Water for the World

Designing Sewer Systems
Technical Note No. SAN. 2.D.4

A sewer system is a network of underground pipes that carries sewage by gravity flow from a number of dwellings. The sewage may be a direct flow of wastewater from water-flushed sanitary facilities or the effluent of settled sewage from septic tanks or aqua privies. It flows to a stabilization pond or other central treatment facility. Designing a sewer system requires the services of an experienced engineer and surveyor. Designing involves making precise field measurements of distance and elevation; determining the position, grade, and lengths of pipelines; and determining labor, materials, and tools needed for construction. The end-products of the design process are precise maps and profile drawings, and a detailed materials list.

This technical note describes the elements involved in designing a sewer system. It does not attempt to explain everything needed to design a sewer system.

Useful Definitions

BASE POINT - A point of reference from which all other points are measured.

EFFLUENT - Settled sewage.

GRAVITY FLOW - Flow of water from high ground to low by natural forces.

INVERT - The inside bottom of a pipe; that is the pipe's lowest inside surface.

Materials Needed

Survey equipment - To obtain precise field information.

Drafting equipment - To produce accurate maps and profile drawings.

Manufacturer's list of pipe and fittings - To refer to during the design process and to prepare cost estimates.

Steps in Design

One method of designing a sewer system leading to a stabilization pond is to follow these five steps:

1. Obtain an accurate contour map of the area to be served. The map must show all houses and buildings, roads, streams, trees, other prominent features, and the proposed site for the stabilization pond. See "Designing Stabilization Ponds," SAN.2.D.5. If such a map is unavailable, one will have to be produced. This will require a survey of the area. The survey generally begins at a base point established near the outlet of the sewer system which is the inlet of the stabilization pond. The base point is assigned an arbitrary elevation, such as 100m and all elevations and distances are measured from it. See Figure 1.

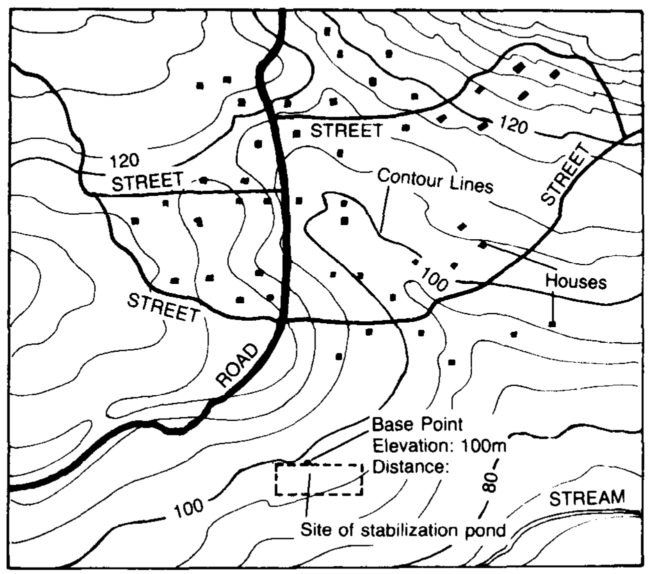

Figure 1. Contour Map

2. Pencil in the proposed sewer lines on the contour map. There are basically three types of sewer lines. The main line runs through the center of the system. All lines empty into it and it empties into the stabilization pond. Main lines generally have a pipe diameter of 200-300mm. Branch lines extend from the main line much like branches from the truck of a tree. The sewage from one or more buildings empties into a branch line which usually has a diameter of 100mm. House laterals, usually 100mm in diameter, carry sewage from a single septic tank to a branch line. All sewer pipes are laid out in straight lines wherever possible and generally meet at right angles. The connection may be curved to ease the flow from the branch to the main.

3. Draw profile sections of the ground line for the sewer main line and branches. This may or may not require more field measurement, depending on the degree of detail on the contour map. See Figure 2.

4. Draw the sewer lines on the profile sections. House laterals slope down to branches, branches slope down to the main line, and the main line slopes down to the stabilization pond. All should have slopes of between 1 in 100 and 1 in 300. Sewer pipes are designed to have a minimum depth of about 0.6m and a maximum depth based on practical construction considerations. The invert elevations along the pipelines and at all pipe intersections are written on the section drawings, along with pipeline lengths and diameters.

5. There are stoppages and failures in sewers. Therefore, there must be access to them to allow inspection and repair. Manholes provide the entrance from the ground surface to the sewer. See Figure 3. On main lines, there must be manholes spaced 100-150m apart. Manhole construction requires skill. The cover, whether concrete or cast iron, must be carefully fitted. Branch lines require only clean-outs. When distances are less than 50m, longer branches require manholes. Figure 4 shows one way to provide a clean-out.

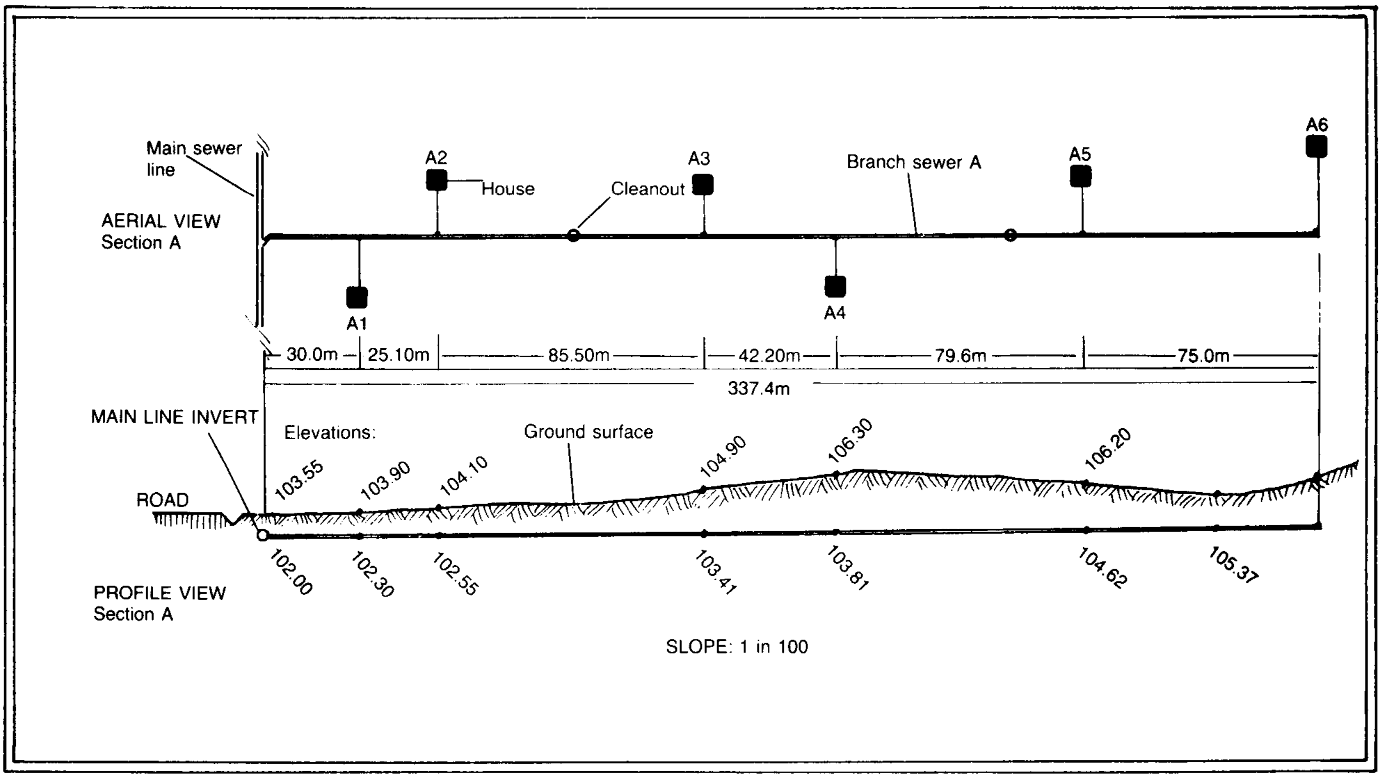

Figure 2. Section Drawing

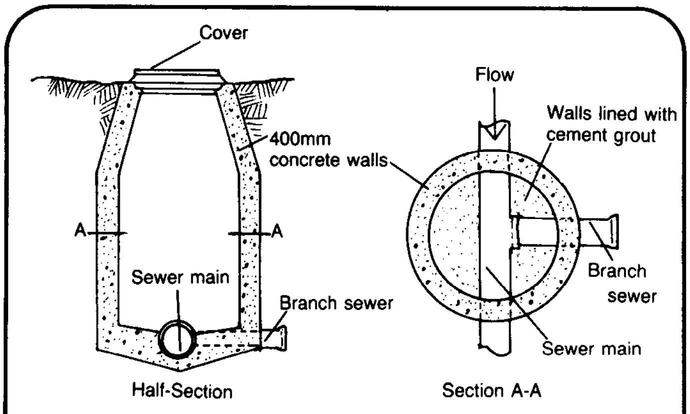

Figure 3. Manhole

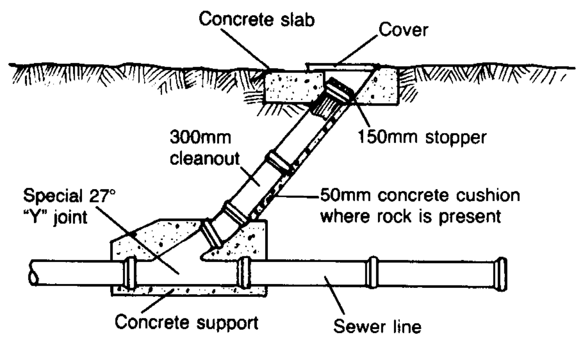

Figure 4. Standard Cleanout

6. Produce a master map of the entire sewer system showing all distances and invert elevations. Or, add the distances and elevations to the contour map so that it becomes the master map. See Figure 5.

Give these maps and drawings to the construction foreman before construction begins.

Determining Labor, Materials, and Tools

The primary labor requirement is a construction foreman with experience in large-scale projects, preferably in sewer construction or water pipeline installation. Because field conditions and constuction practices vary widely from region to region, the construction foreman should be involved in determining the requirements for labor, tools, and equipment.

A surveyor will be needed to make sure the sewer pipe is exactly placed. Because of the amount of work involved and the time required, possibly a number of weeks or months, a fairly large and reliable work force of five to 20 or more people is needed. Most of the work, such as digging trenches, spreading gravel, and laying pipe, requires little or no skill. Some workers should be skilled in carpentry so they can build sheeting and bracing to shore the trench sides, and one or more should be experienced with cement mortar which will be needed for some or all pipe connections.

The major materials cost will be for sewer pipe and fittings. The lengths of pipe of each diameter and the number of fittings needed can be determined from the profile drawings. When ordering pipe lengths, increase the order by 5-10 percent to allow for damage during construction and for future repairs.

A partial list of other materials and tools needed appears in Table 1. A list of this type must be given to the construction foreman before construction begins.

In summary, detailed maps, section profiles, and a materials list must be given to the construction foreman.

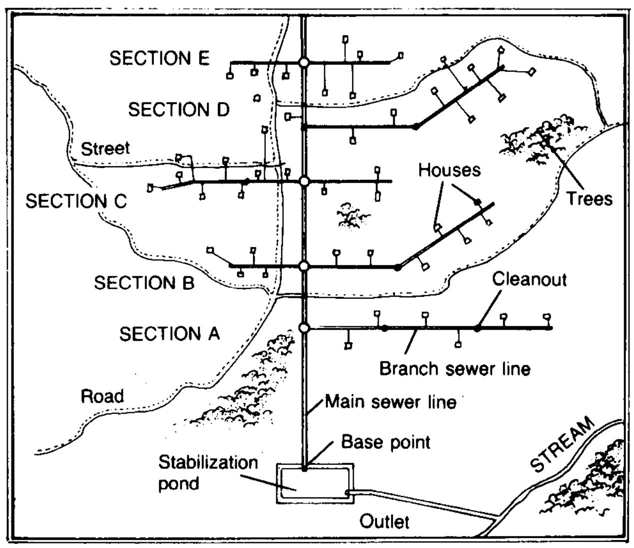

Figure 5. Master Sewer System Map

Table 1. Sample Materials List

Item	Description	Quantity	Estimated Cost
Labor	Construction foreman, experienced with large-scale projects	1	____
	Surveyor	1	____
	Worker, skilled with carpentry	1	____
	Worker, skilled with concrete mortar	1	____
	Workers, unskilled	12	____
Supplies	Sewer pipe; 200mm diameter	____	____
	Sewer pipe; 100mm diameter	____	____
	"T" fittings; 100-200mm	____	____
	Other fittings	____	____
	Gravel	____	____
	Mortar mix	____	____
	Wooden stakes	____	____
	Wood for shoring	____	____
	Nails (double-head and standard)	____	____
Equipment and Tools	Surveyor's transit	1	____
	Surveyor's level	1	____
	Grade rods	2	____
	Pipe sling for lowering pipe into trench	2	____
	Heavy chains or ropes for lowering pipes	2	____
	Shovels	12	____
	Picks	4	____
	Mattocks	2	____
	Pry bars	2	____
	Hammers	4	____
	Saws	2	____
	Sledgehammer	1	____
	Trowels	2	____
	Hoes	2	____
	Wheelbarrows	2	____
	Barricades	6	____

Total Estimated Cost = ____

Technical Notes are part of a set of "Water for the World" materials produced under contract to the U.S. Agency for International Development by National Demonstration Water Project, Institute for Rural Water, and National Environmental Health Association. Artwork was done by Redwing Art Service. Technical Notes are intended to provide assistance to a broad range of people with field responsibility for village water supply and sanitation projects in the developing nations. For more detail on the purpose, organization and suggestions for use of Technical Notes, see the introductory Note in the series, titled "Using 'Water for the World' Technical Notes." Other parts of the "Water for the World" series include a comprehensive Program Manual and several Policy Perspectives. Further information on these materials may be obtained from the Development Information Center, Agency for International Development, Washington, D.C., 20523, U.S.A.

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