

WASTEWATER DISPOSAL PLANNING AND THE SOCIETAL MATRIX

By
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Introduction

The problem of determining an optimum engineered solution to sanitary waste disposal in an unsewered community is often very difficult. The designer is confronted with legislation from many levels of government, residents increasingly inclined to criticize and reject proposals, the need for cost control in public works; and from state and federal agencies, pressures upon client communities for decisive action. In addition to those non-engineering complications, there is the continual evolution in the state-of-the-art. (1,2) Even if not germane to a project, an engineer will likely have to field questions at public hearings about composting toilets, grey water separation, rotating biological contactors, septage treatment, sludge composting and many other subjects now increasingly on the minds of people suspicious of the engineer and his level of knowledge.

This paper presents arguments to support the proposition that additional emphasis must be directed toward optimization of design with due regard to secondary effects on the structure of society if a new system of wastewater disposal is considered. These secondary effects within a community are herein called the "societal matrix". Some examples for a community in Massachusetts will be considered by way of illustration.

No formula is proposed by which the design engineer can hope to ease the travail of completing a design study. However, it is believed that understanding the concept put forth will aid the engineer by sensitizing him to issues likely to surface during the period of public consideration of the engineer's proposal.

General Background

Our thinking on how best to dispose of nightsoil has had several stages of historical development. In medieval Europe it was often thrown into the street where it could mix with stock wastes and, everyone must have hoped, could be washed away in the runoff whenever it rained.

The privy, when it became generally adopted, was much better. Periodically the pit would have to be cleaned. The nightsoil would be loaded into a wagon which would then take it somewhere, often to a farm field, for disposal. In cities the privy became rather elaborate. Multi-storied tenements would have them arranged off the back porch at each level. The wastes would drop via wooden chutes to a hopper below.

As our society changed over to indoor plumbing, it was natural to connect

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the house sanitary drains to the storm sewer. In urban areas horses, mules, donkeys and oxen were the source of motive power, so there was already a strong waste with high solids content to be carried by the storm sewers whenever there was runoff. The contribution from households was relatively insignificant both hydraulically and as a percentage of solids that might collect during low flow.

It is noteworthy that when these early technological advances in waste disposal were taking place, most persons were unaware of the possibility of contamination and disease from human waste. Thus, it appeared logical and certainly most economical to develop a common water carriage disposal system carrying through to the end of the local storm sewer and discharging to a water course or body of water, which, unfortunately, might also serve as a source of domestic water. Some aesthetic problems developed at the end of the pipe, of course, but these were usually relatively local in scope, and part of the price of progress. As people became aware of the disease connection it was certainly easier and safer to purify the water than to correct matters at the source of pollution. Initially purification was by filtration*, later by disinfection by chlorination** as well. To attempt to clean up the flows to the combined sewers or at the outfall would have been a monumental task that, even if one hundred percent effective, would not have assured safety against disease in water supplies.

In the eighteen fifties and sixties as suburbia expanded, septic tank disposal systems proliferated. However, lack of control over siting, design, and density often resulted in high rates of failure. The result has been the evolution of a philosophy that argues for putting in sanitary sewers and treatment plants, thereby eliminating on-site problems. The current Federal Act, PL 95-217, The Clean Water Act of 1977, by the coercive influence of the massive state and federal subsidies it promises, has had the effect of making this approach a national campaign.

We have discovered that there are a few penalties that must be borne as the price of this campaign. In many cases, treated wastewater is released in such large amounts, and sufficiently burdened with nutrients that the water quality of the receiving waters deteriorates. The operation and maintenance costs of treatment plants are large and increasing.

It should be credited to the Environmental Protection Agency (EPA) that it has established an office for small flows. That office will be directing efforts at development of optimum treatment practices for single sources or small clusters of waste generating units.

One can see a pattern in the history of waste disposal: a consistent treatment of the problems by an expedient adequate to meet the immediate need for a solution, but without extensive consideration for effects beyond that.

Today, it is necessary to widen our thinking. We must plan from a more

*Filtration was practiced in some cases, as in Poughkeepsie, N.Y. in 1872,(3) before our awareness of the cause of water borne diseases was developed, to clarify turbid waters.

**Jersey City, N.J. in 1908 was the first municipality in the United States to use chlorine routinely to disinfect its water. Chloride of lime was the source of the chlorine.(4)

difficult perspective regarding our domestic wastewater disposal — a perspective that treats it as but one aspect of the interwoven structure of society.

The demand for prompt elimination of sources of pollution, and the availability of massive subsidies for the construction of many components of a sewerage system including a treatment facility, have generally had a strong impact upon the form of the final design. An additional influence has often been the source of the request for technical assistance. Usually it is a sewer commission or board, set up by a town in response to a rising volume of complaints about on-site waste disposal. Such a body will often phrase its request in such language as to clearly indicate that sewerage of the community is to be the subject studied. The final design recommendation put forth by the consultant under these conditions becomes, more often than not, a blueprint and timetable in which is set forth the starting dates, the scope of work, and the sequence of stages of development of a sewerage plan for the client community. Thus, because the designer is usually overly limited in what he is to study, the study process does not include adequate consideration of the greater societal matrix of which disposal of liquid sanitary waste is but one link.

Present Federal legislation and policy have tried to make some provision for this by requiring the "201 Facilities Plan, Step One" to consider alternatives to comprehensive sewerage; and "208 Areawide Wastewater Management Studies" to clarify the problems and potentials on an integrated, regional, multi-aspect basis. The 201 studies are to be harmonious with the output of the 208 reports.(5)

Any scheme for disposal of sanitary wastes involves and generates linkages between seemingly dissimilar, unrelated aspects of the functioning of our society. Sub-systems of all different types are interrelated and interdependent in a very complex way. Sanitary waste disposal is a sub-system concerned immediately with liquid waste generation, transportation, processing or stabilization, and disposal. It is not adequate to address this sub-system in vacuum.

Optimization of the proposal to develop one sub-system requires that it be looked at with due respect to the interactive points at which it is tied into the whole, through which the effect of internal change is transmitted. For example, it should be demonstrated that the interconnection between generation of liquid domestic sanitary waste and the impact upon the community water supply system have been carefully evaluated. Ignoring such a potentially significant effect while offering a supposedly optimum proposal would seriously flaw the logic of the proposal.

Because each community is unique, no universally applicable formulas can be prescribed by which the wastewater problems of a community can be cured or by which optimum facilities investments are assured.(6) This paper will merely try to offer some insights about where to look for the linkages, the interconnections, between the liquid waste disposal and other services.

The most important objective of the paper is to make the reader more aware of the importance of thinking in terms of the larger social situation

when faced with a specific societal problem. Such an approach is valid whatever the problem. An interesting case for purposes of discussion exists in a community in northeastern Massachusetts. Several engineering studies have been done on its sanitary wastewater disposal problem. There is governmental pressure being put on the town by EPA and the Massachusetts Division of Water Pollution Control to build treatment facilities.

Discussion Model

The following is a simplified model of that community. The town is at present involved in an intense controversy over sewerage. It offers a good model for discussion of the thesis of this paper because it seems to represent a typical situation. About twenty years ago the town consisted of several separated villages with country roads and scattered development along those country roads. (In 1950 the population was 9,000; in 1960, 15,100; in 1970, 31,400 and in 1977, 31,700). The housing densities, except in the village centers, were low, land was open; there was an abundance of it. There were, however, some problem areas even in the fifties. They weren't necessarily viewed at that time as being problem areas, at least not with as much feeling as today, but today we see by hindsight that even then they were. One of the problem areas is in the village closest to the Merrimack River. Several old mills, following the historic pattern typical throughout New England, have sewers and drains connecting directly to the river, or when not to the river, to the tributary stream upon which the mill is located. Locally generated domestic wastes are also conducted to these sewers, or to the storm sewers in the streets. Many of the homes in the area, not connected to the combined sewer, directed their wastewater to what we would frequently judge today to be an inadequate on-lot disposal system, i.e., a cesspool or small septic tank.

Another problem area in town is of more recent origin. It is in an area along a state route passing through the town center. Some of the development took place on land that was low. The not unexpected result is that improperly treated waste finds its way into the local water courses. Many of these water courses are not obvious in that area because they have been put underground in storm drains. However, where they emerge the distinctive odor of improperly treated wastewater can frequently be detected.

As development has progressed over the past years additional problem areas have arisen due to a variety of circumstances, one being the issuance of permits for on-site disposal on lots that had too high a water table for the kind of soil, and housing density, with the result that over the years the water table has been raised. Problems came about as these disposal systems became flooded. And finally there are the scattered situations where disposal systems have become obvious problems because of leach field effluent breakout. These units are located anywhere where the soil conditions are bad due to shallow bedrock or tight soil. Problems also arise from reasons not associated with lot size or regional high groundwater, such as improper design, or installation, or use.

This simplistic model of the town does not attempt to characterize all of the problem situations that face the town, but it is possible none the less to go on and use it as a means for discussing interrelationship, and to illustrate the complexity to be dealt with when trying to determine a solution or solutions for a similar community.

There are, in this example, four dissimilar situations. With such dissimilar conditions to contend with there is not likely to be a simple solution. However, it is worth considering singular solutions because they provide a basis for generating more complex solutions and serving as a base for later comparisons. One commonly pursued solution is to sewer the entire community and build whatever treatment facilities are necessary. This proposal should certainly cure the existing problems, dissimilar in origin or not. Another solution is for the town to adopt the head-in-the-sand, do-nothing approach, — evidently a least cost approach. This might well be preferred by the majority who do not have an immediate problem. Both of the approaches are extreme, and in the second case ignore state and federal statutes. Neither seems to be an optimum solution. Perhaps, however, some partial adoption of both might be a reasonable solution subject to upgrading in the future, i.e. sewer only part of the town.

Indeed, there are many more than two approaches which should be evaluated. The overall problem may involve a multitude of very different solutions; some of which at first glance appear to be uneconomical and even worse than no solution at all. Some might be not even applicable.

While the number of possible unique or unusual solutions that might be considered are many, a few of the more easily identified of these would be: (1) installation of a large sewerage system in the community with associated treatment facilities, (2) use of small area collection and treatment plants of diverse types serving a cluster of units where there is a small isolated problem, (3) the outright purchase and elimination of a waste generating unit where there is a continuous health hazard and no reasonable solution more cost effective for the community, (4) the implementation by the community of an ordinance requiring adoption of a program for periodic pumping of septic tank units so as to enhance or preserve the functioning capability of existing units, (5) municipal acquisition of on-lot systems including access and repair easements, and a municipal program for routine pumping and maintenance of all acquired systems with an appropriate annual service charge per unit, (6) support by the community health agency of installations of dry or composting waste disposal facilities, (7) education of homeowners in water use efficiency, (8) legislation banning high water consuming practices in general, or selectively in areas where there are problems, (9) the imposition of progressive water use rates which make it very uneconomical for individuals to over-consume.

Consideration of Societal Matrix

Up to this point the discussion has basically been traditional in that waste disposal problem situations and possible solutions have been the only topics

considered. We should now go on to look at a second, very important complementary aspect of any such study; i.e. a consideration of linkages between the waste generating units, the proposed solutions for wastewater disposal, and the other aspects of life in the community.

The first and most obvious interrelationship arises from the fact that the origin of most wastewater is the water distribution system. The prospect of a problem in the back yard because of excessive use of water tends to make consumers very careful not to aggravate the condition. Where a community disposal system is installed, the water use per capita or per dwelling unit typically goes up rather considerably. The water consumption prior to completion of sewers is said to have suffered from "use suppression".

A study conducted by the author of conditions in a community in Rhode Island gives a clear demonstration of "use suppression". In the early 1960's water use in one of the historic village centers averaged approximately 35 to 40 gallons per capita daily. This unusually low value was the result of the severe waste disposal restrictions that the local soil conditions imposed on the on-site disposal systems of the affected population, these systems being largely replacements for the privies of an earlier era. People in the same community located only a few blocks from this particular area, and who had what one might call normal water consumption rates, consumed on the order of 100 to 130 gallons per capita daily. Plans were made to sewer the problem area. The author does not know what the current water use is in that former problem area, but it is fair to assume that it must be at least up to the regional mean of about 110 gpcd rather than the suppressed 35 to 40 gpcd to which people were formerly accustomed.

Even in those cases where there had not been a conscious effort on the part of homeowners to conserve water, there is usually a considerable percentage increase in per capita consumption when sewers are installed, partly because of subsequent installation of washers, disposals, etc., and because many things that homeowners knew were unacceptable practices in the past, such as using water to flush grease and coffee grounds and other kitchen refuse down the sink and into the house drain, now become feasible. This fact is generally considered by engineers designing systems. They do not automatically base their flows on a linear extension of water use records when planning for sanitary sewers in previously unsewered areas. (Of course, areas already on combined or obsolete sewers usually have no use suppression and so will not show such a change in consumption.) Thus, the change in opportunity for disposal of additional waste products or alternative means of disposal often brings about an additional demand for potable water from the water supply.

Industry also responds to the installation of sewers. Initially, the plants already in town at the time of the installation may show no significant change. However, once a community is sewered, industries that produce large waste-water flows are now able to come in. As a result there may be the gradual appearance of new industry with higher water consumption patterns than had been expected prior to the installation of sewers.

Another linkage between sewerage and water supply is generated when provision of sewers makes construction of high density housing and industrial parks feasible. Also, when a new sewer services an area that had been, because of bedrock or water table situations, unsuitable for development with on-site disposal facilities, that land may suddenly become very developable. Thus, even with wetland zoning and other land use restrictions, a community suddenly finds an increase in its developable area as sewerage takes place. The impact on water demand, as the opportunities just mentioned are developed, can be dramatic. Therefore, in a community having very limited water sources, sources which are largely already dedicated, the impact of a sewerage program can be extremely traumatic. The cost of finding a water supply solution under those circumstances should be considered along with the cost of sewerage.

The last statements lead us to consider yet another area of profoundly important linkage, perhaps the most important of all: implications of a liquid waste disposal scheme for a community and long term community planning. The policy statement that a community undertakes when it is making its decision on a community liquid waste disposal scheme is a statement of growth policy, and it cannot be understood as anything but that. After all, the provision or the exclusion of sanitary sewers ordains to a great extent what the immediate and long term growth potential shall be in a given part of the community.

In a community that wants to articulate clearly that it wants to grow, to acquire industry, to increase its density, good planning will promote that objective by suggesting to the community that prior to the development period it must provide for sanitary sewers, adequate water distribution systems, fire department capability, and all the other public works bases upon which the growth of the community can take place. Once the growth begins, schools and other services will also be called for.

Not uncommonly a failure to duly consider the impact of constructing wastewater disposal facilities may lead to unexpected impacts upon surface and ground water sources of the community and upon the quality of these sources. An area with a high density of leach field disposal systems, pollution hazard aspects aside, experiences a significant amount of recharge of ground water. The additional ground water helps to maintain stream flow during periods of drought. Sewerage may thus appreciably alter low flow characteristics of streams, and the watertable.

The field of public health in the U.S. has come a long way since the 1900's when typhoid, cholera, dysentery and other enteric water borne diseases were common throughout all of the United States and the rest of the world. Until then, contaminated wastewater all too frequently was discharged into sources of municipal water supply, and the result was tragic. It should certainly not be thought that we can go backward and be more tolerant of unsafe conditions by permitting any increase in the potential for wastewater to contaminate our surface or groundwater supplies. Unfortunately, all too often in the recent past there has seemed to be the point of view taken that we

don't have to worry about these potential hazards any more because our water supplies go through treatment plants which are there to protect our health. It is only, or is largely, our inattention to the continued escape of pollutants into our aquatic environment that makes it so imperative that we have such extensive treatment facilities in so many towns. Because of the pollution loads that many water bodies carry, even treatment does not render the water aesthetically satisfactory for much of the year. Therefore, attention to the aspect called "ultimate disposal" similarly needs attention.

Implications of Sewering

To return more specifically to the given example, it is instructive to discuss relationships and potential ramifications to be considered with regard to sewerage in the model community. As noted earlier, community wastewater collection and treatment has been the only method of community controlled sanitary waste disposal endorsed by state and federal legislation, and thus eligible for state and federal subsidy for certain capital costs.

Sewering our model would be a very extensive public works project. One cost estimate is in the neighborhood of \$47 million, or almost \$1,500 per person. It should be understood that this is only the cost for sewerage. It is often argued that this is really not a large capital expenditure for a community because a large portion of the funds would be provided by state and federal sources. Such an argument is specious since those funds are collected from the community in taxes, both state and federal. But even where most of the capital cost of sewerage is paid for by non-local funds, there are other first costs which must be borne directly by the homeowners along the sewer lines. Among these are the tie-in costs which consist of two parts. The first is the cost of rerouting the house plumbing to the direction of the city sewer and installation and connection of the house drain from foundation to sewer. The second part of the tie-in cost is that associated with abandonment of the on-site system. In many communities it is required that abandoned tanks be pumped out and then filled with inert material. Usually an individual on a street being serviced by a sanitary sewer is not free to choose whether or not he will tie in; he is usually required to tie in by a certain date. He is, therefore, forced to expend his money for this, even if his system has been well maintained and is serviceable. The change-over costs may be several hundred dollars. (Exact values are not critical to this discussion.)

A very important question for citizens of the town to ask is who will be connected to sewers or served with sewers for the \$47 million, more or less, that will have to be paid. Will it be 100% of the citizens of the community or will it be a smaller portion smaller than that, perhaps 40%, 50%, or 60% of the population? If it is much less than 100%, the cost per person served becomes considerably more. The \$1,500 per capita assumed that everyone in the community would be served by the sewers. This is seldom the case no matter how densely the community is developed and how extensive the installation. If a proposed system is to serve part of a town, other questions arise: How

much will it cost to extend the service later? Where will the service be extended? When will it be extended? And, what will be the cost per user?

Finally, the economic analysis must include the salvage value of systems in the ground that are to be superseded by the installation of sewers. These systems have a rather high replacement value; many of them are functional and would remain functional for many years into the future. One must therefore consider the scrapping cost which may be approximated by estimating the percentage of life-time remaining and applying it to replacement cost. The actual cash value is a function of interest rates and there are several available ways of accounting for such worth. The value of abandoned units becomes a net liability for the community because it is impossible to salvage them.

Unfortunately, the first cost of a sewer system is only part of the annual cost that must be borne by the residents of a community. Perhaps the larger part of the total cost of having wastewater disposal by sewers and a treatment plant is the continuing operation and maintenance (O & M) cost. The O & M cost is very sensitive to the cost of energy; and many treatment processes are relatively energy intensive. For example, although the volumetric proportions of solids to liquids in raw sewage is much less than 1%, sludge processing typically is responsible for approximately 50% of the O & M cost of a wastewater treatment plant.(7)

There is another cost category that is not generally included in a sewerage study, but which must be considered when the plan to sewer is considered. It is the potential incremental cost for upgrading to achieve nutrient removal. Conventional treatment, that is, secondary treatment, while it removes most of the organic material from the wastewater stream, leaves the nutrients, the stimulants to aquatic plant and animal growth. All too often the reach of receiving water downstream from the point of discharge becomes a new site of pollution because of eutrophication of the receiving waters. The remedy may be for the community to install tertiary, or advanced wastewater treatment facilities. Such plants are very expensive. Costs for running a treatment process of this type may equal that of the secondary treatment that is typically installed as a first phase.

One last aspect remains with regard to consideration of sewers for a community such as the one used here for an example. It must be considered as soon as one agrees that linkages through the societal fabric are of potential significance. Unfortunately, it is largely outside of local control and hard to see fully, or unequivocally, even in the best of circumstances. It is the deliberate governmental practice of utilizing large public works expenditures to carry out social-welfare economic policies. Projects provide jobs; jobs are essential in a flourishing economy. Construction of sanitary sewers and wastewater treatment facilities provide a tremendous opportunity for the implementation of this policy. For the short term it cannot be denied that these projects will indeed succeed in putting people to work. Many of the alternatives offer much less opportunity for such economic stimulation.

Summary

The need to consider the "societal matrix" when planning for sanitary waste disposal in a community has been demonstrated by means of a simplified model of a community in Massachusetts. The significance of the decisions made with regard to wastewater disposal options, especially as it related to water supply and land use planning, has been shown.

It is suggested that proper planning for domestic wastewater disposal should consider several options and combinations. These options must be considered with due regard to total cost, including operation and maintenance, and costs of septic tank abandonment if called for. Major capital costs for other municipal activities likely to be impacted should be taken into account in addition to the wastewater facilities costs. Impacted activities would certainly include water supply, zoning, retail and other business, and growth policy and land use planning.

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