, W. R. and Stenquist, R. J., Upgrading Lagoons, EPA # 625/4-73-001b.

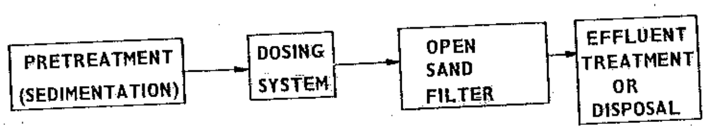
4) U.S. Environmental Protection Agency, Process Design Manual for Wastewater Facilities for Small Sewered Communities, 1977 (Chapter 10).

INTERMITTENT SAND FILTRATION

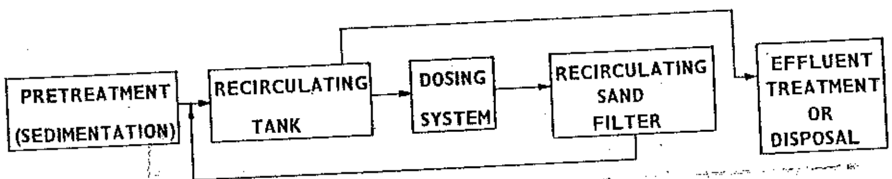
Description: Intermittent sand filtration is a process where physical forces (screening and straining) and biological activity purify the wastewater as it moves through a 2-3 foot bed of relatively uniform sand. Effective removals of oxygen demanding substances and suspended solids are obtained in these systems provided loadings on the filters are maintained at suitable levels. Nitrification of the applied effluent is generally complete as long as an aerobic environment is maintained in the filter.




BURIED SAND FILTER




OPEN SAND FILTER




RECIRCULATING SAND FILTER

Common Types: Buried Sand Filter (BSF), Open Sand Filter (OSF), Recirculating Sand Filter (RSF).

Applications: Sand filters may be used as an effective secondary treatment process following sedimentation (either conventional or a septic tank) or as an effective tertiary treatment process following biological treatment (e.g. extended aeration or aerated lagoons).

Limitations: Cost-effectiveness of the filters depends on the availability of suitable sand sufficiently close to the site so as to not require extensive expenditures for its transport. The effective size and uniformity of the sand control the treatment effectiveness and frequency of scheduled maintenance.

Design Criteria:

| Item | Buried Sand Filter | Open Sand Filter | | | Recirculating Sand Filter |
|---|---|---|---|---|---|
| | | Septic Effluent | Aerobic Effluent | Lagoon Effluent | |
| Depth of Sand (ft) | 2 | 2' Minimum | 2' Minimum | 2.5 - 3 | 2' Minimum |
| Sand Specifications | | | | | |
| Effective Size (mm) | 0.3 - 0.6 | 0.2 - 0.6 | 0.2 - 0.6 | 0.15 - 0.75 | 0.6 - 1.0 |
| Uniformity Coefficient | ≤ 3.5 | ≤ 4 | ≤ 4 | - | ≤ 2.5 |
| Physical Configuration | Duplicate filters, each designed to handle 1/2 of the design flow; Dosing system | Duplicate filters, each designed to handle entire design flow; Dosing System | Single Filter | Duplicate filters, each designed to handle entire flow; Dosing System | Single Filter Recirculating tank; Recirculating pump |
| Design Loading ($gpd/ft^2$) | 0.5 (Year Round) | 5 | 5 | 8 - 15 | 3 (Forward flow) |
| Recirculation Ratio | - | - | - | - | 3:1 - 5:1 |
| Dosing Schedule (no./day) | 3 - 5 | 3 - 5 | 3 - 5 | Continuous for 24 hours | 8 - 12 |
| Frost Protection | 3' Minimum Burial Depth | Insulated Covers | Insulated Covers | None (Suspension of operation during winter) | Insulated Covers; Reduce Recirculation Ratio |

Performance:

Effluent Quality

| | Buried Sand Filter | OSF (All Influents) | RSF |
|---|---|---|---|
| $BOD_5$ (mg/L) | <30 | <10 | < to 5 |
| SS (mg/L) | <40 | <10 | < to 5 |
| N | Nearly Complete Nitrification | Nearly Complete Nitrification (Reduced levels for lagoon effluents in winter. | Nearly Complete Nitrification |
| P | Negligible Long-term Removal | Negligible Long-term Removal | Negligible Long-term Removal |

Status of Technology: Standard technology which has been used for a long period of time. The recirculating sand filter has had only limited applications on off-site installations but a demonstration study listed below has produced excellent results.

Residuals: Used Sand

| Process | Frequency | Amount |
|---|---|---|
| BSF | None | None |
| OSF | | |
| Septic | 90-150 days | .25 $ft^3/ft^2$ filter |
| Aerobic | 6-12 months | .25 $ft^3/ft^2$ filter |
| Lagoon | 30-60 days | .25 $ft^3/ft^2$ filter |
| RSF | 4-6 months | .25 $ft^3/ft^2$ filter |

Reliability: Excellent

Operation and Maintenance:

Labor: Buried Sand Filter - None

Open Sand Filter - Amount of labor required to maintain the filters depends on the character of the applied wastewater and the effective size of the sand.

Septic Tank Effluent: Break up the sand surface by raking or replacement immediately after the bed is taken out of service. Approximate filter run lengths are 30 days for 0.2 mm sand; 90 days for 0.4 mm sand and 150 days for 0.6 mm sand.

Aerobic Unit Effluent: Replace top 3 inches of sand. Frequency depends on the suspended solids in the applied wastewater. For 50 mg/L SS clean once per year; for 100 mg/L SS clean twice per year.

Lagoon Effluent: Clean top 2-3 inches of sand every 30-60 days.

Recirculating Sand Filter - Check recirculation ratio once per week; rake sand filter and replace top 2-3 inches of sand once every 4-6 months.

Energy: May be required for dosing and pumps
Chemicals: None

Environmental Impact: Possible odors if uncovered. Sand disposal.

References:

1) Buried Sand Filters

a. Wisconsin Administrative Code Section NR 110.28.

b. Manual of Septic Tank Practice, U.S. Public Health Service Publication No. 526, Washington, D.C. (1967).

c. Hills, D.J. and Krone, R.B. "Hydraulically Ventilated Underground Filter", Proc. Paper 8596, Journal of the Sanitary Engineering Division, ASCE, 97 SA6, pp 851-866.

d. Salvato, J.A., Jr. "Experience with Subsurface Sand Filters", Sewage and Industrial Wastes, Vol. 27, p 909.

2) Open Sand Filters

a. Sauer, D.K., Boyle, W.C. and Otis, R.J. "Intermittent Sand Filtration of Household Wastewater", Proc. Paper 12295, Journal of the Environmental Engineering Division, ASCE, 102, No. EE4, August, 1976, pp 789-803.

b. Marshall, G.R. and E.J. Middlebrooks, "Intermittent Sand Filtration to Upgrade Exisitng Wastewater Treatment Facilities", PRJEW 115-2, Utah Water Research Laboratory, Utah State University, Logan, Utah.

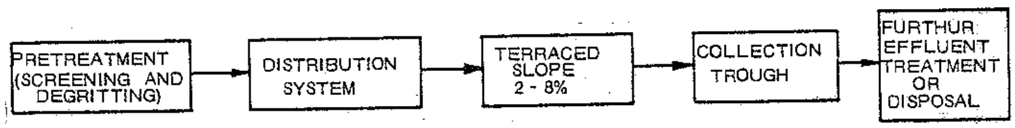
c. Harris, S., Reynolds, J., Hill, D., Fiud, D., Middlebrooks, E. "Intermittent Sand Filtration for Upgrading Waste Stabilization Pond Effluents", JWPCF, Vol. 49, No. 1, p 83, Jan. 1977 (For lagoons)

3) Recirculating Sand Filter

a. Hines, M. and R.E. Faureau, "Recirculating Sand Filter: An Alternative to Traditional Sewage Absorption Systems", Home Sewage Disposal, Amer. Soc. Agr. Engr. Publication, Proc-175, St. Joseph, Michigan.

OVERLAND FLOW

Description: Overland flow systems are land-based systems in which effluent is applied at the top of a uniform slope (2-8%) and forced to flow in a relatively uniform sheet down the slope into a collection channel placed at the toe of the slope. Treatment of the applied wastewater occurs primarily through the biological activity of the mat and the uptake of nutrients by the cover crops. Wastewater is applied in a cycle of continuous dosing followed by resting to insure that ponding does not occur.




Applications: Overland flow systems have been designed for a variety of purposes including treatment of wastewater, production of forage grasses, preservation of open space areas, or removal of nutrients, particularly nitrogen. They are especially useful in areas where the soils have limited permeability.

Limitations: Since treatment in an overland flow system is primarily biological, low temperatures greatly reduce the treatment capabilities of the system. Storage of a minimum of approximately 140 days is required for year-round use of such systems in Wisconsin.

Design Criteria:

| | |
|---|---|
| Slope | 2-8% |
| Hydraulic Loading in/wk | 4-8 |
| $BOD_5$ Loading #/acre/day | 5-50 |
| Soil Permeability | $\leq$ 0.2 in/h |
| Soil Texture | Clay and clay loams |
| Terrace Length (Ft) | 120-150 |
| Application Cycle | 8 hrs on, 16 hours rest |

Performance:

| Constituent | Removals |
|---|---|
| $BOD_5$ | 80-95% |
| SS | 80-95% |
| Total N | 75-90% |
| Total P | 30-60% |

Status: Widely used in food processing installations in the southern United States. Few municipal plants are in operation. Limited experience with such systems in northern climates.

Residuals: Vegetative cover

Reliability: Long-term reliability for municipal effluents in northern climates is unknown. Performance poorer at lower temperatures.

Operation and Maintenance:

| | |
|---|---|
| Labor: | Terrace maintenance/cover crop removal |
| Power: | May be required for distribution |
| Chemicals: | None, phosphorus removal enhanced by adding alum or $FeCl_3$ prior to application. |

Environmental Impacts: Long-term commitment of large land area. Possible odors.

References:


1) United States Environmental Protection Agency, Process Design Manual for Land Treatment of Municipal Wastewater, EPA 625/1-77-008 (Chapters 2, 5, and 6).

2) U.S. Army Corps of Engineers, "State of Knowledge in Land Treatment of Wastewater", Int'l. Symposium, August 20-25, 1978, Hanover, New Hampshire (Volumes 1 and 2).

3) U.S. Environmental Protection Agency, "Land Treatment of Municipal Wastewater Effluents", Technology Transfer Seminar Program, 1976.

4) Wisconsin Department of Natural Resources, Guideline Document for the Design, Construction and Operation of Land Disposal Systems for Liquid Wastes, 1975.

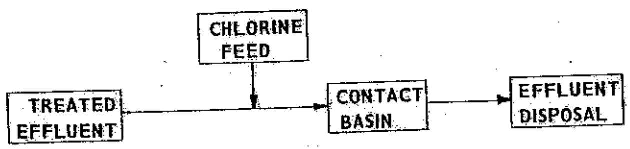
## DISINFECTION

Description: Disinfection processes are designed to reduce pathogens (bacteria and viruses) below some acceptable lower limit. Processes easily adaptable to small waste flows are chlorination, iodination and ultraviolet irradiation.

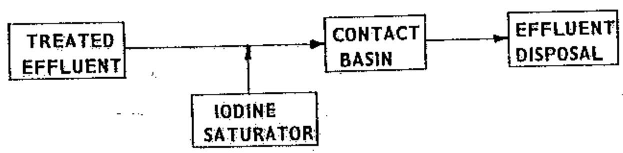
Chlorination: Chlorine can be added to wastewater as a gas ($Cl_2$); a liquid (NaOCl or $Ca(OCl)_2$) or a solid ($Ca(OCl)_2$). Because the gaseous form can be a safety hazard and is highly corrosive, small flow applications normally use the solid or liquid form. After addition, the waste is held for at least a 15 to 30 min contact period before discharge.

Iodination: Iodine is used in a crystalline form ($I_2$). It is added to the treated waste stream as a solution pumped from an iodine saturator containing iodine crystals and tap water. Contact times similar to chlorination are required following addition.

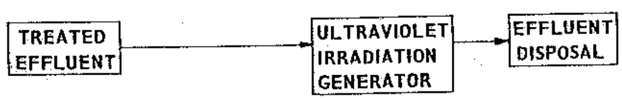
Ultraviolet Irradiation: Ultraviolet (UV) light is germicidal. High intensity, low pressure mercury vapor lamps are normally used to produce the UV light. The lamps are usually encased in clear fused glass quartz tubes. The wastewater is passed over the tubes in a thin sheet to insure sufficient transmittance. Exposures of a few seconds is all that is necessary to achieve disinfection.




CHLORINATION




IODINATION




ULTRAVIOLET IRRADIATION

Application: Disinfection, if required, is usually applied to wastewater that has received at least secondary treatment. Though gaining in popularity the use of iodination and ultraviolet irradation has been limited primarily to areas where chlorine and chloramine residuals and their effects on fish life are a concern.

Limitations:

| | |
|---|---|
| Chlorination: | Possible toxic residuals, high chlorine demand for wastes with high ammonia concentrations. |
| Iodination: | Possible toxic residuals (effects currently unknown). |
| Ultraviolet Irradiation: | Low turbidities required for effective operation. |

Design Criteria: Dosages in the table below are based on sand filtered effluents. Increased dosages required for higher levels of solids in the waste stream. U.V. irradiation functions poorly unless turbidity levels are low (typically less than 10 JTU). High ammonia levels greatly increase the chlorine dosages.

| Process | Dosage | Contact Time (At Peak Flow)(min) |
|---|---|---|
| Chlorination | 1-5 mg/l | 30 |
| Iodination | 5-10 mg/l | 30 |
| UV Irradiation | 16,000 mW-sec/$cm^2$ | - |

Performance: With proper dosages and contact times (listed above) effluents with less than 200 fecal coliforms/100 ml may be produced. Temperature reductions decrease the effectiveness of chlorine and iodine. Consequently, some form of protection against cold weather should be provided.

Status of Technology: Chlorination is well proven for both large and small applications. Iodination and UV irradiation are effective water supply disinfection processes but their use in small wastewater systems is relatively recent.

Residuals: Chlorination and iodine may produce toxic residual compounds.

Reliability: Good for all systems if proper maintenance is provided.

Operation and Maintenance:

| | Chlorination | Iodination | UV Irradiation |
|---|---|---|---|
| Labor: | Replace tablets or feed chemicals, monitor residual $Cl_2$ | Replace chemicals; monitor residual $I_2$ & performance | Clean UV lamp; monitor performance |
| Chemicals: | 2.5-4 lbs/ person/yr | 6-12 lbs/ person/yr | None |
| Energy: | pumps(limited) | pumps(limited) | 1.5 kwhr/day<br>$2.6 \times 10^{-4}$ kwhr/gal |

Environmental Impacts:

| | |
|---|---|
| Chlorination: | Possible toxic residuals |
| Iodination: | Possible toxic residuals |
| UV Irradiation: | None |

References:


1) Water Pollution Control Federation. Wastewater Treatment Plant Design, Manual of Practice No. 8, 1977, (Chapter 20).

2) Weber, Walter J., Jr.; ed. Physicochemical Processes for Water Quality Control, Wiley, 1972, (Chapter 9).

3) Culp, et al., Handbook of Advanced Wastewater Treatment, Van Nostrand Reinhold, 1978, (Chapter 6).

4) Small Scale Waste Management Project, Management of Small Waste Flows, EPA 600/2-78-173, Sept. 1978 (Appendix A, pages A-244 to A-259).

5) Budde, P.E., P. Nehm, W.C. Boyle, "Alternatives to Wastewater Disinfection", JWPCF, Vol. 49, No. 10, Pp 2144-2156.

## NUTRIENT REMOVAL

Description: Nutrients (primarily nitrogen and phosphorus compounds) in the wastewater stream can be removed using a variety of methods including chemical, biological and land treatment processes. Biological processes are not very effective in removing phosphorus, however. The various methods for phosphorus and nitorgen removal are summarized in the tables below.

### NITROGEN AND AMMONIA REMOVAL

| Method | Form of N Affected | End Product(s) | State of Technology | Comments |
|---|---|---|---|---|
| Extended Aeration | $NH_3$ | $NO_3$ | Proven | Requires long detention times and sufficient oxygen |
| Oxidation Ditch | $NH_3$,$NO_3$ | $NO_3$, $N_2$ | Proven | Total removals of N are a function of dissolved oxygen concentrations in basin. |
| Rotating Biological Contactor | $NH_3$ | $NO_3$ | Proven | Requires low loadings on later stages |
| Low-Rate Trickling Filter | Organic N $NH_3$ | $NO_3$ | Proven | |
| Intermittent Sand Filtration | Organic N $NH_3$ | $NO_3$ | Proven for small installations | Requires aerobic conditions and moderate temperatures (>50°F) |
| Stabilization Ponds | Organic N $NH_3$ | $NO_3$ | Proven | Performance in cold weather may be poor |
| Ion Exchange | $NH_3$ | Complete reval as $NH_3$ | Demonstration needed | Disposal of saturated resin is required; expensive |
| Denitrification (Biological) | $NO_3$ | $N_2$ | Proven | Carbon Source required Anaerobic system |
| Land Treatment Irrigation | All forms | $NO_3$,$N_2$ crop tissue | Proven | Removals function of soils and crops |
| Rapid Infiltration | All forms | $NO_3$, $N_2$ | Proven | Removals function of soils and loading required |
| Overland Flow | All forms | $NO_3$, $N_2$ | Proven | Removals by biological processes; cease at low temperatures |
| Mounds | All forms | $NO_3$ | Proven | Removals function of soils and loading schedule |
| Absorption Trenches and Beds | All forms | $NO_3$ | Proven | Removals function of soils and loading schedule |

PHOSPHORUS REMOVAL METHODS

| Method | Form of P Affected | State of Technology | Comments |
|---|---|---|---|
| Precipitation with Al or Fe Salts | $PO_4^{\equiv}$ | Proven for large operations; use in small installations needs demonstration | Sludge; chemical feed and control equipment required |
| Adsorption (Alumina) | $PO_4^{\equiv}$ | Needs demonstration | Expensive |
| Land Treatment | | | |
| Overland Flow | All Forms | Proven | Additional removals; feasible with alum addition |
| Rapid Infiltration | All Forms | Proven | Long term removals function of soil |
| Irrigation | All Forms | Proven | Long term removal; function of soils and crops |
| Mounds | All Forms | Proven | Removals function of soil |
| Absorption Trenches | All Forms | Proven | Removals function of soil. |

Application:

Phosphorus: Removal of phosphorus is generally only required in communities with a population equivalent greater than 2500 located in the Lake Superior or Lake Michigan drainage basins (Section NR 11024 of the Wisconsin Administrative Code). For most small communities (except those discharging into lakes or reservoirs) it is unlikely that phosphorus removal would be required.

Nitrogen and Ammonia: The major concerns over nitrogen and ammonia center primarily around the toxicity and oxygen demanding characteristics. Nitrogen and ammonia removal are required only in those instances where it is felt by the WDNR that such a discharge would have a significant impact on the aquatic life of the receiving stream, lake or reservoir. Another method for effective nitrogen control is to remove it at the source (i.e. home) by segregating the toilet wastes which carry the majority of the wastes and disposing of these toilet wastes separately.

References:

1) United States Environmental Protection Agency, Nitrogen Control, (Oct. 1975).

2) United States Environmental Protection Agency, Phosphorus Removal, EPA 625/1-76-001a (April, 1976).

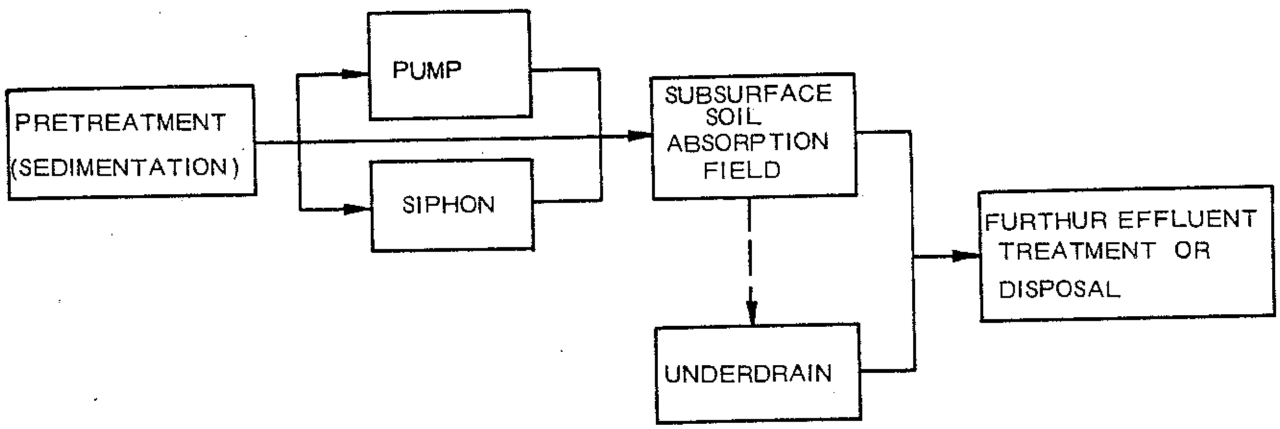
3) Small Scale Waste Management Project, "Management of Small Waste Flows," EPA 600/2-78-173, Sept. 1978 (Especially Appendix A, pp. A-126 to A-244).

4) Siegrist, R.L. and Woltanski, T. "Water Conservation and Wastewater Disposal". Proceedings of the Second National Home Sewage Treatment Symposium, American Society of Agricultural Engineers, 1977.

# DISPOSAL ALTERNATIVES

SUBSURFACE SOIL ABSORPTION

Description: Individually owned subsurface soil absorption systems have long been the conventional technology used to service small unsewered communities. Trenches (or beds) are excavated in the natural soil at depths which vary between 1 and 3 feet. Distribution networks are placed in the trenches which are filled with gravel. Effluent is applied using either gravity or pressure distribution.




Applications: Disposal of septic tank effluent for individual residences, "clusters", community-wide systems in areas with suitable conditions.

Limitations: Use of subsurface soil absorption systems are limited by various site conditions including topography, underlying geology, land availability and soils suitability.

Design Criteria: Design based on soil type

Site Characteristics: Check local codes

Climate: Little effect

Pretreatment: Sedimentation

Loading Rates:

| Soil Type | Loading Rate | # of Doses |
|---|---|---|
| Sands | 1.2 gpd/ft$^2$ | 4 daily |
| Sandy Loam | 0.7 gpd/ft$^2$ | 1 daily |
| Loam | 0.5 gpd/ft$^2$ | 1 daily |
| Silt laoms, some silty clay loams | 1.2 gpd/ft$^2$ | 1 daily |
| Clays, some silty clay loams | 0.2 gpd/ft$^2$ | 1 daily |

Distribution: Gravity or pressure; pressure distribution preferable for large systems and those in coarser soils.

Configuration: Single bed for small installations. Three beds each with 1/2 of the design capacity for larger installations; allows for resting.

Performance:

| Constituent | % Removal |
|---|---|
| $BOD_5$ | 90-95 |
| SS | 90-95 |
| Total N | 25-75 (Complete nitrification) |
| P | 80-90 (until absorptive capacity of soil is exceeded) |

Status of Technology: Small systems proven if installed and sited following the above guidelines. Large systems relatively unproven. Demonstration installation:

Location: Westboro, Wisconsin
Capacity: 30,000 gal/day

Residuals: None

Reliability: Excellent, if not overloaded

Operation and Maintenance:

Labor: Large systems : alternate fields
Energy: May be required for distribution
Chemicals: None

Environmental Impacts: Increases in $NO_3^-$ and $Cl^-$ content of the shallow groundwater around the site. Long-term land commitment.

References:

1) U.S. Environmental Protection Agency, Manual for Onsite Wastewater Treatment and Disposal Systems, Technology Transfer (1980).

2) Otis, R.J., "An Alternative Public Wastewater Facility for a Small Rural Community," Small Scale Waste Management Project, University of Wisconsin, 1978.

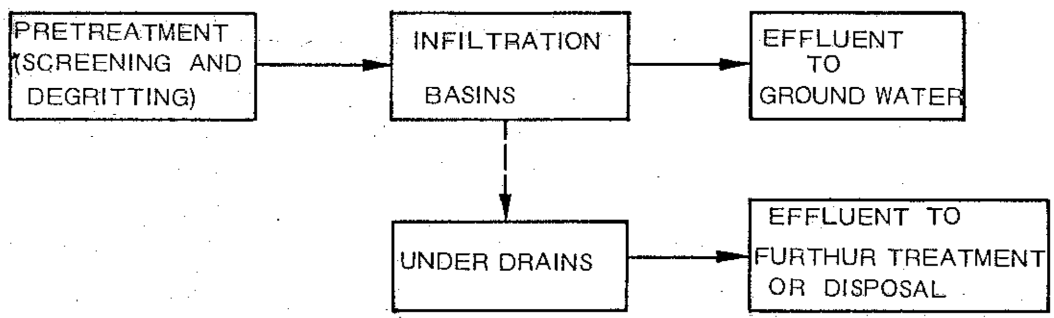
3) Otis, R.J., Converse, J.C., Carlile, B.C. and Witty, J.E., "Effluent Distribution", Proceedings of the Second National Home Sewage Treatment Symposium, American Society of Agricultural Engineers, 1977.

4) Otis, R.J., Plews, G.D. and Patterson, D.H., "Design of Conventional Soil Absorption Trenches and Beds," Proceedings of the Second National Home Sewage Treatment Symposium, American Society of Agricultural Engineers, 1977 (pp. 86-99).

5) Wisconsin Administrative Code (Section H63).

RAPID INFILTRATION

Description: Rapid infiltration systems (commonly called absorption ponds) are basins with prepared surfaces (either vegetated or bare) where the effluent is applied by either flooding or sprinkling techniques. Operation of the systems requires that dosing periods are followed by resting periods during which the design infiltrative capacity is restored either by biological activity, mechanical tillage or crop removal. In small communities in Wisconsin the primary purpose of these systems is the disposal of wastewater into an underlying groundwater aquifer.




Modifications: Application may be made either by sprinkling or flooding (preferred in Wisconsin). Sites may be underdrained if discharge to groundwater is not desirable.

Applications: Useful in areas with no watercourses or watercourses with stringent effluent limitations.

Limitations: Limited to permeable soils (sands, loamy sands)

Design Criteria: Site specific

Site Characteristics:

Soils - Sands, loamy sands
Depth to Groundwater: >10 ft. less if underdrained
Depth to Bedrock: >10 ft.
Topography: Level terrain preferred

Application Rates:

| Permeability | Rate |
|---|---|
| 2.0-6.0 in/wk | 4-20 in/wk |
| 6.0-20.0 in/hr | 8-30 in/wk |
| > 20 in/hr | 12-40 in/wk |

Configuration: Dual basins required

Pretreatment: Minimum of screening or comminution

Performance:

| Constituent | % Removal |
|---|---|
| $BOD_5$ | 95-99 |
| SS | 95-99 |
| Nitrogen | 25-75 (nitrogen not removed in $NO_3^-$ form) |
| Phosphorus | 0-90 |

Status: Well demonstrated

Residuals: None

Reliability: Excellent, if sufficient resting periods are provided.

Operation and Maintenance:

Labor: Alternate basins, clean infiltrative surfaces
Energy: May be required for distribution
Chemicals: None

Environmental Impacts: Odors possible, $NO_3^-$ and $Cl^-$ contamination of groundwater

References:

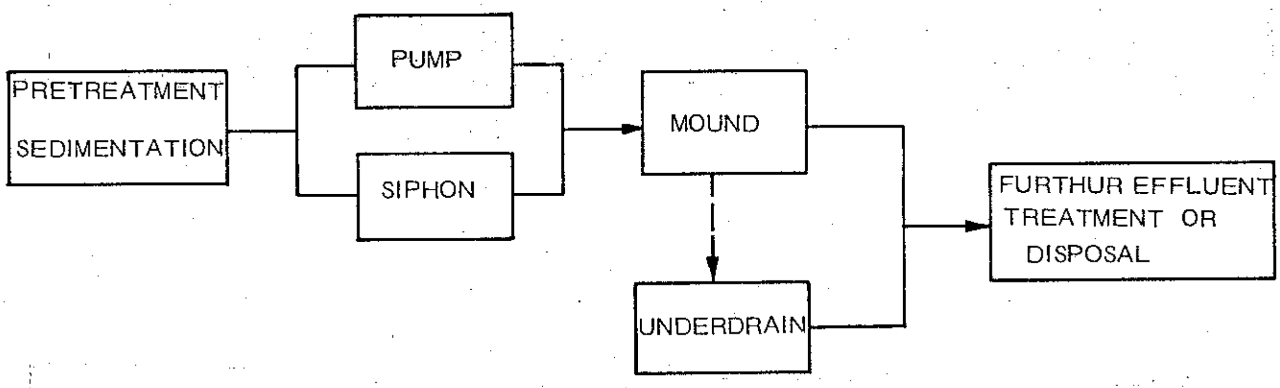

1) Environmental Protection Agency, Process Design Manual for Land Treatment of Municipal Wastewater, 1977 (particularly Chapters 2 and 6).

2) Metcalf and Eddy, Inc., Wastewater Engineering: Treatment, Disposal and Reuse, 2nd Edition, McGraw Hill, 1978 (Chapter 13).

3) Wisconsin Department of Natural Resources, Guideline Document for the Design, Construction and Operation of Land Disposal Systems for Liquid Wastes, 1975.

## MOUND SYSTEMS

Description: Mound systems overcome many of the limitations of other land-based disposal techniques by elevating the actual infiltrative surface above the natural soil and placing it in a fill area of specified material (typically, a medium textured sand). This elevated fill provides additional soil material to treat the wastewater before it reaches the groundwater at sites with shallow or excessively permeable soils and permits the use of the more permeable topsoils on sites with slowly permeable subsoils. Pressure distribution systems using either pumps or siphons are employed to insure uniform distribution of the effluent over the infiltrative surface.




Applications: Used for sites with shallow water tables, shallow creviced or porous bedrock and slowly permeable soils.

Limitations: Use of mound systems requires that suitable fill materials are located within a reasonable distance of the site. Applications currently are limited by various site conditions including topography, underlying geology and soils of the site. Care must be taken in the location of large mound systems.

Design Criteria:

Site Characteristics:

| | Slowly Permeable Soils | Permeable Soils With Shallow Subsoils | | Permeable Soils With High Water Tables | |
|---|---|---|---|---|---|
| Percolation Rate (min/in) | 60-120 | 3-29 | 30-60 | 3-29 | 30-60 |
| Depth to Groundwater | >2 ft. | >5 ft. | >5 ft. | >2 ft. | >2 ft. |
| Depth to Bedrock | >5 ft. | >2 ft. | >2 ft. | >5 ft. | >5 ft. |
| Topography (Slope) | <6% | <12% | <6% | <12% | <6% |

Climate: Little effect

Pretreatment: Primary sedimentation

Sand Specifications: Medium textured sand ($\geq$25% of particles between 2.0 and 0.25 mm; $\leq$50% between 0.25 and 0.05)

Infiltration Rates:

Sand Fill: 1.24 gpd/ft$^2$ (medium textured sand)

Subsoils:

| Percolation Rate (min/in) | Loading Rates (gpd/ft$^2$) |
|---|---|
| 3-29 | 1.2 |
| 30-60 | .75 |
| 60-120 | .25 |

Distribution System: Pressure system sized to allow ~2 ft of head at distil end of system.

Configuration: Single bed for individual installation (<1000 gpd); Multiple beds for larger installations ($\geq$1000 gpd); Three beds each with 1/2 of the design capacity; Allows for resting.

Performance:

Status of Technology: Proven for individual installations. Few large installations exist.

Residuals: None

Reliability: Excellent

Operation and Maintenance:

Labor: Equipment maintenance, field alternation in larger systems
Energy: Distribution
Chemicals: None

Environmental Impacts: Increases in $NO_3^-$ and $Cl^-$ content of the shallow groundwater around the site.

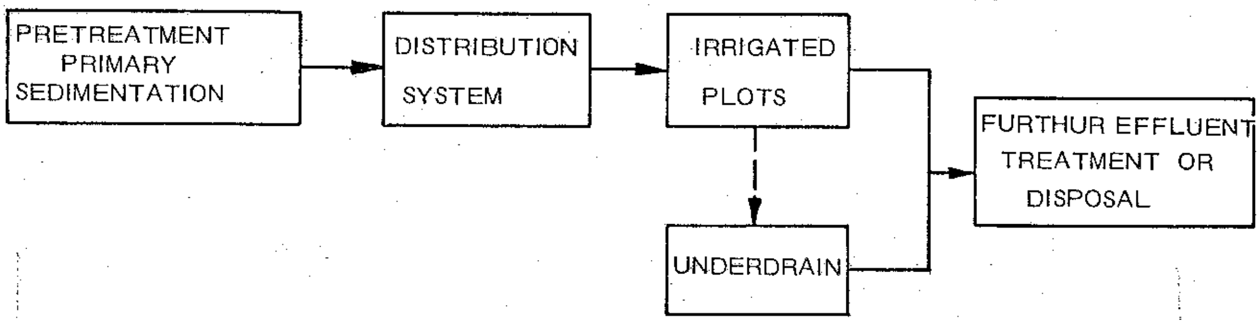
References:


1) U.S. Environmental Protection Agency, Manual for Onsite Wastewater Treatment and Disposal Systems, Technology Transfer (1980).

2) Converse, J.C., "Design and Construction Manual for Wisconsin Mounds", Small Scale Waste Management Project (1978).

IRRIGATION (Slow-Rate Land Application)

Description: Irrigation techniques for wastewater disposal are similar to those used in conventional agricultural practice. Effluent is applied to pasture land, a forested area or crop land either by sprinklers or surface application techniques. Systems for slow-rate land application may be designed to accomplish a wide variety of objectives including the avoidance of surface discharge of nutrients, the economic return from irrigating marketable crops and water conservation. Sites under irrigation may be underdrained with the percolating water discharged to a nearby surface water or reused. Crops grown on the irrigated site are selected based on their suitability to the local climates and soils; water use and tolerance; nutrient uptake and sensitivity to other nutrients, economic value, length of growing season; ease of management.




Applications: Removal of nutrients, use on marketable crops, water reclamation.

Limitations: Application of irrigation is limited by soil types and depth, climate, topography, hydrology (groundwater and surface) and land availability. Hydraulic loading rates depend on soils, climate and the water tolerance and nutrient uptake of cover crops. Significant storage volumes ($\geq$140 days) are required for year round use of irrigation systems in Wisconsin since application should cease when freezing occurs.

Design Criteria:

Pretreatment: Primary sedimentation (function of crop cover and location of application site(s)

Vegetation: Crops required; selected based on objectives of each system

Site Characteristics:

Soils: Sandy loams, loams, clay loams
Depth to Groundwater: 3-5 ft
Depth to Bedrock: 3-5 ft
Topography: <5% (surface application)
(Slope) <15% (crops-sprinkler)
<30% (silvaculture-sprinkler)

Climate: Storage required for cold weather (typically a minimum of 140 days in Wisconsin). Rainfall may limit daily applications.

Hydraulic Loadings:

| Permeability (in/hr) | Application Rate (in/wk) |
|---|---|
| .06-0.2 | 0.5-1.0 |
| 0.2 -0.6 | 1.0-1.5 |
| 0.6 -2.0 | 1.5-3.0 |
| 2.0 -6.0 | 3.0-4.0 |
| 6.0-20.0 | 4.0 |

Performance:

| Constituent | % Removal |
|---|---|
| $BOD_5$ | 90-99 |
| SS | 90-99 |
| Total N | 50-95 (depends on crop uptake) |
| Total P | 80-99 (until adsorptive capacity of soils is exceeded) |

Status of Technology: Widely used for more than 100 years.

Residuals: None

Reliability: Excellent, provided sufficient resting periods are provided.

Operation and Maintenance:

Labor: Crop management, alternate fields
Energy: Required for distribution
Chemicals: None

Environmental Impacts: Odors, long term land commitment

References:

1) Water Pollution Control Federation, Wastewater Treatment Plant Design, MOP No. 8, 1978.

2) United States Environmental Protection Agency, Process Design Manual for Land Treatment of Municipal Wastewater, EPA 625/1-77-008 (Chapters 2, 5 and 6).

3) U.S. Army Corps of Engineers, "State of Knowledge in Land Treatment of Wastewater", Int'l Symposium, August 20-25, 1978, Hanover, N.H. (Volumes 1 and 2).

4) United States Environmental Protection Agency, "Land Treatment of Municipal Wastewater Effluents", Technology Transfer Seminar Program (1976).

# APPENDIX B

# ONSITE SYSTEM EVALUATION QUESTIONNAIRE

# APPENDIX B

## REQUEST FOR INFORMATION ON WASTEWATER DISPOSAL SYSTEM

The following information is being requested for purposes of developing a wastewater facilities plan for your community. It is important that you answer the questions as accurately and completely as possible if the least costly wastewater facility is to be constructed. All information provided will be kept strictly confidential and none will be released for public review. Please return the completed questionnaire using the pre-addressed, stamped envelope.

Name ________________________________________

Address ________________________________________

1. Was your building constructed prior to October 18, 1972? ________, Prior to December 27, 1977? ________

2. How many people live in your household? ________

3. How many bedrooms in your house? ________

4. Does your house have a basement? ________ Basement drain? ________

5. Do you have a garbage grinder? ________ Clothes washer? ________

6. What is the approximate size of your lot?

   ________ less than 2500 sq. ft. ________ 15,000-20,000 sq. ft.

   ________ 2500-5000 sq. ft. ________ 20,000-30,000 sq. ft.

   ________ 5000-10,000 sq. ft. ________ 30,000-40,000 sq. ft.

   ________ 10,000-15,000 sq. ft. ________ over 40,000 sq. ft.

7. Is your house used on a year-round or seasonal basis?

   year-round ________ seasonal ________

8. What type of water supply do you have?

   municipal supply ________ private well ________

9. If you have a well, please provide the following information.

   Do you share the well with other homes? ________ How many? ________

   What type of well is it?

   drilled ________ driven ________ dug ________

   How deep is it? ________

   How deep is the well casing? ________

   Is it a flowing well? ________ If not, what is the depth to water? ________

What is its distance from your septic tank? ________; absorption area?________
Has it ever been tested? ________ What was the result? ________

10. What type of wastewater disposal system do you have?
septic tank/soil absorption field _____; septic tank seepage pit ______;
cesspool ______; drain to surface water or drainage ditch ______;
holding tank ______; other (describe): ______________________________________

11. When was the system installed? _____________

12. What water sources are connected to your disposal system?

| | | | |
|---|---|---|---|
| Toilet | ________ Yes | ________ No | ________ Do not know |
| Kitchen | ________ | ________ | ________ |
| Laundry | ________ | ________ | ________ |
| Bathing | ________ | ________ | ________ |
| Water Softener | ________ | ________ | ________ |
| Roof Drain | ________ | ________ | ________ |
| Foundation Drain or Basement Sump | ________ | ________ | ________ |

13. If any of the above wastes are not discharged into your disposal system, where are they discharged?__________________________________________________

14. Have you had any problems with your wastewater disposal system?
Yes ________ No ________
If you answered "no", please skip to question 19.

15. If you answered "yes" to question "14", please check the type of problem that best describes your problem (check more than one if necessary).

Slow drainage in sink or other water using appliance ________
Drains or toilet occasionally back up ________
Odors outside ________
Liquid is visible on the ground surface ________
Other ______________________________________________________________________

16. How often do you have problems with your system?
5 to 10 times per year ________ 1 to 5 times per year ________
less than once a year ________

17. When do you generally have problems? (check more than once if appropriate)
spring ________ summer ________ fall ________ winter ________
after periods of frequent or heavy rainfall ________

18. If you still have a problem, how are you coping with it?

pumping ________ how often? weekly ______ monthly ______ quarterly ________
reducing water use ________ how? ________________________________________
repairing system ________ how? ________________________________________
other ________ describe ________________________________________

19. If you have ever repaired your system, please answer the following:

when was it last done? ________________________________________
what was done? ________________________________________

20. Have you repaired your system more than once?

yes ________ no ________ if yes, how many and when ________________________

________________________________________________________________

21. If you have not recently had a problem, how often do you have your system pumped?

once a year ________ once every three years ________
once every two years ________ never ________
other ________

22. If you have a holding tank, how often is it pumped? ________

How much does it cost per pumping? ________

23. Do any of your neighbors have problems with their wastewater disposal system?

yes ________ no ________

if yes, what type of problem is it?

odors ________ frequent pumping ________ liquid visible on ground surface ________ other (describe): ________________________

________________________________________________________________

# APPENDIX C

# REHABILITATION OF SEPTIC TANK-SOIL ABSORPTION SYSTEMS

## Appendix C

## Rehabilitation of Septic Tank Soil Absorption Systems

Occasionally, soil absorption systems fail, necessitating their rehabilitation. The causes of failure can be complex, resulting from poor siting, poor design, poor construction, poor maintenance, hydraulic overloading, or a combination of these. To ascertain the most appropriate method of rehabilitation, the cause of failure must be determined. Figure B-1 suggests ways to determine the cause of failure and the corresponding ways of rehabilitating the system.

The failure frequency should be determined before isolating the cause. Failure may occur periodically or continuously. Periodic failure manifests itself with occasional seepage on the ground surface, sluggish drains, or plumbing backups. These usually coincide with periods of heavy rainfall or snowmelt. Continuous failure can have the same symptoms but on a continuous basis. However, some systems may be seriously contaminating the ground water with no surface manifestations of failure. These failures are detected by ground water sampling.

### Periodic Failure

The cause of periodic failure is much easier to determine and rehabilitation can be more simple. Since the system functions between periods of failure, design and construction usually can be eliminated as the cause. In these instances, failure is the result of poor siting, poor maintenance, or hydraulic overloading. Excessive water use, plumbing leaks, or foundation drain discharges are common reasons for overloading. These can be corrected by the appropriate action as shown in Figure C-1.

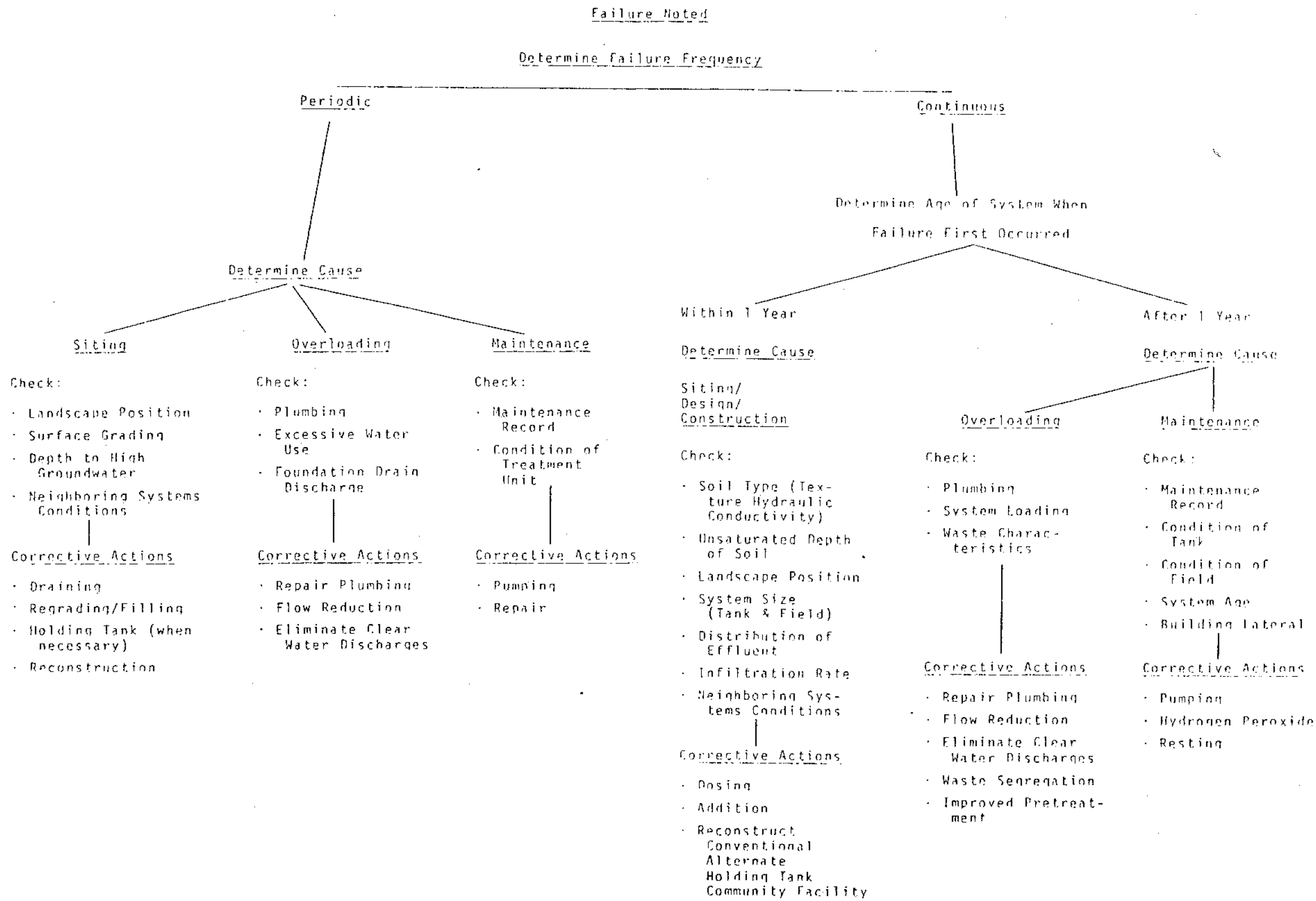
The next step is to investigate the site of the absorption system. Occasional failure usually is due to poor drainage or seasonally high water table conditions. The surface grading and landscape position should be checked for poor surface drainage conditions. The local soil conditions should also be investigated by borings for seasonally high water tables. Checking the condition of neighboring soil absorption systems installed at similar elevations can be useful to differentiate between surface drainage and seasonally high water table as the problem. If most systems have problems during wet periods, then surface drainage is probably the cause. Corrective actions include improving surface drainage by regrading or filling low areas. High water table conditions may be corrected in some instances by installing subsurface drains. Maintenance of the treatment unit preceding the soil absorption field may also be a cause of occasional failure. The unit should be pumped and leaks repaired.

### Continuous Failure

The causes of continuous failure are more difficult to determine. However, learning the age of the system when failure first occurred is very useful in isolating the cause. If failure occurred within the first year or two

# FIGURE C-1

## RECOMMENDED METHODS OF SOIL ABSORPTION FIELD REHABILITATION



of operation, the cause is probably due to poor siting, design, or construction. If the system had many years of useful service before failure occurred, hydraulic overloading or poor maintenance is usually the cause.

The first step is to find out as much about the system as possible. A sketch of the system showing the size, configuration, and location should be made. A soil profile description should also be obtained. These items may be on file at the local regulatory agency but their accuracy should be confirmed by an onsite visit. If the system had provided several years of useful service, evidences of overloading should be investigated first. Wastewater volume and characteristics (solids, greases, fats, oil) should be determined. Overloading may be corrected by repairing plumbing, installing flow reduction fixtures, and eliminating any clear water discharges from foundation drains. If the volume reductions are insufficient for the size of the infiltrative surface then additional infiltrative areas must be constructed. Systems serving commercial buildings may fail because of the wastewater characteristics. High solids concentrations or large amounts of fats, oils, and greases, can cause failure. This is particularly true of restaurants, laundromats, and meat packing houses. These failures can be corrected by segregating the wastes to eliminate the troublesome wastes or by improving pretreatment.

Lack of proper maintenance of the treatment unit may have resulted in excessive clogging due to poor solids removed by the unit. This can be determined by checking the maintenance record and the condition of the unit. If this appears to be the problem, the unit should be pumped and repaired, or replaced if necessary. The infiltrative surface of the absorption field should also be checked. If siting, design, or maintenance do not appear to be the cause of failure, excessive clogging is probably the problem. In such cases, the infiltrative surface can sometimes be rejuvinated by oxidizing clogging mat. This can be done by allowing the system to drain and rest for several months. To permit resting, a new system must be constructed with means provided for switching back and forth, or the septic tank must be operated as a holding tank until the clogging mat has been oxidized. Another method, still in the experimental stage, is the use of the chemical oxidant, hydrogen peroxide. Because it is new, it is not known if it will work well in all soils. Extreme care should be exercised when applying the chemical because it is a strong oxidant and can eat through clothing and skin. Protective rubber clothing and eye glasses should always be worn when working with hydrogen peroxide.

If failure occurred soon after the system was put into operation, the cause is probably due to poor siting, design, or construction. It is useful to check the performance of neighboring systems installed in similar soils. If they have similar loading rates and are working well, the failing system should be checked for proper sizing. A small system can be enlarged by adding new infiltration areas. In some instances, the sizing may be adequate but the distribution of the wastewater is poor due to improper construction. Providing dosing may correct this problem. Damage to the soil during construction may also cause failure in which case the infiltrative area is insufficient. Reconstruction or an addition is necessary. Alternate systems should be considered if the site is poor. This would include holding tanks or investigating the feasibility of a cluster or community system.

# BIBLIOGRAPHY

1. SCS Engineers and Rural Systems Engineering, Manual for Onsite Wastewater Treatment and Disposal Systems, U.S. EPA, Office of Water Programs, Washington, D.C. (in press).

2. University of Wisconsin, "Management of Small Waste Flows", U.S. Environmental Protection Agency, Publication EPA-600/2-78-173, Cincinnati, Ohio (1978) 810 p.

3. Harkin, J. M. and M. D. Jawson, "Clogging and Unclogging of Septic System Seepage Beds", Proceedings Second Illinois Private Sewage Disposal System Symposium. Illinois Department of Public Health, Champaign, Illinois (1977) pp 11-21.

# APPENDIX D

# WORKSHEETS AND INSTRUCTIONS FOR A SCREENING PROCEDURE FOR WATER POLLUTION CONTROL PROJECTS

# Worksheets and Instructions for a Screening Procedure for Water Pollution Control Projects

DETERMINATION OF DEBT
CAPACITY OF COMMUNITIES
AND CITIES

prepared by
The Municipal Finance Officers Association
and Peat, Marwick, Mitchell & Co.
EPA Contract No. 68-01-4343

5/7/79

## BACKGROUND AND PURPOSE OF THE SCREENING PROCEDURE

In recent years several communities in the United States have initiated water pollution control projects that have resulted in excessive costs to its residents. In some communities the increased sewage charges have resulted in residents leaving the community, refusing to pay sewage charges, or being unable to pay the charges. This creates hardships and in some cases leaves municipalities with insufficient funds to cover operating expenses and debt service payments.

The purpose of this screening procedure is to give the community and reviewing authorities a tool for analyzing a proposed project in its development stage to determine if the community can afford the proposed project.

Many 201 water pollution control projects are managed by special sanitary districts and authorities which include several communities. Because of overlapping boundaries, it is often difficult to identify a community's share of the project's debt and operating expenses. However, if a community identifies its share of the project early in the project's development (during step 1 of the EPA grant process) it can perform an analysis to determine if it can afford its share of the project's cost.

The attached worksheets are intended to give community officials and reviewing authorities a basis for reviewing the financial impact of the project on the community.

## INSTRUCTIONS FOR COMPLETING THE SCREENING FORM

The form is divided into three parts:

- Part I: Identification of the community's share of the proposed project.
- Part II: Development of the community's financial characteristics and capacity (with and without the project).
- Part III: Analysis of the ability of the community to support the proposed project given the community's financial characteristics and capacity.

Completion of each part of the worksheets may require data from the project engineer, the managing pollution-control agency, the community's finance director, local bankers, and financial advisors to the community. (See Attachment "A" for a description of Sources of Information.)

# PART I

## IDENTIFICATION OF THE COMMUNITY'S SHARE OF THE PROPOSED PROJECT

### INSTRUCTIONS

Part I provides a worksheet for determining the total capital and annual costs for the proposed project. Sections 1 and 2 provide an analysis of capital costs with the new project and item 2i converts the local share of capital costs into an annual debt service charge (the repayment of principal and payment of interest).

Section 3 allows you to calculate total annual costs for the project, combining the amounts needed for operations, debt service, and any needed reserves. It should be calculated on the basis of when the proposed project starts full operations.

Section 4 is provided to help determine the community's share of annual total project costs if it is part of an overlapping district or authority. This will be based on a percentage allocation of costs agreement between the managing agency and your community.

Section 5 calculates the community's sewer charge for residential units with the proposed system.

Section 6 provides the same information with the existing system (without the proposed project). Be careful to show changes in the industrial share of costs and the number of residential unit served if these are to change with the proposed project. Try to use the most recent data available for the present system to reduce the error due to different time periods, since projects may take two to three years or longer to complete.

## PART I

## WATER POLLUTION CONTROL PROJECT ANALYSIS WORKSHEET

Identification of a community's share of the proposed project (to be completed by the community or the sewage managing agency).

| | TOTAL |
|---|---|
| 1. Total Capital Cost of Proposed Project | |
| a. treatment plant or individual systems | ______ |
| b. interceptor | ______ |
| c. collection system | ______ |
| d. total cost (a + b + c) | ______ |
| 2. Capital Cost Analysis for Proposed Project | |
| a. total cost | ______ |
| b. costs ineligible for EPA construction grant funds | ______ |
| c. costs eligible for EPA grant funds | ______ |
| d. EPA share (@____%) | ______ |
| e. state share (@____%) | ______ |
| f. local share of eligible costs | ______ |
| g. local share of ineligible costs | ______ |
| h. total local share (f + g) | ______ |
| i. total annual local share of capital costs (use a 20-year period for loan or bond maturity at estimated interest) | ______ |
| 3. Annual Project Costs (when project starts operation) | |
| a. operating and maintenance cost | ______ |
| b. debt service (2i above) | ______ |
| c. any required reserves (such as for industrial cost recovery) | ______ |
| d. total annual costs (a + b + c) | ______ |
| 4. Community's Share of Annual Costs of New Project (if a multi-community project)[1] | |
| a. annual O&M costs (@____% of 3a) | ______ |
| b. annual debt service (@____% of 3b) | ______ |
| c. annual reserves requirement (@____% of 3c) | ______ |
| d. total (4a + 4b + 4c) | ______ |
| 5. Community's Sewer Charges for Proposed Project | |
| a. total annual cost for the project (4d) | ______ |
| b. industry share of annual cost | ______ |
| c. residential share of annual costs | ______ |
| d. number of users served | ______ |
| e. annual charge per user (5c/5d) | ______ |
| 6. Community's Present Sewer Charges | |
| a. present total annual cost | ______ |
| b. industry share of present annual cost | ______ |
| c. residential share of annual costs | ______ |
| d. number of users served | ______ |
| e. annual charge per user (6c/6d) | ______ |
| 7. Community's Total Sewer Charges (present plus proposed project) | |
| a. total annual cost (5c + 6c) | ______ |
| b. total annual charge per user (5e + 6e) | ______ |

[1] For single community projects the percentages in this Section would all be 100%.

# PART II

## DEVELOPMENT OF THE COMMUNITY'S FINANCIAL CHARACTERISTICS

## INSTRUCTIONS

Part II provides a format for calculating key ratios that you can use to measure the community's ability to pay for the proposed sewer project. It is largely based on the types of measures used by credit analysts to determine a community's ability to repay debt. It is useful here because most communities borrow their share of sewer project costs and because the ability to pay for a project is of major concern to lenders.

The table is set up so that two major types of local financing can be analyzed: use of the tax-supported (general obligation) bond of the user-charge (revenue) bond. If the community plans to borrow for its share using a general obligation bond, fill out Part II G.O. (page 5). If the community will use a revenue bond, fill out Part II REV. (page 6). If you are uncertain as to which type of debt will be used to finance the local share, check with the finance officer or local financial adviser. You should enter the appropriate numbers for the most recent year, both without the project and assuming the project goes ahead. For example, were the community to do the project, the added debt and other costs you incur will be included in the figures in the column labeled "With the Project."

Several sources of information may be needed to get the figures used in Part II. (See Attachment "A" Sources of Information.) Figures relating to debt, taxable property value, current expenditures, property taxes and collections, and sewer operations and charges (where relevant) should be obtainable from the municipal finance officer and/or the sewer department or sanitary district. Information on population and income may be gotten from the municipal planning department, engineering consultant preparing the project, local economic development agency, or the U.S. Census. In all cases, attempt to use the most recent numbers available. Be prepared to make estimates of some recent values so that all numbers are for the same period, if at all possible.

## PART II GENERAL OBLIGATION
## WATER POLLUTION CONTROL PROJECT ANALYSIS WORKSHEET

Development of the Community's Financial Characteristics (with and without the project)

| Financial Characteristics[1] | Without the Project Value | Without the Project Ratio | With the Project Value | With the Project Ratio |
|---|---|---|---|---|
| I. Population Change (annual rate of growth for the last 5-10 years) % change | | | | |
| II. Net Direct Debt/Full Taxable Market Value | | | | |
| A. Net Direct Debt | | | | |
| 1. general obligation (tax supported) debt | | | | |
| 2. other direct (non-tax-supported) debt | | | | |
| 3. gross direct debt (1+2) | | | | |
| 4. offsets and deductions (self-supporting) | | | | |
| 5. net direct debt (3-4) | | | | |
| B. Full Taxable Market Value of Real Estate | | | | |
| III. Overall Local Debt/Full Taxable Market Value | | | | |
| A. Overall Local Debt | | | | |
| 1. net direct debt (from above) | | | | |
| 2. overlapping (net) debt | | | | |
| 3. overall local debt (1+2) | | | | |
| B. Full Taxable Market Value of Real Estate | | | | |
| IV. Net Direct Debt/Personal Income | | | | |
| A. Net Direct Debt (from above) | | | | |
| B. Total Personal Income of Community | | | | |
| V. Overall Local Debt/Personal Income | | | | |
| A. Overall Local Debt (from above) | | | | |
| B. Total Personal Income of Community | | | | |
| VI. Surplus/Total Current Expenditures | | | | |
| A. Operating Surplus | | | | |
| 1. total current revenue | | | | |
| 2. total current expenditures | | | | |
| 3. operating surplus (1-2) | | | | |
| B. Total Current Expenditures | | | | |
| VII. Overall Local Property Tax/Full Market Value | | | | |
| A. Overall Local Property Tax (current year) | | | | |
| B. Full Taxable Market Value (from above) | | | | |
| VIII. Property Tax Collection Rate | | | | |
| A. Property Tax Collections (current year) | | | | |
| B. Property Tax Levy (current year) | | | | |
| IX. Annual Sewer Charge/Median Household Income | | | | |
| A. Annual Sewage Charge (from section 6e and 7b of Part I Worksheet) | | | | |
| B. Median Household Income | | | | |
| X. Bond Rating (outstanding bonds of jurisdiction) | | | | |
| XI. Percent of Long-Term Debt Due in Five Years | | | | |
| A. Debt Due in Five Years | | | | |
| B. Outstanding Direct Debt | | | | |

[1] Typical sources of data and a glossary of terms are appended to these worksheets as Attachment "A" and "B".

REV.

## PART II REVENUE BOND

## WATER POLLUTION CONTROL PROJECT ANALYSIS WORKSHEET

Development of the Community's Financial Characteristics (with and without the project)

| Financial Characteristics[1] | Without the Project Value | Without the Project Ratio | With the Project Value | With the Project Ratio |
|---|---|---|---|---|
| I. Population Change (annual rate of growth for the last 5-10 years) % change | | ____ | | ____ |
| II. Overall Local Debt/Personal Income | | | | |
| A. Overall Local Debt (from above) | ____ | ____ | ____ | ____ |
| B. Total Personal Income of Community | ____ | | ____ | |
| III. Overall Local Debt/Full Taxable Market Value | | | | |
| A. Overall Local Debt | | | | |
| 1. net direct debt | ____ | | ____ | |
| 2. overlapping (net) debt | ____ | | ____ | |
| 3. overall local debt (1+2) | ____ | ____ | ____ | ____ |
| B. Full Taxable Market Value of Real Estate | ____ | | ____ | |
| IV. Annual Sewer Charge/Median Household Income | | | | |
| A. Annual Sewage Charge (from section 6e and 7b of Part I Worksheet) | ____ | ____ | ____ | ____ |
| B. Median Household Income | ____ | | ____ | |
| V. Net Sewer Operating Fund Income/Debt Service | | | | |
| A. Net Operating Income | | | | |
| 1. operating revenue | ____ | | ____ | |
| 2. operating and maintenance expenses | ____ | | ____ | |
| 3. net operating income (1-2) | ____ | ____ | ____ | ____ |
| B. Debt Service | ____ | | ____ | |
| VI. Rating (outstanding bonds of jurisdiction) | | ____ | | ____ |
| VII. Percent of Long-Term Debt Due in Five Years | | | | |
| A. Debt Due in Five Years | ____ | ____ | ____ | ____ |
| B. Outstanding Direct Debt | ____ | | ____ | |

[1] Typical sources of data and a glossary of terms are appended to these worksheets as Attachments "A" and "B."

# PART III

## ANALYSIS OF THE COMMUNITY'S ABILITY TO SUPPORT THE PROJECT

### INSTRUCTIONS

Part III presents the key items that lend themselves to quantification and the establishment of general characteristics of the strength and weakness of a community's financial ability. The analysis is constructed so as to indicate the values that will tend to be associated with strong credit quality and weak credit quality.

The worksheet in Part III is designed to help you compare a community's key ratio values as calculated on Part II with the "weak" and "strong" values for that characteristic. You should enter the ratios as calculated in the with the project column of Part II, in order to see how the project will affect the community's ratios if the project is done. (However, it may also be helpful to review the ratio values without the project in order to determine the degree to which the ratios are influenced by doing the project.)

Depending on the characteristic in question, values for the with the project analysis lying to the left of the "strong" value (or the right of the "weak" value) given will be considered as strong or weak in that characteristic. Values lying between the two values will be seen as not being necessarily strong or weak, but most likely "average".

G.O.

PART III

GENERAL OBLIGATION BONDS

| RATIO: | QUALITY CHARACTERISTICS | COMMUNITY'S RATIO OR VALUE[1] | CHECK WHERE YOUR VALUE FALLS:[3] STRONG | IN BETWEEN | WEAK |
|---|---|---|---|---|---|
| I | Population Change (annual rate for next 5 to 10 years) | ______ | Above 1% ____ | 1 to -1% ____ | Below -1% ____ |
| II | Net Direct Debt/Full Market Value of Taxable Property | ______ | Below 2% ____ | 2 to 6% ____ | Above 6% ____ |
| III | Overall Local Debt/Full Market Value of Taxable Property | ______ | Below 4% ____ | 4 to 8% ____ | Above 8% ____ |
| IV | Net Direct Debt/Personal Income | ______ | Below 5% ____ | 5 to 15% ____ | Above 15% ____ |
| V | Overall Local Debt/Personal Income | ______ | Below 10% ____ | 10 to 20% ____ | Above 20% ____ |
| VI | Operating Surplus/Total Current Expenditures[2] | ______ | Above 5% ____ | 5 to 0% ____ | Below 0% ____ |
| VII | Overall Local Property Tax Rate/Full Market Value | ______ | Below 2% ____ | 2 to 5% ____ | Above 5% ____ |
| VIII | Property Tax Collection Rate | ______ | Above 98% ____ | 98 to 96% ____ | Below 96% ____ |
| IX | Annual Sewer Charge/Median Family Income | ______ | Below 1% ____ | 1 to 2% ____ | Above 2% ____ |
| X | Rating (Outstanding Bonds of Jurisdiction) | ______ | Aa or Above ____ | A ____ | Baa or Below ____ |
| XI | Percent of Debt Due in 5 Years | ______ | Above 30% ____ | 30 to 10% ____ | Below 10% ____ |
| | TOTAL CHECKS | | ______ | ______ | ______ |

[1] Ratios and Values with the project from page 5 for General Obligation.

[2] Please indicate if there is a liability for payments to a pension program and the current status of those payments.

[3] The values shown form extreme parameters beyond which a particular credit characteristic value would in most cases be seen as "weak" or "strong." These values are subject to high degrees of local and regional variation.

REV.

## PART III
## REVENUE BONDS

| RATIO: | QUALITY CHARACTERISTICS | COMMUNITY'S RATIO OR VALUE[1] | CHECK WHERE YOUR VALUE FALLS:[2] STRONG | IN BETWEEN | WEAK |
|---|---|---|---|---|---|
| I | Population Change | ______ | Above 1% ____ | 1 to 1% ____ | Below -1% ____ |
| II | Overall Local Debt/Personal Income | ______ | Below 10% ____ | 10 to 20% ____ | Above 20% ____ |
| III | Overall Local Debt/Full Taxable Market Value | ______ | Below 4% ____ | 4 to 8% ____ | Above 8% ____ |
| IV | Annual Sewer Charge/Median Family Income | ______ | Below 1% ____ | 1 to 2% ____ | Above 2% ____ |
| V | Net Sewer Fund Operating Income/Debt Service | ______ | Above 200% ____ | 200 to 110% ____ | Below 110% ____ |
| VI | Rating — (Outstanding Bonds of Jurisdiction) | ______ | Aa or Above ____ | A ____ | Baa or Below ____ |
| VII | Percent of Long-term Debt Due in Five Years | ______ | Above 30% ____ | 30% to 10% ____ | Below 10% ____ |
| | TOTAL CHECKS | | ____ | ____ | ____ |

[1] Ratios and Values with the project from page 6.

[2] The values shown form extreme parameters beyond which a particular credit characteristic value would in most cases be seen as "weak" or "strong". These values are subject to high degrees of local and regional variation.

Three important considerations must be underscored:

(1) The values of characteristics shown are subject to regional variations. Certain characteristic values that might have been seen as "average" in some areas would be considered as "strong" or "weak" in other settings. The intervals between the two benchmarks are broad enough to overcome most of this problem, but attention must be given to local and regional situations.

(2) Weakness in some characteristics may be offset by strengths in others, or there may be special circumstances. What must be looked for is a systematic pattern — a syndrome — of weaknesses or strengths.

(3) The quantitative analysis is no better than the basic data used to develop the ratios. Collection of reliable and up-to-date data can be difficult and estimates may have to be used to fill in the gaps.

Reviewing the twelve items in part II, 11 characteristics relate to general obligation debt analysis and 7 are typically of use in revenue bond analysis. Of these, when any three or more exhibit a "weak" value, evidence trends toward "weak" values, or where several cluster in the vicinity of "weak" values, the community can be expected to have or to anticipate difficulties in supporting the proposed project. Of course, many additional problem areas might surface in the course of an examination and these need to be weighed in consideration.

Communities that determine that a proposed project will result in excessive burden to its residents should:

- Review the adequacy and accuracy of the cost-effective analysis, particularly noting whether all the feasible alternatives have been considered and if the cost estimates are reasonable.
- Review the method of financing the local share and whether all the sources of supplemental funding such as the following had been sought out.

  Farmers Home Administration
  Assistance funds from the State
  Other grant sources (HUD, EDA, CSA, ARC, etc.)

- Review effluent requirements with state and EPA representatives to determine if a discharge variance could be obtained.

*Attachment A*

## SOURCES OF INFORMATION

| TYPE OF INFORMATION | RESPONSIBLE PARTIES | TYPICAL PUBLICATIONS |
|---|---|---|
| Population, personal income, family income | Local, county, or state planning departments; economic & community development districts; U.S. Census Bureau; state department of community affairs | Sub-state current population and income reports, local economic planning documents, and statistical reports |
| Information on existing and proposed sewer system project (capital costs, future operating costs) | Local or regional project management agency, local sewer departments, districts, or authorities | Sewer agreements, engineer feasibility studies, or financial analyses of projects |
| Local government financial information (property values, revenues, expenditures, debt, etc.) | Local or county finance officers, treasurers, town accountants or clerks. Local bankers or financial advisers | Local government budgets, financial statements, or annual reports |

Attachment B

## GLOSSARY OF FINANCIAL TERMS

Assets: Property owned by a goverment which has monetary value.

Balance Sheet: A statement presenting the financial position of an entity by disclosing the value of its assets, liabilities, and equities as of a specified date.

Bond: A written promise to pay (debt) a specified sum of money (called principal) at a specified future date (called the maturity date(s)) along with periodic payments at a specified percentage of the principal (interest rate).

Bond Rating: Letter designations used by credit rating agencies (Moody's and Standard & Poor's) to indicate relative credit quality of security (Moody's ratings from highest quality to lowest (Aaa, Aa, A, Baa, B (highly speculative), and C (default)).

Budget: A plan of financial operation giving an estimate of proposed expenditures for a given period (typically a fiscal year) and the proposed means of financing them (revenue estimates).

Capital Assets: Assets of significant value and having a useful life of several years. Capital assets are also fixed assets.

Capital Budget: A plan of proposed capital expenditures and the means of financing them. The capital budget is usually enacted as part of the complete annual budget which includes both operating and capital outlays.

Debt Service: Payment of interest and repayment of principal to holders of a government's debt instruments.

Deficit: (1) The excess of an entity's liabilities over its assets (See Fund Balance). (2) The excess of expenditures or expenses over revenues during a single accounting period.

Direct Debt: Debt which a government has incurred in its own name and relying on its own tax or other resources for repayment.

Expenditures: Depending on the type of accounting system used, either cash payments for goods received or services rendered, or the cost of such goods and services, whether cash payments have been made or not.

General Obligation Bonds: When a government pledges its full faith and credit and taxing power. Informally, to the repayment of the bonds it issues, the term is also to refer to bonds which are tax-supported, being repaid from taxes and other general revenues.

Household: As defined by the U.S. Census, a household consists of all the persons who occupy a housing unit. It includes related family members, unrelated persons such as lodgers, foster children, wards, or employees who share the housing unit, a person living alone, or a group of unrelated persons sharing a housing unit as partners. (Households include families.)

Liability: Debt or other legal obligations arising out of past transactions.

Long-Term Debt: Debt that is due with a maturity of more than 1 year.

Maturities: The dates on which the principal of debt obligations come due for payment.

Median Household Income: As defined by the U.S. Census, the total money income of a household that lies in the middle of the distribution of all household incomes (half of the households receive more and half receive less).

Net Direct Debt: General obligation (tax-supported debt) minus debt that is self-supporting (non-tax supported debt).

Attachment B-2

Non-tax-supported Debt: Debt that is repaid from sources other than general taxes of a jurisdiction and are not backed by its full taxing powers. (See revenue bond.)

Operating Surplus (or Deficit): The difference between current expenditure and current receipts during an accounting period (usually a year).

Overlapping Direct Debt: The proportionate share of debt of local governments whose boundaries overlap the unit in question. Usually calculated where several governments show a common tax base, such as counties, towns, and school districts that levy property taxes.

Personal Income: Total money income of residents as defined by U.S. Census. Total income from community is the per capita income multiplied by the total population of the community.

Property Tax Collection Rate: The percentage of the property tax year.

Reserve: An account used to indicate that assets are legally restricted for a specific purpose.

Revenue: The term generally represents current receipts from taxes, charges, and other proceeds from current operations.

Revenue (Limited Liability) Bonds: Bonds which do not pledge the full faith credit and taxing power of the jurisdiction. Typically, pledges are made to dedicate one specific revenue source to repay these bonds. Although some revenue bonds are based on special taxes, most are secured by fees and charges of an enterprise and, thus, are formally called "non-tax-supported debt."

Tax Rate: The percentage rate at which a municipality levies a tax.

True Value of Taxable Property: The market value of all real property within a jurisdiction that is subject to an ad-valorem property tax. Not to be confused with the assessed property value which is the legal value at which properties are assessed for tax-paying properties and often is only a fraction of the true value.

Tax-supported Debt: Debt that is repaid from the general taxes of a jurisdiction and is backed by its full taxing power (see general obligation bond).