Water for the World

Designing a System of Two or Three Stabilization Ponds
Technical Note No. SAN. 2.D.6

A system of stabilization ponds is an arrangement of two or more ponds connected by pipes that receives sewage, detains it so that biological processes can destroy most of the disease-causing organisms and discharges the effluent as treated sewage. Designing a system of stabilization ponds requires the help of an experienced engineer. Designing involves deciding if more than a single pond is necessary; determining the type and number of ponds in the system; calculating the size of each pond; deciding on the layout of the system; and determining the labor, tools, and materials needed for constructing the interpond piping. The products of the design process are: (1) an overview drawing of the system, (2) design drawings of interpond connections, and (3) a materials list supplement to the basic materials list from "Designing Stabilization Ponds," SAN.2.D.5.

This technical note describes the basic design features of a system of stabilization ponds.

Useful Definitions

EFFLUENT - Settled sewage.

INFLUENT - Liquid flowing into a sewage treatment unit such as a stabilization pond.

SEWAGE - All washwater, excreta, and water used to flush excreta that flows from a building or buildings through a sewer system and into a septic tank, cesspool, or stabilization pond.

TREATED SEWAGE - The liquid that flows out of a stabilization pond or series of ponds; treated sewage is safer than settled sewage and may be used to irrigate crops not intended for human consumption.

Materials Needed

The technical note "Designing Stabilization Ponds," SAN.2.D.5, and all technical information and drawings contained therein.

General Design Information

The three types of stabilization ponds are anaerobic, facultative, and maturation. Each type varies in size and performs a distinct function.

Anaerobic Ponds. These ponds receive sewage with a high organic load or a high degree of solids. That is, sewage flowing into an anaerobic pond has not been presettled in a septic tank or other settling unit. Anaerobic ponds allow solids to settle, partially treat the sewage, and discharge effluent to a facultative pond. They are between 2-4m deep, and they detain the sewage for five to ten days. The main biological action is by organisms that do not require dissolved oxygen for their feeding and reproduction.

Facultative Ponds. These ponds receive sewage from a sewer system or anaerobic ponds, detain the effluent for 10-20 days, and discharge treated sewage to a dry ditch or a maturation pond. Faculative ponds are the most common. If a single pond is to be used, it will be of this type. Faculative ponds are discussed in detail in "Designing Stabilization Ponds," SAN.2.D.5. These ponds vary in depth from 1-1.5m. In a facultative pond, the biological action is both anaerobic and aerobic. Aerobic organisms require dissolved oxygen for their feeding and reproduction.

Maturation Ponds. These ponds are about 1m deep. They receive treated sewage from faculative ponds, detain it for five to ten days to improve its quality and safety, and discharge the treated sewage to a dry ditch or to an irrigation ditch leading to crop land. Maturation ponds can be used to grow food fish and aquatic birds. The action is by aerobic organisms requiring dissolved oxygen for their life proceses.

Ponds can be connected in series or in parallel. In a series arrangement, sewage or effluent is treated in one pond, then discharged to a second pond, then to a third. Each pond in a series discharges a better quality of effluent than the pond before it. In a parallel arrangement, two ponds, side by side, simultaneously receive effluent from the same source and simultaneously discharge treated sewage to the same outlet or ditch. The quality of the discharge from both ponds is similar.

The advantages of a series system are that it can receive unsettled or raw sewage, and it can improve the quality of the effluent for use to irrigate crops or raise food fish.

The advantage of a parallel system is that one pond can remain in operation while the other is drained for maintenance or repair. The retention time in one pond can be controlled by a schedule of discharges, first from one, then from another. This will involve partial drawdown, not complete emptying.

Deciding on One Pond or a System

In most cases, a system of ponds is better than a single pond. The major constraint to a system of ponds is the increased area needed. The site must allow gravity flow, without excessive earth moving. Two parallel, half-size facultative ponds are as effective as a single full-sized pond and they allow for flexibility of operation.

A system of ponds is necessary if:

- sewage is to be more highly treated;
- food fish are to be raised;
- a pond is to be cleaned without shutting off the sewer system.

Determining Type and Number of Ponds

The type and number of ponds depend on the quality of the influent and the desired quality of the treated sewage. Table 1 can be used as an aid in making this decision.

Table 1. Criteria for Selecting Pond Types

Criteria	Pond Types
If influent is sewage	Aerobic pond, followed in series by facultative pond
If influent is effluent	Facultative pond; preferably two ponds in parallel
If treated sewage used for food fish or crop irrigation	Facultative pond (preferably two), followed by maturation pond
If influent is raw sewage, and treated sewage to be used for fish or irrigation	Anaerobic, followed by one or two facultative, followed by maturation

Calculating Pond Size

There are a number of good methods for calculating pond size, each involving certain assumptions and requiring different data. The method described in "Designing Stabilization Ponds," SAN.2.D.5, requires, among other things, determining the average annual water temperature. The method described here is based on the design depth for each type of pond, the design retention time, and the expected daily flow of sewage or sewage effluent. See "Estimating Sewage or Washwater Flows," SAN.2.P.2.

The area of the pond equals the expected daily flow times the retention time divided by the design depth.

$$\text{Area} = \frac{\text{flow x time}}{\text{depth}}$$

For example, suppose the expected flow of sewage is 100,000 liters per day, and the pond system consists of an anaerobic pond, followed by a facultative pond, followed by a maturation pond.

First convert the flow to cubic meters.

$$\text{cubic meters} = \frac{\text{liters}}{1000}$$

$$\text{daily flow} = \frac{100000\ \text{liters}}{1000\ \text{liters/m}^3} = 100\text{m}^3$$

(Worksheet A, Lines 1-2)

Worksheet A. Calculating Pond Sizes in a Pond System

1. Estimated daily flow (from SAN.2.P.2) = 100000 liters
2. Flow expressed in cubic meters = $\frac{\text{Line 1}}{1000}$ = $\frac{(100000)}{1000}$ = 100 m^3

Type of pond (check one): [X] anaerobic [X] facultative [X] maturation

Anaerobic pond

3. Retention time (5-10 days) = 7.5 days
4. Depth (2-4m) = 3 m
5. Area = $\frac{\text{Line 2 x Line 3}}{\text{Line 4}}$ = $\frac{(100) \times (7.5)}{(3)}$ = 250 m^2
6. Proposed width = 10 m
7. Length = $\frac{\text{Line 5}}{\text{Line 6}}$ $\frac{(250)}{(10)}$ = 25 m

Facultative pond

8. Retention time (10-20 days) = 15 days
9. Depth (1.0-1.5m) = 1.25 m
10. Area = $\frac{\text{Line 2 x Line 8}}{\text{Line 9}}$ = $\frac{(100) \times (15)}{1.25}$ = 1200 m^2
11. Proposed width = 24 m
12. Length = $\frac{\text{Line 10}}{\text{Line 11}}$ = $\frac{(1200)}{(24)}$ = 50 m

Maturation pond

13. Retention time (5-10 days) = 7.5 days
14. Depth = 1.0m
15. Area = $\frac{\text{Line 2 x Line 13}}{\text{Line 14}}$ = $\frac{(100) \times (7.5)}{(1.0)}$ = 750 m^2
16. Proposed width = 20 m
17. Length = $\frac{\text{Line 15}}{\text{Line 16}}$ = $\frac{(750)}{(20)}$ = 37.5 m

For the anaerobic pond, the average depth is 3m and the average retention time is 7.5 days. The area equals $100m^3$ per day times 7.5 days divided by 3m:

$$\text{Area} = \frac{100m^3/\text{day} \times 7.5 \text{ days}}{3m} = 250m^2$$

(Worksheet A, Lines 3-7)

For the facultative pond, the average depth is 1.25m and the average retention time is 15 days. The area equals $100m^3$ per day times 15 days divided by 1.25m:

$$\text{Area} = \frac{100m^3/\text{day} \times 15 \text{ days}}{1.25m} = 1200m^2$$

(Worksheet A, Lines 8-12)

For the maturation pond, the average depth is 1.0m and the average retention time is 7.5 days. The area equals $100m^3$ per day times 7.5 days divided by 1.0m:

$$\text{Area} = \frac{100m^3/\text{day} \times 7.5 \text{ days}}{1.0m} = 750m^2$$

(Worksheet A, Lines 13-17)

Ponds are generally rectangular and the length and width of each pond in the example may vary. A few sample dimensions:

anaerobic:	10m wide by 25m long = $250m^2$
facultative:	24m wide by 50m long = $1200m^2$
maturation:	20m wide by 37.5m long = $750m^2$

Determining the Layout of the System

The layout, or arrangement, of the system depends on the type and number of ponds and the slope and area of the system's site. In general, each pond in a series system must be lower than the preceding pond. Two ponds in a parallel system are usually at the same elevation.

The layout of the system determines the configuration of connecting pipes and the placement of valves. Valves are generally placed so that one pond may be drained while the other pond or ponds remain in operation.

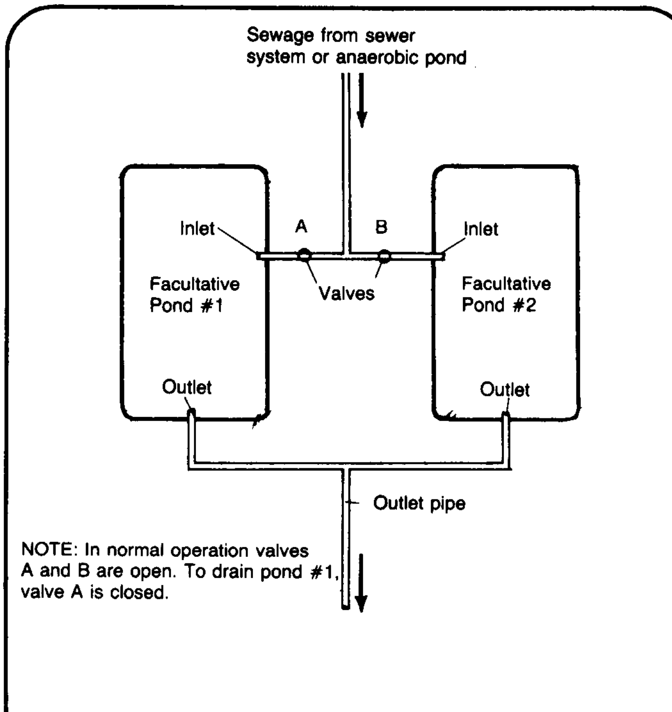

Figure 1. Parallel System Layout

Figures 1 and 2 show two pond system layouts. When the layout has been determined, prepare a drawing similar to one of the figures showing the arrangement of ponds, and the type, width, length, and depth of each pond. Give the drawing to the construction foreman.

Figure 3 shows a typical section of interpond piping. The connecting pipe has a downward slope of at least 1 in 200 (one unit of elevation for every 200 units of distance). Prepare a drawing of each interpond connection showing the length and slope of pipes and give them to the construction foreman. Elevations must be carefully determined and construction must follow the drawings accurately.

Determining Labor, Tools, and Materials

The required labor, tools, and materials for each pond are discussed in "Designing Stabilization Ponds," SAN.2.D.5. The only other consideration is interpond piping. From the layout drawing of the system, determine the total length of interpond pipes needed as well as the number of valves. Attach this information to the materials list described in SAN.2.D.5 and give it to the construction foreman.

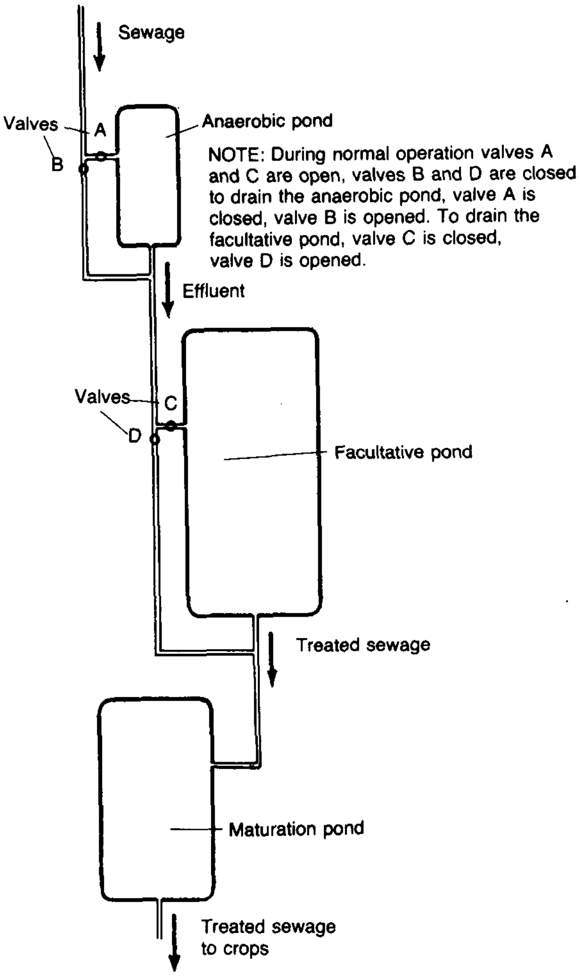

Figure 2. Series System Layout

In summary, prior to construction give the construction foreman all materials described in "Designing Stabilization Ponds," SAN.2.D.5, a drawing of the pond system layout similar to Figure 1 or 2, drawings of all interpond connections similar to Figure 3, and a materials list attachment similar to Table 2.

Table 2. Sample Materials List Attachment for Interpond Piping

Description	Quantity	Estimated Cost
Sewer pipe (100mm diameter) Sewer pipe (200mm diameter)	____m ____m	____ ____
Valves (100mm diameter) Valves (200mm diameter)	____ ____	____ ____

Total Estimated Cost

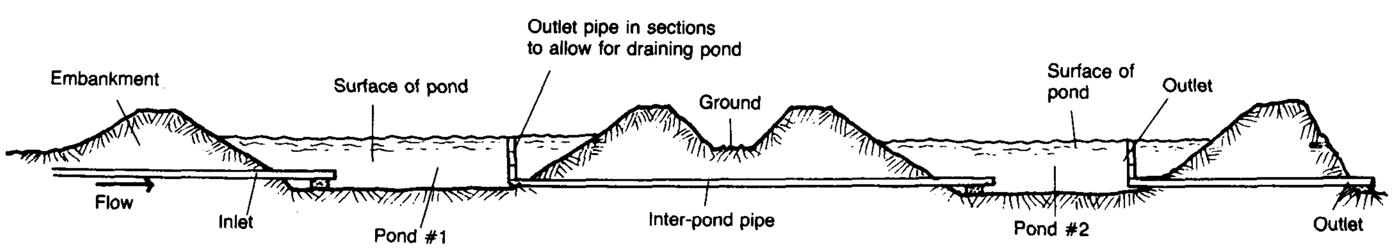

Figure 3. Inter-Pond Piping