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INTERMEDIATE SEWERAGE: COST-EFFICIENT SEWERAGE

Albert M. Wright and Alex E. Bakalian

Hydraulic theory, advances in technology and satisfactory experience have provided the basis for modifications in the standards governing certain design parameters for conventional sewerage. These have led to a variety of sewerage systems that provide service levels similar to those of conventional sewerage at a fraction of the cost.

INTRODUCTION

In a previous Infrastructure Note (Water and Sanitation No. WS-3), two principal types of intermediate sanitation technologies were identified. Both were said to be lower in cost than conventional sewerage. In one type, the lower cost was attributed to certain physical devices installed within the sewerage system; in the other, it was attributed to modifications in the design standards applied to conventional sewerage. This Note deals with the second type of intermediate sanitation technologies.

BACKGROUND

The first separate sewerage system in the United States was built in Memphis, Tennessee in 1880. Since then, the design standards for conventional sewerage have remained substantially the same. Yet, there have been several attempts at modifying the standards that govern certain cost-sensitive design parameters, with the view to reducing costs. These design parameters include the following:

- **minimum depth** (or minimum cover)
- **minimum slopes**
- **minimum diameter**
- **spacing and location of manholes**
- **connections between house sewers and laterals or street sewers**

The minimum depths and slopes significantly influence the extent to which the average depth can be reduced; the minimum diameter affects the magnitude of the average diameter of the laterals, which can account for up to 80 percent of the pipes in a sewerage system; manhole spacing determines the number of manholes, which account for up to 25 percent of sewerage costs; and the way in which house connections are made affects the overall length of the sewer system.

The work on changes in design standards has been mostly uncoordinated and aimed at addressing specific local problems; but it has led to lower-cost alternatives to conventional sewerage that are similar to one another. These alternatives have been justified on the basis of hydraulic theory, advances in technology, satisfactory experience, and acceptable risk. Examples of such intermediate sanitation systems are flat grade sewerage systems, shallow sewerage and simplified sewerage.

FLAT GRADE SEWERAGE

Flat grade sewerage is based on modifications in the design standards affecting only the **minimum** slopes and the minimum diameter. It allows for flatter minimum slopes than is permissible for conventional sewerage; and it permits the use of laterals with a minimum diameter of 6 inches instead of the conventional minimum of 8 inches. It was developed in Nebraska (USA) some 70 years ago because it was found that adherence to the conventional standards for minimum slopes in the prevailing flat terrain led to deep excavations and a frequent need for pumping stations; both these consequences were prevented through the use of flat grade sewerage and resulted in savings not only in construction costs but also in operation and maintenance costs. In several places, construction below the groundwater table was also averted and resulted in further savings by avoiding dewatering operations.

The use of flat grade sewerage has been justified on theoretical grounds and on the basis of satisfactory experience. Under conditions where sewers would not run full at peak flow (such as the upper reaches of sewerage systems), 6-inch diameter sewers can be shown to perform better than 8-inch diameter sewers at all slopes; and, contrary to conventional wisdom, the experience of the past 70 to 80 years in Nebraska, coupled with the more recent experience in Missouri, indicates that they do not require noticeably more maintenance than conventional sewerage.

SHALLOW SEWERAGE

The distinctive feature of shallow sewerage is not its shallowness (*all* intermediate sewerage systems are shallow!); it is rather the way in which sewer connections are made within blocks of houses. In conventional sewerage, each house or property is independently connected to the public sewerage system. But in shallow sewerage, it is the block of houses rather than the individual house itself that is connected to the public sewer system. Shallow, small diameter sewers laid at flat gradients run through backyards, passing through private properties as they receive flows from short lengths of house connections, as illustrated in Figure 1. This results in savings in overall lengths of sewers; but it involves the risk that a blockage in a downstream house sewer may affect upstream houses.

For small systems, the waste from one or more blocks can be discharged directly to a treatment facility like an upflow anaerobic sludge bed reactor. But for larger systems, the waste can be discharged into a conventional or simplified sewerage system, or into a solids-free sewerage system through a communal solids interceptor tank.

Shallow sewerage applies only to the design of sewer networks within blocks of houses. It is suitable for middle and, particularly, low income high density residential areas; it has been used in a number cities and towns in such Northeastern Brazilian states as Pernambuco, Rio Grande do Norte, Ceara, and Sergipe; it has also been used in Orangi, Pakistan, and PDR Yemen, where it is known as sweeper passage sewerage. The key to its successful application lies in strong community organization and participation, because it requires a high degree of interaction with the beneficiaries in its planning and implementation. Cost savings and operational requirements are similar to those for simplified sewerage.

SIMPLIFIED SEWERAGE

Simplified sewerage may be viewed as the general case of intermediate sanitation systems based on modifications of the design standards for conventional sewerage; (both flat grade sewerage and shallow sewerage are, essentially, special cases of simplified sewerage). It is the outcome of changes in the standards for several design parameters, including the standards for minimum depth, minimum slopes, minimum diameters and the spacing (and location) of manholes. In addition, it involves design periods that are considerably shortened. The result is a lower cost sewerage system with **smaller, shallower, and flatter sewers which have fewer manholes or cleanouts.**

The modifications in design standards have been justified on various grounds. Thus, theoretical considerations and satisfactory experience provide the basis for the reduction of the minimum diameter from 200 millimeters or 150 millimeters to 100 millimeters. Shallow sewerage has been justified because, in addition to the absence of risk from frost damage in places where simplified sewerage has been used, changes in design practice have been adopted under which sewers are located away from traffic loads (on sidewalks); moreover, there is no requirement that sewers be connected to basements or cellars. Furthermore, the use of simpler and fewer manholes spaced at longer intervals has been justified on several grounds: for instance, experience has shown that the vast majority of manholes are never opened; moreover, modern hydraulic and mechanical sewer cleansing equipment can be used to clean long lengths of sewers from one point; this has rendered obsolete the conventional standards for manhole design and spacing that have remained the same as they were 100 years ago when they were fixed on the basis of the length of manual sewer cleaning rods available at that time.

Simplified sewerage was developed and first implemented in Brazil, especially in the state of Sao Paulo (where they have been used in about 100 projects) and also in the state of Parana. They have been applied in such other Latin American countries as Bolivia (Cochabamba and Oruro), Colombia (Bogota and Cartegena), and Cuba (Matanzas). They are also being used in subprojects being proposed for funding under a current World Bank loan in Brazil, "Water Sector Project for Low-Income Areas and Municipalities."

A limited survey shows that they have been used for populations ranging from 2,000 to 400,000. Cost savings range from 20 percent to 50 percent of conventional sewerage costs.

COST-EFFICIENT SEWERAGE

Intermediate sanitation technologies have been defined as those sanitation technologies whose costs and levels of service fall in between those of conventional sewerage and on-site sanitation. But this review would indicate that it is only their costs that are intermediate between conventional sewerage and on-site sanitation, and that there is no evidence from experience or theory that any of them, with the possible exception of shallow sewerage, is likely to provide a level of service lower than is attainable with conventional sewerage. On the contrary, from the standpoint of cost or carrying capacity, they are a more efficient system. It may therefore be inappropriate to denote them as "intermediate sanitation" because of possible misleading connotations; instead, they may be denoted as "cost-efficient sewerage," which may be defined as a sewerage system which provides a similar level of service as conventional sewerage at a lower cost.

ONGOING INUWS WORK

INUWS is collaborating with the Environmental Protection Agency of the United States to review the U.S. experience with cost-efficient sewerage. In addition, independent work is underway in INUWS on experience with such technologies in other countries, particularly, in Latin America, Australia and Africa. The results will be summarized in publications that will provide information on the design and construction costs of these technologies.

To Learn More

1. *Gakenheimer, R. and C.H.J. Brando, "Infrastructure Standards" in "Shelter and Development", edited by Lloyd Rodwin, Allen and Unwin Publishers, Boston, 1984.*

2. *Sinnatamby, G., D. Mara, and M. McGarry, "Shallow Systems Offer Hope to Slums", World Water, January, 1986.*

3. *United Nations Centre for Human Settlements (HABITAT), "The Design of Shallow Sewer Systems", Nairobi, Kenya, 1986.*

4. *Gidley, J.S., "Case Study Number 11: Ericson, Nebraska Flat Grade Sewers", Small Flows Clearing House, West Virginia University, September, 1987.*

5. *Australian Water Resources Council, "Low-Cost Sewerage Options Study", Water Management Series, No. 14, Canberra, 1988.*

6. *Companhia de Saneamento Basico do Estado de Sao Paulo (SABESP), "Aperfeicoamento de Projectos Hidraulicos--Sistemas de esgotos Sanitarios", February, 1989.*

For further information, contact Albert Wright (ext. 32705) or Alex Bakalian (ext. 38427).

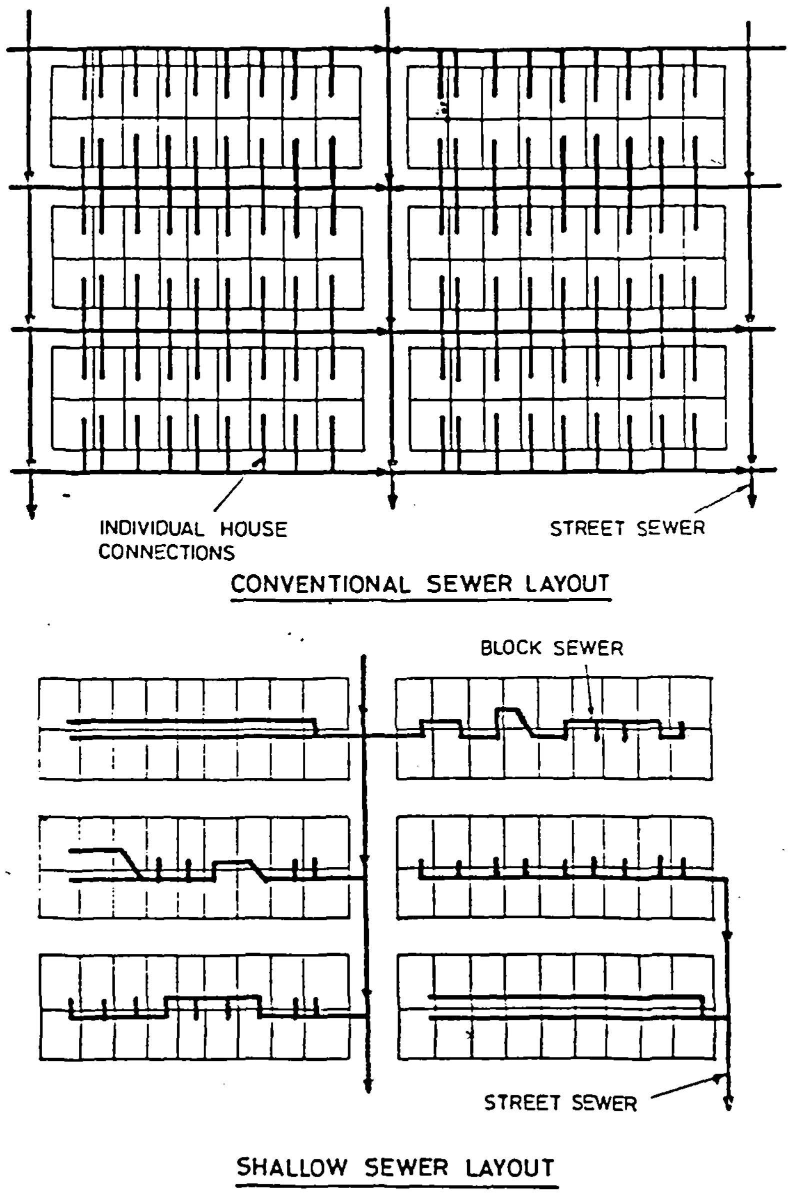

Figure 1. Schematic layout of conventional and shallow sewer systems

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Source: J.C.R. de Melo, "Sistemas condominais de esgotos" Engenharia Sanitaria (Rio de Janeiro), vol.24, No.2, (April-June 1985), pp 237-338.